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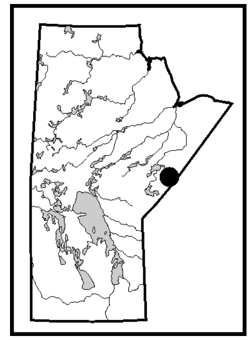
GS-20 Preliminary results and economic significance of geological mapping and structural analysis at Sharpe Lake, northern Superior Province, Manitoba (parts of NTS 53K5 and 6)

by C.J. Beaumont-Smith, S.D. Anderson, A.H. Bailes and M.T. Corkery



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Summary

Geological mapping and structural analysis of the Sharpe Lake area have significantly upgraded the geological understanding of this economically important portion of the northern Superior Province. The Sharpe Lake area is transected by the crustal-scale, ductile-brittle Stull Lake–Wunnummin Fault Zone (SWFZ), which separates middle amphibolite facies supracrustal rocks of the Sharpe Lake greenstone belt (SLGB) to the north from upper amphibolite to possible granulite facies orthogneissic rocks of the Richardson Arm gneiss complex (RAGC) to the south. Geological mapping of both domains has succeeded in defining their internal stratigraphy and deformational episodes.

Both the SLGB and the RAGC have experienced complex deformational histories. Five deformational events (D_1–D_5) have been recognized in the SLGB. Structures of the D_2 deformation, which dominate in the SLGB, are overprinted and truncated by the SWFZ, a D_3 structure in the greenstone belt. In the RAGC, a somewhat more complex deformation history is recognized, involving five episodes of deformation (G_1–G_5, with the SWFZ being a G_4 structure). In both domains, the development of the SWFZ took place under greenschist-facies conditions, resulting in pronounced retrogression of rocks affected by the deformation zone.

The Stull Lake–Wunnummin Fault Zone in the Sharpe Lake area represents the western strike-extension of the deformation zone that transects the Monument Bay–Twin Lakes area and hosts significant gold mineralization. Detailed structural analysis of the SLGB has better delineated the extent of the SWFZ, determined the kinematics of the shear zone in this area, and identified a number of significant zones of alteration and mineralization within the shear zone. The mineralogy and styles of the alteration are highly favourable for gold mineralization, which reinforces the notion of the SWFZ as a regional-scale gold metallotect.

Introduction

Supracrustal rocks in the Sharpe Lake map area are the moderately well exposed, along-strike equivalent of the southern segment of the Stull Lake greenstone belt in Ontario. These rocks extend from Ontario through the Monument Bay–Twin Lakes area west to Sharpe Lake and continue to the northwest, possibly linking with the Knee Lake greenstone belt (Fig. GS-20-1). Mapping in 2003 at Sharpe Lake extends the recent mapping coverage of the Archean greenstone belts in the Stull Lake map sheet (NTS 53K; Corkery et al., 1997; Corkery and Heaman, 1998; Corkery and Skulski, 1998) and expands map coverage of the highly gold prospective Stull Lake–Wunnummin Fault Zone (SWFZ).

Fieldwork in 2003 entailed 1:50 000-scale geological mapping of supracrustal rocks, and gneissic and plutonic rocks within selected portions of NTS 53K5 and 6 in Manitoba. Except for the west half of NTS 53K5, the Sharpe Lake area had never been systematically mapped. The aim of this mapping program is to apply modern techniques of lithotectonic mapping, structural analysis, geochronology and isotopic studies to this metallogenically and tectonically significant area.

Previous work

Existing maps for the Sharpe Lake area include the regional 1:125 000-scale map by Downie (1938) and the 1:50 000-scale map of the extreme west end of Sharpe Lake by Martin (1973). In Ontario, the Downie (1938) map represents the earliest regional geological synthesis. The Ontario Department of Mines also published a map of the Stull Lake area in 1937 (Satterley, 1937). More recent mapping was done by Riley and Davies (1967), and the supracrustal belt was reexamined by Thurston et al. (1987). Stone and Pufahl (1995) remapped the Stull Lake belt at 1:50 000-scale as part of an ongoing regional mapping program. Stone and Hallé (1997) reported on mapping in the Sachigo, Stull and Yelling lakes area of Ontario.

Supracrustal rocks in the Sharpe Lake area have historically been subdivided into Hayes River Group and Oxford

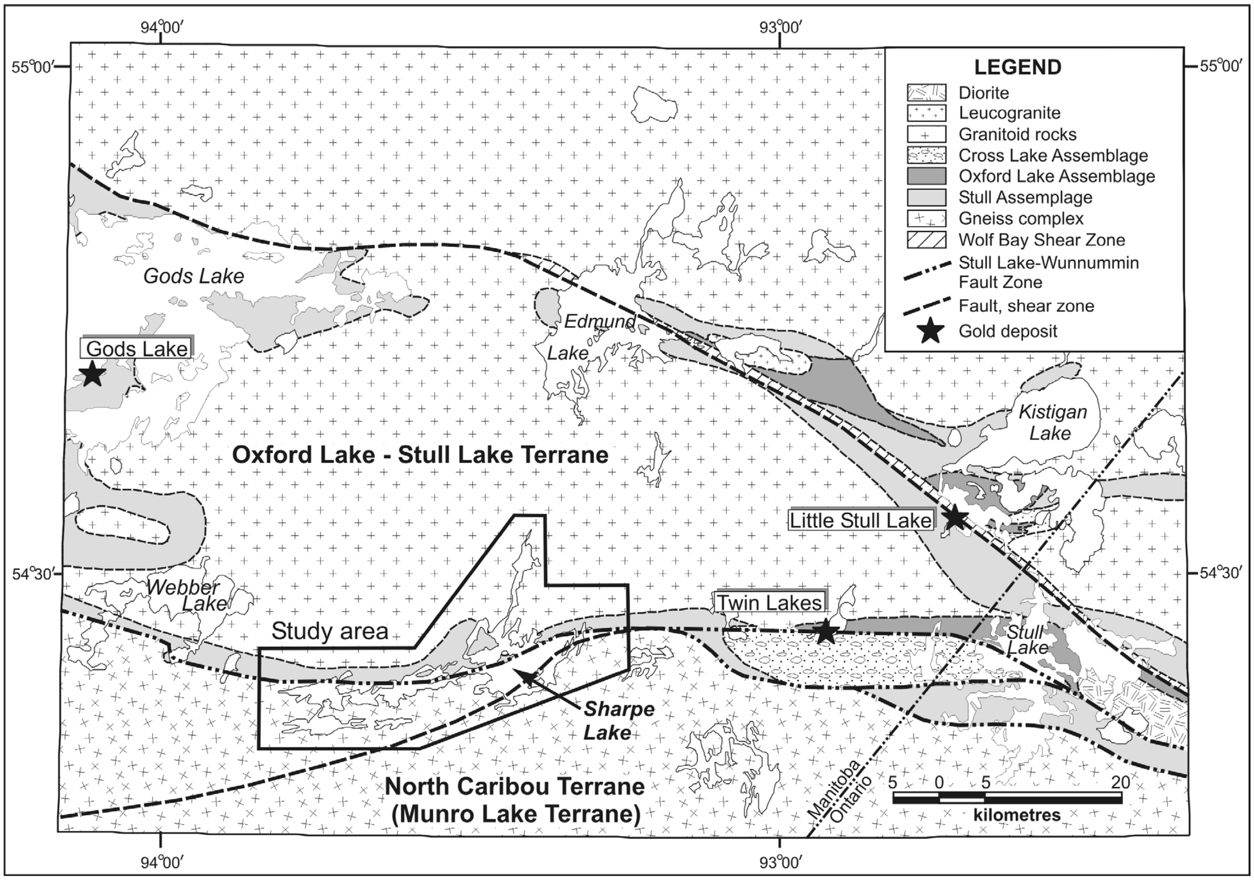

Figure GS-20-1: General geology of the Sharpe Lake area.

Group (Downie, 1938). The original subdivision was based on the distinction between a predominantly volcanic sequence, the Hayes River Group, ranging from basaltic through rhyolitic in composition with minor intercalated sedimentary rocks, and a younger, unconformably overlying sequence, the Oxford Group, dominated by sedimentary rocks and marked at the base by polymictic conglomerate. In the 1970s, a major mapping program in the greenstone belts of the Gods, Knee and Oxford lakes area to the west reevaluated the supracrustal sequences. Based on this work, Hubregtse (1985) redefined the Oxford Group, separating it into a lower metavolcanic and volcaniclastic subgroup and an overlying metasedimentary subgroup. These subgroups were then included in the new Oxford Lake assemblage.

A 12 000 km^2 area along the Ontario-Manitoba border was recently mapped under the auspices of the Western Superior NATMAP project (1996–2001). This work provided new geological maps, defined new lithotectonic subdivisions, furnished an assessment of the mineral potential and supplied an overview of regional tectonic evolution. This study builds on the regional tectonic overview begun under the Western Superior NATMAP.

Regional setting

In northern Manitoba and northwestern Ontario, the Western Superior NATMAP (Stone et al., in press) focused on further refining the tectonostratigraphy and collisional orogenic history of the various Archean crustal blocks that constitute the northwestern Superior Province. Skulski et. al. (2000) reported that major crustal blocks are bounded by anastomosing, northwest-trending, dextral-slip, greenschist-facies shear zones, spaced 10 to 50 km apart. Granitoid rocks dominate the crustal domains and provide windows to understanding the crustal evolution and deformation history in these blocks. Supracrustal rocks preserved in greenstone belts are, in part, cut by the major shear zones, but also preserve an internal tectonic subdivision that predates shear-zone formation.

One of the major revelations of the Western Superior NATMAP studies was the definition of crustal-scale boundaries (Skulski et al., 2000), marked by fault zones such as the SWFZ through Sharpe Lake. Geological mapping, in conjunction with Nd isotopic and U-Pb (by sensitive high-resolution ion microprobe [SHRIMP]) isotopic surveys of plutonic rocks between Sachigo Lake and Yelling Lake (Skulski et. al., 2000), have revealed that fault-bounded, isotopically juvenile, 2.71 Ga crust separates the 3.0 Ga North Caribou Terrane in the south from the >3 Ga Northern Superior Superterrane in the north. Recent, detailed (1:20 000-scale) mapping of the Stull Lake–Edmund Lake and Knee Lake greenstone belts provides key structural, stratigraphic and geochronological constraints on the broad collision zone between these two protocratonic blocks (Corkery, 1996; Corkery et al., 1997; Syme et al., 1997, 1998; Corkery and Skulski, 1998; Corkery and Heaman, 1998; Corkery et al., 1999). These data are consistent with a three-fold subdivision of the northwestern Superior Province in the map area (Fig. GS-20-1), which includes 1) the Munro Lake Terrane (*modified after* Thurston et al., 1991), which is the crustal block lying south of a splay of the Wolf Bay–Stull–Wunnummin Shear Zone in the southern Stull Lake–Edmund Lake greenstone belt and including the Sachigo Lake–Ponask Lake greenstone belt; 2) the Oxford Lake–Stull Lake Terrane (*modified after* Thurston et al., 1991), which includes the area between the Wolf Bay–Stull–Wunnummin Shear Zone in the Stull Lake–Edmund Lake greenstone belt and the North Kenyon Fault; and 3) the Northern Superior Superterrane (Skulski et al., 1999), which is defined as the area north of the North Kenyon Fault.

This report focuses on the geology of the Sharpe Lake area along the SWFZ. To the south of the fault, rocks of the Oxford Lake–Stull Lake Terrane are well exposed as upper amphibolite to granulite-grade gneissic and plutonic rocks. The Sharpe Lake greenstone belt (SLGB) is situated immediately north of the SWFZ and is intruded to the north by voluminous granodiorite plutons of the Oxford Lake–Stull Lake Terrane.

General geology

The geology of the Sharpe Lake area is dominated by a major deformation zone, the Stull Lake–Wunnummin Fault Zone (SWFZ). This crustal-scale structure represents the boundary between variably retrograded upper amphibolite to possibly granulite-facies gneissic rocks of the RAGC to the south, and middle amphibolite facies supracrustal rocks of the SLGB and a variety of felsic plutonic rocks to the north. In order to facilitate correlation of units in the SLGB to other supracrustal belts in the northern Superior Province, the authors have adhered to the presently accepted regional supracrustal stratigraphy. Accordingly, the supracrustal stratigraphy is subdivided into the mafic volcanic Stull assemblage, overlain by coarse clastic sedimentary rocks of the Oxford Lake assemblage, which is in turn overlain by arenaceous rocks of the Cross Lake assemblage (Fig. GS-20-2).

Richardson Arm gneiss complex (RAGC)

The Richardson Arm gneiss complex outcrops south of the SWFZ along the full length of Sharpe Lake. On a regional scale, it forms a continuous band of gneiss, 5 to 20 km wide, from southwest of Stull Lake through the Gods Narrows area to the west end of Oxford Lake (Fig. GS-20-1). This continuous band of gneiss is bounded to the north by the SWFZ and forms the north flank of the Munro Lake Terrane.

On southern Stull Lake, hornblende tonalite gneiss (unit 2) contains an injection phase with a U-Pb zircon age of 2848 ±7 Ma and a 3.02 Ga Nd model age (initial ε_{Nd} of –0.280; Skulski, 2000). The Nd data suggest that ca. 3.0 Ga crust may have been implicated in the source of the tonalitic gneiss (Skulski, 2000). The oldest injection phase in the hornblende tonalite gneiss south of Gods Lake Narrows, to the west, has been dated at 2883 Ma by D. Davis at the Royal Ontario Museum (pers. comm., 1986).

Three distinct generations of gneiss and several younger granitoid intrusive phases dominate the Richardson Arm gneiss complex. The hornblende tonalite gneiss (unit 2) is typically well layered and contains inclusions and interlayers of mafic to intermediate orthogneiss (unit 1). Younger, more weakly layered biotite granodiorite gneiss (unit 3) shows intrusive relationships with the hornblende tonalite gneiss. Small intrusive bodies and crosscutting dikes of granodiorite to granite intrude the gneiss.

Mafic to intermediate orthogneiss (unit 1)

Xenoliths of mafic to intermediate orthogneiss (unit 1) within the hornblende tonalite (unit 2) could provide an indication of the early crustal history along the northern margin of the North Caribou Terrane. Assuming continuity of the RAGC from Sharpe Lake to Gods Lake Narrows, the 2.88 Ga age of the host hornblende tonalite (unit 2) provides a lower age constraint for unit 1. Textures and composition of better preserved inclusions and enclaves of orthogneiss (unit 1) may therefore provide a glimpse of pre–2.88 Ga, deep crustal events along the northern margin of the North Caribou Terrane and possibly represent the 3 Ga crustal source suggested by Skulski (2000).

Massive to layered amphibolite (unit 1a; Fig. GS-20-3) commonly forms concordant bands in the tonalite gneiss (unit 2), and also forms mappable layers up to several hundred metres thick and hundreds of metres long. Discontinuous

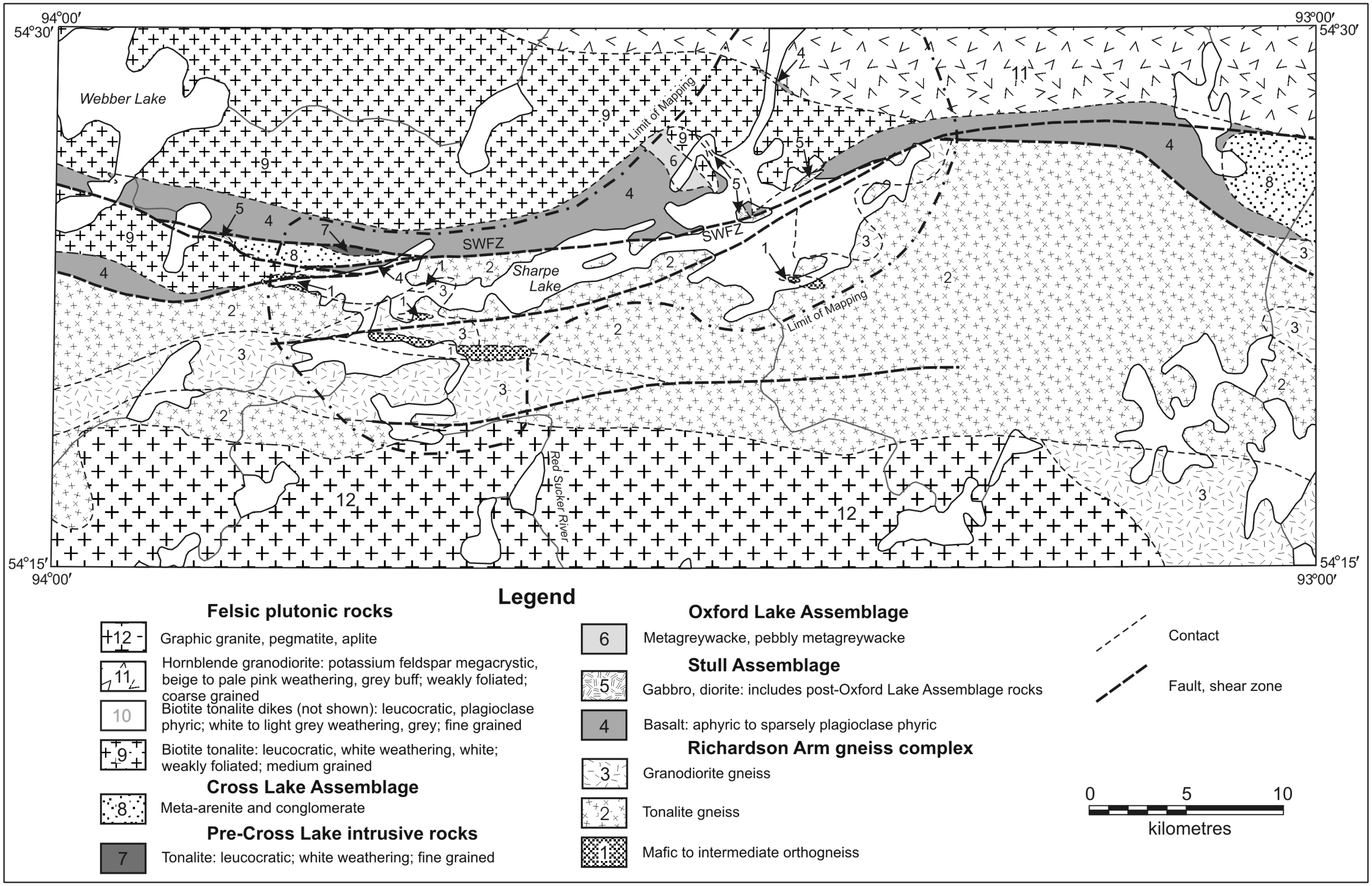

Figure GS-20-2: Updated geology of the Sharpe Lake area.

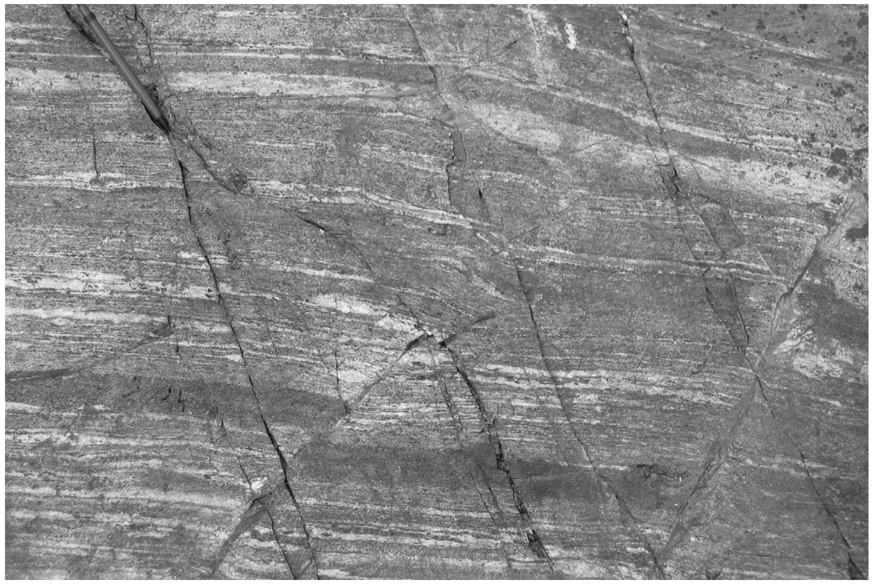

Figure GS-20-3: Typical layered amphibolite (unit 1) from a 200 m thick inclusion in tonalite gneiss (unit 2), central Sharpe Lake (pencil for scale).

hornblendite layers with clinopyroxene probably represent metapyroxenite layers.

In the least deformed zones, the amphibolite is compositionally layered, fine to medium grained, black weathering and dark grey to black. Texture is granoblastic to weakly foliated. It contains variable amounts of plagioclase, minor quartz, epidote and sphene, and abundant hornblende, and may contain minor clinopyroxene.

Well-preserved mafic to intermediate granulite (unit 1b) was observed at only one location. Here, compositional layering indicates that the protolith was a layered pyroxenite-gabbro complex. Both ortho- and clinopyroxene occur in the layered granoblastic to weakly foliated gneiss. As well, mobilizate containing two pyroxenes (Fig. GS-20-4) indicates early M_1, granulite-grade metamorphism. The gneiss is variably retrograded to garnet-amphibole gneiss, possibly during the formation of the enclosing tonalite gneiss. Previous investigations by Hubregtse (1985) south of Oxford Lake noted the close association of clinopyroxenite with the tonalite gneiss and suggested a common evolution. Nevertheless, the observed retrogression of granulite mineral assemblages restricted to unit 1 gneiss implies two distinct metamorphic events that formed an early gneissic fabric G_1 at granulite grade and a younger fabric G_2 or G_3 in the tonalite gneiss.

Tonalite gneiss (unit 2)

This unit is dominated by schollen- to stromatic-textured hornblende tonalite gneiss (unit 2c), characterized by

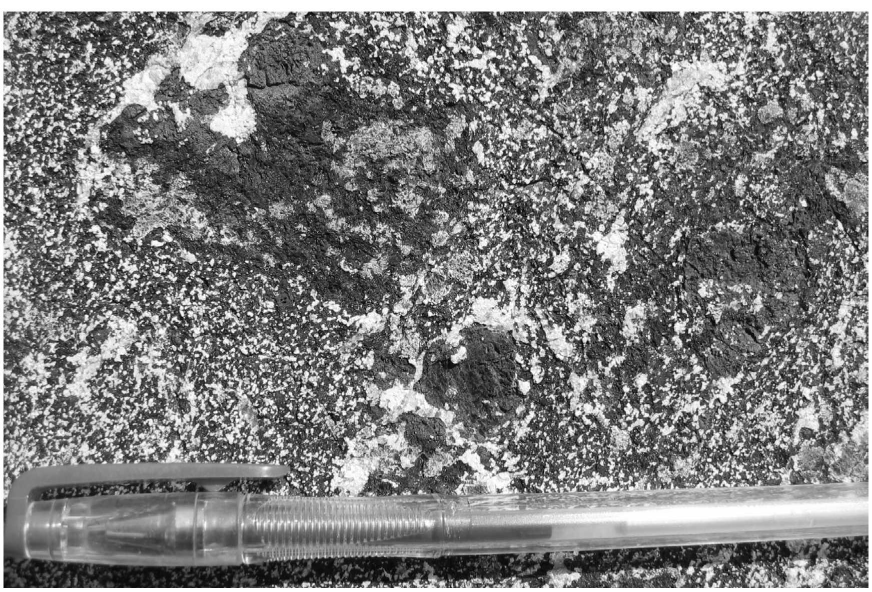

Figure GS-20-4: Mobilizate pod containing both ortho- and clinopyroxene in granoblastic intermediate granulite, western Sharpe Lake.

conspicuous gneissic layering (G_2 fabric, *see* below) and common layers and inclusions of amphibolite, hornblendite and mafic granulite (unit 1). The latter dominate unit 2c and distinguish it from the foliated and generally more weakly layered and monotonous tonalite gneiss (unit 2b) and the weakly foliated hornblende tonalite (unit 2a).

Unit 2 gneiss is fine to medium grained and moderately to strongly foliated with variably developed metamorphic layering (Fig. GS-20-5). It is composed of white plagioclase, grey to pink quartz and aggregates of hornblende. Alteration of the hornblende to hornblende–biotite–green amphibole occurs locally. Primary potassium feldspar is locally present but is more commonly associated with late granitoid veinlets.

The layered tonalite gneiss (unit 2c) is fine to medium grained and displays a metamorphic layering defined by compositional banding that ranges from a few millimetres to 5 to 10 cm in thickness. White to grey, quartz- and plagioclase-rich, hornblende-poor leucosome layers are interlayered with layers rich in dark grey to black hornblende (±biotite–green amphibole). This layering is enhanced by discontinuous, concordant, 20 cm thick bands of amphibolite and by irregularly shaped inclusions of massive to layered hornblendite, pyroxenite and amphibolite, ranging from a decimetre to several metres in thickness. The latter are interpreted as inclusions of unit 1.

Hornblende tonalite gneiss (unit 2b) is similar to the previous subunit but with a less pronounced metamorphic banding. It is moderately to strongly foliated and layered, with up to 15% concordant, discontinuous amphibolite layers and rounded inclusions or boudinaged inclusion trains of unit 1 metapyroxenite.

Fine- to medium-grained hornblende tonalite (unit 2a) is the dominant leucosome throughout unit 2 and forms irregular lens-shaped bodies, up to several hundred metres wide, throughout unit 2. These bodies have diffuse contacts, grade into the more strongly layered gneiss and generally have a long dimension parallel to the gneissosity. These more homogeneous bodies of hornblende tonalite are white to light grey weathering, weakly to moderately foliated and medium to coarse grained.

Granodiorite gneiss (unit 3)

Areas of granodiorite gneiss are unevenly distributed within the tonalite gneiss throughout the map area (*see* Preliminary Maps PMAP2003-4 and PMAP2003-5). They are composed of white plagioclase, blue-grey quartz, pink to grey microcline (often as 3 to 8 mm megacrysts), with green-brown biotite±hornblende. The unit is moderately to strongly foliated and has more nebulitic gneissic layering (G_3 fabric) than unit 2 gneiss. It contains discrete, large (outcrop-scale) rafts of unit 2 gneiss but generally lacks the discrete layers of the amphibolite and hornblendite common in unit 2 tonalite gneiss. The separation of G_2 and G_3 is difficult in most outcrops; however, at some locations, the early G_2 gneissosity is truncated by G_3 fabric (Fig. GS-20-6).

Biotite granodiorite gneiss (unit 3a) is beige to pink weathering, grey to pale pink, moderately to strongly foliated and weakly layered. It contains variable amounts of units 1 and 2 as rafts. Localities in the southeast bay of Sharpe Lake contain tonalite gneiss inclusions that range gradationally in abundance from 10 to 80%, making the boundary between units difficult to define.

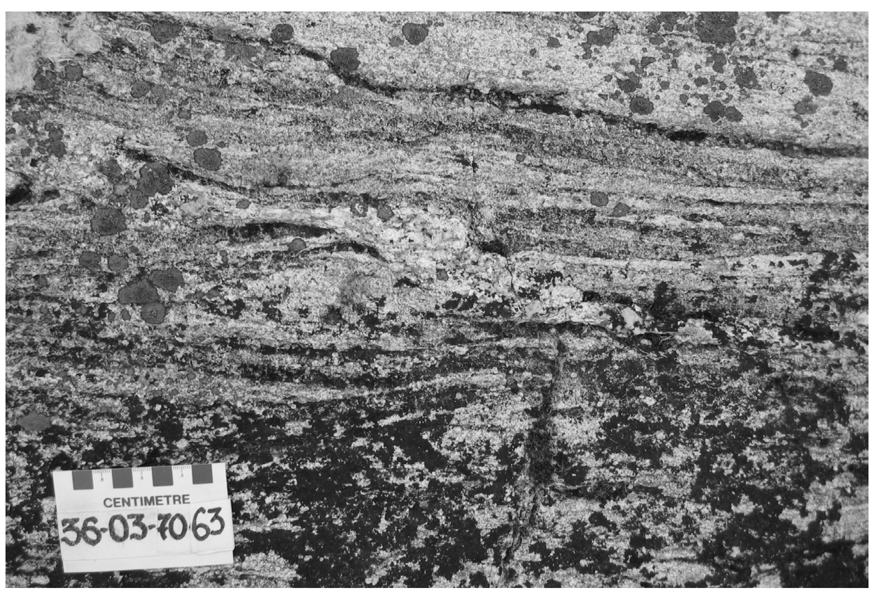

Figure GS-20-5: Strongly foliated, well-layered hornblende tonalite gneiss, eastern Sharpe Lake.

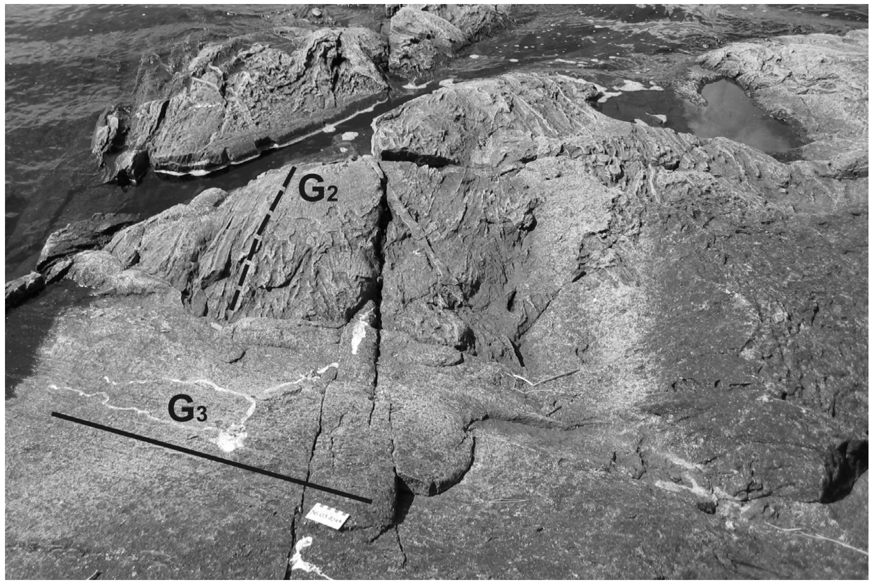

Figure GS-20-6: Large raft of hornblende tonalite gneiss (unit 2; G_2 layering in dashed line) intruded by granodiorite gneiss (unit 3; G_3 fabric and gneissic layering in solid line), eastern Sharpe Lake (scale card in foreground).

Augen granodiorite gneiss and tectonized granodiorite gneiss (unit 3b) form several east-trending bands in the RAGC. They represent tectonized equivalents of the RAGC and are therefore described more fully in the 'Structural analysis' section.

Stull assemblage

The Stull assemblage includes all metavolcanic rocks of the Hayes River Group in the Sharpe Lake area. Central and northern Sharpe Lake are underlain by basalt flows (unit 4), volumetrically minor mafic intrusions (unit 5) and derived amphibolite and mafic tectonite. This east-trending panel of mafic rocks, over 3 km in width, has been traced along strike for more than 45 km on Sharpe Lake. It is bounded to the south by a major D_3 fault, which separates the basalt from the RAGC (units 1 to 3), and is intruded to the north by younger plutonic rocks (units 9 and 11). The basalt flows are interpreted to correlate with Stull assemblage volcanic rocks exposed 40 km to the east, on the south shore of Stull Lake in Ontario.

Stull assemblage rocks in Ontario, which comprise mainly pillowed basalt, attain a thickness of up to 3 km and have been traced for over 50 km along strike in an easterly direction (Stone et al., in press). They include at least two chemical varieties of tholeiite. Those most likely to correspond to the mafic flows at Sharpe Lake display primitive-mantle–normalized trace-element profiles with Th $\cong$ Nb < La, slight depletion in LREE and high ε_{Nd}. Stone et al. (in press) have interpreted these lavas to have been erupted in an ocean-floor environment and inferred them to be late Mesoarchean in age, based on their chemical similarity with basalts of the 2875 Ma Sachigo assemblage.

One of the objectives of this project is to subdivide the mafic volcanic rocks of the Sharpe Lake area into distinct lithogeochemical packages and to correlate them with other volcanic sequences in the Oxford–Stull Lake domain. Twenty-five samples of mafic volcanic rocks from the Sharpe Lake area have been submitted for ICP-MS chemical analysis. Results of the geochemical analyses will be reported in next year's *Report of Activities*.

Aphyric to sparsely plagioclase phyric basalt and derived mafic tectonite (unit 4)

Mafic rocks at Sharpe Lake comprise a monotonous sequence of basaltic rocks (unit 4) that are typically aphyric to sparsely plagioclase phyric, pillowed and nonamygdaloidal (Fig. GS-20-7). Pillows locally display moderate to weak development of internal epidosite alteration domains and varioles, have narrow selvages and show only minor development of interpillow hyaloclastite. Massive flows and flows with prominent development of amoeboid pillows are rare. Flow contacts were not observed, probably due to the generally high degree of imposed deformation, the small size of many outcrops, the absence of interflow sedimentary rocks and, possibly, a scarcity of well-developed internal flow organization. The younging direction and strike of the basalt flows has not been reliably determined due to lack of identified flow contacts and only three top determinations. The observed younging directions, which are all based on pillow shapes, consistently indicate that the sequence youngs to the south. The absence of reliable information on the strike of flows and their younging directions hampers development of a stratigraphy for the basalt sequence.

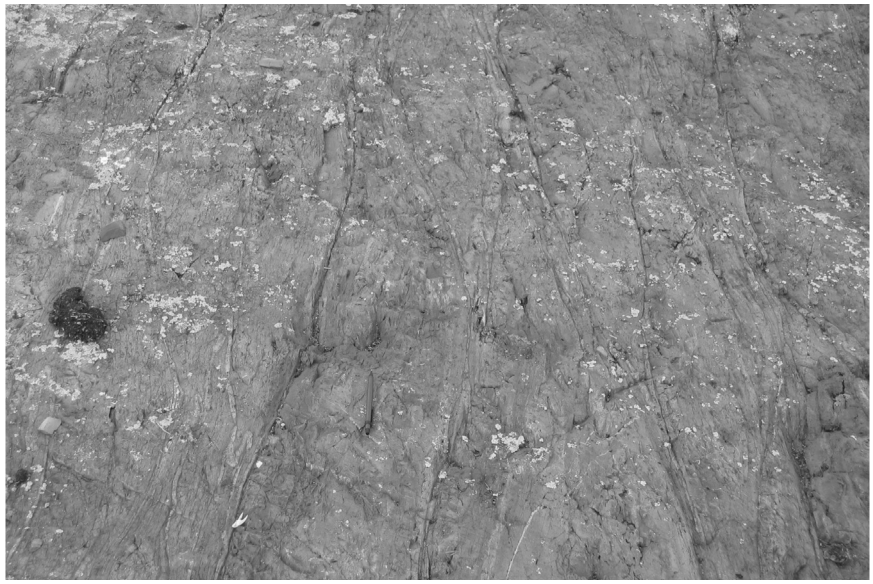

Figure GS-20-7: Pillowed, aphyric basalt, central Sharpe Lake; note the narrow selvages and lack of interpillow material.

Subunits identified in unit 4 have unknown stratigraphic significance and are based solely on physical parameters, such as weathered and fresh colour, presence or absence of variolites and degree of deformation.

Units 4a and 4b, which volumetrically dominate the exposed Stull assemblage at Sharpe Lake, comprise aphyric to sparsely plagioclase phyric basalt (unit 4a) and its variolitic equivalent (unit 4b). These basalt flows weather pale buff-brown, pale buff-green, pale grey-green and medium green, and are pale grey-green, pale green and medium green on fresh surfaces. Lighter coloured weathered and fresh surfaces are typical of flows that are least recrystallized, least deformed or both. Flows are most recrystallized in proximity to later granitic intrusions (units 9 and 11) that border the sequence north of Sharpe Lake and are most deformed in proximity to the major D_3 structure along their contact with the RAGC on central Sharpe Lake. In least recrystallized and deformed outcrops of units 4a and 4b, pillows are up to 3 m in size with rusty brown weathering selvages and interpillow hyaloclastite. Most pillows are strongly deformed (flattened and lineated), so observed pillow dimensions on horizontal surfaces rarely exceed half a metre.

Black to dark grey weathering aphyric flows (unit 4c) with dark green fresh surfaces are a minor component of unit 4. These flows occur most prominently in the central portion of the belt and were sampled for geochemical analysis as possible high-Mg flows with potential komatiitic affinities. In most respects, other than their unique colour and higher amygdule content, they are similar to flows of units 4a and 4b.

Laminated, dark green to rusty brown mafic tectonite (unit 4d) occurs within and spatially associated with high-strain zones developed during D_2 and D_3 deformation. On many outcrops, the modification of recognizable pillowed basalt to tectonically laminated mafic rock is transitional. The first stage in the transition from pillowed basalt is a laminated rock in which highly attenuated pillows with local complete pillow selvages are still recognizable. With further deformation, only incomplete pillow selvages and remnant epidosite alteration domains remain. In the mafic tectonite (unit 4d), original pillow selvages are no longer preserved and the rock is characterized by strong colour banding (a remnant of the colour variations in the original pillows prior to deformation). These latter rocks typically have a strong phyllonitic fabric and, in the most intensely deformed varieties, display local sericite-rich zones, quartz veining and iron-rich intrafolial carbonate impregnations.

Gabbro and diorite (unit 5)

Small intrusions of grey-green to dark green weathering gabbro and diorite (unit 5) are common throughout the mafic volcanic rocks of unit 4. The intrusions vary in width from less that a metre to mappable units with grain size progressing from fine to medium as the size of the intrusion increases. Most of the intrusions are subophitic in texture, with 40 to 60% lath- to tablet-shaped plagioclase, 40 to 60% amphibole after original pyroxene, and up to 15% quartz. The exact timing of emplacement of individual intrusions is unknown, but most are considered to have been emplaced as synvolcanic bodies or during closely related magmatic activity. Local intrusions of gabbro and diorite within younger sedimentary rocks of the Oxford Lake assemblage indicate that at least some of the intrusions may be much younger.

Oxford Lake assemblage

Metagreywacke, metasiltstone and polymictic conglomerate (unit 6), which are exposed in small shoreline outcrops at the west end of a large bay on the north side of central Sharpe Lake (Fig. GS-20-8), are tentatively interpreted to belong to the Oxford Lake assemblage. This is based on the presence of small gabbro dikes and sills, a feature uncharacteristic of Cross Lake assemblage sedimentary rocks but common in those of the Oxford Lake assemblage.

Although no contacts between these rocks and those of the Stull assemblage were observed, the paucity of gabbro intrusions (unit 5) in unit 6 compared to the Stull assemblage basalt (unit 4) suggests that these metasedimentary rocks are younger than the volcanic rocks of the Stull assemblage. Structural breaks between the mafic volcanic rocks of the Stull assemblage and the metasedimentary rocks of the Oxford Lake assemblage were not observed but cannot be precluded.

Stone et al. (in press) have placed similar metagreywacke and metasiltstone at Stull Lake (Ontario) within a lower, marine member of the Cross Lake assemblage. Detrital zircons in the metagreywacke and metasiltstone of unit 6, however, display youngest ages ranging from 2723 to 2718 Ma, which overlap zircon ages of 2732 to 2717 Ma from extrusive calcalkalic and alkalic rocks of the Oxford Lake assemblage. For this reason, and because Sharpe Lake metagreywacke and metasiltstone are cut by gabbro intrusions, the interpretation of these rocks as part of the Oxford Lake assemblage is preferred.

a)

b)

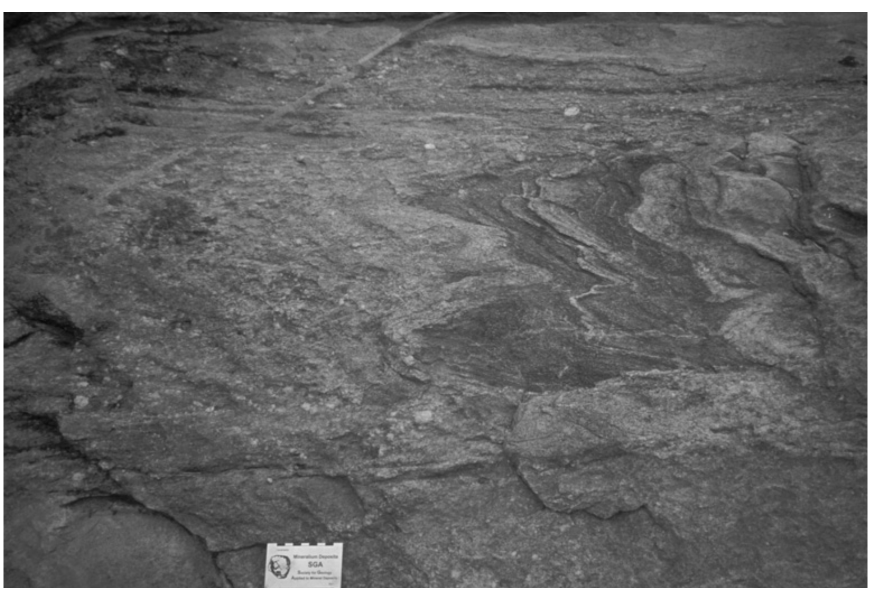

Figure GS-20-8: Oxford Lake assemblage rocks, north-central Sharpe Lake: a) finely laminated metagreywacke (unit 6a), b) strongly lineated polymictic conglomerate (unit 6b).

Metagreywacke and pebbly metagreywacke (unit 6)

Feldspathic metagreywacke and metasiltstone (unit 6a) are medium to dark grey in colour. Bedding is well defined, of medium thickness and parallel sided, with observed grain-size gradation but no reliable top determinations. The metasiltstone contains metamorphic biotite and porphyroblasts of mauve-coloured garnet. Some beds contain 0.5 to 1 cm, light grey domains that could be andalusite.

Unit 6b includes polymictic pebble conglomerate interlayered with greywacke. Because of the high level of deformation in this unit, primary features are poorly preserved. Pebbles in this unit commonly display D_2 flattening at up to 50:1 ratios. Despite this deformation, the pebbles were observed to be matrix supported and rounded. Clasts in the conglomerate are typically fine grained and felsic to intermediate in composition. They were likely derived from contemporaneous Oxford Lake volcanism.

Pre–Cross Lake assemblage intrusions

Leucotonalite (unit 7)

The Sharpe Lake greenstone belt is intruded by equigranular to quartz-phyric leucotonalite (unit 7) that predates deposition of the Cross Lake assemblage. This unit outcrops at the northwest end of Sharpe Lake. The leucotonalite is truncated by a D_3 fault to the north and is unconformably overlain by meta-arenite and conglomerate (unit 8) to the south. The leucotonalite varies from fine to medium grained. It locally contains 5 to 10% quartz phenocrysts that are typically 1 to 2 mm in size but are locally up to 10 mm. The tonalite is white in colour on weathered surfaces and light grey to white on fresh surfaces.

Pale green and rusty weathering domains in the leucotonalite reflect alteration spatially associated with D_3 ductile to brittle deformation zones. The alteration is characterized by sericite, local iron carbonate, quartz veining and disseminated pyrite. Local malachite and azurite staining are present in some of the sulphide-rich portions. Locally, up to 20% of unit 7 is overprinted by sericite and iron-carbonate alteration. The alteration and associated brittle deformation also overprint the unconformably overlying meta-arenite and conglomerate (unit 8).

Cross Lake assemblage

Meta-arenite and conglomerate (unit 8) at Sharpe Lake unconformably overlie leucotonalite (unit 7) and contain no dikes and sills of gabbro (unit 5). They are interpreted to be younger than the metagreywacke, metasiltstone and polymictic conglomerate (unit 6) of the Oxford Lake assemblage and most likely belong to the Cross Lake assemblage.

The Cross Lake assemblage is widely considered to postdate amalgamation of the various terranes in the central and northern Superior Province, and to possibly represent late fluvial and shallow-marine sedimentation in pull-apart basins developed along transpressional faults that accompanied collisional tectonics (e.g., Stone et al., in press). Cross Lake assemblage meta-arenite at Stull Lake contains youngest detrital zircons ranging from 2713 to 2709 Ma (Stone et al., in press) and a wide age range of zircon grains that are as old as 2905 Ma (Skulski et al., 2000). The older detrital zircons are interpreted to represent the presence of older crust in source areas for the continental fluvial systems feeding the pull-apart basins.

Meta-arenite and conglomerate (unit 8)

Quartz-rich meta-arenite (unit 8a) and polymictic tonalite cobble-rich conglomerate (unit 8b) form a 500 m wide and over 7 km long unit on northwestern Sharpe Lake. The unit is bounded to the south by a faulted contact with the RAGC and to the north by a nonconformable contact with unit 7 leucotonalite.

Although the nonconformable contact between the leucotonalite (unit 7) and the sedimentary rocks of unit 8 is not exposed, the nature of this contact can be clearly demonstrated. In outcrops closest to the leucotonalite, unit 8 is composed entirely of leucotonalite cobbles, boulders and pebbles in a matrix of detrital quartz and feldspar (Fig. GS-20-9). The cobbles, boulders and pebbles are subrounded to rounded and clast supported, and consist of various textural varieties of the underlying leucotonalite intrusion, including clasts up to 1 m in diameter. With increasing distance from the leucotonalite contact, the clast populations are more diverse and the sedimentary rocks finer grained. In these outcrops, the conglomerate locally contains clasts of lithic arenite, potentially indicating local uplift of lithified portions of the sedimentary sequence and subsequent erosion and redeposition. Fine-grained sericite-rich clasts in the meta-arenite may be altered mudstone clasts or, alternatively, could be fragments of the sericite-rich alteration that overprints the leucotonalite (unit 7). The latter would indicate that the alteration was early and incorporated rapidly into adjacent sedimentary rocks.

Figure GS-20-9: Cross Lake assemblage conglomerate (unit 8b) containing cobbles of leucotonalite (unit 7), west end of Sharpe Lake.

Felsic plutonic rocks

Supracrustal rocks of the Stull, Oxford Lake and Cross Lake assemblages are flanked to the north by a plutonic terrane composed mainly of younger biotite tonalite (unit 9) and hornblende granodiorite (unit 11). Dikes and sills of biotite leucotonalite (unit 10) and aplitic granite, graphic granite and pegmatite (unit 12) also locally cut supracrustal rocks of the Stull, Oxford Lake and Cross Lake assemblages. Dikes and sills of the biotite leucotonalite (unit 10) cut the biotite tonalite (unit 9) but were not observed to intrude units 11 or 12.

Biotite tonalite and leucotonalite (unit 9)

Unit 9 comprises a large pluton, which directly borders the northern margin of the supracrustal rocks at Sharpe Lake. It consists of medium- to coarse-grained, white-weathering biotite tonalite and leucotonalite (Fig. GS-20-10). A weak but ubiquitous foliation, defined by aligned biotite and flattened, annealed quartz grains, characterizes most outcrops of unit 9. The quartz grains are commonly lineated as well as aligned in a foliation. The tonalite consists of 30 to 40% quartz, 50 to 60% equant to lath-shaped feldspar and 2 to 7% biotite.

The biotite tonalite (unit 9) is clearly intrusive into the supracrustal rocks and includes trains of recrystallized mafic xenoliths derived from unit 4 basalt and a metamorphic contact aureole in which unit 4 basalt is recrystallized to amphibolite grade.

Figure GS-20-10: Weakly foliated biotite tonalite, northeastern Sharpe Lake.

Biotite leucotonalite dikes (unit 10)

Dikes of white-weathering biotite leucotonalite, ranging from less than 1 m to several metres in width, cut across and are chilled against unit 9 biotite tonalite. These dikes also intrude mafic volcanic rocks (unit 4), sedimentary rocks of units 6 and 8, and locally the Richardson Arm gneiss complex (units 1–3). The dikes were likely emplaced during late D_2 deformation, as they have been observed to cut across D_2 high-strain zones but to also contain a weakly developed D_2 fabric (Fig. GS-20-11). The emplacement of these dikes into the RAGC defines the lower age limit for the amalgamation of the supracrustal rocks of the Stull, Oxford Lake and Cross Lake assemblages to the Richardson Arm gneiss complex.

The distinguishing characteristics of unit 10 biotite leucotonalite are emplacement as narrow dikes and sills, late D_2 intrusion and the feldspar-phyric nature of many of the intrusions. Dikes locally contain up to 50% feldspar phenocrysts (2 to 4 mm). Most dikes contain between 5 and 15% feldspar phenocrysts (2 to 4 mm). A sample of this material was collected for future U-Pb zircon dating.

Hornblende granodiorite (unit 11)

The northern part of the Sharpe Lake map area is underlain by a large late pluton of potassium-feldspar megacrystic hornblende granodiorite (unit 11). The pluton is typically coarse grained, locally pegmatitic and featureless except for rare mafic xenoliths and a weak shape fabric defined by quartz grains. The southern contact of the pluton (unit 11) was observed at one locality, where a mafic tectonite (unit 4d) containing dikes of leucotonalite (unit 10) is truncated by the granodiorite. The contact is sharp and the granodiorite is chilled against the mafic tectonite.

The granodiorite is pale buff to buff-pink weathering. It is composed of 20 to 30% potassium-feldspar megacrysts (5 to 35 mm), 30 to 35% quartz (2 to 8 mm), 35 to 40% equant plagioclase (2 to 5 mm) and 5 to 7% clots (2 to 8 mm) of hornblende and biotite.

Graphic granite, pegmatite and aplite (unit 12)

Discrete granite bodies and numerous late granite, pegmatite and aplite dikes and sills occur throughout the Richardson Arm gneiss complex. These dikes and sills postdate the development of gneissic fabrics G_1 to G_3 and are deformed only in the late shear zones.

The most abundant of the late intrusions is a beige to pale pink weathering, light brown biotite granite. It is generally medium to fine grained, massive, and equigranular to sparsely microcline megacrystic. It is composed of microcline, plagioclase, quartz and biotite, with minor magnetite. Larger bodies of homogeneous massive biotite granite intrude the RAGC in the bays south of the west end of Sharpe Lake (*see* Preliminary Map PMAP2003-5). This unit is generally fresh in appearance and crosscuts all other units, but is deformed in the late east-west deformation zones, where it may contain epidote and chlorite.

Several other generations of late granite pegmatite and aplite dikes cut the RAGC. Crosscutting relationships are

Figure GS-20-11: Weakly S_2 foliated leucotonalite dike (unit 10) crosscutting D_2 high-strain zone, central Sharpe Lake.

observed, but the age relationships were not systematically documented other than to note that they postdate the G_3 fabric and were cut by the younger granite.

Structural analysis

Structural analysis of the Sharpe Lake area focused on the delineation of fabric elements throughout the study area, with the goal of determining the deformational history across the Stull Lake–Wunnummin Fault Zone (SWFZ). The SWFZ represents a major structural discontinuity, which potentially juxtaposed terranes having different structural histories. Accordingly, the results of the structural analysis are presented separately for the two domains, with the fabric development associated with the SWFZ described for each domain. The correlation of structural elements across the SWFZ provides evidence of a shared deformational history that postdates juxtaposition of the domains, with older deformations and fabric elements reflecting deformational histories involved with the development of the respective domains.

An ancillary result of structural analysis of the Sharpe Lake area is an improved understanding of the kinematics of the SWFZ. The SWFZ represents a major gold metallotect in the northern Superior Province. Numerous gold showings and deposits are hosted by the SWFZ west of Sharpe Lake in Manitoba and Ontario, and the Sharpe Lake area represents a relatively well exposed segment of the SWFZ for which very little structural information exists. Accordingly, the detailed understanding of the potentially complex movement history of the SWFZ not only provides important tectonic constraints, but may also be of practical use to ongoing gold exploration in this region.

Sharpe Lake greenstone belt (SLGB)

Overprinting relationships between fabric elements north of the SWFZ indicate that the structural history of the greenstone belt involves five generations of ductile and brittle deformations (D_1 to D_5). Evidence of the early deformation history (D_1) in the Sharpe Lake belt is found in the north-central portion of the belt, within a single outcrop of bedded metagreywacke of the Stull assemblage. This outcrop contains an early, penetrative, planar S_1 fabric that is oriented slightly oblique to bedding and is defined by fine-grained foliated biotite. The S_1 foliation is overprinted by a penetrative, finely spaced crenulation cleavage that is also defined by fine-grained biotite but is assigned to the S_2 generation on the basis of the clear overprinting relationship. The S_2 cleavage dips steeply south and parallels bedding in the metagreywacke. The asymmetry of the S_1-S_2 crenulation fabric changes across the outcrop, indicating the presence of isoclinal F_2 fold closures. The L^1_2 intersection lineation plunges steeply and, in one location, appears to overprint a steep stretching lineation that is defined by slightly elongate pebbles in the metagreywacke. This lineation is assigned to the L_1 generation. Outcrops of polymictic conglomerate, 200 m to the north, contain flattened clasts with aspect ratios in horizontal outcrop surfaces that locally exceed 50:1. This fabric is attributed to the D_2 deformation because it is axial planar to isoclinal, rootless and intrafolial folds of an earlier fabric. Idioblastic porphyroblasts of garnet that range up to 1.0 cm in diameter overgrow the S_2 foliation in this outcrop, indicating that the D_1 and D_2 deformations likely predate the metamorphic peak in at least this part of the Sharpe Lake belt. On a regional scale, younging criteria in the supracrustal rocks in the Sharpe Lake belt indicate a south-younging monoclinal succession, which could represent the truncated limb of a macroscopic, isoclinal, F_1 or F_2 fold closure.

Fabric elements of the D_2 deformation are represented by the regionally penetrative deformation north of the SWFZ. The regional S_2 foliation parallels the trend of the greenstone belt. In the north-central portion of the greenstone belt, the trend of the belt shifts from the northeast orientation that characterizes its western half to a northwest trend, producing a macroscopic fold of the northern margin of the supracrustal belt in this area. The main S_2 foliation becomes increasingly penetrative and pervasive, with a coincident change in orientation to a more northwest trend that parallels the margin of the supracrustal belt. Along this margin, metagabbro and pillowed metabasalt of the Sharpe Lake assemblage are inhomogeneously transposed into a 100 to 200 m thick zone of amphibolite-facies mafic tectonite that is attributed to D_2 deformation. In these rocks, the tectonite layering is defined, in part, by lenticular domains of relatively lower finite strain in which primary igneous or volcanic textures are preserved. Acicular porphyroblasts of hornblende, with subordinate biotite, define a penetrative S>L or L>S tectonite fabric that dips steeply northeast, with a prominent mineral lineation that plunges moderately to the east-southeast. This lineation parallels a locally pronounced stretching lineation defined by highly elongate pillows. The tectonite contains tight to isoclinal, locally intrafolial and rootless folds that plunge to the east, typically with a marked S-asymmetry. Generally, these folds plunge subparallel to the associated L-fabric; however, local variations from down-dip to subhorizontal plunges may indicate curvilinear fold axes. No sheath folds were observed. Biotite leucotonalite dikes (unit 10) discordantly cut the D_2 tectonite fabric but contain a moderate to strong L>S fabric that is concordant with that in the hostrocks.

In north-central Sharpe Lake, the northwest-trending, D_2, amphibolite-facies tectonite is progressively overprinted to the south by east- to east-northeast-trending D_3 deformation structures that are associated with a 100 to 400 m thick zone of greenschist-facies D_3 mylonite, which marks the southern margin of the supracrustal belt (Fig. GS-20-12a). This shear zone is interpreted to represent the westward continuation of the SWFZ from the Stull Lake belt. Approximately 1.5 km north of the SWFZ, D_3 structures are manifested as a weak, spaced, fracture cleavage that trends, in general, east and is axial planar to open, Z-asymmetric, steeply east-southeast-plunging F_3 folds of the S_2 fabric. Further south, the S_3 fabric becomes increasingly penetrative and locally constitutes a well-developed shear-band cleavage. Along the northern margin of the SWFZ, the S_3 fabric intensifies into discrete, widely spaced, greenschist-facies shear zones that range up to 5 m thick and trend east-northeast. These shear zones are characterized by a finely spaced, phyllonitic S_3 cleavage to penetrative, mylonitic S_3 foliation. These fabrics dip steeply to the north or north-northwest, and locally contain a subhorizontal ridge-in-groove and chlorite lineation. Shear bands, foliation fish and asymmetric quartz boudins (Fig. GS-20-12b) are very well developed and consistently indicate dextral strike-slip shear, with minor components of reverse and normal dip-slip shear. The F_3 folds are Z-asymmetric, and range from open to isoclinal, with axes that generally plunge to the east. In most locations, the D_3 shear zones contain mesoscopic evidence for progressive folding and transposition during dextral shear, with a clear progression from open, weakly Z-asymmetric, steeply north-plunging folds (F_{3b}) to tight, markedly Z-asymmetric, shallowly east-plunging (F_{3a}) folds that are typically intrafolial in S_3. Typically, the short limbs of tight to isoclinal F_{3a} folds are strongly transposed and

a)

b)

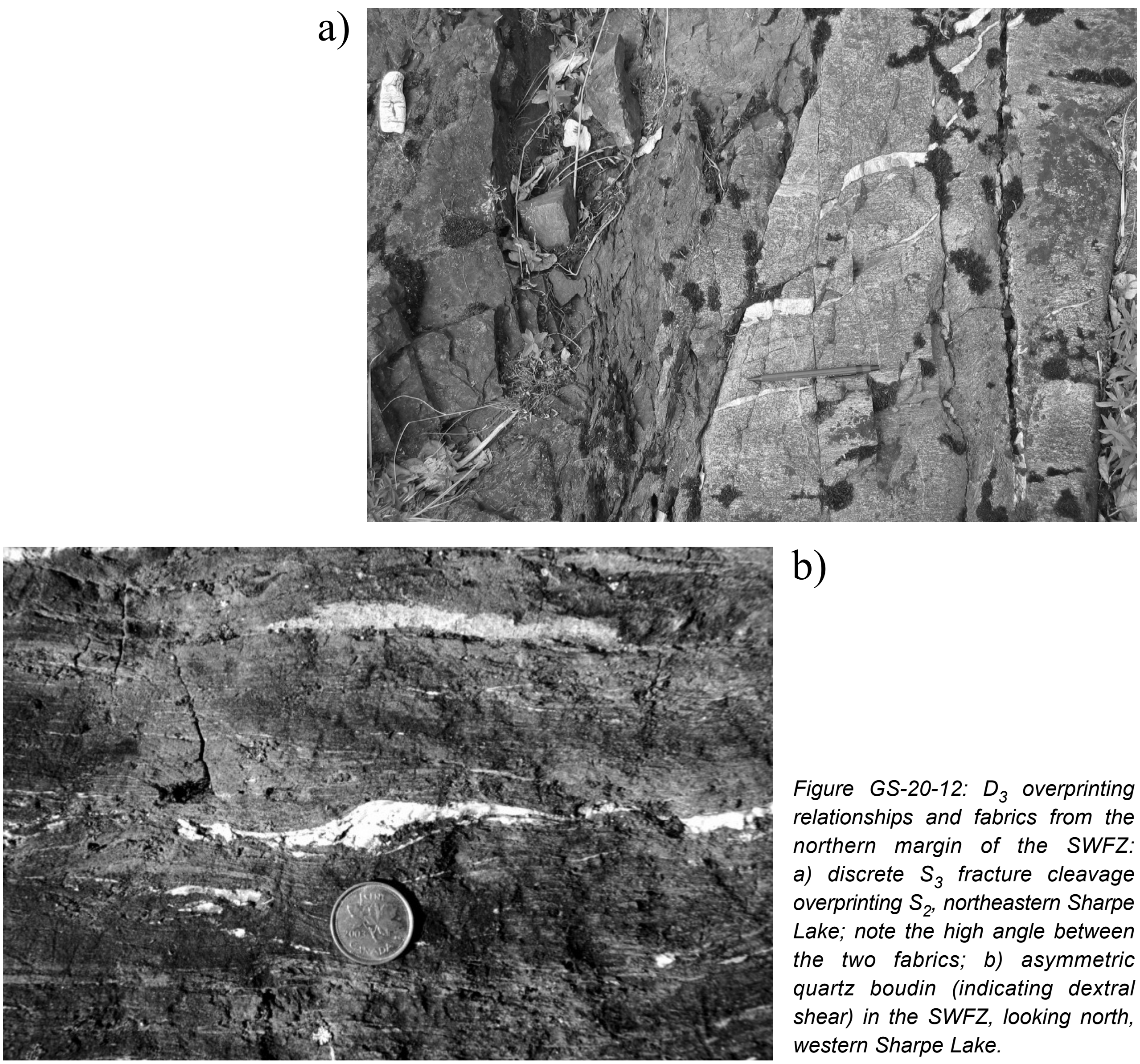

Figure GS-20-12: D_3 overprinting relationships and fabrics from the northern margin of the SWFZ: a) discrete S_3 fracture cleavage overprinting S_2, northeastern Sharpe Lake; note the high angle between the two fabrics; b) asymmetric quartz boudin (indicating dextral shear) in the SWFZ, looking north, western Sharpe Lake.

are preserved as trains of asymmetric foliation fish in S_3. Locally, the F_{3b} folds are associated with a weak, spaced, S_{3b} fracture cleavage that overprints the main S_3 mylonitic foliation.

Associated with the phyllonite to mylonite development that defines the core of the SWFZ is intense greenschist-facies retrogression of the older amphibolite-facies assemblages that characterize the greenstone belt beyond the effects of the SWFZ. In several areas, the shear-hosted retrogression is characterized by the development of assemblages commonly associated with gold mineralization. The alteration is locally pervasive and is typified by the presence of ankerite and locally fuchsite, and variable degrees of silicification and disseminated sulphide emplacement in addition to the ubiquitous chlorite and sericite retrograde products.

Unit 10 biotite leucotonalite dikes in the D_3 shear zones are strongly boudinaged and disrupted, indicating that they predate much, if not all, of the D_3 deformation. A U-Pb age from these dikes will thus provide a syn-D_2, pre-D_3 age constraint.

Shear-fracture networks (Riedel type) of the D_4 deformation, with south-southwest-trending sinistral R′ and south-east-trending dextral R-shears, probably formed at the same time as northwest-trending, quartz-filled tension gashes. These structures are probably the products of late dextral faulting.

Structures of the D_5 deformation reflect a period of north-south shortening, manifested by brittle faults that dip moderately to the north. These structures are characterized by well-developed slickenlines and slickensteps that indicate north-over-south movement.

Richardson Arm gneiss complex (RAGC)

The RAGC preserves a complex history of magmatism, metamorphic recrystallization and deformation that appears to largely predate the deformational history of the Stull assemblage north of the SWFZ. South of the SWFZ, the RAGC is dominated by hornblende-biotite tonalite gneiss (unit 2). Crosscutting relationships indicate that the unit 2 tonalite was emplaced into layered amphibolite (unit 1) that contained a pre-existing gneissic fabric (G_1). Tight to isoclinal, similar-style folding of the G_1 fabric also predated tonalite emplacement. Subsequent to emplacement, unit 2 tonalite was overprinted by a regional, weak to moderate gneissosity (G_2) that is most prominently defined by elongate inclusions of amphibolite in the tonalite. The G_2 fabric is, in turn, discordantly cut by light pinkish grey, medium-grained, biotite±hornblende granodiorite (unit 3), which represents the last major pulse of magmatism prior to development of the regional, generally east-trending gneissic fabric (G_3) that characterizes the RAGC.

Typically, G_3 is a moderate to strong, straight to wavy gneissosity that appears to have formed through inhomogeneous transposition of the G_1-G_2 gneissic fabrics, as indicated by the common preservation of rootless and intrafolial, isoclinal fold closures in G_3. The folds are upright and exhibit both S- and Z-asymmetry, although the S-asymmetric folds appear to be locally predominant. The fold hinges are invariably shallow plunging, both to the east and west. In many locations, the G_3 gneissosity is characterized by a high-temperature cataclastic fabric that contains nonretrogressed hornblende porphyroclasts. In these rocks, layers of cataclastic granodiorite or tonalite alternate with subordinate layers of amphibolite and leucocratic mobilizate. In the area southwest of Sharpe Lake, a characteristic feature of the G_3 gneiss is the presence of prominent asymmetric foliation fish of layered amphibolite or tonalite gneiss, which consistently indicate dextral strike-slip shear.

The G_3 gneissic fabric, and the dextral shear fabrics, are discordantly cut by straight-walled, medium-grained to pegmatitic dikes of biotite granite (unit 12) that locally account for up to 10% of individual outcrops in the RAGC. In the west basin of Sharpe Lake, immediately adjacent to the south margin of the supracrustal belt, dikes of granitic pegmatite discordantly cut an early, high-temperature, cataclastic gneissic fabric (G_3) and are overprinted by a porphyroclastic ribbon mylonite fabric (G_4) that contains 10 to 15%, subangular, fractured, potassium-feldspar porphyroclasts up to 5 cm across. The fine-grained matrix that surrounds the porphyroclasts contains spectacular quartz ribbons up to 5 cm long, as well as strongly foliated wisps of fine-grained biotite, sericite and epidote. The mylonitic fabric trends east-southeast, and is oriented at a distinct angle to the general east-northeast trend of the supracrustal belt in this area. Quartz ribbons locally define a prominent, subhorizontal stretching lineation. Shear bands and asymmetric tails on the porphyroclasts indicate sinistral shear. Sinistral shear fabrics are also locally present in the adjacent cataclastic (G_3) gneiss (Fig. GS-20-13).

Near the southern margin of the supracrustal belt, the G_1 to G_3 fabrics are overprinted by zones of greenschist-facies retrogressed, G_4 cataclastic gneiss that range to more than 50 m in thickness. Cataclasite zones of G_4 generally trend east and are characterized by complete, or nearly complete, retrogression of hornblende to a fine-grained assemblage of biotite, chlorite and epidote. The retrogressed gneiss locally contains discrete, 0.1 to 5.0 m thick zones of chloritic mylonite that trend east-northeast, subparallel to the southern margin of the supracrustal belt. The shear zones

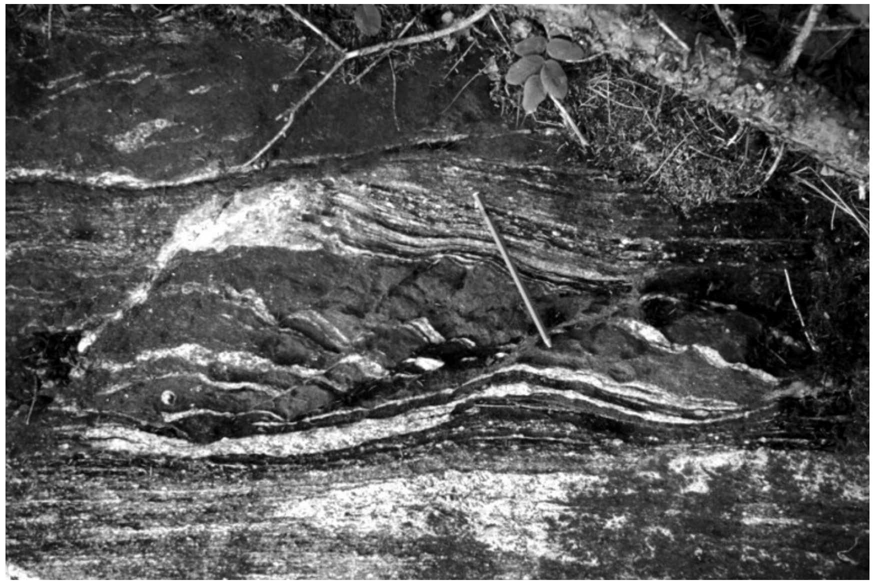

Figure GS-20-13: Asymmetric shear bands (sinistral shear) and foliation boudinage in nonretrogressed cataclastic gneiss, southwestern Sharpe Lake; top end of pencil indicates north.

locally contain a shallowly west-plunging quartz-ribbon lineation, and are characterized by well-developed asymmetric fabrics that indicate dextral strike-slip shear. Along the margins of these shear zones, the cataclastic gneiss locally contains Riedel-type shear-fracture networks, which also indicate dextral strike slip. The location, deformational style and associated greenschist-facies retrogression associated with the G_4 deformation represent the effect of the SWFZ along the northern margin of the RAGC.

The latest structures observed in the gneissic rocks are brittle shear fractures (G_5) that locally form well-developed conjugate sets, with west-southwest-trending sinistral and west-northwest-trending dextral shear fractures. These structures locally contain thin veinlets of pale green pseudotachylite. Overall, the geometry of the shear fractures is compatible with roughly north-south shortening of the earlier fabrics.

Correlation of structures between the SLGB and RAGC

The correlation of structures between the Sharpe Lake greenstone belt and the Richardson Arm gneiss complex involves inferring structural-fabric development across a major terrane boundary. The Stull Lake–Wunnummin Fault Zone represents a major, crustal-scale, ductile-brittle fault zone, so structural fabrics predating the fault zone may not correlate across the discontinuity.

Overprinting relationships in the supracrustal rocks north of the SWFZ indicate that it is a D_3 structure. This correlates with the G_4 cataclastic and augen gneisses within the RAGC. Both generations of fabric elements are overprinted by dextral transcurrent shear fabrics developed under retrograde metamorphic conditions. Post-SWFZ fabric elements can also be correlated directly across the SWFZ. The conjugate fracture networks that characterize D_4 fabrics in the greenstone belt can be correlated with the conjugate G_5 fabrics developed in the RAGC.

Correlating fabric elements older than the SWFZ in the two domains is not apparent, reflecting the potential for vastly different deformation and tectonic histories in the belts. North of the SWFZ, the development of a strong, L_2 stretching lineation in Cross Lake Group conglomerates in the greenstone belt indicates that D_2 postdates the Cross Lake Group. Elsewhere in the northern Superior Province, deposition of the Cross Lake Group coincides with terminal collision, reflecting the final accretion of the supracrustal belts to the older cratonic fragments assembled to form the Superior Province. This relationship suggests that the D_2 structures developed in the Cross Lake Group at Sharpe Lake may reflect the accretion of the supracrustal rocks to the RAGC or possible equivalents. Accordingly, it is possible that D_2 in the greenstone belt may correlate with the regional G_3 gneissosity developed in the RAGC, with both generations of fabrics being the product of a major period of collisional orogenesis. It may well be significant that the granitic pegmatite bodies (unit 12) in the RAGC are overprinted by G_3 gneissic fabrics but are not observed intruding the immediately adjacent supracrustal rocks of the SLGB. A U-Pb date for this granitic magmatism may thus provide an upper age limit for juxtaposition of the RAGC with the SLGB during collisional orogenesis. A somewhat more conservative alternative would be to avoid the direct correlation of D_2 and G_3 due to juxtapositioning of the two domains as a result of major displacements on the SWFZ. This approach is supported by the significant shift in metamorphic grade across the SWFZ and a large potential age gap between the 2713 to 2709 Ma age of the Cross Lake

Group at Stull Lake (Stone et al., in press) and the age of G_3, which is unknown but postdates the 2848 to 2883 Ma age of G_2 migmatite injection in the RAGC.

Economic considerations

The Sharpe Lake area contains a 35 km exposed portion of the Stull Lake–Wunnummin Fault Zone, a major gold metallotect in the northern Superior Province. Based on limited sampling during the course of lithotectonic mapping and structural analysis of the Sharpe Lake belt, it is apparent that the gold potential of the SWFZ is not limited to the presently explored Stull Lake to Monument Bay–Twin Lakes area.

Although the core of the SWFZ underlies Sharpe Lake, several zones of pervasive, shear-hosted, greenschist-facies alteration were delineated. The alteration assemblages identified are typical of shear-hosted lode-gold deposits in the northern Superior Province. The most common assemblages consist of sericite-chlorite-ankerite, sericite-chlorite-fuchsite and ankerite-chlorite, and were accompanied by varying degrees of silicification and the local emplacement of finely disseminated pyrite and rare arsenopyrite. The areas of significant alteration intensity generally coincided with zones of tight, Z-asymmetrical, F_3 chevron folding. The development of these folds is interpreted to be the result of progressive D_3 deformation in a dextral transcurrent releasing bend in the SWFZ. The change in boundary conditions caused by the releasing-bend geometry may have resulted in bulk dilation of the SWFZ during progressive D_3 deformation. The principal manifestation of this dilation is the F_3 folds, the propagation of which compensated for the volume increase within the releasing bend. This model is supported by the restricted development of F_3 chevron folds in those portions of the SWFZ that exhibit a releasing-bend geometry, and the synshear timing for the fold development. The latter is demonstrated by the evolution of steeply plunging, open F_{3a} folds through to shallow plunging, tight F_{3b} folds, an evolution that indicates progressive rotation of F_3 axes toward the displacement vector of the shear zone.

Favourable alteration was identified in most major units affected by the SWFZ. Preliminary geochemical results indicate that several of the alteration zones sampled contain anomalous concentrations of gold. At the west end of Sharpe Lake, leucotonalite and the nonconformably overlying conglomerate of the Cross Lake assemblage contain pervasive sericite alteration that ranges from weak to strong and is associated with patchy, weak to moderate ankerite and silica alteration. In one location, strongly sheared and gossanous leucotonalite contains 1% finely disseminated pyrite, with local malachite and azurite. A grab sample of this material returned a value of 1.4 g/t Au. This result not only confirms the gold prospectivity of the SWFZ in the Sharpe Lake area, but demonstrates the need for systematic prospecting and geochemical sampling of the many alteration zones developed within the SWFZ.

The tectonic environment of the Sharpe Lake area is similar in many respects to that of the Red Lake area. Both areas reflect the accretion of younger supracrustal rocks onto an older cratonic nucleus (North Caribou Terrane; cf. Sanborn-Barrie et al., 2001). In the case of the Sharpe Lake area, this is manifested by a major terrane-bounding fault zone (SWFZ), which separates isotopically juvenile supracrustal rocks of the Stull assemblage from the older, isotopically contaminated rocks of the RAGC (*see* Skulski et al., 2000). Accordingly, the authors believe that the Sharpe Lake greenstone belt, and other supracrustal belts to the west along the SWFZ, are characterized by a favourable, first-order tectonic control for the development of significant, shear-hosted (orogenic), lode-gold mineralization.

Conclusions

Geological mapping and structural analysis in the Sharpe Lake area have succeeded in identifying and delineating the western strike-extension of the SWFZ. This regional-scale, dextral transcurrent, ductile-brittle fault zone separates middle amphibolite facies supracrustal rocks of the Sharpe Lake greenstone belt from upper amphibolite to local granulite facies orthogneissic rocks south of the fault zone. The Sharpe Lake greenstone belt is composed of a large volume of aphyric pillowed basalt, constituting the Stull assemblage, which is in turn overlain by lesser amounts of Oxford Lake assemblage and Cross Lake assemblage clastic sedimentary sequences. The gneissic rocks exposed south of the SWFZ have been assigned to the Richardson Arm gneiss complex (RAGC), which has been subdivided into three orthogneiss units based on their relative age, as defined by contact relationships and foliation development.

The structural history of the Sharpe Lake greenstone belt involves three generations of structural fabrics. Fabric elements of D_2 represent the regional fabrics within the belt and are overprinted along the southern margin of the greenstone belt by the D_3 Stull Lake–Wunnummin Fault Zone. The SWFZ is characterized by dextral transcurrent kinematics. South of the SWFZ, the structural history of the RAGC involves five generations of structures, the SWFZ being a fourth-generation structure. The deformation associated with the SWFZ occurred at greenschist facies, resulting in an intense retrograde of the middle to upper amphibolite facies supracrustal and gneissic rocks. The SWFZ also hosts a large number of variably silicified alteration zones containing sericite-chlorite-ankerite and sericite-chlorite-fuchsite alteration assemblages. The style of alteration and the presence of finely disseminated sulphides in many of these alteration zones suggest excellent gold mineralization potential in this area.

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