GS-14 PRELIMINARY RESULTS FROM THE CHURCHILL RIVER-SOUTHERN INDIAN LAKE TARGETED GEOSCIENCE INITIATIVE

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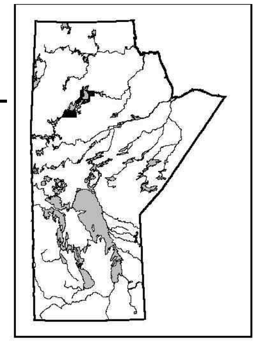

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SUMMARY

This paper reports on the first field season of a new Targeted Geoscience Initiative (TGI) aimed at providing a regional tectonostratigraphic context for supracrustal and plutonic rocks along a transect extending from the north flank of the Kisseynew Domain, through the Lynn Lake, Leaf Rapids and Southern Indian domains, to the south margin of the Wathaman–Chipewyan Batholith. It follows on from a similar transect, recently completed along the northwestern flank of the Reindeer Zone in Saskatchewan, that provided new constraints on terrane composition and assembly, and tectonic environments of formation/deposition. That transect led to the discovery of new exploration targets and renewed economic interest in the region. This field season's program included a re-evaluation of the lithotectonic framework along a transect from the northwestern margin of the Rusty Lake belt to the Partridge Breast belt, as well as a companion study on the mineral potential of the Rusty Lake belt (Barrie and Taylor, 2001).

Preliminary results show that most of the lithotectonic entities defined along Reindeer Lake in Saskatchewan can be traced with a certain degree of confidence into Manitoba. These include

- the Milton Island assemblage, a fore-arc–accretionary prism deposited on the northern flank of the La Ronge–Lynn Lake arc;
- the Crowe Island Complex, the arc's plutonic root; and
- the Park Island assemblage, a potential foreland or molasse basin.

Work in Saskatchewan has demonstrated that most of the large precollisional plutons that intrude the La Ronge Domain can be related to the Wathaman Batholith, and that together they effectively stitch the accreted supracrustal rocks to the margin of the Archean Hearne craton. We have systematically sampled volcanic and plutonic rocks for geochemical analysis and, where warranted, U-Pb dating and Sm-Nd tracer-isotope studies. Major sedimentary assemblages were also sampled for U-Pb sensitive high-resolution ion microprobe (SHRIMP) dating of detrital zircons. Analytical results will be outlined in subsequent publications.

INTRODUCTION

The Lynn Lake Multidisciplinary Geoscience Project was initiated by the Manitoba Geological Survey (MGS) in 2000, in order to provide an integrated and updated view on the regional geology and economic-mineral potential of the Lynn Lake Belt and surrounding area. In the summer of 2001, the Geological Survey of Canada joined the MGS through a new federal government Targeted Geoscience Initiative (TGI), with the specific goal of providing a regional tectonostratigraphic context for volcanic, sedimentary and plutonic assemblages that occur along a transect spanning the entire northern flank of the Trans-Hudson Orogen (THO), from the Kisseynew Domain to the Wathaman–Chipewyan Batholith (Fig. GS-14-1). This transect incorporates the better known Rusty Lake belt (which hosts the Ruttan Cu-Zn mine), part of the Lynn Lake Belt, the lesser known Partridge Breast belt and other minor supracrustal segments isolated by large intrusions.

This new TGI project covers parts of four 1:250 000 scale maps (NTS sheets 64A, 64B, 64G and 64H) and follows on from a similar, multidisciplinary, bedrock mapping project that was recently completed along Reindeer Lake in Saskatchewan (Corrigan et al., 1997, 1998a, 1998b, 1999a, 1999b, 2000; Maxeiner, 1997, 1998; Corrigan, 2000a, 2000b, 2001; Maxeiner and Demmans, 2000). The Reindeer Lake Project has yielded an improved and updated tectonostratigraphy and a better understanding of the internal framework and mutual relationships between the Kisseynew, La Ronge, Rottenstone and Peter Lake domains (Fig. GS-14-1), as well as providing new U-Pb ages and Sm-Nd tracer-isotope constraints on the nature and provenance of protoliths. One of the primary aims of the Lynn Lake Multidisciplinary Geoscience Project, and specifically of this TGI, is to complete a similar transect from the northern flank of the Kisseynew Domain, across the Lynn Lake–Leaf Rapids and Southern Indian domains, and into the southern margin of the Wathman–Chipewyan Batholith (Fig. GS-14-2). The new data will enable us to better understand the tectonostratigraphic framework and tectonic evolution of the Lynn Lake and associated belts in northern Manitoba. The ultimate integration of the results with those from the Reindeer Lake transect will further our understanding of the Trans-Hudson Orogen, provide a tectonic context for ore formation and mineralization, and permit comparisons with other known metallotects, such as the Flin Flon and Snow Lake belts.

Results presented herein highlight preliminary findings of the first of two planned field seasons. Emphasis during this field season was not particularly on systematic bedrock remapping, since it had been previously done in relative detail, but rather on the re-evaluation of lithological assemblages in terms of protolith origin, geochemical signature, isotopic age,

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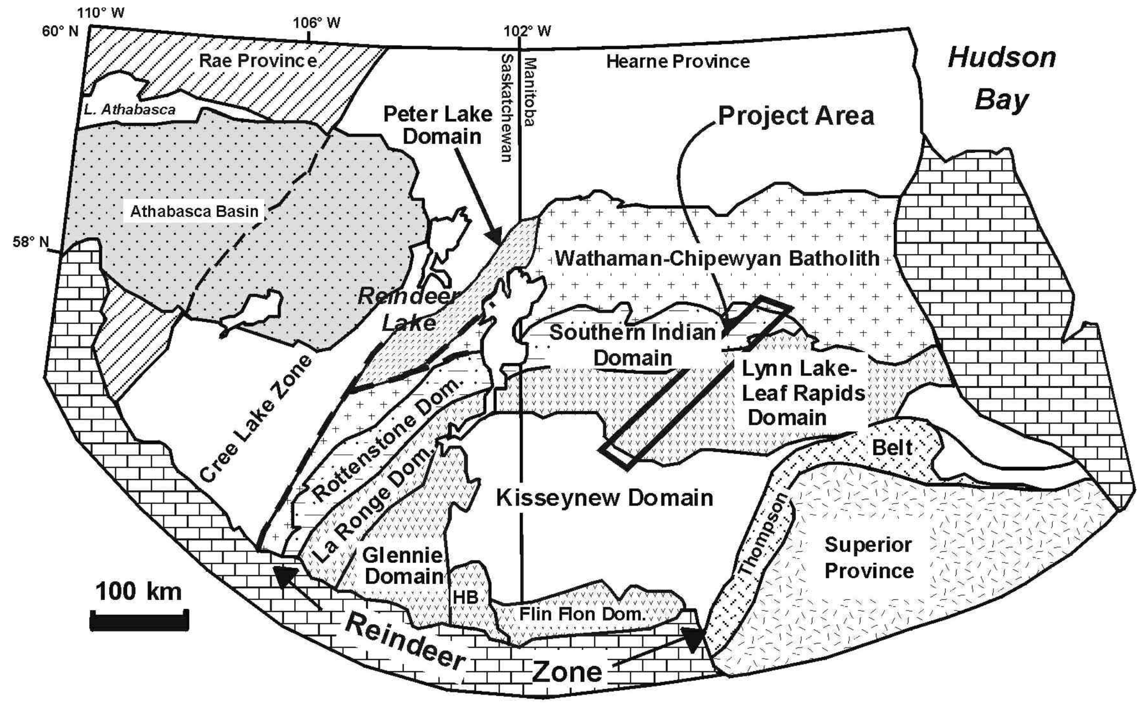

Figure GS-14-1: Main geological divisions of the Trans-Hudson Orogen in Manitoba and Saskatchewan (modified after Hoffman, 1988).

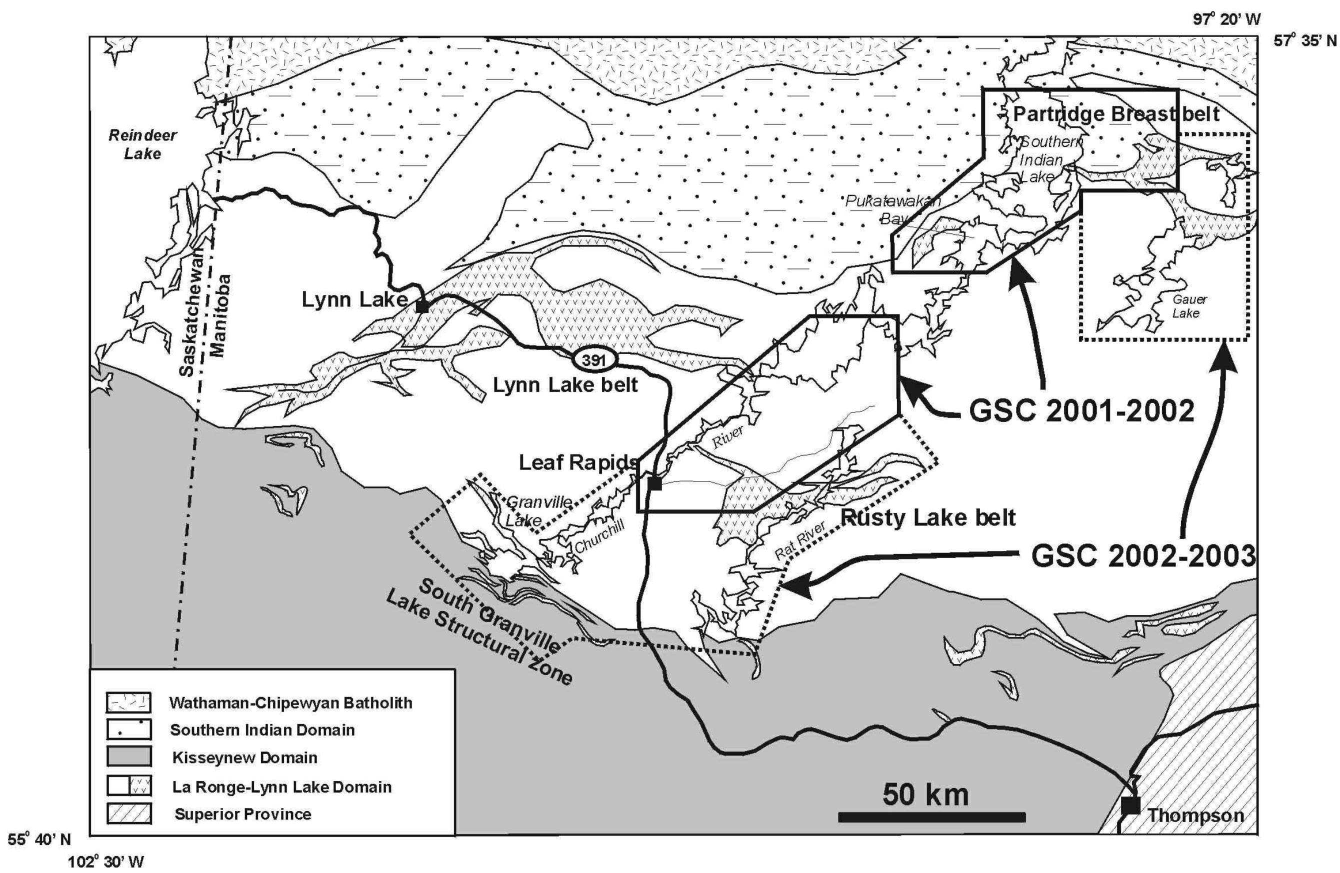

Figure GS-14-2: Simplified geology of the greater Lynn Lake area, showing the main lithological associations.

tectonic environment of emplacement/deposition and, in the case of major sedimentary units, provenance. In addition, an effort has been made to collect samples that will provide constraints on the tectonometamorphic history of the region, in order to provide an orogenic context to regional deformation. A mineral-potential study of the Rusty Lake belt is also currently underway (Barrie and Taylor, 2001). Our work 'dovetails' with detailed structural, geochronological and metallogenic studies of the Lynn Lake belt undertaken by the Manitoba Geological Survey (Beaumont-Smith and Rogge, 1999; Beaumont-Smith et al., GS-11, this volume), in collaboration with the universities of Alberta and New Brunswick, and Laurentian University. The planned fieldwork for this TGI will be completed next field season, with work being concentrated in the Granville Lake, Rat River and Gauer Lake areas. This past summer, our work covered, at various scales, an area of approximately 8000 km^2 and consisted mainly of traverses by boat and on foot along the shoreline and islands of the Churchill River–Southern Indian Lake system, as well as a transect, mainly by road access, across the northwestern portion of the Rusty Lake belt. The principal findings are summarized below.

REGIONAL GEOLOGY

The supracrustal and associated plutonic rocks on the northern flank of the THO in Manitoba have been previously assigned to three main lithological packages, identified as the Kisseynew, Lynn Lake–Leaf Rapids and Southern Indian domains. The Kisseynew Domain comprises mainly upper amphibolite to granulite facies metaturbidite of the Burntwood Group, which is flanked to the north by fluvial to shallow-marine, meta-arkosic and psammitic rocks of the Sickle Group. Geochronological data obtained mainly from the southern and western margins of the Kisseynew Domain constrain the age of deposition between 1850 and 1840 Ma for the Burntwood Group and 1840 and 1835 Ma for the Sickle Group (Ansdell and Yang, 1995). The structural boundary between the Burntwood and Sickle groups is also the site of a narrow but laterally continuous unit (more than 400 km in strike length) that comprises folded and boudinaged mafic flows and sills of mid-oceanic ridge basalt (MORB) affinity (Zwanzig, 2000), interlayered with calcareous psammite, metapelite and minor quartzite. This package, named the Levesque Bay assemblage in Saskatchewan (Corrigan et al., 1998b), is intruded by 1896 +18/–16 Ma leucogranite dykes (D. Corrigan, unpublished preliminary data), suggesting that it may be either contemporaneous with, or older than, the La Ronge–Lynn Lake arc. It stratigraphically correlates with the MacLean Lake Belt in Saskatchewan (Thomas, 1993; Harper, 1998) and the Granville Lake Structural Zone in Manitoba (Zwanzig, 2000).

The Kisseynew Domain is flanked to the north by the Lynn Lake–Leaf Rapids Domain, which comprises a tectonic collage of ca. 1900 to 1880 Ma (Baldwin et al., 1987) volcanic and associated epiclastic and sedimentary rocks. Most of its tectonostratigraphic elements can be correlated with units in the La Ronge Domain in Saskatchewan (Maxeiner and Demmans, 2000). Two major volcanic belts, the Lynn Lake and Rusty Lake belts, have been identified, and each of these has been further subdivided into separate lithotectonic components and subcomponents based on geochemical signature and inferred plate-tectonic setting, including tholeiitic arc, calc-alkaline arc, MORB-like and ocean island basalt (OIB)-like rocks (Syme, 1985; Ames and Taylor, 1996; Zwanzig et al., 1999). Field relationships suggest that the various volcanosedimentary assemblages were aggregated into a tectonic collage before the emplacement of calc-alkaline plutons, which include ca. 1876 Ma gabbro stocks and tonalite (Baldwin et al., 1987).

The Southern Indian Domain flanks the Lynn Lake–Rusty Lake belt to the north and, for the most part, correlates with the Rottenstone Domain in Saskatchewan. It is dominated by foliated granitoid orthogneiss and clastic sedimentary rocks, including conglomerate, greywacke and metaturbidite, and subordinate amounts of volcanic rocks. Recent work on Reindeer Lake in Saskatchewan has led to the recognition of at least two distinct sedimentary basins in the Rottenstone Domain. They are the Milton Island assemblage (Corrigan et al., 1997), interpreted as a fore-arc or accretionary complex formed north of the advancing La Ronge–Lynn Lake arc, and the Park Island assemblage (Corrigan et al., 1998b), interpreted as forming part of a foreland or molasse basin that was deposited on the Hearne continental margin and its cover sequence as a result of tectonic loading of the La Ronge–Lynn Lake arc onto the craton. Stratigraphic equivalents of the Park Island assemblage have also been interpreted to occur in the upper sequence of the Wollaston Domain (Janice Lake assemblage; Yeo, 1998). Patterns on aeromagnetic anomaly maps suggest that both the Milton and Park Island assemblages should be expected to continue into the Southern Indian Domain.

The area north and south of the Southern Indian Domain is dominated by the voluminous Chipewyan Batholith and related Baldock and Livingston plutons. The Chipewyan Batholith is the Manitoba equivalent of the Wathaman Batholith and consists of a continental magmatic arc that was emplaced during the interval 1860 to 1850 Ma (Fumerton et al., 1984; Van Schmus and Schledewitz, 1986; Meyer et al., 1992). Compositions within the batholith range mainly from quartz diorite to syenogranite, with hornblende-biotite monzogranite being the most abundant rock type. The ca. 1855 Ma (U-Pb zircon age cited in Manitoba Energy and Mines, 1990) Baldock granite intrudes supracrustal rocks and orthogneiss of the Southern Indian Domain along its northern margin and appears to merge with the Chipewyan Batholith east of the Partridge Breast belt. It intrudes supracrustal and plutonic rocks of the Rusty Lake belt on its southern flank. The Livingston granodiorite forms another east-trending elongate pluton that intrudes the Rusty Lake belt on its northern margin and the Sickle and Burntwood groups along its southern margin. Its emplacement age is presently unconstrained.

TECTONOSTRATIGRAPHY

Leaf Rapids Domain

The Rusty Lake Belt, which forms the main supracrustal element of the Leaf Rapids Domain, has been the focus of two major studies, involving bedrock mapping and geochemical and petrological work, in the past two decades (Baldwin, 1981, 1987, 1988; Ames et al., 1990; Ames and Scoates, 1992; Ames and Taylor, 1996). Because the bedrock geology in the general vicinity of the Ruttan deposit is described in relative detail in the above publications, we decided it was unnecessary to remap the area. Instead, we have focused our attention on providing additional information by systematically sampling volcanic and plutonic rocks outside the mine area for major-, trace- and rare-earth–element geochemistry, in order to determine the nature of the source rocks and to constrain the plate-tectonic environment of formation. We have also collected samples for U-Pb geochronology and Sm-Nd tracer-isotope studies, which will provide further constraints on the absolute age of formation and model the amount of mantle-crust interaction.

Baldwin (1981) separated the Rusty Lake belt into four fault-bounded structural components named the Ruttan, Northern, Karsakuwigamak and Eastern blocks, which he interpreted as being stratigraphically unrelated. The Eastern and Ruttan blocks comprise mainly basaltic flows, with lesser amounts of mafic wacke, felsic breccia, polymictic conglomerate and minor rhyolite. The Karaskuwigamak Block contains a thick sequence of basal volcanic conglomerate, meta-arenite and psammite, which is overlain by a rhyolitic sequence comprising massive flows, brecciated flows, ignimbrites, airfall deposits, debris-flow deposits, volcanic conglomerate and meta-arenite. The Northern Block is dominated by sedimentary rocks, including a 'lower unit' of basal polymictic conglomerate and metaturbidite and an 'upper unit' of tonalite-cobble conglomerate, meta-greywacke, sulphide-facies iron-formation and iron-rich basalt. The only published age so far in the Rusty Lake belt is from a subaerial rhyolite in the Karsakuwigamak Block, dated by U-Pb zircon at 1878 ± 3 Ma (Baldwin et al., 1987). This age, which is significantly younger than the presently constrained age of volcanism in the Lynn Lake belt (1910 +15/–10 Ma), has been used as a criterion to differentiate the Lynn Lake belt from the Rusty Lake belt.

This past summer, our work in the Rusty Lake belt was separated into two different components. The first consisted of an exploration-geochemistry study centred on the Ruttan Block, but which expanded to some of the other blocks as well. The reader is referred to Barrie and Taylor (2001) for a synopsis of preliminary findings. The second component, which is part of this study, consisted of a re-evaluation of the tectonostratigraphic and geochemical framework of the Rusty Lake belt, outside of the better studied Ruttan mine area in the Ruttan and Northern blocks. The Karsakuwigamak and Eastern blocks will be revisited and sampled next field season. Since most of our observations agreed with earlier maps, we have not deemed it worthwhile to prepare a new bedrock geological map; however, the reader is referred to Barrie and Taylor (2001) for an alternative view on the local tectonostratigraphy and relationships between the different crustal 'blocks'. In order to add constraints on the age of volcanism and sedimentation, we have sampled a quartz-feldspar porphyry rhyolite from the upper felsic and volcaniclastic unit on the Ruttan mine property, as well as a metaturbidite from the Powder Magazine formation, which sits conformably on the latter. The quartz-feldspar porphyry rhyolite will provide constraints on the U-Pb age of the youngest volcanic activity in the Ruttan Block. Analysis of detrital zircon by SHRIMP will provide constraints on the minimum age of deposition of the Powder Magazine formation, as well as on the age spectrum of source rocks.

One observation of regional significance involves the 'upper sequence' of the Northern Block (unit 'W' on Manitoba Energy and Mines, 1986). It consists of grey, tightly folded, migmatitic greywacke-turbidite with characteristic, apatite-bearing, quartzofeldspathic and quartz-rich leucosome separated from the paleosome by thin, biotite-rich melanosome. It stratigraphically overlies volcanic and volcaniclastic units of the Northern Block and is intruded by amphibolite dykes, as well as by the Chipewyan-age Baldock granite. Its stratigraphic position above the volcanic rocks, its array of metamorphic textures and composition, and its relationship with intrusive units are all very reminiscent of the Milton Island assemblage, which sits in a similar tectonostratigraphic position with respect to the La Ronge volcanic assemblage in Saskatchewan (Corrigan et al., 1997). We have sampled this unit for U-Pb SHRIMP geochronology in order to test this hypothesis, and to compare with data from the Milton Island assemblage (Ansdell et al., 1999).

Another aspect of the Leaf Rapids Domain that we examined this past field season was its tectonomagmatic evolution. The objective of this study is to determine whether more than one plutonic suite exists and, if so, to which tectonic event(s) they can be correlated. Evidence so far suggests that at least some of the gabbroic and granitic rocks associated with the Rusty Lake belt are contemporaneous with volcanism (Baldwin et al., 1987; Ames and Taylor, 1996). There is also evidence that the Baldock and other large K-feldspar megacrystic intrusions may be related to the Chipewyan suite. However, other intrusions or intrusive complexes of different relative ages and tectonic settings may be present as well. They include a strongly foliated, migmatitic diorite to granite orthogneiss complex identified on roadside outcrops south of Issett Lake, as well as large, virtually undeformed and nonrecrystallized monzogranitic plutons of potential syn- to postcollisional age. Representative samples of all the above suites and potential suites have been collected for systematic geochemical studies, as well as targeted U-Pb zircon dating and Sm-Nd isotopic characterization.

SOUTHERN INDIAN DOMAIN

Most of the mapping effort in the Southern Indian Domain was concentrated on Southern Indian Lake, where two of the domain's most important and regionally lesser known supracrustal components occur (Fig. GS-14-3). One of the targeted areas was the Pukatawakan Bay area, which lies on the western shore of Southern Indian Lake and was mapped previously by Frohlinger and Cranstone (1972). The other was the Missi Falls–Partridge Breast Lake area, located on the eastern shore of Southern Indian Lake and extending inland along the lower Churchill River (Fig. GS-14-2). It had been previously mapped at reconnaissance scale (*see* Lenton and Corkery, 1981). The intervening area, underlain mainly by large felsic plutons, was also examined, but in lesser detail.

Pukatawakan Bay

The occurrence of mafic volcanic rocks with locally preserved pillow structures had been previously described from a relatively small occurrence of supracrustal rocks in the Pukatawakan Bay area (named here the 'Pukatawakan belt', for geographic reference). This summer we revisited the area with the intention of documenting the various metavolcanic rocks and associated sedimentary rocks, including small units of meta-arkosic and related fluviodeltaic rocks that had been historically linked with the Sickle Group. As well, plutons and other intrusive rocks were examined to provide constraints on the local and regional magmatic evolution.

The most lithologically complex and potentially oldest component in this region is a heterogeneous unit of migmatitic orthogneiss and paragneiss that includes predominantly metapelite and metagreywacke, interlayered with metaplutonic sheets of amphibolitic (metagabbro) to syenogranitic composition. Both ortho- and paragneiss are generally interlayered at outcrop scale and transposed parallel to the regional east-west foliation. This gneissic unit, which is relatively well exposed on the shoreline of Long Point, contains metapelitic diatexite and locally hosts partially retrograded mafic granulite boudins (Fig. GS-14-4), suggesting a metamorphic high (of unknown age) in the immediate area. The field relationship between the gneissic unit and the metavolcanic rocks could not be established due to lack of exposure. However, the fact that the gneiss assemblage reached granulite facies whereas the metavolcanic rocks are only middle-amphibolite facies, in the absence of a major shear zone, suggests that the gneissic rocks may be older. There is, as yet, no absolute age control on this unit.

On the structural top of the north-dipping gneissic unit lies a narrow layer (a few tens of metres) of amphibolite-facies garnet-sillimanite-biotite metapelite. This unit is conformably overlain by black, amphibolite-facies mafic metavolcanic rocks with locally recognizable pillow structures (Fig. GS-14-5) that suggest younging to the north, up the structural section. The mafic volcanic rocks are, for the most part, riddled with veins along which severe calc-silicate alteration occurred. On most outcrops, the calc-silicate alteration veins were subsequently transposed and now form bands that are parallel to the regional foliation, giving the rock a particular light green and black, striped or patchy appearance. Similar rocks are common in the La Ronge belt and Levesque Bay assemblage, where they represent altered, deformed and metamorphosed basaltic flows and sills. More commonly, volcanogenic amphibolite in the Pukatawakan Bay area occurs in banded gneiss, interlayered with metasedimentary rock of psammitic composition, narrow sulphide- and silicate-facies iron-formation, and fine-grained rock of intermediate composition that may represent either deformed and metamorphosed volcanic layers or transposed subvolcanic intrusions. In areas of lower strain, dykes of mixed andesite and quartz-feldspar porphyry granite are observed cutting the mafic volcanic rocks, suggesting that they are indeed subvolcanic intrusions. We sampled one of these dykes for U-Pb geochronology in order to constrain the minimum age of mafic volcanism and the age of potential feeder dykes. Elongate, dark green gabbro sills or dykes intrude the mafic volcanic rocks and associated sediments. All of the above were systematically sampled for major-, trace- and rare-earth–element analysis.

Another distinct sedimentary rock unit that occurs in the Pukatawakan Bay area consists of pink to pale beige meta-arenite and calcarenite. These magnetite-bearing metasedimentary rocks preserve many primary features, such as compositional banding, laminated beds and crossbeds, and have historically been interpreted as potential Sickle Group equivalents. In the Pukatawakan Bay area, they are uniquely preserved as small screens and enclaves in megacrystic biotite±hornblende monzogranite (Fig. GS-14-6). It is noteworthy that this arkosic suite sits at a similar tectonostratigraphic level as, and is compositionally similar to, the Park Island assemblage of the Reindeer Lake area, which yielded detrital zircon ages suggesting a predominant detrital source from the La Ronge belt (Corrigan, unpublished data).

The gneissic and supracrustal rocks of the Pukatawakan Belt are intruded by a number of plutons that are likely related to the Wathaman–Chipewyan suite. These form large, compositionally homogeneous and nonmigmatitic bodies that range in composition from gabbroic to monzodioritic to syenogranitic, but consist mainly of coarse-grained to K-feldspar megacrystic, hornblende-bearing monzogranite. They can generally be distinguished from older suites by the local preservation of relict igneous minerals and general absence of migmatitic textures. Although none of the local intrusions have been dated, most are similar in texture and composition to plutonic rocks from the Big Sand Lake area, about 60 km northwest of Pukatawakan Bay, which yielded U-Pb zircon ages of 1857 ± 9 Ma and 1854 ± 12 Ma (Van Schmus and Schledewitz, 1986). One large, gabbroic to monzodioritic intrusion related to this suite, located between Pukatawakan Bay and Whyme Bay, locally contains up to 2% disseminated chalcopyrite and pyrite. In order to constrain the absolute age of this plutonic suite, as well as provide a minimum age for the meta-arkosic unit, we sampled the K-feldspar megacrystic monzogranite on the west shore of Whyme Bay, where it contains numerous, large, meta-arkose rafts.

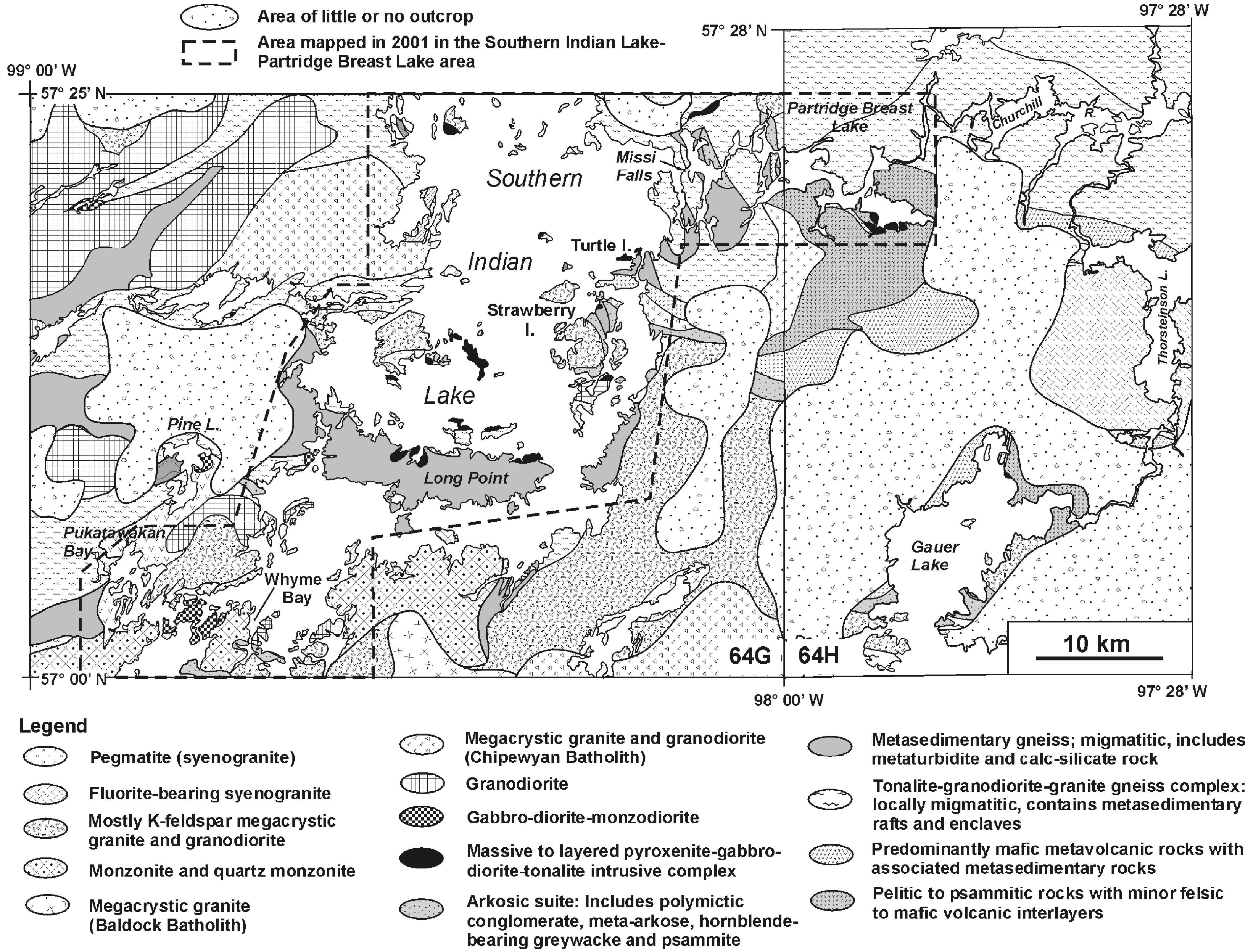

Figure GS-14-3:Simplified geology of the Pukatawakan Bay-Partridge Breast Lake area (modified from Manitoba Energy and Mines, 1987, 1990). Asymmetrical Z-fold formed by D^2 dextral movement along the Johnson Shear Zone.

Figure GS-14-4: Boudins of mafic granulite (small fragments next to hammer) and garnet-clinopyroxene rock in a diatexitic metapelite matrix, north shore of Long Point.

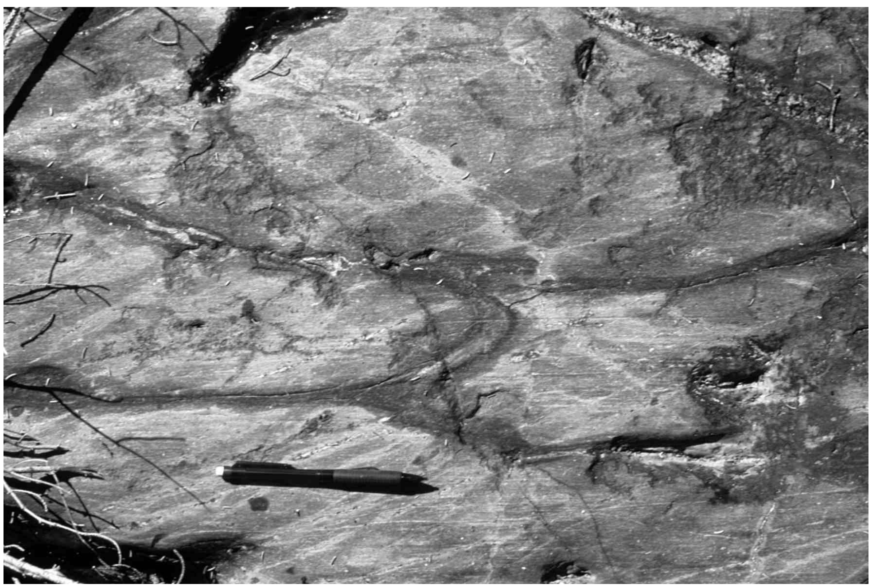

Figure GS-14-5: Pillow structures in mafic volcanic rocks of the Pukatawakan belt; light patches and streaks represent calc-silicate alteration; pencil for scale.

Figure GS-14-6: Coarse-grained hornblende monzogranite intruding laminated meta-arkose, western shore of Whyme Bay; pocket knife for scale.

Missi Falls–Partridge Breast Lake Area

The Partridge Breast belt, which outcrops east of Southern Indian Lake, mainly between the Churchill River and Gauer Lake, contains the largest volume of rocks of probable volcanic origin in the Southern Indian Domain. This past field season, we examined in detail exposures of supracrustal and associated rocks on the well-exposed shoreline and islands of Southern Indian Lake and on the lower Churchill River system, from Southern Indian Lake to the east end of Partridge Breast Lake. The area had been previously mapped at reconnaissance scale and is described in reports by Cranstone (1972) and Lenton and Corkery (1981). In essence, the local geology can be subdivided into three rock associations of differing compositions and ages.

One of the three 'packages', named herein the 'Missi Falls gneiss association' consists mainly of banded orthogneiss of tonalitic, trondhjemitic, granodioritic and syenogranitic composition. The orthogneiss is generally well foliated and completely recrystallized (Fig. GS-14-7), with local development of partial melt.

Interestingly, some of the syenogranitic components, as well as granitic pegmatite bodies, host large faserkiesel (knots of fibrolite+K-feldspar+quartz±magnetite) that are deformed into flat ellipses. The faserkiesel-bearing syenogranitic gneiss bears a strong resemblance to some portions of the Sickle meta-arkose, and could be easily misinterpreted for the latter. In this case, however, the syenogranite, as well as granitic pegmatite bodies intruding the latter, are clearly of plutonic origin, suggesting that the faserkiesel, some reaching 6 cm in length, are likely of metasomatic origin. The orthogneiss package contains inclusions of, and is structurally concordant with, clastic metasedimentary rocks dominated by migmatitic metapelite with a garnet+biotite+K-feldspar±sillimanite±cordierite±melt assemblage. All of the above are intruded by amphibolite, pyroxenite and syenogranite dykes that are now transposed subparallel to the regional foliation. A monzogranite from the Missi Falls gneiss association has been sampled for U-Pb zircon dating and Sm-Nd isotopic-tracer studies. Its contact with supracrustal rocks of the Partridge Breast Belt is not exposed. A similar dioritic to granitic orthogneiss assemblage was identified in the Southern Indian Domain extension in Saskatchewan (Rottenstone Domain) and named the 'Crowe Island Complex' (Corrigan et al., 1997).

The second distinct lithological 'package' consists of predominantly mafic volcanic rocks with minor intermediate and felsic components, associated with clastic sedimentary rocks. This package forms the dominant rock type in the Partridge Breast Belt and is intruded by altered, elongated, dioritic to metagabbroic bodies. A thick sequence of mafic volcanic rocks occurs on Turtle Island and extends inland on the eastern shore of Southern Indian Lake. It is fine to medium grained, dark green to black and highly strained, and locally contains thin dark rinds interpreted as transposed pillow selvages. Calc-silicate alteration is widespread, giving the rock a characteristic light green and black banded appearance. This rock is structurally overlain by pink to grey meta-arkose and polymictic conglomerate, although the contact between the two units is not exposed and indicators of younging direction have not been observed. The polymictic conglomerate contains mostly fine- to medium-grained, pebble- to cobble-sized, granitic to syenitic clasts (Fig. GS-14-8). The overall range in composition and textures in the mafic volcanic rocks, and the presence of meta-arkosic rocks and conglomerate immediately to the south of these, are reminiscent of the same association in the Pukatawakan Bay area, suggesting a continuity, albeit disrupted by later plutonism.

Volcanic rocks are also well exposed on a large island at the eastern end of Partridge Breast Lake. At that location, two distinct north-trending basaltic flows, with individual thicknesses of approximately 5 and 20 m, appear to sit concordantly within a heterogeneous metasedimentary assemblage that includes metapelite, crossbedded meta-arkose, thin polymictic conglomerate and debris flows. The westernmost of the two mafic volcanic layers contains abundant carbonate alteration, whereas the easternmost flow is highly silicified, giving the mafic rock a more 'felsic appearance'. The debris flow contains subangular, boulder-sized and smaller fragments of volcanic and volcaniclastic rocks of mafic to intermediate composition

Figure GS-14-7: Highly strained, banded granite and tonalite from the Missi Falls gneiss association intruded by megacrystic granite, south shore of large island east of Bear Narrows, Southern Indian Lake; photographed area is about 2 m across.

Figure GS-14-8: Polymictic conglomerate with subangular to subrounded felsic clasts, north shore of Strawberry Island; pencil for scale.Bear Narrows, Southern Indian Lake; photographed area is about 2 m across.

(Fig. GS-14-9). Although poorly preserved, features resembling pillow keels suggest that tops are toward the west. The metavolcanic rocks are associated with metaturbidite that contains metapelitic layers bearing orthogonal fibrolite clots up to 6 cm long and 2 cm across, which appear to pseudomorph andalusite porphyroblasts. This would suggest that an earlier metamorphism at low pressure and temperature was followed by a second metamorphic event at medium pressure and temperature.

Thick sequences of pink to grey, polymictic conglomerate interlayered with metapsammite also occur within this assemblage, either as thin layers interbedded with the volcanic rocks or as relatively thick sequences near the stratigraphic top (*see also* Lenton and Corkery, 1981). Rock fragments in the conglomerate are subrounded to well rounded and are mainly of fine-grained meta-igneous origin. The precise contact between the thick conglomerate sequence and the mafic volcanic rocks is not exposed, but both rock units are subparallel and occur within a few metres of each other. The absence of an intervening shear zone or fault suggests a conformable relationship between the two.

The third lithological 'association' in the Missi Falls–Partridge Breast belt area consists of post-D_1 plutons that intrude the Missi Falls gneiss association and Partridge Breast belt supracrustal rocks. Two different 'suites' are noted. One suite (unit 'D' on Manitoba Energy and Mines, 1987, 1990) consists of intensely stretched (L>>S), mixed intrusions of ultramafic to tonalitic composition that occur in the form of small to medium plutons, sills and dykes. One of the better exposed of these occurs on the north shore of Turtle Island (Fig. GS-14-3), where it intrudes metapelitic rocks of the Partridge Breast belt. It contains recrystallized but relatively well preserved igneous layering on a metre to centimetre scale, with individual layer compositions including pyroxenite-hornblendite, metagabbro, leucogabbro, diorite, quartz diorite and tonalite. There is local evidence for multiple injection in a dynamic magma chamber, as indicated by the presence of pseudocrossbeds in rhythmically layered diorite (Fig. GS-14-10), numerous angular mafic to ultramafic xenoliths in intrusions cutting the layering (Fig. GS-14-11), and the local presence of a fine network of ultramafic veinlets cutting earlier fabrics. Metagabbroic and metadioritic plutons and sills also intrude supracrustal rocks in the Partridge Breast Lake area and contain a similar L>>S fabric,

Figure GS-14-9: Large clast of felsic tuff-breccia in debris-flow horizon immediately below a mafic flow, north shore of island on the west side of Partridge Breast Lake; hammer for scale.

suggesting a possible link with the Turtle Island pluton and other local intrusions. In addition to systematic sampling for geochemical analysis, a quartz diorite from the Turtle Island pluton was sampled for U-Pb geochronology. For reference, we have unofficially named this suite the 'Turtle Island suite'.

The other 'suite' consists of much larger, more compositionally homogeneous, coarse-grained to K-feldspar megacrystic, biotite±hornblende monzodiorite plutons (Fig. GS-14-12). They generally preserve a large proportion of igneous minerals and are not as strongly lineated as the 'Turtle Island suite'. Their textural, compositional and structural similarity to plutons of the Chipewyan Batholith suggests that they likely belong to that suite. Representative samples were collected for geochemical characterization.

DISCUSSION

Field observations this past season have enabled us to gain a better understanding of the tectonostratigraphic framework of the Leaf Rapids and Southern Indian domains, as well as establish specific links with components of the La Ronge and Rottenstone domains in Saskatchewan. Based on a single U-Pb analysis in each of the Rusty Lake and Lynn Lake belts, they had been interpreted as totally separate entities (i.e., Baldwin et al., 1987). However, caution should be exercised in attributing too much weight to the radiogenic ages until more become available. Our preliminary observations suggest that the belts may not necessarily be exotic with respect to one another. For example, in a recent study, Maxeiner and Demmans (2000) demonstrated continuity of the Lynn Lake and La Ronge belts, which also implies that the Milton Island assemblage, a fore-arc and/or accretionary complex that flanks the La Ronge Belt to the north, should likely have a lithological equivalent in Manitoba. A potential candidate that bears many lithological and tectonostratigraphic similarities to the Milton Island assemblage is the Zed Lake assemblage, which flanks metavolcanic rocks of the Lynn Lake Belt to the north (Gilbert et al., 1980). As previously mentioned (*see* 'Leaf Rapids Domain' section), the 'upper sequence' of the Northern Block also shares many similarities with the Milton Island assemblage, providing a potential link and perhaps establishing regional continuity.

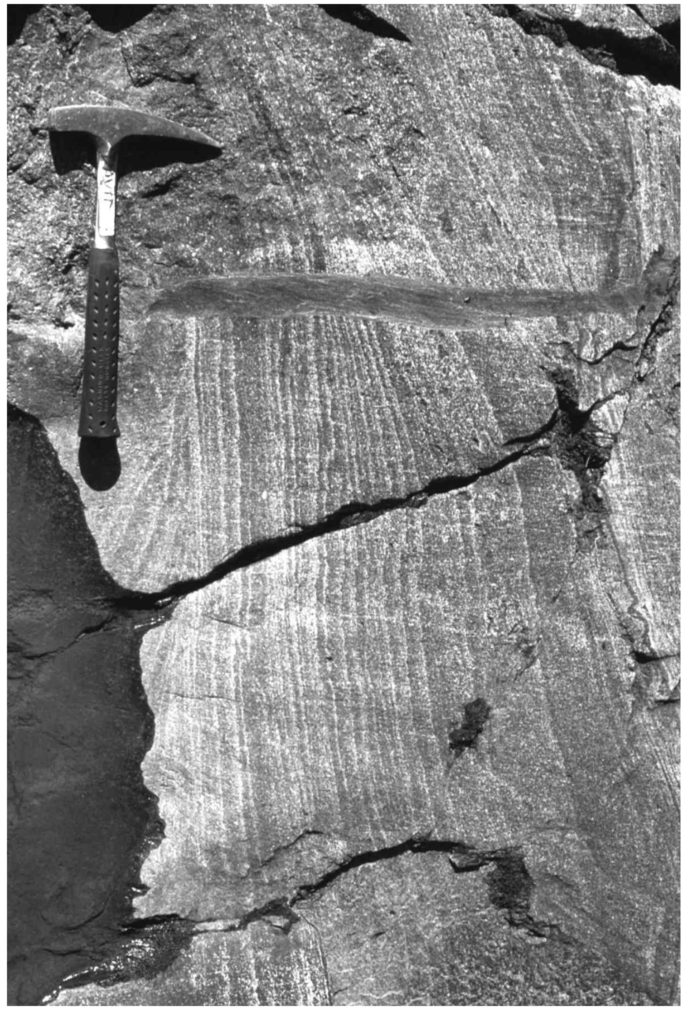

Figure GS-14-10: Rhythmic igneous layering in metamorphosed gabbro-leucogabbro, north shore of Turtle Island, Southern Indian Lake; note the disrupted layering and cross-bedded effect just below the geological hammer.

Preliminary investigations of supracrustal assemblages in the Pukatawakan Bay and Missi Falls–Partridge Breast Lake areas have also yielded important observations on their respective stratigraphies and potential links. Volcanic rocks from Pukatawakan Bay and the Partridge Breast belt have many similarities and very likely represent lateral equivalents, although disrupted by Chipewyan-age plutonism. They are mainly represented by basaltic flows and show similar calc-silicate alteration, except for the one flow on Partridge Breast Lake that has undergone silicate alteration. Felsic to intermediate components do occur but are relatively rare. The stratigraphic interlayering of the mafic volcanic units with crossbedded meta-arkose, psammite and predominantly quartzofeldspathic polymictic conglomerate, however, distinguishes this volcanic sequence from those of the La Ronge–Lynn Lake arc, which are predominantly associated with deep-marine sediments and iron-formation. Systematic sampling of mafic volcanic rocks for geochemical analysis will permit comparisons among the various belts.

Historically, meta-arkose and conglomerate from the Pukatawakan Bay and Partridge Breast belt area had been tentatively named 'Sickle-type' (Cranstone, 1972). A direct correlation with the Sickle Group had been questioned by Lenton and Corkery (1981), who preferred to use the term 'arkosic suite' until an unequivocal correlation is established. According to compilation maps NTS 64F and 64G (Manitoba Energy and Mines, 1989, 1990), the 'arkosic suite' is interpreted to occur, although discontinuously, throughout the Southern Indian Domain as far west as Reindeer Lake. At that location, it correlates with the Park Island assemblage, whose deposition was constrained by U-Pb zircon dating at ca. 1870 to 1860 Ma, with the minimum age provided by the crosscutting Wathaman Batholith (Corrigan et al., 1999b). In the Pukatawakan Bay area, 'Chipewyan-type' plutons intrude rocks of the 'arkosic suite', indicating a more likely correlation with the Park Island assemblage instead of the ca. 1840 to 1830 Ma Sickle Group.

Figure GS-14-11: Angular xenoliths of pyroxenite (dark) and diorite (light grey) in a homogeneous metagabbro dyke cutting rythmic layering (not shown), north shore of Turtle Island, Southern Indian Lake; light-coloured lines oriented subparallel to the hammer handle are glacial striations; hammer for scale.

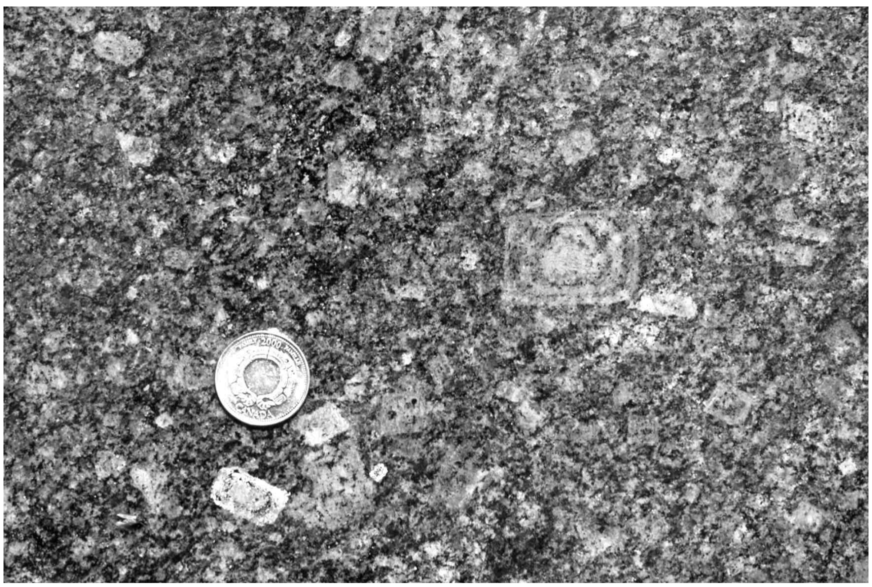

Figure GS-14-12: Megacrystic hornblende monzogranite likely related to the Chipewyan Batholith, western shoreline of Strawberry Island, Southern Indian Lake; note the excellent preservation of igneous textures, including zoning in feldspar; coin is 2.5 cm across.

In the Reindeer Lake area, three main tectonothermal phases were recognized:

- Pre-Wathaman, orogen-parallel, large-scale recumbent folds (F_1) related to terrane accretion onto the Hearne craton margin (D_1-M_1);
- South-vergent thrusting and thrust-stacking associated with 1825 to 1800 Ma terminal collision, which produced tight to isoclinal, nearly coaxial, syn–peak metamorphic, F_2 folds and high-strain zones (D_2-M_2); and
- Late-tectonic, upright, open crossfolds (F_3) produced during a late-orogenic D_3 event that may locally be associated with retrograde metamorphism (D_3-M_3; Corrigan et al., 1999b).

Along the Churchill River–Southern Indian Lake transect, evidence for D_1-M_1 and D_2-M_2 is widespread, but late-orogenic D_3 folds are either poorly developed or simply absent. Although these are the only three ‘events’ that can be correlated at a regional or ‘tectonic’ scale, more detailed studies have revealed further complexities (i.e., Beaumont-Smith and Rogge, 1999) that may reflect local boundary conditions during the accretionary and collisional phases of the orogen.

ECONOMIC POTENTIAL

The Lynn Lake and Rusty Lake belts host numerous economic gold and volcanogenic massive-sulphide deposits, and undoubtedly have the potential to contain yet more undiscovered ore. However, potential also exists for other types of ore deposits, such as gold deposits near the reworked margins of large plutons, a common feature in the La Ronge Belt in Saskatchewan (Lafrance, 1999). Our preliminary work in the Rusty Lake belt has shown that there may be a potential for similar deposits in the marginal zones of plutons, near contacts with supracrustal rocks. Other units of interest include gabbro-monzodiorite with disseminated sulphides in the Pukatawakan Bay area and layered mafic-ultramafic-intermediate intrusions in the Turtle Island area. The gabbro-monzodiorite intrusion between Pukatawakan Bay and Whyme Bay (*see*

‘Pukatawakan Bay’ section) is poorly exposed, but one small outcrop on the shore of Southern Indian Lake contained 1 to 2% disseminated sulphide minerals that locally form clots up to 5 mm in diameter containing approximately equal proportions of chalcopyrite and another sulphide, possibly pyrite. Assay results were not yet available at the time of publication. The mafic-ultramafic-intermediate layered intrusion on the north shore of Turtle Island contains only a small proportion of ultramafic rock and only minor sulphides. However, it shows evidence of multiple injections in a dynamic, mafic magma system, a feature considered significant in exploration for platinum-group elements.

Only a relatively minor amount of sulphide minerals was observed in association with the Pukatawakan Bay and Partridge Breast belt volcanic assemblages. However, only small portions of the belts were exposed in the areas visited, so potential may exist in unexposed segments. Carbonate and silicate alteration does appear to be pervasive, suggesting that fluids were present, as does the local alteration of metagabbro to a garnet-cummingtonite assemblage. One other notable observation was the presence of a number of tourmaline- and locally beryl-bearing pegmatite dykes emplaced in supracrustal rocks of the Partridge Breast belt along the banks of the lower Churchill River between Southern Indian Lake and Partridge Breast Lake. These may present potential targets for rare-earth elements.

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