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NATMAP
Canada's National Geoscience Mapping Program
Le Programme national de cartographie géoscientifique du Canada

DESCRIPTIVE NOTES

INTRODUCTION

As a contribution to the Western Superior NATMAP project, detailed mapping of the southeastern margin of the Sturgeon Lake greenstone belt area was undertaken in order to further understand the relationship between rocks of the supracrustal belt and those of the central Wabigoon subprovince and Nesqueheni supracrustal rocks of the western Wabigoon subprovince(Fig. 1).

GEOLOGICAL SETTING

The central Wabigoon subprovince was postulated to represent Mesoarchean basement (Thurston and Davis, 1995) to supracrustal units of the western Wabigoon subprovince (Blackburn *et al.*, 1991). Near the interface between these two distinct regions, the Sturgeon Lake-Savant Lake greenstone belt consists of several different volcanic successions ranging in age from Mesoarchean to Neoarchean (Thurston *et al.*, 1991). Evidence for Archean rifting and formation of the Jutten continental margin sequence, subsequently, oceanic plateau (2.775 Ga), arc (2.745–2.720 Ga) and arc-rift (2.715 Ga) sequences formed outboard of the continental margin (Sanborn-Barrie and Skulski, 1999; Skulski *et al.*, 1999). Collision between the continental margin sequence and composite oceanic terrane occurred by ca. 2.7 Ga; the interface is marked by the ~ 2.704 Ga Savant Lake sedimentary group, interpreted to underlie the eastern end of the map area (Wallace and Stott, 1986; Stott *et al.*, 2001). The Savant Lake greenstone belt is located approximately 40 km east of the map area (Fig. 1). It is divided into 3 parts. The southern assemblage is a northward-younging package of mafic and felsic (2.724–2.712 Ga) volcanic rocks (Percival *et al.*, 1994). The central and northern assemblage by a core zone made up mainly of gabbroic rocks (Sage, 1999) dated at 2.720 Ga (Tomlinson *et al.*, 1999). The northern assemblage consists largely of southward-younging mafic volcanic and metasedimentary units, as well as serpentinite and gabbroic intrusive bodies. Detrital zircon populations from sandstone units provide maximum depositional ages of 2.724 and 2.702 Ga (Tomlinson *et al.*, 1999; Percival *et al.*, 2000). Geochronology and geochemistry of volcanic rocks in the area are described by Thurston *et al.* (1991), Sage (1999) and Tomlinson *et al.* (Percival, McNicoll, and Stott 2000). Located at the southeastern margin of the Sturgeon Lake greenstone belt, the present map area straddles the interface between the western north and central Wabigoon subprovince (Fig. 1). Rogers (1964) first mapped attenuated screens of supracrustal rock extending from the greenstone belt eastward into the map area. Trace element geochemical data from these supracrustal screens allow correlation of most of these units with the supracrustal rocks of the Sturgeon Lake greenstone belt, although some units may also correlate with volcanic rocks in the Obonga belt (Breen, 2003).

LITHOTECTONIC MAP UNITS

The Hilltop Creek fault (HCF) and Robert Lake fault (RLF) (Fig. 2) divide the map area into structural panels with distinctive supracrustal packages. From south to north, the grain size of amphibolites increases with the volume of pegmatitic intrusions, suggesting that the deepest structural levels are exposed in the northernmost panel.

NEOARCHEAN SUPRACRUSTAL ROCKS:

SOUTHERN PANEL

Amphibolite of the southern panel (unit As) is fine to medium-grained, with mineral assemblages containing 70 - 90% hornblende with subsidiary plagioclase, minor clinopyroxene and garnet, and accessory amounts of titanite, epidote, quartz and opaque minerals. Amphibolite is commonly interlayered with up to 10% of a felsic to intermediate sequence(2.715 Ga-arc-rift-sequence of Sanborn-Barrie and Skulski, 1999). A small unit of relatively massive, coarse-grained gabbro (unit Gb) occurs in the hinge of the map-scale N-S fold centered on Mountairy Lake. This unit is mylonitic in southern Mountairy Lake. North of Mountairy Lake, the amphibolite screen is bound by sedimentary rocks to the south and north. To the south, sedimentary packages and Sa consists of sandstone and greywacke, whereas the Robert Lake fault to the north is underlain by a thick succession of conglomerate (Sc). Sc is commonly clast-supported greywacke. Clastic facies iron formation occurs in proximity to the Hilltop Creek fault. The two sedimentary units can be correlated with the Post and Quest Lake sedimentary packages respectively, of the Sturgeon Lake greenstone belt (Troswell, 1983; Skulski *et al.*, 1999). West of the map area, graded bedding and scour features indicate younging to the north in both packages.

CENTRAL PANEL

Amphibolite of the amphibolite units (unit Ac) are medium-grained with mineral assemblages containing hornblende-plagioclase ± garnet ± clinopyroxene ± epidote ± titanite ± quartz. Plagioclase is variably altered to saussenite. A thick unit of amphibolite associated with quartz-rich sandstone (unit Sq) and conglomerate (unit Sc) is referred to as the Rude Lake package. Conglomerate at the southern edge of the package is in tectonic contact with amphibolite, possibly along a splay of the HCF. The narrow (< 10 m) unit of conglomerate consists of pebble-sized clasts of granite, gneiss and amphibolite in a sandy matrix. Sandstone (Sq) is the dominant lithology in the sedimentary package, meter-scale layers of quartz-rich, biotite-plagioclase-quartz sandstone (unit Sq) are interlayered with garnetiferous amphibolite. A quartz-rich rock yielded detrital zircon ages between 2.76 and 2.701 Ga (J. Breen and V. McNicoll, unpublished data, 2000, 2001). These rocks were deposited after 2.701 Ga, the age of the youngest grain, and may correlate with the Savant sedimentary group to the west and northern Obonga sediments to the east.

A 3 km thick pod of fine grained felsic rock (unit Fs) occurs within the Rude Lake package. The contacts of the homogeneous, plagioclase-quartz ± biotite ± muscovite ± pyrite rock are not exposed. The felsic unit is associated with amphibolite, and is in tectonic contact with sandstone and conglomerate. The felsic unit yielded a detrital zircon age of preliminary U-Pb age of 2707 ± 2 Ma, interpreted as its crystallization age (J. Breen and V. McNicoll, unpublished data, 2000) and provide a minimum age for the Rude Lake mafic package.

The northernmost amphibolite unit within the central panel is exposed in the southern Robert Lake area. It is associated with thin units of muscovite-garnet-sillimanite-cordierite metapelite (unit Sp) and silicate-facies iron-formation (unit Si). Sp is similar to the Sp unit in the Sturgeon Lake greenstone belt. The amphibolite package is northeast to Hilltop Lake on the basis of aeromagnetic data. In several locations near Harmon Lake, this unit is in tectonic contact with granitoid units to the north. The fault zones are characterized by steeply plunging folds, extensive epidote alteration, and local brecciation.

NORTHERN PANEL

Amphibolite (unit An) in the northern panel is coarse-grained with mineral assemblages consisting of hornblende-plagioclase ± garnet ± clinopyroxene ± epidote ± titanite ± quartz. Amphibolite is commonly interlayered with several generations of pegmatite, and in some areas can be traced only as enclave trains within pegmatite. Migmatitic zones occur locally in amphibolite. Intense retrograde alteration to chlorite-muscovite-saussenite is widespread. Pseudomorphs of plagioclase after garnet are common.

Ultramafic rocks (unit Um) occur as pods and layers of distinctive coarse-grained pyroxenite with individual crystals up to 10 cm in size, associated with gabbroic layers containing nodular plagioclase phenocrysts.

NEOARCHEAN INTRUSIVE ROCKS:

Tonalite gneiss (units Tg and TgR)

These rocks are fine to medium-grained biotite-plagioclase-quartz rocks, with up to 30% leucosome layers forming mm to cm-scale banding. Compositional layering is generally parallel to grain-scale foliation, either composite S_1/S_2 in complex units (unit TgR), or S_2 in less complexly deformed bodies (unit Tg). A lens of tonalite gneiss northwest of Rude Lake (unit TgR) is the most structurally complex unit in the region, illustrating up to 11 phases of deformation, and yielded a detrital zircon age of 2.774 Ga (J. Breen and V. McNicoll, unpublished data, 2000) and a titanite age of 2776 ± 1Ma (J. Breen and V. McNicoll, unpublished data, 2000). However, similar rocks east of Harmon Lake (unit Tg), 12 km northeast of the map area, have complex crosscutting relationships and geochronology indicating that the youngest phase has an age of ca. 2.67 Ga with a second generation of zircon at ca. 2.693 Ga (V. McNicoll, unpublished data, 1999).

Tonalite (units Th and T):

Based on crosscutting relationships and existing geochronology, several generations of tonalite are present within the map sheet. A tonalite body north of Robert Lake (unit Th) can be distinguished on the basis of its lithological and structural complexity. The coarse- to medium-grained hornblende-biotite-plagioclase-quartz rock has an S_2 foliation and contains rafts of unit TgR. Th is cut by a 2.715 Ga phase of unit Tg, and a set of mafic dykes (unit Md) in central Robert Lake cut S_2 foliated tonalite, but are cut by granodiorite and pegmatite.

Elsewhere, tonalite (unit T) has not been subdivided further, as there is insufficient geochronological control. For the most part, tonalite bodies are medium-grained plagioclase-quartz-biotite ± hornblende rocks. Igneous zircon from one body east of Harmon Lake was dated at 2774 ± 2 Ma, with metamorphic grains at 2697 ± 2 Ma (Davis, 1995).

Medium- to coarse-grained, S_2 foliated, homogeneous, biotite tonalite is common as sheets and dykes throughout the region. A tonalite dyke from Harmon Lake was dated at 2714 Ma (V. McNicoll unpublished data, 1998). The dyke cuts tonalite gneiss carrying D_1 and D_2 structures (Percival, 1996, Fig. 6).

Granodiorite:

S_2 foliated, medium-grained, homogeneous, biotite granodiorite (unit Gd) occurs in the southeastern corner of the map sheet. It is progressively reworked within the Brightsand River shear zone, and structurally underlies most of the southern panel. Homogeneous biotite granodiorite from Sesegangaa Lake 20 km north of the map-sheet yielded a U-Pb age of 2709 Ma (Percival *et al.*, 1995).

Small bodies of coarse-grained, K-feldspar porphyritic, biotite-hornblende granodiorite (unit Gdp) may be related to the granodiorite suite (unit Gd). Igneous zircon from one body yielded an age of 2719 Ma (V. McNicoll unpublished data, 1998). Narrow dykes (< 1 m in thickness) of medium- S_2 foliated, fine-grained biotite ± muscovite granodiorite intrude supracrustal rocks west of Robert Lake.

Foliated, medium-grained diorite to quartz-diorite occurs as dykes and stocks, in one locality, south of Scruffy Lake, it appears to be late-comagmatic with fine-grained biotite granite (< 10% biotite).

Granite (unit Gg):

Late, massive to weakly S_2 foliated leucocratic granitic rocks (~ 5–10% biotite) occur commonly, as dykes, sills, and plugs of pegmatite, aplite, and medium-grained monzogranite. Several generations of late granites are evident through crosscutting relationships. Many of the pegmatites are garnet and muscovite bearing, rarely with tourmaline (unit Gg).

DEFORMATION AND METAMORPHISM

Within the southeastern Sturgeon belt area up to 4 phases of deformation are recognized and constrained by geochronological and structural relationships.

D_1 and S_1 structures are rarely preserved in the map area owing in part to overprinting by penetrative planar D_2 fabrics. D_1 generously, present in gneisses on Harmon Lake and west of Rude Lake, is folded into tight, upright, F_2 folds. At west north of Robert Lake, hornblende-biotite tonalite and tonalite gneiss carry a penetrative S_1 foliation which is crenulated into tight to close, locally chevron type F_2 folds, in turn openly folded by F_3.

The oldest deformation event (D_1) is constrained to be older than 2719 Ma by Sturgeon Lake dated at 2714 Ma (Percival *et al.*, 1995), which cuts S_1 generously and F_2 folds, but not carries an S_2 foliation. The complex tonalite gneiss from west of Rude Lake (unit TgR) dated at 2715 ± 7 Ma provides a maximum age for D_1.

The D_2 event affected most rock types, resulting in the development of a penetrative foliation in pressurely undeformed rocks and folding of heterogeneous, layered rocks into F_2 folds. In some areas, S_2 foliation is defined by migmatitic layering, formed near the metamorphic peak. Thermobarometry with equilibrium constraints (THCG) estimates of garnet-sillimanite-cordierite-biotite plagioclase-quartz mineral assemblages in metapelite near Robert Lake yield metamorphic conditions of 650°C ± 50°C, at pressures between 3 and 4 kbars, and a best fit line at temperature of 650°C ± 50°C, consistent with amphibolite facies metamorphic conditions.

East of Mountairy Lake, the Hilltop Creek fault is a ~ 100m wide cataclastic zone (unit C) with fragments of granite, amphibolite, exhalative sedimentary rocks, and silicate facies iron formation, set in a foliated, fine-grained matrix with abundant chlorite, epidote, hematite, metamorphic rutile, and finely disseminated sulphides. The HCF is curved at the eastern end of Mountairy Lake, where it is folded around the nose of a D_2 synform, and is subsequently overprinted by east-trending folds of probable D_3 generation. Accordingly, the Hilltop Creek fault represents a zone of pre-D_2 to late-deformation that was subsequently folded.

An open, map-scale fold centered on Mountairy Lake plunges steeply north and affects bedding, S_2 foliation, and the Hilltop Creek fault. Its trend is at a high angle to regional D_2 structures and rocks on its eastern flank exhibit F_2 folds overprinted by F_3 folds and crenulations (see Fig. 2 and Fig. 3). The Mountairy Lake F_3 fold is interpreted at this fold preserves L_2 mineral lineations, and exhibit "S" folds that could be parasitic to the Mountairy Lake fold.

West of Robert Lake, foliated biotite-muscovite granodiorite dykes crosscut S_2 tapering and foliation in supracrustal rocks. The dykes intrude along the trend of regional F_2 axial traces (DB) and carry a weak to moderate S_3 foliation. Igneous zircon from one such dyke yielded an age of 2697 Ma, yielding a minimum age for the regional D_2 event, and a maximum age for D_3 (V. McNicoll unpublished data, 1998).

D_3 structures occur most commonly as gently ENE-plunging folds, and mesoscale F_3 folds of S_2 layering are common. Broad hinge zones are accompanied by shallow-plunging quartz nodding and other mineral lineations (L_3), whereas limbs of F_3 folds are generally steep. Within the central panel, the axial trace of a map-scale F_3 synform is roughly parallel to the trend of most map units.

The Brightsand River, Rude Lake, and Robert River shear zones are east-northeast-trending sinistral ductile D_3 structures characterized by subhorizontal quartz stretching lineations (Percival *et al.*, 1995). The Robert Lake fault is a ductile feature characterized by steeply to moderately-dipping east-northeast-trending mineral lineations, similar in style to the regional D_3 shear zones. Third tectonic blanks from the Brightsand River shear zone provided a minimum U-Pb age of 2678 Ma for D_3 deformation (J. Brown and V. McNicoll, unpublished data, 2000).

D_4 structures are recognized on the basis of map-scale, open, upright folds in supracrustal panels as they deflect into the regional Wapikaimaski Lake and Brightsand River shear zones, consistent with an overall sinistral sense of transcurrent movement. Brown et al. (2000) used Lithoprobe seismic data to examine the attitudes of these faults in the third dimensions, in conjunction with borehole-plagioclase thermometry of amphibolites to determine differences in metamorphic temperature across the faults and between panels. The resulting interpretation is that both faults dip steeply north. The Hilltop Creek fault is a high-angle reverse structure, whereas the Robert Lake fault is a late, north-dipping feature with normal slip. Therefore the central panel has pop-up geometry, although its bounding faults are probably of different generations.

ACKNOWLEDGMENTS

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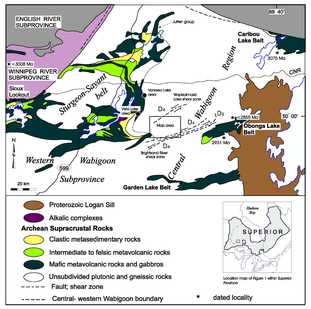


Figure 1: Location map of the Central Wabigoon Region. The Savant Lake and Sturgeon Lake greenstone belts mark the boundary with the Western Wabigoon Region.

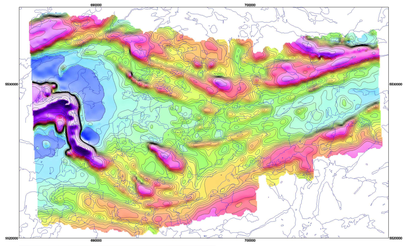
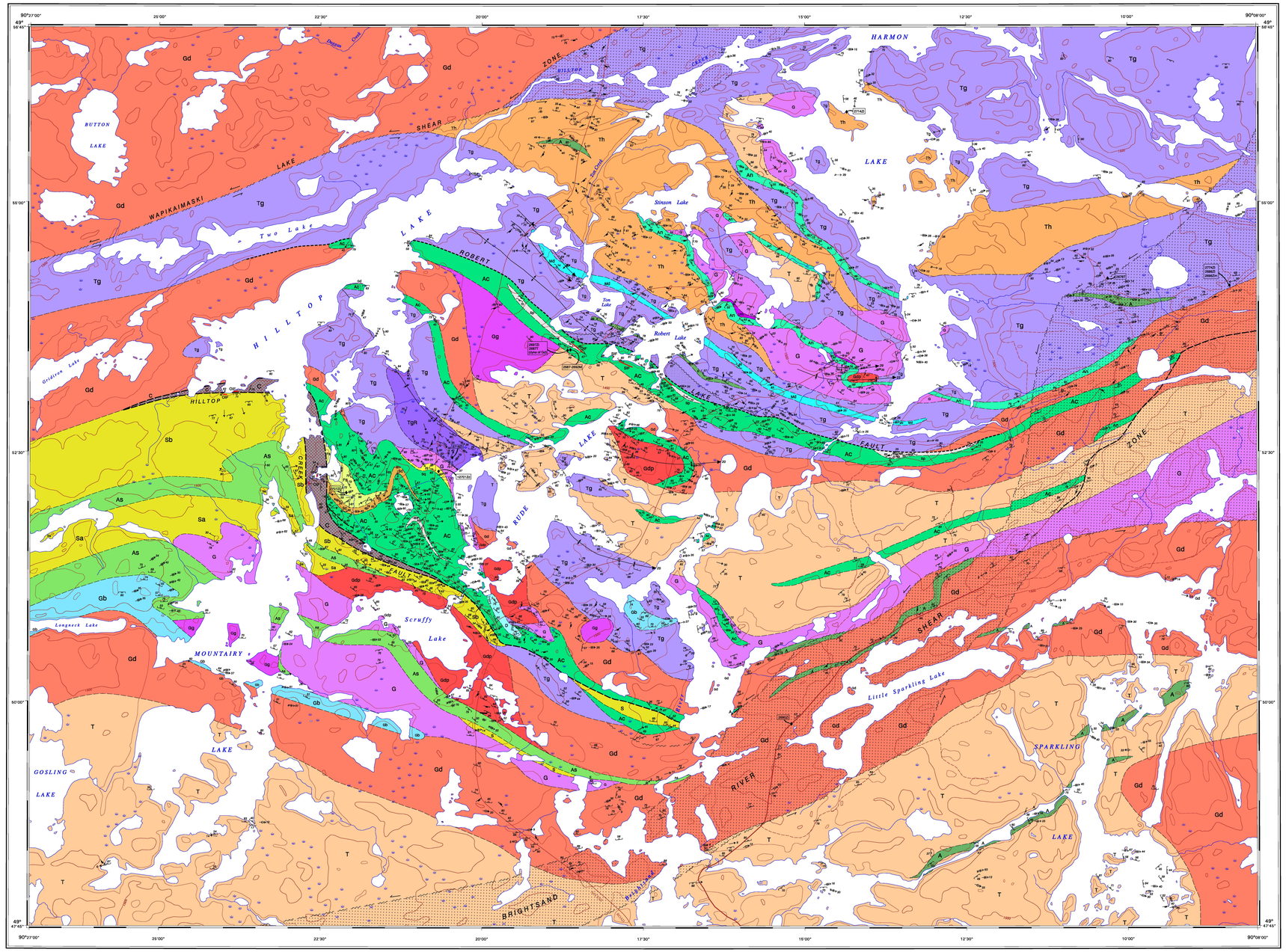


Figure 2. Aeromagnetic map of the southeastern Sturgeon Lake area based on proprietary data acquired from Noranda Ltd. and processed by Campbell et al., (2000). Magnetic lineaments reflect the trends of lithological units and faults. (Coordinates in UTM zone 15)



LEGEND

ARCHEAN
NEOARCHEAN

- FAULT RELATED ROCKS -

- C — *Cataclasite (Hilltop Creek fault): foliated cataclastic breccia containing rounded and angular fragments of granite, amphibolite, exhalative sedimentary rocks, and oxide-facies iron formation, set in a granular, fine-grained matrix consisting of chlorite, epidote, hematite, sulphides, and metamorphic rutile*

- INTRUSIVE ROCKS -

- G — *Granite: medium- to coarse-grained to pegmatitic or aplitic, massive to weakly S_2 foliated, biotite ± magnetite granite; occurs as plutons and pegmatite dyke swarms*
- Gg — *Granite; weak S_2 foliated to late, unfoliated leucocratic with biotite ± muscovite ± garnet granite; occurs as plutons and pegmatite dyke swarms*
- D — *Diorite: medium-grained, foliated to migmatitic, hornblende-biotite diorite, varies to gabbro, quartz diorite, quartz gabbro*
- Gdp — *Porphyritic granodiorite (ca. 2695 Ma): medium- to coarse-grained, K-feldspar porphyritic or megacrystic, homogeneous, weakly foliated biotite ± hornblende granodiorite. Varies to monzodiorite, quartz monzodiorite, quartz diorite, and quartz monzonite*
- Fs — *Felsic sill (2707 Ma): fine-grained, plagioclase-quartz-biotite-pyrite tonalite associated with central panel amphibolites; includes some muscovite-biotite pyrite schist*
- Gd — *Granodiorite (ca. 2709 Ma) medium- to coarse-grained, homogeneous, foliated biotite-granodiorite; locally migmatitic with 5–10% leucocratic segregations*
- Md — *Mafic dyke-bearing zone: zone containing medium-grained amphibolite dykes cutting tonalite and foliated granite (units Tg, Tb), foliated and transposed adjacent to the Robert Lake fault*
- Gb — *Gabbroic intrusions: medium- to coarse-grained, weakly to strongly foliated to massive*
- T — *Tonalite (ca. 2774 – 2714 Ma): medium-grained, homogeneous, foliated biotite ± hornblende tonalite; locally migmatitic (5–10% leucocratic segregations); varies to quartz diorite and trondhjemite; may include older homogeneous tonalite (2770 - 2930 Ma)*
- Th — *Hornblende ± biotite tonalite: medium- to coarse-grained, strongly foliated tonalite to granodiorite; locally hornblende porphyritic*
- TgR — *Tonalite orthogneiss (Rude Lake) (ca. 2715 Ma): Compositionally layered metavolcanic rocks (intrusive rocks injected with several generations of leucocratic tonalite and granodiorite, parallel and sub-parallel to gneissosity. Distinguished from tonalite orthogneiss (unit Tg) by complex structural chronology including refolded folds*
- Tg — *Tonalite orthogneiss (ca. >2870 Ma): compositionally layered rocks consisting of medium-grained biotite tonalite melanosome and 5–20% leucosome of medium-grained leucocratic tonalite*

- SUPRACRUSTAL ROCKS -

SOUTHERN PANEL

- S — *Metasedimentary rocks: unsubdivided mixture: to coarse-grained quartz-plagioclase-biotite meta-psammite.*
- Sa — *Fine- to medium-grained, biotite-plagioclase- quartz ± muscovite schist, mainly from wacke with minor argillaceous beds, includes quartz-rich arenite horizons*
- Sb — *Includes grandual-clast conglomerate, breccia, slate, greywacke, and oxide-facies (magnetite) iron formation*
- As — *Amphibolite, southern panel: fine-, medium- or coarse-grained, foliated, hornblende-plagioclase ± chlorite ± epidote ± garnet ± clinopyroxene schist and gneiss derived from massive and pillowed basalt and andesite; includes some pebbly, chlorite and epidote felsic volcanic (<2 m thick) layers*

CENTRAL PANEL

- Sp — *Semipelite: coarse-grained garnet-cordierite-sillimanite schist and paragneiss associated with oxide and silicate-facies (garnet-grunerite) iron-formation (SIF)*
- Sc — *Conglomerate: clast-supported conglomerate consisting of pebble-sized plutonic clasts in a fine-grained matrix ranging from biotite- to quartz-, feldspar-rich; interlayered with quartz-rich arenite layers. Highly attenuated in proximity to the Hilltop Creek fault*
- Sq — *Quartz-rich sandstone (>2701 Ma): quartz-plagioclase-biotite schist with locally preserved bedding*
- Ac — *Amphibolite, central panel: medium- to coarse-grained, foliated, hornblende-plagioclase ± garnet ± quartz ± clinopyroxene ± epidote schist and gneiss*

NORTHERN PANEL

- Um — *Mafic-ultramafic intrusions: medium-grained, plagioclase porphyritic metagabbro; Includes some very coarse-grained pyroxenite (grain size to 10 cm); associated with northern panel amphibolite units*
- An — *Amphibolite, northern panel: coarse- to medium-grained, foliated to gneissic, hornblende-plagioclase-quartz-biotite ± clinopyroxene schist and gneiss; common retrograde assemblages of actinolite-plagioclase-epidote and fine-grained chlorite-saussenite*

UNSUBDIVIDED UNITS

- A — *Amphibolite: medium- to fine-grained, foliated to gneissic hornblende-plagioclase-biotite schist*

SYMBOLS

Geological boundary; compiled from existing sources or interpreted from aeromagnetic data (approximate)

Fault (approximate; 3rd, unknown generation)

Shear zone, D_4 approximate (sinistral)

Deformation (or shear) zone, D_4

Fault zone of uncertain relative age

F_2 fold (antiform); arrow indicates plunge 20

F_2 fold (synform); arrow indicates plunge 20

Stilkenifnus (unknown generation)

Intersection lineation (4th generation)

Stretching lineation (4th, unknown generation; rodding)

U fold (2nd, 3rd, 4th, unknown generation)

S fold (2nd, 3rd, 4th, unknown generation)

Z fold (2nd, 3rd, 4th, unknown generation)

Fold (2nd, 3rd, 4th generation)

Dyke

Vein

Joint 80

Macroscopic fault (dextral, unknown asymmetry)

Macroscopic shear zone (dextral, sinistral)

Fold axial trace (2nd, 3rd, 4th, unknown generation) F_2 F_3 F_4

Foliation, inclined (1st, 2nd, 3rd, 4th, unknown generation) S_1 S_2 S_3 S_4

Bedding, inclined S_0

U-Pb age, Ma (Z: zircon; T: titanite; M: monazite; I: igneous; d: detrital; m: metamorphic) 2719Z

Iron-formation:
Oxide facies OIF
Silicate facies SIF

OPEN FILE 4286
GEOLOGY
SOUTHEASTERN STURGEON LAKE
GREENSTONE BELT
ONTARIO

Scale 1:25 000/Échelle 1/25 000
metres 500 0 500 1000 1500 2000 mètres

Universal Transverse Mercator Projection
North American Datum 1983
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Projection transverse universelle de Mercator
Système de référence géodésique nord-américain, 1983
© Sa Majesté la Reine du chef du Canada 2003

Geology by J.L. Brown[1] and J.A. Percival[2] 1998–1999

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Any revisions or additional geological information known to the user would be welcomed by the Geological Survey of Canada

Digital base map from data compiled by Geomatics Canada, modified by ESS Info

Magnetic declination 2003, 2°59'W, increasing 2.9' annually

Elevations in feet above mean sea level

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