Revised geology of Notigi Lake, Manitoba 2007

compiled by
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Manitoba

Summary

The Notigi Lake area is an example of the stratigraphic and structural geology typical of the north flank of the Kisseynew Domain. It includes clean exposures of the Paleoproterozoic Burntwood and Sickle groups as well as an amphibolite unit that is herein reinterpreted as metavolcanic and to mark a regional crustal suture proposed by White et al. (2000). The updating of previous geological investigations, which involves subdividing the Sickle Group and taking new structural measurements, provides new details of the structural geometry and tectonic history of this important area (PMAP 2007-2). Interpretation of the field data compiled during the 2007 summer delineates four stratigraphic units in the Sickle Group at Notigi Lake. This is based on the presence of certain metamorphic minerals that denote the compositions of arkose- and lithic arenite-derived gneiss. The structure is tentatively interpreted as a small refolded nappe, which may serve as a model for the crustal-scale structure that appears to feature recumbent isoclinal folding and upright refolding. With further work this model may help to determine the three-dimensional distribution of 1) the amphibolite, which contains traces of gold elsewhere, 2) newly discovered iron formation in the Burntwood Group, 3) traces of copper (malachite staining) in the Sickle Group, and 4) older gneiss southeast of Notigi Lake with nickel potential.

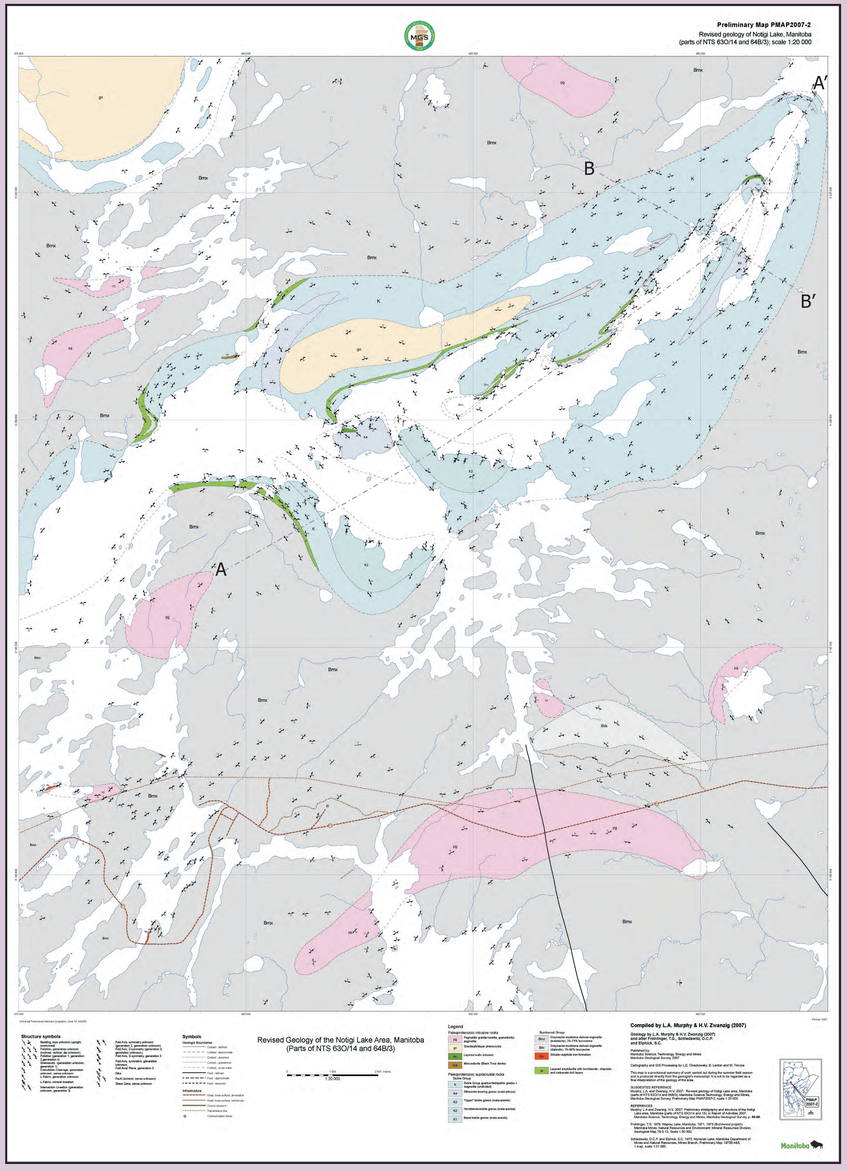
Introduction

Notigi Lake is located approximately 100 km west of Thompson along Provincial Highway 391 (Figure 1), and along strike from areas that contain rocks now known to be of Archean age or provenance. During the summer of 2007, the eastern part of Notigi Lake was remapped at 1:20 000 scale (Murphy and Zwanzig, 2007). The work was undertaken to delineate stratigraphic units in detail and to start a structural interpretation that, after further work, will cover a total of about 350 km^2.

Previous mapping in the Notigi Lake area by the Manitoba Geological Survey began in 1969 during the Southern Indian Lake Project (Elphick, 1972; Schledewitz, 1972) and was completed during the Burntwood Project (Baldwin et al., 1979; Frohlinger, 1979). The emphasis during the Burntwood Project was to distinguish and map the pelitic to psammitic gneiss (present Burntwood Group), the quartzofeldspathic paragneiss (Sickle Group) and the associated intrusive rocks, in order to determine the mineral potential of the Kisseynew Domain. However, despite this mapping, the structure, stratigraphy and mineral potential of this part of the Kisseynew Domain have remained poorly understood and, recent work in this area has found hitherto unknown Archean orthogneiss and associated paragneiss with Archean provenance, and economic potential that may be similar to that of rocks in the Thompson Nickel Belt (TNB) (Percival et al., 2006; Zwanzig et al., 2006).

Manitoba Hydro completed the Churchill River Diversion in 1977 and redirected water from the Churchill River south along the Rat River through Notigi Lake into the Burntwood River. Notigi Lake was flooded to its present level and, in the process, new clean shoreline exposures were developed. The present project captures structural data and geological contacts from the original Burntwood Project mapping, which was undertaken on pre-flooding shoreline outcrops, and combines this information with remapping of the Sickle Group and adjacent parts of the Burntwood Group at the present lake level.

This project has been undertaken in collaboration with the Geological Survey of Canada as part of the Targeted Geoscience Initiative III (TGI-3) Flin Flon Project (Percival et al., 2006; Percival et al., 2007). The purpose of the work at Notigi Lake is to define the tectonostratigraphy, structural geology and tectonic history of an accessible area on the eastern part of the north flank of the Kisseynew Domain. Future work and interpretation will involve additional mapping (2008), as well as geochemical and isotopic analysis of the granitoid intrusions, amphibolite and sedimentary rocks. A new aeromagnetic survey (Coyle, pers. comm., 2007), which will be available by next field season, will provide additional data to assist mapping.



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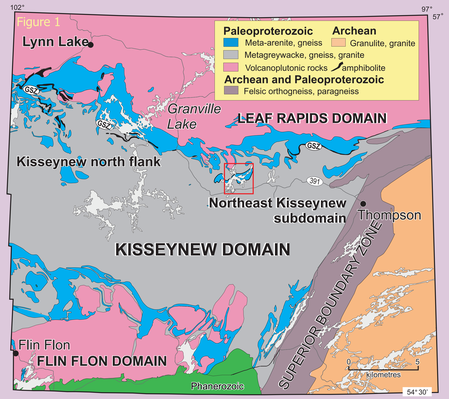


Geological units

The main supracrustal units at Notigi Lake are: 1) layered amphibolite with local calcsilicate rock; 2) the Burntwood Group migmatite, derived from greywacke-mudstone with minor iron formation; and 3) quartzofeldspathic paragneiss of the Sickle Group.

The main igneous rocks at Notigi Lake are: 1) mafic intrusion; 2) monzodiorite and; 3) granite and pegmatite.

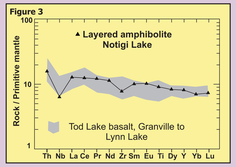
The stratigraphic order of the supracrustal units cannot be determined in the study area, but the structural order is the same as in the regional setting and, by correlation, is inferred to be Burntwood Group-fault-amphibolite-unconformity-Sickle Group. The amphibolite is inferred to be the oldest unit, and the Sickle Group the youngest. No depositional or early fault contacts between the major units are preserved at Notigi Lake. All units in the Notigi Lake area have been metamorphosed to upper amphibolite or transitional granulite facies; the prefix 'meta', although not used in the protolith names, is implied.

Layered amphibolite

The amphibolite consists of uniform layers that can grade into discontinuous pods and lenses (Figure 2). The layers are dark grey-green to black where the dominant minerals are hornblende-plagioclase, and medium grey-green where dominated by diopside-pyroxene-plagioclase. Whole-rock major- and trace-element analysis on a sample of relatively unaltered-looking dark green amphibolite suggests derivation from a mafic rock similar to the Tod Lake arc-rift basalt. The arc affinity of Notigi Lake amphibolite is illustrated in a normal mid-ocean-ridge basalt (N-MORB) normalized multi-element plot by negative Nb and Zr anomalies and a Th spike (Figure 3). The rift affinity is suggested by its weak fractionation of rare earth elements (REE) and lack of negative Ti anomaly.

Burntwood Group

All Burntwood Group greywacke and mudstone (Figure 4) have undergone high-grade metamorphism and various degrees of migmatization. Progressive melting and injection resulted in metatexite with well-developed lit-par-lit layering and more uniform coarser diatexite. The mineral content of the Burntwood Group greywacke-mudstone includes garnet, biotite, cordierite, tourmaline and locally orthopyroxene. Graphite is identified locally. Lean silicate-facies iron formation is found in two locations at the south end of Notigi Lake (Figure 5). It displays similar layering to the greywacke with alternating greywacke layers, cherty layers and layers laminated with pyrrhotite, magnetite and rare chalcopyrite.



Sickle Group

Subunits in the Sickle Group were mapped using distinct compositional changes defined by their dominant mineralogy. These subunits generally appear adjacent to (stratigraphically above) the amphibolite in the following order: 1) basal biotite gneiss (Figure 6); 2) hornblende-biotite gneiss (Figure 7); 3) generally more silicic biotite gneiss that is probably stratigraphically higher in the succession; and 4) sillimanite-bearing arkosic gneiss of uncertain stratigraphic position but most likely forming the uppermost subunit (Figure 8). Rarely the biotite gneiss exhibits remnant cross bedding in protoquartzite (Figure 9) and malachite laminae (Figure 10)

Mafic intrusion

The centrally located mafic intrusion contains layering composed of four separate rock types that grade into one another: 1) coarse-grained garnetiferous and biotite-rich unit, 2) hornblende-rich unit that grades to less hornblende; and 3) plagioclase-rich unit up to 1.5 m wide and containing up to 60% plagioclase at the top; overlain by 4) darker amphibolite. Layers are thick and internally uniform (Figure 11), and are interpreted to result from crystal fractionation. A second occurrence in the northeastern part of Notigi Lake has similar layering to that in the central part but also contains garnet-bearing lenses and a trace of carbonate.

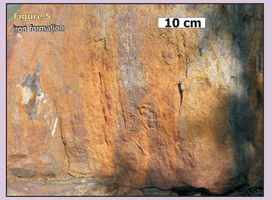
Monzodiorite

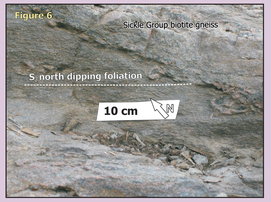
A biotite-rich monzodiorite unit intrudes the Sickle Group on the west side of the Rat River channel and south of Timew Narrows. This is correlated to Black Trout diorite that extends from Granville Lake (Zwanzig and Cameron, 2002) to areas southeast of Lynn Lake (Milligan, 1960). The unit contains abundant magnetite and titanite, and displays a uniform schistosity.

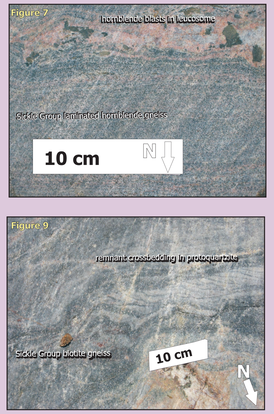
Granite intrusion and pegmatite

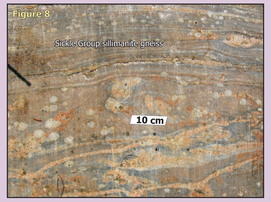
The granitoid rocks intruding Burntwood greywacke in the southern part of the map area range from white plagioclase-rich tonalite to leucogranite. Several ages of pink to red pegmatite have been injected as sheets into all units and at the north part of the lake has intruded a late stage fault between Burntwood gneiss and layered amphibolite (Figure 12).

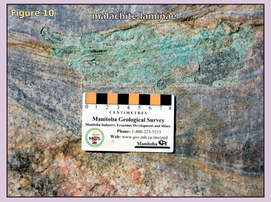
North of Timew Narrows, a large granite intrusion (Notigi granite) that cuts mainly Sickle Group rocks is in local contact with the layered amphibolite unit. It is a pink feldspathic rock with a biotite parting.

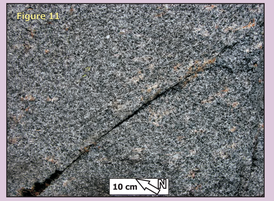


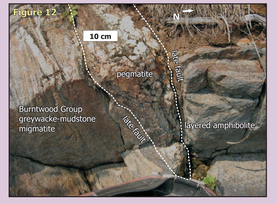




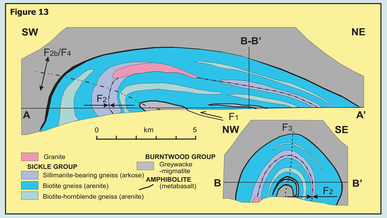








Structural interpretation and regional implications

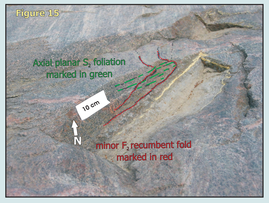


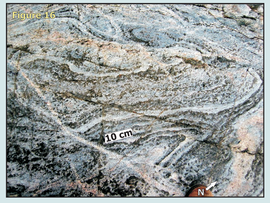
The new mapping and the early work in the vicinity of Notigi Lake indicate that the overall shape of the Notigi structure is an asymmetric dome with a moderately plunging northeastern closure and a steeply dipping southern margin. This geometry may have formed by non-cylindrical northeast-trending F_3 upright folding superposed on a large recumbent F_2 synform. Another possible origin involves gentle F_4 refolding of the F_3 hinge on an east-west trend, but no related fabrics or minor structures were observed. It is also possible, alternatively, that a late F_2 south-verging anticline has caused the curved hinge line and an inherited asymmetry of the later dome. This last interpretation is most consistent with the preliminary structure section (Figure 13, A to A' and B to B' locations are marked on the Notigi map).

The tight or isoclinal F_2 folding (Figure 14) has caused repetition of the Sickle Group stratigraphic sequence in a vertical stack that was later involved in possible F_{2b} reclined folding (Figure 15) and the F_3 doming (Figure 16). The Burntwood Group and layered amphibolite, overlain by the lowermost (upright) succession of the Sickle Group is interpreted to be a structural window. Therefore the Burntwood Group overlies and underlies the sheet-like F_2 structure. If the F_2 synclinal closure is to the south, as suspected, tectonic transport was north and consistent with the occurrence of (inverted) Burntwood Group in structural basins north of Notigi Lake (Schledewitz, 1972). Fold vergence was reversed to a southerly direction during later (F_{2b} and/or F_4) folding.

The best indication of a regional F_1 thrust contact between the Burntwood Group and the layered amphibolite is the correlation of the latter with the inferred 1.9 Ga (allochthonous) Tod Lake basalt. The correlation is based on the geochemistry of the amphibolite and its alternating hornblende- and diopside-rich components formed from pillow structure and prominent calcsilicate alteration domains. The tight interlaying of these components at Notigi Lake is shared with a mafic tectonite on Granville Lake that was traced along strike into well preserved Tod Lake pillow basalt. This zone extends from the Saskatchewan border east for 300 km to an area north of Thompson (GSZ in Figure 1).

A belt of Sickle Group, up to 25 km wide, lies north of the Granville Lake structural zone, separating it from the Leaf Rapids arc domain. The Notigi structure contains the same distinctive mappable units in the Sickle Group, and are mantled by the same amphibolite, as in the Granville Lake structural zone. The conversion of pillows and alteration domains into thinly layered mafic tectonite (undivided amphibolite in Zwanzig and Cameron, 2002) argues for an extreme attenuation of the entire tectonostratigraphic package at Notigi Lake and isoclinal folding at a crustal scale in the north- and northeast parts of the Kisseynew Domain. Archean orthogneiss and associated paragneiss are expected to occupy deeper levels than the Notigi structure but are part of the same crustal-scale layering.





Economic considerations

The updated geological maps provide a modern geological context for future nickle, platinum group elements and gold exploration along the north flank of the Kisseynew Domain. The presence of small gold showings in the Tod Lake basalt, south of Granville Lake, make the correlative layered amphibolite at Notigi Lake and in adjoining areas a possible exploration target. Traces of malachite staining in the Sickle Group may indicate a similar style of mineralization as the sedimentary copper mineralization reported by Baldwin (1980) at Russell Lake.

The inferred strongly layered crustal structure of the northeastern part of the Kisseynew Domain has an implication for the geometry of Archean orthogneiss and Ospwagan-like paragneiss that have a similar competency and probable structural style as the Notigi structure. The extreme attenuation suggests that the best preservation of such rocks and possible nickel deposits may be in the hinge zones of F_2 recumbent folds brought to surface by F_3 crossfolds.

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