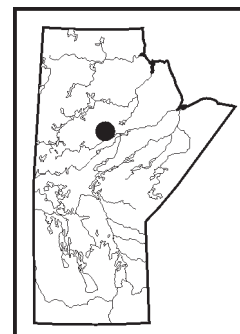


**Northern extension of the Thompson Nickel Belt,
Manitoba (NTS 64A3 and 4)
by H.V. Zwanzig and C.O. Böhm**



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Summary

The preliminary compilation of Nd isotope data, including data from company drillcore, and reconnaissance mapping in the Pearson Lake–Rock Lake–Orr Lake area indicate that the basement gneiss typical of the Thompson Nickel Belt (TNB) and narrow belts of Ospwagan Group supracrustal rocks extends northeast of the main part of the TNB to Pearson Lake. In this northern area, crustal-residence Nd model ages (T_{CR}) continue to be a tool for clearly separating the Archean basement gneiss ($T_{CR} = 3.2\text{--}3.7$ Ga) from the Ospwagan Group cover ($T_{CR} = 2.9\text{--}3.0$ Ga), with its high nickel potential, and from overthrust barren Burntwood Group ($T_{CR} = 2.2\text{--}2.5$ Ga). A probable suture zone marked by Paleoproterozoic arkosic metasandstone (Sickle Group), northwest of the belt of Burntwood Group paragneiss forms the limit of exploration for Thompson-type nickel deposits. The variation in inheritance of ancient crustal material in the Archean gneiss may serve as a tool to help further unravel the complexly interleaved structure of this crust and allow tracing of Ospwagan Group structural keels.

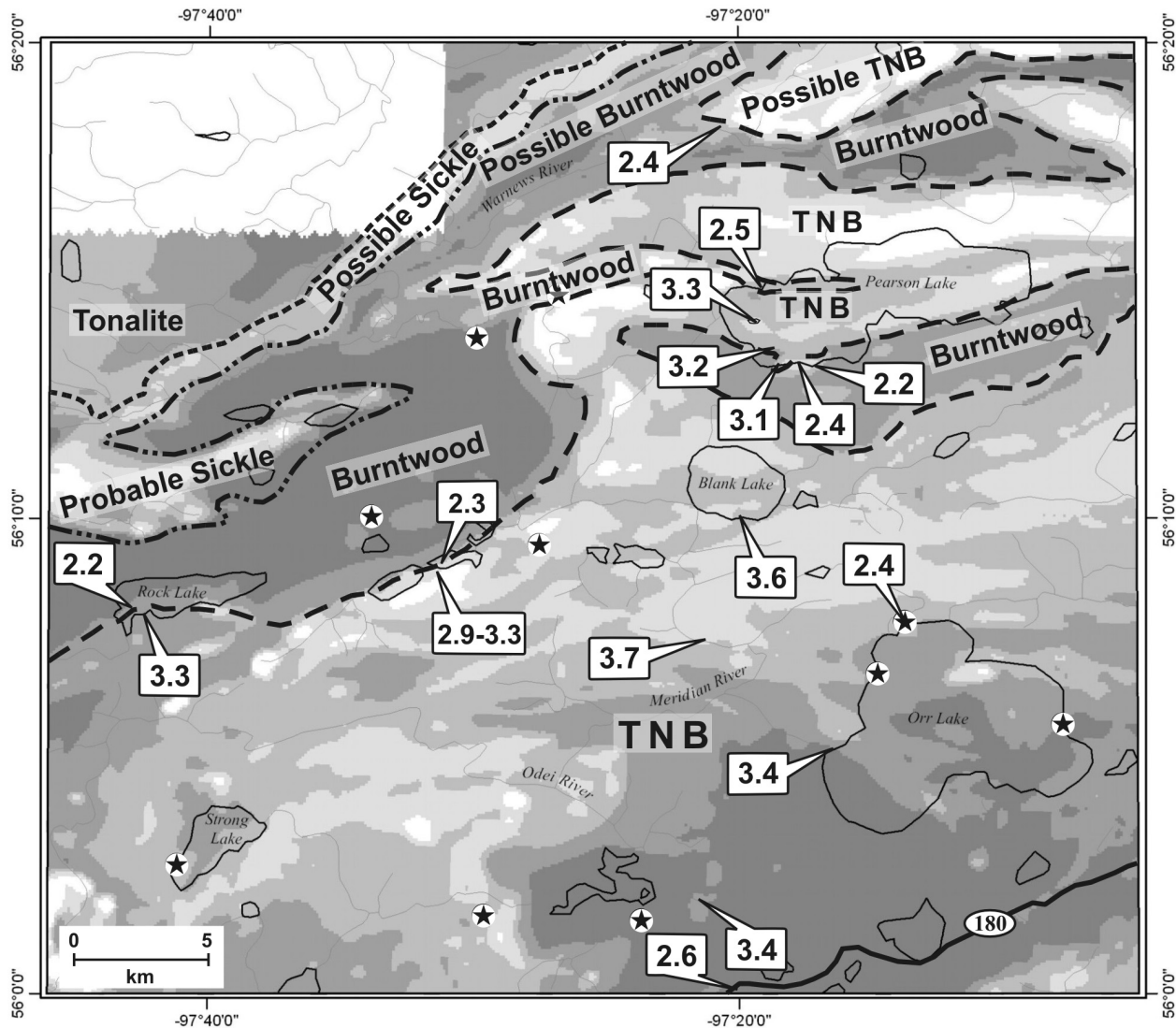
Introduction

Scattered outcrops were examined and sampled for geochemical analysis and Sm-Nd isotope analysis in the Pearson Lake–Rock Lake–Orr Lake area, in order to trace the geology typical of the Thompson Nickel Belt north beyond the areas that are presently better mapped. This low-lying terrain, lacking extensive outcrop and suitable lakes for fixed-wing access, required helicopter support and the sampling and outcrop studies were therefore brief. The shore of Orr Lake was examined by boat in 2004, using a light-weight inflatable. The work was guided by an advance copy of the intermediate-level aeromagnetic survey flown by the Geological Survey of Canada in the spring of 2004. Units with high, intermediate and low magnetic intensity were sampled along and across strike to allow an interpretive map to be made of the area in the future (Figure GS-10-1). Other important guides for choosing new collecting sites were recent mapping, relogging of proprietary core, and existing analytical reconnaissance work (Böhm et al., 2000; Zwanzig et al., 2001; Zwanzig and Böhm, 2002). Preliminary results from the recent work, including data from relogging and resampling of drillcore accessed through Anglo American Ltd. and Hudson Bay Exploration and Development Co. Ltd., are summarized in this report. The data from these sources have confirmed that the Ospwagan Group, which hosts the ultramafic intrusions with nickel deposits, extends north to Rock Lake, as had been found during nickel exploration by industry. The work continues to provide a definite distinction between the rocks of the TNB, which are worth prospecting, and the barren sedimentary gneiss typical of the Kisseynew Domain, as had been found in a recent study (Zwanzig and Böhm, 2002). Moreover, a pattern is emerging that suggests systematic changes in the Nd isotope ratios across the Archean crust of the Superior craton boundary zone, where it forms the basement gneiss of the TNB. The different types of crust may have important implications for the tectonic evolution and the nickel and gold distribution in the area.

Previous and new results

Pearson Lake area

Shoreline mapping and sampling of Pearson Lake had revealed predominantly Archean orthogneiss with relatively ancient, depleted-mantle, Nd model ages (averaged crustal residence time [T_{CR}] of Goldstein et al., 1984) of 3.2–3.3 Ga, similar to other basement gneiss along the northwest margin of the TNB (Zwanzig and Böhm, 2002 and unpublished data, 2003). The new magnetic data (Coyle et al., 2004a, b) and the 2004 fieldwork suggest that the TNB basement and cover units extend in a northeasterly direction, defining a tight, large-scale fold pattern, and not in an easterly direction as previously assumed from the structural fabric (e.g., Lenton and Corkery, 1981; Corkery et al., 1985). The new studies suggest that the TNB basement gneiss and keels of Ospwagan Group are more extensive north of Mystery Lake than previously noted, and have been identified as far northeast as Pearson Lake. The newly obtained magnetic pattern suggests that the metagreywacke (Burntwood Group) forming part of the south shore of Pearson Lake occupies a closed triangle-shaped structure, probably a structural basin floored by a major folded fault (i.e., a klippe) overlying Archean gneiss (Figure GS-10-1). This is consistent with the conclusion (Zwanzig and Böhm, 2002) that the Kisseynew



Tonalite: Proterozoic, pre(?) - and post-Sickle

Sickle: Felsic, magnetite-bearing gneiss (derived from arkosic sandstone)

Burntwood: Garnet-biotite gneiss (derived from greywacke-turbidite)

TNB: Felsic-intermediate layered orthogneiss (Archean basement), local Proterozoic paragneiss (Ospwagan Gp)

★ Sample site

--- Possible Granville Lake Suture Zone - - - Thrust fault ····· Intrusive contact

Total field (nT)

60 143 - 62 435
59 847 - 60 142
59 648 - 59 846
59 452 - 59 647
59 137 - 59 451

Nd model age (Ga)

3.2

Figure GS-10-1: Sketch map of the northern part of the Thompson Nickel Belt, partly interpreted from new aeromagnetic data, showing Nd model ages previously determined and the new sample sites.

paragneiss has been thrust over the rocks in the northernmost TNB, and that the thrust package was complexly folded.

Archived samples from the south side of Pearson Lake, taken close to the northern boundary with the Burntwood Group (sample 80-386-1A) and a short distance within the unit (sample 80-387-1A), yielded Nd model ages of 3.05 and 2.4 Ga (Böhm, unpublished data, 1999; Figure GS-10-1). Both collection sites had been mapped as metagreywacke and recent mapping has indicated that they are migmatitic, locally being cordierite-rich diatexite close to the boundary. Sample 80-387-1A yielded a Nd model age only slightly older than nearby leucosome-free metagreywacke ($T_{CR} = 2.2$ Ga) of Zwanzig and Böhm (2002), whereas the other sample may be contaminated with leucosome derived from the

adjacent Archean orthogneiss, or it may represent a thin sliver of Ospwagan Group pelite, which has model ages between 2.8 and 3.2 Ga in the main part of the TNB (Zwanzig and Böhm, 2002 and unpublished data, 2003). Such narrow belts of Ospwagan Group paragneiss occur locally in the same structural position (the footwall of the overthrust Burntwood Group) on the west boundary of the TNB in contact with basement gneiss that had a similar isotopic evolution. For example, one sample from the Mel zone (Zwanzig and Böhm, 2002) and two samples from farther south yielded Nd model ages of 3.6 Ga (Zwanzig and Böhm, unpublished data, 2003). Chemical and petrographic work may provide further clues to the origin of sample 80-386-1A.

Helicopter reconnaissance north of Pearson Lake, sponsored by Anglo American Ltd., encountered migmatized garnet-biotite gneiss resembling the Burntwood Group, a sample of which yielded a Nd model age of 2.4 Ga, consistent with its stratigraphic assignment. It suggests that a previously analyzed garnet-biotite gneiss from the northeast shore of Pearson Lake ($T_{CR} = 2.5$ Ga) probably also belongs to the Burntwood Group, but that some of the more northerly samples have a significant proportion of Archean detritus mixed with the juvenile Paleoproterozoic detritus that dominates south of Pearson Lake. The date is consistent with the prominent population of Archean detrital zircons in the Sickie Group east of Lynn Lake (N. Machado, pers. comm.), where this group is interpreted as the temporary fluvial depository of detritus that was resedimented as the Burntwood Group turbidite along the north flank of the Kisseynew Domain (Zwanzig, 1990). If the authors' interpretation of the Pearson Lake paragneiss sample is correct, relatively narrow fault slices or tight folds of Archean gneiss are structurally intercalated with the Burntwood Group at the flank of the Kisseynew Domain north of Thompson, a situation that makes nickel exploration more challenging than in the south.

Exposures of garnet-biotite gneiss and migmatite 3 and 5 km west of and along strike from Pearson Lake, as well as an outcrop 8 km southwest of Pearson Lake and closer to Rock Lake, are all interpreted as part of the same belt of presumed Burntwood Group with a low magnetic signature. The rocks contain an estimated 15–20% small garnet porphyroblasts, 40–65% granitoid leucosome and local cordierite and sillimanite. Rarely preserved transitions between layers interpreted to be sandy and shaly metagreywacke suggest that the protolith was a turbidite with repetitive graded bedding. One more sample will be tested for its Nd model age to confirm this stratigraphic interpretation.

Previously mapped magnetite-bearing felsic gneiss forms a belt with high magnetic signature northeast of the main belt of the Burntwood Group (Figure GS-10-1). This belt was previously mapped as Sickie Group arkosic metasandstone (Lenton and Corkery, 1981; Corkery et al., 1985) and probably extends into similar rocks that yielded Paleoproterozoic Nd model ages at Leftrook and Harding lakes to the east (Zwanzig and Böhm, 2002 and unpublished data, 2003). The adjoining foliated tonalite probably extends into plutons dated as pre and post Sickie (Zwanzig and Böhm, 2002 and unpublished data, 2003). This tectonostratigraphic sequence also forms the hangingwall of the Granville Lake suture zone (Zwanzig, 1990; White et al., 2000). If the present interpretation is correct, the southwest boundary of the highly magnetic belt marks the northwestern limit of the Kisseynew Domain and hence the limit of the Thompson Nickel Belt.

Rock Lake

Mapping and sampling carried out by the authors on Rock Lake at the end of the 2003 field season, and geochemical and Nd isotope work done on these samples in early 2004, yielded results that also suggest large-scale thrusting at or near the north end of the TNB. Rock Lake is underlain mainly by the garnetiferous paragneiss of the Burntwood Group ($T_{CR} = 2.2$ Ga), but the western half of the south shore consists of banded quartzofeldspathic gneiss, garnetiferous amphibolite and well-preserved mafic meta-intrusive rock (Figure GS-10-1). The orthogneiss or its protolith had a long crustal residence time ($T_{CR} = 3.3$ Ga) and is therefore interpreted as Archean basement. The mafic intrusions are probably Proterozoic dikes. The paragneiss, on the other hand, cannot contain a significant amount of detritus from the Archean gneiss because of its relatively young, Paleoproterozoic Nd model age, representing a short (averaged) crustal residence time for its detritus. The basement-paragneiss contact must be a fault rather than an unconformity. A long lateral extension of the fault is indicated by a magnetic break between the graphitic Burntwood Group and the magnetite-bearing orthogneiss (Figure GS-10-1).

Early results from geochemistry and Nd isotope ratios confirm that the 2002 and 2003 drilling by Hudson Bay Exploration and Development Co. Ltd. directly southeast of Rock Lake also encountered Burntwood Group, Ospwagan Group and TNB basement orthogneiss. This is indicated by the drillcore tectonostratigraphy and Nd model ages ($T_{CR} = 2.2$ Ga, 2.9–3.0 Ga and 3.3 Ga, respectively). The same model ages occur in very similar rocks in the main parts of the TNB and Kisseynew Domain. One inferred basement gneiss in the north is a relatively pelitic sample that yielded a Nd model age of 3.3 Ga, similar to nearby banded orthogneiss, but has higher plagioclase and biotite contents, is

peraluminous and may represent an Archean metagreywacke. In one drillcore, mylonitic garnet-biotite paragneiss of the Burntwood Group is in contact with silicate-facies iron formation of the Oswagan Group (Pipe Formation, P3 member) in an upward (i.e. northwest)-facing succession that contains calcsilicate rock and thin marble (Thompson Formation, a stratigraphically lower unit) near the base of the hole. The same tectonostratigraphy in the Mel zone, southwest of Rock Lake (Zwanzig and Böhm, 2002), raises the possibilities that 1) the belt of Oswagan Group is continuous and extends for 40 km or more; and 2) a very large 'flat' in the hangingwall and footwall of an early thrust fault has carried the Burntwood Group for a considerable distance over the Oswagan Group. Such overthrusting at a lower structural level would also explain the presence of the allochthonous Burntwood Group south of Pearson Lake, on Rock Lake and farther south along the northwest margin of the TNB.

Blank Lake

The area of previously sampled orthogneiss along the Odei River northwest of Orr Lake and on Blank Lake was revisited only along its northeast margin with the (presumed) Burntwood Group (Figure GS-10-1). This site is underlain by granodiorite gneiss with about 40% thin granitic veins. The previously sampled granodiorite gneiss on Blank Lake and hornblende-biotite granodiorite gneiss from the rapids in the Odei River, 5 km south of Blank lake, yielded relatively ancient Nd model ages of 3.6 and 3.7 Ga (Böhm, unpublished data, 1998). The Nd isotope ratios of these samples reduce to $\epsilon_{\text{Nd}} = -8.3$ and -10.0 (calculated at 2.70 Ga), and clearly indicate a long crustal history of their protoliths. These rocks form the central part of an area of high aeromagnetic amplitude and may represent older gneiss than those farther to the southwest.

Orr Lake

This shallow lake is underlain by various types of orthogneiss and amphibolite cut by pegmatitic granite dikes, in an assemblage typical of the Archean rocks that are the basement of the Oswagan Group (Figure GS-10-1). Although the rocks differ considerably in detail, there is no obvious mappable change across the lake. About 60% of outcrops consist of strongly layered orthogneiss, estimated to be of granodioritic to dioritic composition. In a number of localities, leucosome veins contain coarse prisms of hornblende that crystallized in a high-temperature melt, possibly as original pyroxene. The rocks may have been at hornblende-granulite facies before retrogression. Most exposures on Orr Lake contain mafic dikes or layers and lenses of amphibolite with thin veins of leucosome. In about 20% of the outcrops, amphibolite predominates or forms the only rock type. There appear to be several ages (probably Archean and Paleoproterozoic), mostly interpreted as dikes in various states of recrystallization and granite injection. Part of the west shore of the lake is underlain by relatively homogeneous gneissic granodiorite.

Neodymium data from two archived samples of layered gneiss gave model ages of 3.4 and 2.4 Ga (Böhm, unpublished data, 1998). The former lies within the range typical for TNB basement, but the latter is unexplained. The revisited sampling site comprises layered granodiorite gneiss with lenses of amphibolite that locally grade into darker bands of the gneiss. This is typical of the Archean TNB basement. A sample will be analyzed for Nd isotopes to further test the origin of the gneiss.

A sample of layered felsic migmatite collected more recently from the rapids in the Odei River, 6 km southwest of Orr Lake, has the same old Nd model age ($T_{\text{CR}} = 3.4$ Ga) as the archived sample on the lake. The Nd isotope ratios of these samples yield negative ϵ_{Nd} values of -8.2 and -6.5 (calculated at 2.70 Ga), when they were also quite isotopically evolved, suggesting Mesoproterozoic protoliths.

Farther south, along Highway 280 near Troy Lake, a sample of layered granodiorite gneiss yielded a Nd model age of 2.6 Ga (Böhm, unpublished data, 1998; Figure GS-10-1). This gneiss may represent a change in the predominant type of Archean orthogneiss or suggest the presence of isotopically evolved Paleoproterozoic rock. The Nd isotope ratios of this sample yielded a ϵ_{Nd} value of $+5.4$ (calculated at 2.6 Ga). This is similar to depleted mantle in the Paleoproterozoic or latest Archean, so that it provides the maximum possible crystallization age of the granodiorite but one that would prohibit any contribution by older crust in its origin. The sample is from an area of low aeromagnetic intensity that extends north-northeast for more than 10 km. Judging from exposures of veined granodiorite 5 km north of the road and at the nearby rapids, the area is underlain by rock that is petrographically similar to isotopically more evolved Archean gneiss farther north and elsewhere. The lack of difference in outcrops of this magnetically weak area and the stronger area to the northwest suggest that the magnetic signature may reflect the breakdown of magnetite during retrogression and mylonite development, and its reappearance during high-grade Hudsonian metamorphism and annealing.

Economic considerations

The preliminary compilation of Nd isotope data, including data from company drillcore, and reconnaissance mapping of the Pearson Lake–Rock Lake–Orr Lake area indicate that the basement gneiss typical of the TNB and narrow belts of Ospwagan Group supracrustal rocks extend northeast of the main part of the TNB to Pearson Lake. Although the structure involves complex interleaving with the generally barren Burntwood Group, the area is promising for further nickel exploration. Where the stratigraphic section is decapitated by Burntwood thrust sheet(s), the lower to middle portion of the Ospwagan Group, which generally contains most of the ultramafic bodies associated with the mineralization, is still preserved. An inferred suture zone, marked by Paleoproterozoic arkosic metasandstone (Sickle Group) northwest of the overthrust Burntwood Group, forms the limit of exploration for Thompson-type nickel deposits.

Neodymium model ages as old as 3.7 Ga suggest the presence of Mesoarchean crust, which contains the gold deposits presently under exploration at Assean Lake. Systematic variations in the amount of ancient crustal inheritance, if confirmed, may serve to help unravel the complex structure of the Archean gneiss in the effort to locate previously unidentified keels of Ospwagan Group for nickel exploration.

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