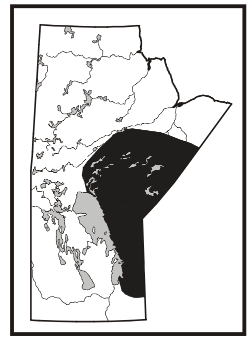

GS-20 WESTERN SUPERIOR NATMAP: AN INTEGRATED VIEW OF ARCHEAN CRUSTAL EVOLUTION

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INTRODUCTION

The western Superior NATMAP project aims to provide a modern geoscience synthesis of northwestern Ontario and eastern Manitoba using resources of the federal, Ontario and Manitoba Geological Surveys, working at a variety of detailed and regional map scales. Key areas have been selected to address questions regarding relationships between Mesoarchean and Neoarchean sequences of the western Superior Province (Fig. GS-20-1; Percival et al., 1997), through new mapping, geochemistry, geochronology and GIS-based compilation. In 2000, the fourth year of field operations, focus was on the Uchi Subprovince (Fig. GS-20-2) at the southern margin of the Mesoarchean North Caribou Terrane, with continued work on the Wabigoon and Sachigo subprovinces.

In this paper, we present highlights of 2000 field and ongoing laboratory studies. Further syntheses in the form of a series of compilation maps will be released over the next year.

UCHI SUBPROVINCE

Lake Winnipeg Area

A collaborative mapping program in the Black Island area (Fig. GS-20-2) followed initial reconnaissance studies (Bailes, 1999; Percival and Whalen, 2000). At least three distinct supracrustal sequences are present, in addition to a ca. 3 Ga basement complex.

Basement complex

Hornblende-biotite tonalite of the East Shore complex represents basement to the Lewis–Storey assemblage. These coarse-grained, homogeneous rocks with characteristic blue quartz resemble tonalitic units in the vicinity dated at 3006 to 2998 Ma (Ermanovics, 1970, 1981; Krogh et al., 1974; Turek and Weber, 1994; V. McNicoll, unpublished data, 2000). North-trending, chlorite-grade shear zones (D_1) carry distinctive shear-band fabrics indicating dextral strike-slip motion.

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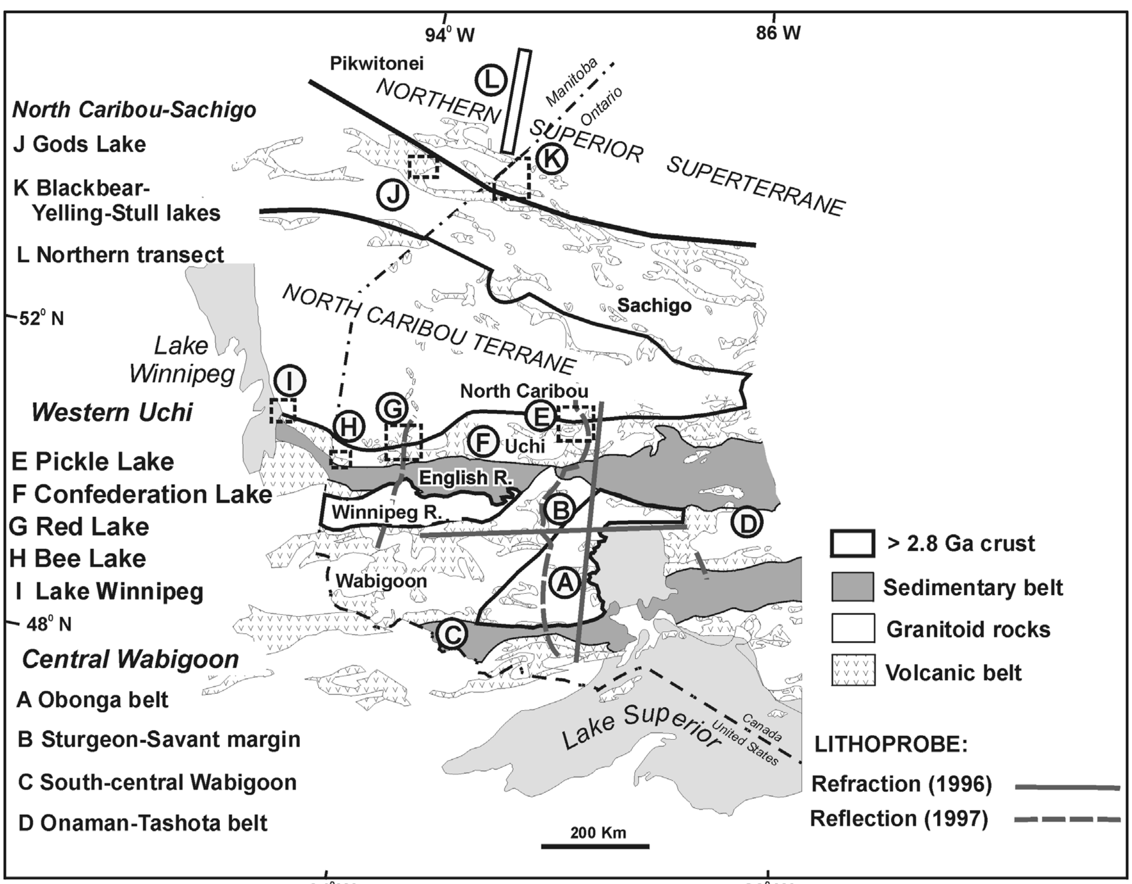

Figure GS-20-1: Schematic tectonic map of the western Superior Province, showing locations of areas under study.

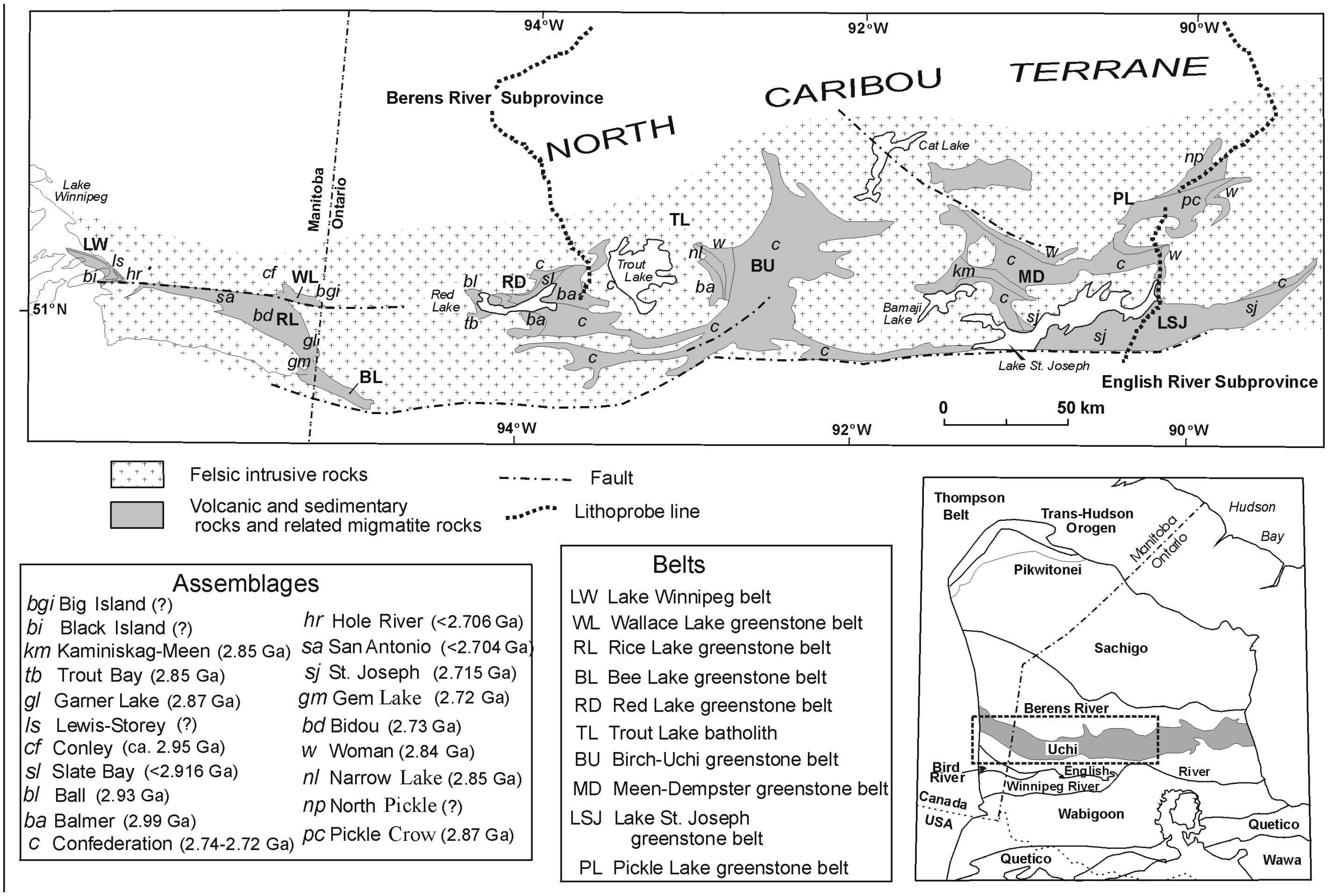

Figure GS-20-2: Generalized tectonic map of the western Uchi Subprovince, showing locations of assemblages discussed in the text (modified from *Stott and Corfu, 1991; Sanborn-Barrie et al., 2000).*

The East Shore complex and English Lake complex to the east (3006–2992 Ma) share distinctive geochemical features. Rocks ranging in composition from tonalite to diorite and gabbro have multi-element profiles with modest negative Ti and Nb anomalies, and strongly depleted Th and Rb. These primitive-arc characteristics may be the product of an ultradepleted mantle source.

Lewis–Storey assemblage

A west-facing sedimentary-volcanic sequence lies unconformably above the East Shore complex and may represent a Mesoarchean rift succession (Thurston and Chivers, 1990). A similar quartzite–carbonate–iron-formation–komatiite package has been dated at Wallace Lake, 70 km to the east, at between 2.92 and 3.0 Ga (Poulsen et al., 1996; Sasseville and Tomlinson, 2000; Tomlinson and McNicoll, unpublished data, 2000). The unconformity, documented at six localities over 30 km of strike length, separates tonalite from a unit of coarse, massive to thick-bedded grit with a chloritic matrix. Thinly laminated, fine-grained quartz arenite occurs in units up to a few metres thick, in association with muscovite-rich schist, aluminosilicate-bearing schist and talc schist. Overlying komatiite has spinifex with radiating clinopyroxene up to 20 cm long (*see* Percival and Whalen, 2000, Fig. 5). Associated iron-formation consists of centimetre-scale layers of carbonate, chert, magnetite and sericite schist. Mafic sills up to 15 m thick intrude both the basement and cover sequence adjacent to the unconformity.

Black Island sequence

The homoclinal, west-facing Black Island sequence comprises two basalt-dominated packages (Bailes and Percival, Fig. GS-26-5, this volume). A lower stack of thick massive flows, the Gray Point sequence, has flat multi-element profiles (approx. 5x chondrite) with light rare-earth element (LREE), Th and Nb depletion. It is separated by a thin volcaniclastic unit from an upper unit of pillow basalt, the Drumming Point sequence, of calc-alkaline affinity. A thin unit of lithic wacke caps the sequence. Ermanovics and Wanless (1983) reported an age of 2732 Ma for Black Island rhyodacite; however, the relationship between this east-facing outcrop, located structurally beneath the basalts, and the main Black Island sequence is not known.

Hole River sequence

Pink and grey arkose and rare conglomerate of the Hole River sequence occur mainly on islands. The fine- to coarse-grained sandstone contains detrital zircons with ages as young as 2706 Ma (V. McNicoll and J. Percival, unpublished data, 2000).

All units carry a penetrative, north-trending, steeply west-dipping S_1 foliation and widespread concordant D_1 high-strain zones up to 40 m wide. Shear-sense indicators, including late D_1 'Z' folds (F_{1a}), suggest dextral kinematic sense. In the eastern part of the area, ductile D_1 fabrics are truncated by sheets and plutons of biotite granodiorite that may be correlative with granodiorite dykes with a poorly constrained age of ca. 2715 Ma (Krogh et al., 1974). Southwest-trending S_2 crenulations are common in thinly laminated high-strain (D_1) zones. A steeply dipping, east-trending zone of dextral greenschist-facies high strain (D_3) forms the linear shoreline in the vicinity of Seymourville. It translates the basement-cover sequence approximately 7 km to the west, into the Pelican Harbour area.

A poorly preserved sedimentary-volcanic sequence lies along the southern margin of an east-trending body of hornblende-biotite tonalite in the Wanipigow River area. Both the tonalite and supracrustal rocks resemble those in eastern Lake Winnipeg, although an unconformity was not observed. The tonalite is bordered to the south by a grit unit up to 10 m thick and is overlain by fine-grained, thinly laminated siliceous siltstone. Sporadic magnetite-chert and hematite-chert ironstone is also present at this structural level. Gabbroic sills with minor serpentinite schist layers occur structurally above the iron-formation, as well as within the tonalite.

A working hypothesis involves deposition of the Lewis–Storey rift sequence on the western margin of 3 Ga basement of the North Caribou terrane, with subsequent spreading recorded by mafic sill emplacement. The margin collapsed as the Black Island sequence was juxtaposed, probably in a strike-slip regime, ca. 2.72 Ga. Hole River sediments were deposited in strike-slip basins during continued D_1 oblique convergence. Waning deformation became focused in shear zones during D_3 and D_4 transcurrent shear events.

Bee Lake Belt

The Bee Lake greenstone belt (Fig. GS-20-1, -2), which straddles the Manitoba–Ontario border, represents the southeastern extension of the Rice Lake belt. Due to its limited (float plane only) access and relatively small size (approx. 170 km^2), this belt has not been mapped in detail since Shklanka (1967). Consequently, no geochronology or geochemical data are available.

The Bee Lake belt consists of a relatively simple volcano-sedimentary sequence that has undergone two ductile deformation (folding) events (referred to herein as D_1 and D_2), as well as subsequent brittle-ductile faulting. These rocks have been intruded by several generations of dykes and plutons, from which the timing of deformation events will be constrained.

The volcano-sedimentary sequence consists of a basal suite of probably calc-alkaline basaltic flows, pillow basalt and pillow breccia, which are overlain by interbedded felsic volcanic and clastic sedimentary rocks. The felsic volcanic rocks are predominantly epiclastic volcanic breccia, whereas the sedimentary rocks typically consist of arkosic sandstone and conglomerate. Locally, the conglomerate contains boulder-sized clasts of granodiorite that have undergone little or no pre-entrainment deformation.

The main deformation event in the belt, D_1, consists of at least three pulses of folding, interspersed with intrusions of tonalitic dykes that are generally transposed nearly parallel to the S_1 cleavage. The D_1 folds trend west-northwest, with a major east-southeast-plunging syncline centred on Bee Lake and a corresponding anticline centred on Odd Lake. The D_2 deformation is synchronous with intrusion of the Wingiskus Lake granodiorite pluton, which forms the core to a dome. The D_1 and D_2 structures are cut by late granodioritic intrusions, such as the Reahil Lake pluton. All rocks are cut by conjugate sets of brittle faults that are probably related to movement of the Sydney Lake–Lac St. Joseph Fault, which marks the southern margin of the belt.

The Bee Lake greenstone belt was previously correlated with the Confederation assemblage. However, the noticeably different rock types and stratigraphy between this region and the type section for the Confederation assemblage in the Birch–Uchi greenstone belt, and its extension in the Red Lake greenstone belt, suggest that this correlation may not be valid. Rather, the Bee Lake belt may correlate with the ca. 2.72 Ga Gem Lake subgroup of the adjacent Rice Lake greenstone belt.

Red Lake Greenstone Belt

The second field season of western Superior NATMAP activities in the Red Lake greenstone belt (Fig. GS-20-2; cf. Sanborn-Barrie et al., 2000) focused on integrating geological mapping with new and previously available lithogeochemical, geochronological and GIS data to further advance an understanding of 1) the interplay between magmatism, alteration, deformation and mineralization; 2) the relationships between Meso- and Neoarchean assemblages; and 3) the tectonic setting of the belt through 300 m.y. of Archean history. Collectively, these data highlight a history of episodic magmatic activity and sedimentation along the south margin of the North Caribou protocraton, and orogenic activity that culminated in collision with the Winnipeg River protocraton during a ca. 2.72 Ga phase of the Kenoran orogeny.

The earliest magmatism is represented by the ca. 2.99 Ga Balmer assemblage, which is dominated by submarine, high-TiO_2 tholeiitic basalts that range from LREE and large-ion lithophile element (LILE) depleted, to slightly enriched with small positive Th/Nb anomalies. Komatiite (olivine spinifex) and komatiitic basalt (pyroxene spinifex) are LREE depleted with positive Th/Nb anomalies. In contrast, komatiite and basalt of the ca. 2.94 to 2.92 Ga Ball assemblage are associated with voluminous intermediate to felsic volcanic rocks, have calc-alkaline affinities and low TiO_2 contents, and show a greater degree of LREE and LILE enrichment. Resurgence of calc-alkaline magmatism and volcaniclastic deposition at 2894 Ma, followed by quiescent marine conditions, is recorded by the Bruce Channel assemblage. New field, geochronological and geochemical data from the southwest part of the belt indicate the presence of the Trout Bay assemblage (Fig. GS-20-1), consisting of ca. 2.85 Ga intermediate tuff and marine siliciclastic and chemical sedimentary rocks overlain by coarse fragmental rocks and submarine, low-TiO_2 tholeiitic basalt that are strongly depleted in LREE and LILE. Finally, new data allow subdivision of the Neoarchean Confederation assemblage into the 2748 to 2742 Ma McNeely sequence, a shallow marine, calc-alkaline, mafic to felsic succession; the overlying 2744 to 2739 Ma Heyson sequence of tholeiitic basalt, F3 rhyolite and minor calc-alkaline volcanic rocks; and the younger ca. 2.73 Ga Graves sequence, comprising an intermediate, calc-alkaline, volcano-plutonic complex.

This protracted history of magmatic activity is punctuated by sedimentary episodes involving deposition of locally derived clastic detritus and precipitation of chemical sediments. Compositionally immature clastic rocks occur within the Balmer, Bruce Channel and Trout Bay assemblages, in contrast to compositionally mature fuchsitic quartz arenite and conglomerate interstratified with ca. 2.94 to 2.925 Ga felsic volcanic rocks of the Ball assemblage and forming the post-2912 Ma Slate Bay assemblage that disconformably overlies Balmer basalt. A regionally extensive unit of polymictic conglomerate marks the interface between Mesoarchean and Neoarchean strata, consistent with an emerging view that the main stages of crustal growth in the Red Lake belt from ca. 3 Ga to 2.7 Ga were primarily depositional, not tectonic.

The Red Lake greenstone belt is polydeformed, with an early (pre-2748 Ma) nonpenetrative deformational event (D_0) and at least two recognizable generations of ductile structures (D_1, D_2) imposed after ca. 2742 Ma volcanism. Early deformation involved overturning of Balmer pillowed basalt, as documented by opposing facing directions on either side of the regionally extensive angular unconformity in the Madsen and central Red Lake areas, and is interpreted to have involved recumbent folding. The main stages of penetrative deformation resulted in two sets of folds (F_1 and F_2), established by opposing younging and structural-facing directions. Planar and/or linear fabrics associated with D_1 trend northerly and are locally recognized throughout the belt, whereas widespread, weakly to moderately developed L-S fabrics associated with F_2 folds (D_2) trend east to northeast. The timing of deformation is established by field relationships involving the 2718 Ma Dome Stock, which contains foliated xenoliths of local country rock but is itself weakly to moderately foliated with a penetrative northeast-striking fabric, characteristic of the regional S_2 foliation. The orientation of interpreted D_2 fabrics deviates from the regional (east- to northeast-striking) S_2 trend to an east-southeast–striking, low-strain corridor between Cochenour and Balmertown. This deviation may have evolved through shifting local boundary conditions in the eastern Red Lake belt if, as predicted, the Trout Lake Batholith (Fig. GS-20-1) includes a major phase of ca.

2.72 Ga magmatism. Localization of strain into a belt-scale system of conjugate shear zones (cf. Andrews et al., 1986) was not substantiated during this study.

The majority of gold deposits in the Red Lake district are the end-product of hydrothermal replacement and constitute atypical greenstone-hosted gold types. The Campbell–Red Lake deposit consists mainly of early to syn-D_2, quartz- and arsenopyrite-rich, selective replacement zones of colloform-crustiform iron-carbonate veins and breccia. These silicified carbonate veins are hosted mainly by heterogeneously foliated basalt within the east-southeast-trending D_2 strain corridor informally designated the 'mine trend'. The Madsen deposit is an amphibolite-grade, disseminated-replacement–style gold deposit hosted by mafic volcaniclastic rocks. On the basis of style and mineralogy, this deposit has been interpreted as a gold-rich skarn-like deposit (Dubé et al., 2000). All the major Red Lake deposits are proximal to a regionally extensive angular unconformity between the ca. 2.99 Ga Balmer and ca. 2.74 Ga Confederation assemblages.

The district has been affected by large-scale hydrothermal alteration systems, resulting in strong to intense calcite carbonatization that affects rocks of the Balmer, Ball, Bruce Channel and Confederation assemblages. Less extensive areas of strong to intense ferroan-dolomite alteration enclose the majority of gold deposits in the greenstone belt and represent proximal alteration envelopes that affect the Balmer, Ball and Confederation assemblages. The proximal zones are characterized by a greater volume of ferroan-carbonate veins and disseminated sulphide mineralization than in calcite-altered areas. Potassic alteration, in the form of pervasive biotitization, occurs in proximal alteration zones. Metamorphosed proximal alteration zones are characterized by a diverse assemblage of aluminosilicate minerals such as andalusite, staurolite, garnet and chloritoid.

Carbonatized mafic metavolcanic rocks adjacent to the Killala–Baird Batholith have been metasomatized and pervasively replaced by a calc-silicate assemblage of diopside, orange garnet, epidote, tremolite, calcite and quartz. Diopside veins also cut and replace early ferroan-carbonate veins and are associated with gold zones at Madsen. If it can be shown that diopsidic veins and skarn development are related to a phase of the Killala–Baird Batholith, the batholith could be implicated in gold mineralization of this part of the belt. This would, in turn, open up new areas of exploration for skarn-type gold deposits in the camp.

The tectonic evolution of the Red Lake belt appears to have involved ca. 2.99 Ga plume-related rifting, followed by development of a ca. 2.94 to 2.92 Ga calc-alkaline arc complex (cf. Tomlinson et al., 1998; Hollings et al., 1999). Intercalation of komatiite units within this arc complex may reflect rifting and/or impingement of a plume in a subduction-zone setting (Hollings et al., 1999). Renewed arc volcanism at 2.89 Ga, followed by tectonic quiescence and subsidence across the continental margin, may reflect major changes in relative plate convergence, in which orthogonal convergence was accompanied by arc volcanism and oblique convergence by magmatic quiescence. This may have led to accretion of the 2.85 Ga Trout Bay island arc–back arc complex with the southern North Caribou margin, resulting in pre-2.75 Ga recumbent folding, uplift and sedimentation. Unconformably overlying rocks record a Neoarchean history of renewed emergent-arc volcanism at 2.75 to 2.74 Ga (McNeely sequence), followed by subsidence and intra-arc rifting at 2.74 Ga (Heyson sequence). A final phase of Andean-style arc magmatism at ca. 2.73 Ga, recorded at Red Lake (Graves sequence) and throughout the Berens arc, is diachronous along the margin between 2.73 and 2.72 Ga. This is interpreted to reflect subduction beneath the southern North Caribou margin, leading to collision with the Winnipeg River protocraton at ca. 2718 Ma, during the Uchian phase of the Kenoran orogeny.

A co-operative GIS-database project involving the Geological Survey of Canada (GSC), the Ontario Geological Survey (OGS) and mineral industry partners is underway in the Red Lake belt. The purpose is to assemble, integrate and release hard-copy maps and a CD-ROM containing all available digital and analog geoscience data. To date, emphasis has been on compiling public-domain information. The main geoscience themes compiled to date include bedrock and surficial geology; regional lithogeochemistry; diamond drilling and other types of mineral exploration assessment work; airborne magnetic, EM and gamma-ray data; and Landsat imagery. A preliminary release of data in ArcInfo, ArcView and MapInfo formats is scheduled for early December. A short field program was conducted in June 2000 to sample areas of anomalous carbonate, sericite and silica alteration, based on preliminary analysis of lithogeochemical data. Analyses will be compared with the regional data set to assess possible patterns. The data will be integrated with other exploration tools and criteria (regional unconformities, fault zones, etc.) in the GIS to produce mineral-prospectivity maps.

Confederation–Birch–Uchi Belt

Additional geochronology is currently being conducted in the Confederation–Birch–Uchi greenstone belt (Fig. GS-20-2) in an attempt to constrain whether the ca. 2.84 Ga Woman assemblage is present at its type locality. Initial attempts to directly date this sequence failed, whereas chemically and petrographically indistinguishable rocks adjacent to the type locality have yielded dates typical of the Confederation assemblage (ca. 2.74 Ga). However, evidence for a pre-Confederation assemblage has been obtained in the form of a ca. 2.81 Ga quartz-feldspar porphyry dyke along the western shore of Woman Lake (V. McNicoll, unpublished data, 2000). Hence, the likely volcanic stratigraphy for the Birch–Uchi greenstone belt is as follows:

1) Balmer assemblage: andesitic to rhyolitic volcanism (2989–2975 Ma), separated by an early (D_0) deformation event from
2) Narrow Lake assemblage: tholeiitic pillow basalt that unconformably overlies the Balmer assemblage (bracketed between 2975 and 2832 Ma; most likely ca. 2855 Ma from comparison to the Red Lake greenstone belt)
3) Woman assemblage: pillow basalt overlain by ignimbritic rhyolite that disconformably overlies the Narrow Lake assemblage (bracketed between 2.88 and 2.81 Ga)
4) Confederation assemblage: three petrographically, chemically and spatially distinct belts of mafic to felsic volcanism (ca. 2.74 Ga)

Pickle Lake Belt

Fieldwork in the Pickle Lake area (Fig. GS-20-2) during the 2000 field season was aimed at testing the hypothesis that the lithotectonic assemblages constituting the Pickle Lake greenstone belt were either built on, or accreted to, the south margin of the ca. 3.0 Ga North Caribou Terrane protocraton. Stott's (1996) summary of stratigraphic, structural and geochronological studies favoured an accretionary model for the southern part of the Pickle Lake belt. However, new results to the west (Birch–Uchi and Red Lake greenstone belts; Rogers et al., 2000; Sanborn-Barrie et al., 2000) have established that the main stages of crustal growth were primarily depositional, not tectonic.

Of the four lithotectonic assemblages making up the Pickle Lake belt, concerted effort was directed at the two northerly assemblages, the North Pickle and Pickle Crow. The North Pickle assemblage is composed mainly of massive and pillowed basalt flows, interbedded with carbonate-siliceous banded iron-formation and minor clastic units, as well as sill-like mafic intrusive sheets. The assemblage was interpreted as the southern extension of the ca. 3.0 Ga McGruer assemblage of the North Caribou belt, based on aeromagnetic patterns (Stott, 1996). However, limited facing directions determined from pillow tops indicate a northwesterly younging direction, opposite to that of the McGruer assemblage. The Pickle Crow assemblage consists of massive to pillowed basaltic flows, dacitic pyroclastic flows, carbonate-siliceous banded iron-formation interbeds (which are macroscopically very similar to those of the North Pickle assemblage), and a locally derived polymictic conglomerate where most clasts are of the same provenance. Limited facing directions, determined from grading in the conglomerate and sparse pillow tops, indicate local northwesterly younging, but tight folds preclude attaching regional significance to this determination. Quartz porphyry sills intruded the basaltic sequence and zircons from one sill yielded a crystallization age of 2.86 Ga and an inherited age of 2892 Ma (Corfu and Stott, 1993).

Two major deformation events and an early localized strain event are recorded in the two northerly assemblages. The main regional event, D_1, is defined by a belt-wide, weakly to moderately developed, northwest-dipping foliation generally parallel to stratigraphic contacts, with similar trends in both assemblages. In the North Pickle and southern Pickle Crow assemblages, S_1 fabric is weakly developed. It is more prominent in the north-central Pickle Crow area, in a zone of tight F_1 folding. The D_1 fabric is overprinted by contact strain aureoles, here termed D_2, associated with ca. 2740 Ma felsic plutons and stocks. The intensity of D_2 is variable across the belt, ranging from a moderate crenulation in the east to strong, amphibolite-grade flattening in the west. Evidence of pre-D_1 deformation is found in the north-central Pickle Crow area, where D_1 fabrics related to F_1 folds crenulate an older foliation developed in carbonatized basalt. The pre-D_1 fabric is cut by ca. 2.86 Ga quartz porphyry sills, indicating localized Mesoarchean deformation. The aeromagnetic pattern shows that stratigraphic and fold-axis trends are similar in both assemblages across the assumed boundary. Also, the boundary itself is at an angle (approx. 30º clockwise) to stratigraphic contacts, and fold axes are not parallel to the fabric in the Pickle Crow, as would be predicted if the Pickle Crow assemblage had accreted onto the southern margin of the North Pickle assemblage.

Without absolute age constraints and in light of the recent observations, evidence is insufficient to separate the North Pickle and Pickle Crow assemblages into distinct lithotectonic entities. The aeromagnetic discordance between the two appears to be related to a fault that offsets sequences of the same lithotectonic assemblage. Questions remain as to the age and kinematic significance of the aeromagnetically defined fault.

WABIGOON SUBPROVINCE

Onaman–Tashota Greenstone Belt

The Onaman–Tashota greenstone belt forms the central feature of the eastern Wabigoon Subprovince. The main portion of this belt has been remapped in the past 5 years (Fig. GS-20-1), and the results show a much greater volume of synvolcanic to late orogenic gabbroic intrusions than previously thought (e.g. Stott and Straub, 1998). Current geochronological (D. Davis and colleagues, Royal Ontario Museum), Nd isotopic, and geochemical work on widely distributed rock samples from this belt will be used to assist in subdividing the belt into several tectonostratigraphic assemblages. Some of these assemblages are, in a first-order sense, apparent from significant differences in age of volcanism. Analysis of the chemistry and petrogenetic characterization of assemblages is currently in progress; some age determinations remain to be completed in areas where intermingling of assemblages is being resolved. The current geochronological record, including the most recent U-Pb zircon age determinations from various units in the Onaman–Tashota belt, shows a more varied history of volcanism than previously thought. On the basis of field relationships, some of the ages from intrusions are interpreted to be inherited, reflecting older, underlying crust. A spectrum of Meso- to Neoarchean ages is represented in detrital zircons from sandstone units across the belt, including the southern margin of the English River Subprovince.

Chondrite-normalized rare-earth element (REE) patterns for almost 200 samples of tholeiitic basalt across the width of this greenstone belt are mostly flat or have weakly depleted LREE and slightly greater than 10x chondrite. Some units show a slight negative Eu anomaly. Trace-element variation diagrams for basalt samples suggest a predominantly juvenile, non-arc affinity, with exceptions in the southern part of the belt underlying tuff sequences of the 2.74 Ga calc-alkaline volcanic centres and some strata in the vicinity of Willet Lake, east of Toronto Lake.

Built upon these assemblages of basalt are calc-alkaline felsic to intermediate volcanic centres that decrease in age southward from the 2739 Ma Marshall Lake assemblage, through 2734 to 2722 Ma volcanic centres at Venus Lake and Metcalfe Lake, respectively, to a less than 2707 Ma dacitic sequence on Humboldt Bay, Lake Nipigon. The latter might correspond episodically with less than 2707 Ma metasedimentary strata above the Metcalfe Lake dacite and a 2703 Ma dacitic sequence west of Lake Nipigon (Tomlinson et al., 1999, 2000) in the northern Obonga belt. The intermediate to felsic volcanic rocks across the Onaman–Tashota belt are typically strongly enriched in Th and have a pronounced negative Nb anomaly. They show LREE enrichment and heavy REE depletion with little or no Eu anomaly, features that are typical of calc-alkaline arc magmatism. The presence of large, 2735 to 2740 Ma, felsic volcanic centres on the north and south margins of the greenstone belt creates an apparent symmetry of crustal growth on the flanks of the belt. These broad centres contain synvolcanic plutons and accompanying hydrothermal alteration, and the most notable base-metal mineralization in the belt (e.g. Marshall Lake). Synorogenic alteration associated with gold mineralization is concentrated in three domains: the complexly faulted Beardmore–Geraldton belt, strained zones in the Metcalfe Lake felsic volcanic centre, and farther north in the Tashota Lake–Emily Lake road area.

A suite of 64 samples of volcanic and intrusive rocks from across the greenstone belt has been analyzed for Nd isotopes. The felsic rocks (volcanic and plutonic) from throughout the region show predominant Nd model ages of 2.8 to 2.9 Ga, and initial epsilon Nd (ε_{Nd}) values of -0.1 to +1.5 (28 of 41 samples). Five samples from the north, at Marshall Lake, Toronto Lake, Girvan Lake, Tashota and the Esnagami tonalite, have Nd model ages in the 3.0 to 3.3 Ga range. Both the synvolcanic Onaman pluton at the centre of the belt and the late tectonic Sollas pluton on the northern margin have Nd model ages of 2.9 to 3.0 Ga. Several other synvolcanic to late tectonic plutons from throughout the region have Nd model ages of 2.8 to 2.7 Ga. The mafic rocks have initial ε_{Nd} values of +1.0 to +4.0, with the majority between +2 and +3, indicating a lack of significantly older recycled crust. The exception is at Toronto Lake in the north, where lower ε_{Nd} values are observed.

Together, the isotopic data suggest several conclusions. First, 2.74 to 2.72 Ga felsic volcanism cannibalized older felsic crust. Widespread evidence of recycled early Neoarchean to Mesoarchean crust is comparable to the complex pattern of crustal contamination noted by Tomlinson et al. (1999, 2000) in the central Wabigoon. Second, associated mafic volcanism was relatively juvenile. Third, the basement in the northern half of the belt may contain a much older crustal component than is currently recognized at the surface. The oldest dated rock from this region, a porphyry sill, is 3056 Ma, but three felsic volcanic rocks have significantly older Nd model ages of 3.28, 3.21 and 3.19 Ga.

The overall structural geometry of the belt has a remarkably consistent northward dip. Bedding and parallel tectonic schistosity dip moderately to steeply north, similar to those in the Shebandowan greenstone belt in the Wawa Subprovince and the central part of the Uchi Subprovince. This regional structural observation across widely spaced greenstone belts may mirror the dominant, north-dipping, crustal reflectivity from Wawa to Uchi subprovinces, evident from the Western Superior LITHOPROBE Transect (White et al., 1999). This structural character continues across the northern boundary of the Onaman–Tashota belt into the English River Subprovince. The northern margin of the Onaman–Tashota belt is affected by regional D_2 transpressive deformation. Northeast of Marshall Lake at the English River Subprovince boundary, a 2692 Ma intrusion, possibly a phase of the Sollas pluton, is interpreted, from its internal structures and relation to surrounding metasedimentary rocks, to have intruded during the late stage of regional D_2 deformation. This deformation corresponds in style to that observed throughout the English River Subprovince (Stott and Corfu, 1991; Corfu et al., 1995) and adjacent greenstone belts. It significantly predates a similar, transpressive deformation that affected the Quetico Subprovince and adjacent greenstone belts at 2685 to 2680 Ma (Corfu and Stott, 1998).

South-Central Wabigoon

A project aimed at defining the extent of Mesoarchean crustal precursors in the south-central Wabigoon Subprovince stems from recent mapping and isotopic studies that indicate scattered material of 3.4 to 3.0 Ga age (Henry et al., 1998; Tomlinson et al., 1999; Percival et al., 1999; Tomlinson, 2000) in this region. In the Shikag–Garden Lake area, tonalite, tonalite gneiss and anorthositic rocks generally have Nd model ages of less than 2.9 Ga, whereas granodiorite and granite have model ages in excess of 3.0 Ga and, in two locations, in excess of 3.3 Ga (Tomlinson and Percival, 2000). Farther to the west, biotite granite of the Indian Lake Batholith (north of Ignace) has Nd model ages, from two locations, of 2.80 and 2.84 Ga, and older precursors are indicated in tonalite gneiss of the Hillyer Creek dome (2.95 Ga), felsic fragmental rocks of the Perch Lake belt (3.03 Ga), tonalite gneiss west of Mine Centre (2.98 Ga), tonalite gneiss northwest of Eltrut Lake (2.90 Ga), tonalite gneiss from the Valora area (2.91 Ga) and foliated tonalite south of Ignace (2.85 Ga; Tomlinson and Percival, 2000). A significantly older Nd model age of 3.26 Ga comes from a hornblende-biotite tonalite gneiss west of Raven Lake. Collectively, these data suggest that Mesoarchean crust in the southern Wabigoon Subprovince is not restricted to the Marmion Batholith and the Steep Rock and Lumby Lake greenstone belts, but appears to extend west, at least to Mine Centre in the southwest and Valora in the northwest, and northeast to the Obonga Lake–Garden Lake area. Model ages greater than 3.34 Ga suggest the presence of crust of Winnipeg River vintage beneath some parts of the central Wabigoon (Tomlinson and Percival, 2000). The U-Pb geochronology will further constrain the age and extent of crustal precursors.

Mapping of the Petry River area in the south-central Wabigoon Subprovince focused on establishing regional controls on gold, platinum-group element and rare-earth element mineralization, as well as examining the origin of and relationships between Mesoarchean and Neoarchean rocks. Within this area, narrow Archean greenstone belts are cut by several varieties of foliated to gneissic plutonic rocks and massive granite batholiths. The greenstone belts comprise metabasalt with rare gabbro, sedimentary units and a single komatiite locality. A platform sequence, represented by a 30 m thick section of quartz arenite, separates metabasalt from biotite tonalite in an area 25 km northwest of Graham, Ontario. The platform sequence and the komatiite provide geological evidence that volcano-plutonic sequences of the Petry River area form an extension of the Mesoarchean domain in the Atikokan–Lumby Lake area.

Regional mapping traced the Marmion Fault 100 km northeast from Atikokan to Selwyn Lake. Splays of the fault are mineralized with gold in the Atikokan area and dykes of peraluminous granite are broadly associated with the fault at Selwyn Lake. The peraluminous granite dykes, some of which contain visible molybdenite, are a possible bedrock source for anomalous concentrations of Li, Mo, Th, U, rare-earth elements, Y and Nb in lake-bottom sediment in the Selwyn–Wawang lakes area. A mafic intrusive complex of Archean gabbro and Proterozoic diabase occurs at Little Trewartha Lake, and a hornblendite stock is present south of Weaver Lake. These intrusions are recommended as exploration targets for platinum-group elements.

SACHIGO SUBPROVINCE

Blackbear, Yelling and Stull Lakes Areas

Mapping (1995–2000) of a 12 000 km^2 area along the Ontario–Manitoba border (Fig. GS-20-1) is providing new geological maps and an assessment of the mineral potential and regional tectonic evolution. The east-southeast-trending Ponask–Sachigo, Stull, Ellard and Yelling greenstone belts are separated by plutonic domains and the broad Stull–Wunnummin, South Kenyon and North Kenyon fault zones. Work in the current season at Blackbear Lake marked the completion of regional mapping in the southeast corner of the area. Eastern extensions of the Stull and Ellard greenstone belts, as well as the Stull–Wunnummin and South Kenyon faults, were traced through this area. Transects along the Stull, Wapikani and Yelling rivers identified western extensions of major batholiths, greenstone slivers and the Kenyon faults. The largest greenstone belt in the area, Stull Lake, consists of four structural panels (Stone and Pufahl, 1995), and has been re-examined in detail in the last two seasons. New mapping, sampling and geochronology have focused on defining positions of major faults in the belt, examining its poorly exposed western extremities, distinguishing alkaline and calc-alkaline volcanic sequences, and studying the relationships between various sedimentary and volcanic packages.

Preliminary isotopic and geochronological studies indicate that the area is divisible into an early Neoarchean to Mesoarchean domain south of the Stull–Wunnummin Fault, a Neoarchean domain between the Stull–Wunnummin and Kenyon faults, and a Paleoarchean domain north of the Kenyon Fault (Skulski et al., 1999). These domains possibly represent crustal blocks that were tectonically accreted during growth of the Superior Province and whose boundaries have been subsequently reactivated as faults. A lack of regional data inhibits extrapolation of these domains across the northern Superior Province or correlation with other tectonic domains in the south.

The northern Superior Province has potential for a wide variety of mineral commodities, including rare-earth elements, platinum-group elements, base metals, gold, diamonds and carving stone. Numerous gold occurrences associated with regionally extensive faults indicate high potential for economic deposits of gold. Anomalous numbers of kimberlite-indicator grains in modern alluvium suggest that the area is worthy of exploration for diamonds.

Knee Lake–Gods Lake Area

Integrated studies of the Knee Lake belt (cf. Corkery et al., 1999) continued in the northeastern Gods Lake area in 2000 (Fig. GS-20-1). Two distinct sequences of Hayes River Group metavolcanic rocks with opposing facing directions are separated by a northeast-trending dextral fault. In addition to its transcurrent component, north-side-up dip-slip motion on the fault carries amphibolite-facies rocks on the northwest over greenschist-facies units to the southeast. Geochronological studies on units of the Oxford Lake Group to the southwest show that the volcanic subgroup has a depositional age of 2720 Ma, whereas the sedimentary subgroup has a broad range of detrital zircon ages ranging from 3647 to 2711 Ma. Possible sources of ancient (ca. 3.6 Ga) zircons occur in fault-bounded blocks along the northern margin of the northern Superior Province. Geochronological data from the Knee Lake area date Hayes River volcanism at 2.83 Ga, and sensitive high-resolution ion microprobe (SHRIMP) data on detrital zircons indicate that turbiditic sandstone is synvolcanic and volcanic-derived. Folding of the Hayes River Group predates deposition of coarsening-upward clastic sedimentary rocks and iron-formation, the former containing 2937 to 2822 Ma detrital zircons. The Oxford Lake volcanic subgroup was extruded at 2722 Ma in the southern Knee Lake area and was followed by deposition of fluvial-clastic, sedimentary subgroup sandstone with detrital zircons ranging from 2798 to 2707 Ma.

A unique feature of Gods Lake is that it provides access to the granitoid terrane separating the Munro Lake and Knee Lake greenstone belts (Fig. GS-22-1). This well exposed section of gneiss complexes and plutons was mapped and sampled for geochemistry in a co-operative MGS–GSC program. As well as contributing to the Knee Lake greenstone belt mapping project, this section will provide geochemical, isotopic and geochronological information to a regional transect focusing on the age and history of plutonic and gneissic terranes across the northwestern Superior Province.

Assean Lake Area

The Assean Lake block at the northwestern margin of the Superior Province represents a collage of east-southeast-trending Archean crustal segments that is overprinted by northeast-trending zones of Neoarchean and Paleoproterozoic deformation and metamorphism. The Assean Lake block can be subdivided into three lithotectonic domains. In the south, a belt of migmatitic supracrustal rocks includes quartz arenite, arkose and metagreywacke, with some amphibolite and silicate-facies iron-formation. A central panel is dominated by tonalitic orthogneiss, which cuts the northern package consisting of mafic to intermediate metavolcanic rocks and migmatitic greywacke.

Combined Sm-Nd isotopic and U-Pb zircon (thermal-ionization mass spectrometry (TIMS) and SHRIMP) results indicate that the Assean Lake block preserves Paleo- to Mesoarchean crust that underwent a complex and prolonged history spanning more than two billion years. These integrated mapping and isotopic studies across the northwestern Superior Province margin have resulted in a re-interpretation of the location and nature of the boundary zone between Archean rocks of the Superior Province and Paleoproterozoic rocks of the Trans-Hudson Orogen in the region northeast of Thompson.

Northern Transect

The poorly exposed Northern Superior Superterrane (Skulski et al., 2000) was mapped and sampled for geochemical, tracer isotopic and geochronological studies in a transect from Kistigan Lake to northeast of Red Cross Lake. Major geological domains sampled include the northern Sachigo Subprovince and Pikwitonei gneiss complex. The northwest-trending North Kenyon Fault is a kilometre-scale mylonite zone; narrower mylonite zones of similar trend characterize the South Kenyon Fault.

DISCUSSION

Elucidation of the tectonic history of the Uchi Subprovince remains key to understanding the relationship between the North Caribou and adjacent terranes. There exists widespread yet cryptic evidence of an early, nonpenetrative deformation event (pre-D_1) across the southern margin of the North Caribou craton, in the Pickle Lake (pre-2860 Ma), Confederation Lake (ca. 2.85 Ga) and Red Lake (2894–2750 Ma) greenstone belts. The first penetrative deformation event (D_1) recorded in this region may have been diachronous from pre-2.74 Ga in the Pickle Lake area, to between 2733 and 2724 Ma in the Confederation Lake area, to between 2742 and 2718 Ma in the Red Lake belt. The timing of subsequent D_2 deformation, interpreted to be related to collision between the North Caribou and Winnipeg River cratons (Uchian phase of the Kenoran orogeny) appears best constrained in the Red Lake belt at ca. 2718 Ma. Diachroneity may also characterize this event, as units as young as 2713 Ma were affected in the St. Joseph assemblage to the west.

The southwestern part of the Uchi Subprovince (Rice Lake–Lake Winnipeg belts) shows little evidence of affinity with the North Caribou margin prior to 2.72 Ga, and records a younger tectonic history that involves tectonic juxtaposition of units after 2704 Ma, the age of post-tectonic plutons in the Red Lake and Confederation Lake belts. Post-2704 Ma events may be related to deformation that affected the English River Subprovince (cf. Corfu et al., 1995). Together, these observations show that the southern margin of the North Caribou Terrane had an extended history of magmatism and deformation, perhaps reflecting transient conditions at a long-standing Andean margin.

Within the Uchi Subprovince, evidence for the presence of crustal fragments that are exotic to the North Caribou margin is limited. Candidates include the Pickle Crow assemblage, with evidence of pre-2.86 Ga deformation, which would have been accreted prior to 2745 Ma. Geochemical, isotopic and geochronological studies are underway to test this hypothesis. The ca. 2.85 Ga Trout Bay assemblage in the Red Lake belt may represent a juvenile oceanic terrane that faces toward older strata built on the North Caribou margin and was juxtaposed prior to 2.75 Ga. The undated Black Island assemblage in the Lake Winnipeg area has ocean-floor and arc geochemical signatures, faces toward a continental-margin sequence, and is separated from it by D_1 shear zones formed after 2704 Ma.

Along the northern margin of the North Caribou Terrane, slivers of juvenile crust are bounded by major, late, strike-slip shear zones. Ongoing mapping, in concert with geochronology and isotopic-tracer studies, is unravelling the complex interaction between the North Caribou Terrane and Northern Superior Superterrane.

Ongoing work in the central and eastern Wabigoon regions is defining the age and extent of Mesoarchean crustal blocks and their relationships to Neoarchean sequences. At least two discrete Mesoarchean sources are present: 1) a northern, terrane, greater than 3.34 Ga, with probable affinity to the Winnipeg River Subprovince, known from ancient detrital zircons in Mesoarchean platform sequences and old Nd model ages in Neoarchean granite; and 2) a southern block, ca. 3 Ga, exposed in the Marmion Batholith and environs. Whether the two Mesoarchean blocks were assembled during tectonism ca. 2.7 Ga, which also juxtaposed juvenile Neoarchean rocks of the western Wabigoon, or carry an older common history, is an avenue of current research. Integrating the tectonic and magmatic history with crustal profiles derived from LITHOPROBE seismic data represents a unique challenge and opportunity.

REFERENCES

Andrews, A.J., Hugon, H., Durocher, M., Corfu, F. and Lavigne, M. 1986: The anatomy of a gold-bearing greenstone belt: Red Lake, northwestern Ontario; *in* Proceedings of GOLD ’86, an International Symposium on the Geology of Gold Deposits, (ed.) A.J. Macdonald; Konsult International Inc., Toronto, Ontario, p. 3–22.

Bailes, A.H. 1999: Geochemical sampling and geological reconnaissance of the western Rice Lake greenstone belt; *in* Report of Activities 1999, Manitoba Energy and Mines, Geological Services, p. 102–105.

Corfu, F. and Stott, G.M. 1993: Age and petrogenesis of two late Archean magmatic suites, northwestern Superior Province, Canada: zircon U-Pb and Lu-Hf isotopic relations; Journal of Petrology, v. 34, p. 817–838.

Corfu, F. and Stott, G.M. 1998: Shebandowan greenstone belt, western Superior Province: U-Pb ages, tectonic implications and correlations; Geological Society of America Bulletin, v. 110, p. 1467–1484.

Corfu, F., Stott, G.M. and Breaks, F.W. 1995: U-Pb geochronology and evolution of the English River Subprovince, an Archean low P–high T metasedimentary belt in the Superior Province; Tectonics, v. 14, p. 1220–1233.

Corkery, M.T., Lin, S., Bailes, A.H. and Syme, E.C. 1999: Geological investigations in the Gods Lake narrows area (parts of 53L/9 and 53L/10); *in* Report of Activities 1999, Manitoba Energy and Mines, Geological Services, p. 76–80.

Dubé, B., Balmer, W., Sanborn-Barrie, M., Skulski, T. and Parker, J. 2000: A preliminary report on amphibolite-facies, disseminated-replacement-style mineralization at the Madsen gold mine, Red Lake, Ontario; Geological Survey of Canada, Current Research 2000-C17, 12 p. (online; http://www.nrcan.gc.ca:80/gsc/bookstore).

Ermanovics, I.F. 1970: Precambrian geology of the Hecla–Carroll Lake map area, Manitoba–Ontario (62P E½, 52M W½); Geological Survey of Canada, Paper 69-42, 33 p.

Ermanovics, I.F. 1981: Geology of the Manigotagan area, Manitoba; Geological Survey of Canada, Paper 80-26.

Ermanovics, I.F. and Wanless, R.K. 1983: Isotopic age studies and tectonic interpretation of Superior Province in Manitoba; Geological Survey of Canada, Paper 82-12, 17 p.

Henry, P., Stevenson, R.K. and Gariepy, C. 1998: Late Archean mantle composition and crustal growth in the western Superior Province of Canada: neodymium and lead isotopic evidence from the Wawa, Quetico and Wabigoon subprovinces; Geochimica et Cosmochimica Acta, v. 62, p. 143–157.

Hollings, P., Wyman, D. and Kerrich, R. 1999: Komatiite-basalt-rhyolite volcanic associations in northern Superior Province greenstone belts: significance of plume-arc interaction in the generation of the proto-continental Superior Province; Lithos, v. 46, p. 137–161.

Krogh, T.E., Ermanovics, I.F. and Davis, G.L. 1974: Two episodes of metamorphism and deformation in the Archean rocks of the Canadian Shield; Carnegie Institution of Washington, Geophysical Laboratory Yearbook, p. 573–575.

Percival, J.A. and Whalen, J.B., 2000: Observations on the North Caribou terrane–Uchi subprovince interface in western Ontario and eastern Manitoba; Geological Survey of Canada, Current Research 2000-C15, 8 p. (online; http://www.nrcan.gc.ca:80/gsc/bookstore).

Percival, J.A., McNicoll, V., Whalen, J.B., Castonguay, S., Brown, J.L. and Harris, J.R. 1999: Tectonomagmatic evolution of the central Wabigoon region in the Sturgeon–Obonga Lake corridor; Geological Association of Canada–Mineralogical Association of Canada, Joint Annual Meeting, Abstract Volume 24, p. 98.

Percival, J.A., Thurston, P.C. and Corkery. M.T. 1997: Western Superior NATMAP: tectonic evolution and mineral potential of Archean continental and oceanic blocks; *in* Summary of Field Work and Other Activities 1997; Ontario Geological Survey, Miscellaneous Paper 168, p. 41–43.

Poulsen, K.H., Weber, W., Brommecker, R. and Seneshen, D.N. 1996: Lithostratigraphic assembly and structural setting of gold mineralization in the eastern Rice Lake greenstone belt, Manitoba; Geological Association of Canada–Mineralogical Association of Canada, Joint Annual Meeting, Field Trip Guidebook A4, 106 p.

Rogers, N., McNicoll, V., Tomlinson, K.Y. and van Staal, C.R. 2000: Lithogeochemical studies in the Uchi–Confederation greenstone belt, NW Ontario: implications for Archean tectonics; Geological Survey of Canada, Current Research 2000-C16, 12 p. (online; http://www.nrcan.gc.ca:80/gsc/bookstore).

Sanborn-Barrie, M., Skulski, T., Parker, J. and Dubé, B. 2000: Integrated regional analysis of the Red Lake greenstone belt and its mineral deposits, Ontario; Geological Survey of Canada, Current Research 2000-C18, 16 p. (online; http://www.nrcan.gc.ca:80/gsc/bookstore).

Sasseville, C. and Tomlinson, K.Y. 2000: Tectonostratigraphy, structure and geochemistry of the Mesoarchean Wallace Lake greenstone belt, southeastern Manitoba; Geological Survey of Canada, Current Research 2000-C14, 9 p. (online; http://www.NRCan.gc.ca:80/gsc/bookstore).

Shklanka, R. 1967: Geology of the Bee Lake area; Ontario Department of Mines, Geological Report 47, 42 p.

Skulski, T., Percival, J.A., Whalen, J.B. and Stern, R.A. 2000: Archean crustal evolution in the northern Superior Province; *in* Tectonic and Magmatic Processes in Crustal Growth: A Pan-LITHOPROBE perspective; LITHOPROBE Report 75, p. 128–129.

Skulski, T., Whalen, J.B., Stern, R.A., Stone, D. and Corkery, T. 1999: Archean terranes and their boundaries in the northern Superior Province; Geological Association of Canada–Mineralogical Association of Canada, Joint Annual Meeting, Abstract Volume 24, p. 118.

Stone, D. and Pufahl, P. 1995: Geology of the Stull Lake area, northern Superior Province, Ontario; *in* Summary of Field Work and Other Activities 1995; Ontario Geological Survey, Miscellaneous Paper 164, p. 48–51.

Stott, G.M. 1996: The geology and tectonic history of the central Uchi sub-province; Ontario Geological Survey, Open File Report 5952, 178 p.

Stott, G.M. and Corfu, F. 1991: Uchi Subprovince; Chapter 6 *in* Geology of Ontario, (ed.) P.C Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott; Ontario Geological Survey, Special Volume 4, Pt. 1, p. 145–236.

Stott, G.M. and Straub, K.H. 1998: Geology of Gledhill–Willet lakes area, Onaman–Tashota greenstone belt; *in* Summary of Field Work and Other Activities 1998; Ontario Geological Survey, Miscellaneous Paper 169, p.119–126.

Thurston, P.C. and Chivers, K.M. 1990: Secular variation in greenstone sequence development emphasising Superior Province, Canada; Precambrian Research, v. 46, p. 21–58.

Tomlinson, K.Y. 2000: Neodymium isotopic data from the central Wabigoon subprovince, Ontario: implications for crustal recycling in 3.1 to 2.7 Ga sequences; Geological Survey of Canada, Current Research 2000-F8; Radiogenic Age and Isotopic Studies: Report 13, 10 p. (online; http://www.nrcan.gc.ca:80/gsc/bookstore).

Tomlinson, K.Y. and Percival, J.A. 2000: Geochemistry and Nd isotopes of granitoid rocks in the Shikag–Garden lakes area, Ontario: recycled Mesoarchean crust in the central Wabigoon subprovince; Geological Survey of Canada, Current Research 2000-E12, 11 p. (online; http://www.NRCan.gc.ca:80/gsc/bookstore).

Tomlinson, K.Y., Davis, D.W., Percival, J.A., Hughes, D.J. and Thurston, P.C. 1999: Neoarchean supracrustal development in the Central Wabigoon Subprovince: Nd isotopic data and U/Pb geochronology; *in* 1999 Western Superior Transect Fifth Annual Workshop, (ed.) R.M. Harrap and H.H. Helmstaedt; LITHOPROBE Secretariat, University of British Columbia, LITHOPROBE Report No. 70, p.147–152.

Tomlinson, K.Y., Davis, D.W. and Stott, G.M. 2000: Nd isotopes in the central and eastern Wabigoon subprovince: implications for crustal recycling and regional correlations; Western Superior LITHOPROBE–Western Superior NATMAP 2000 Annual Meeting, LITHOPROBE Secretariat, University of British Columbia, LITHOPROBE Report No. 77, p. 119–126.

Tomlinson, K.Y., Stevenson, R.K., Hughes, D.J., Hall, R.P., Thurston, P.C. and Henry, P., 1998: The Red Lake greenstone belt, Superior Province: evidence of plume-related magmatism at 3 Ga and evidence of an older enriched source; Precambrian Research, v. 89, p. 59–76.

Turek, A. and Weber, W. 1994: The 3 Ga granitoid basement to the Rice Lake supracrustal rocks, southeast Manitoba; *in* Report of Activities 1994, Manitoba Energy and Mines, Geological Services, p. 167–169.

White, D., Helmstaedt, H.H., Harrap, R.M., Thurston, P.C., van der Velden, A., Hall, K. and Davis, D. 1999: Accretionary tectonics in the Late Archean? First results from the LITHOPROBE Western Superior Transect; *in* 1999 Western Superior Transect, Fifth Annual Workshop, (ed.) R.M. Harrap and H.H. Helmstaedt; LITHOPROBE Secretariat, University of British Columbia, LITHOPROBE Report No. 70, p. 168.