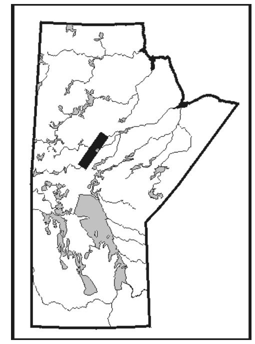
GS-12 PETROGENETIC AND METALLOGENIC SIGNIFICANCE OF MAFIC-ULTRAMAFIC DYKES AND VOLCANIC SEQUENCES IN THE THOMPSON NICKEL BELT: PRELIMINARY RESULTS (PARTS OF NTS 63J, 63O, AND 63P)



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SUMMARY

New field observations obtained from mafic and mafic to ultramafic intrusions and volcanic sequences in the Thompson Nickel Belt (TNB) indicate that the larger "dyke-like" intrusions occur along major tectonic boundaries and potentially record the development of pre-collisional extensional faults. Ongoing and related geochemical and geochronological studies should help to establish the temporal and genetic relationships between the dykes, volcanic sequences and mineralized ultramafic sills in the TNB. Currently, this is not possible in light of recent geochronological data for the 2.09-1.86 Ga "Molson dyke swarm" and the lack of age information for the TNB.

The best preserved and perhaps the largest intrusion in the TNB occupies the Grass River lineament. Here, a layered mafic-ultramafic intrusion (or multiple intrusions) was emplaced along a fault that, in places, separates the Archean Superior Province from the Ospwagan Group on the east side of the TNB. The Grass River intrusion appears to be younger than adjacent mafic volcanic rocks and, accordingly, could postdate all of the sedimentary rocks in the Ospwagan group. The occurrence of apparently exhalative sulphide mineralization in pillow basalt-argillite-iron formation associations is recognized at two different locations in the TNB. This type of sulphide mineralization may have pre-dated some of the mafic-ultramafic magmatism in the TNB and could have provided an alternative to the Pipe Formation as a source for external sulphur - an essential element in the generation of large, magmatic Ni sulphide deposits.

INTRODUCTION

The majority of Ni occurrences and deposits within the Thompson Nickel Belt (TNB) are developed within or proximal to primitive ultramafic intrusions (dunite, harzburgite; see Peredery, 1979; Bleeker, 1990; McRitchie, 1995) that were emplaced into predominantly siliciclastic metasedimentary rocks of the Ospwagan Group (Scoates et al., 1977). Recent geochronological data suggest that some of the mineralized ultramafic bodies crystallized at ca. 1.881 Ga (L. Hulbert and M. Hamilton, Geological Survey of Canada, written communication, July, 1998) and are therefore coeval with the Fox River Sill and some of the "Molson dykes" from the western Superior Province (Heaman et al., 1986). New geochronological data also suggest that the "Molson dyke swarm" does not represent a single magmatic event, but rather comprises dykes that have crystallization ages of ca. 2.09, 2.07, 1.88 and 1.86 Ga (Heaman et al., 1986; Zhai et al., 1994; Heaman and Corkery, 1996; Peck and Heaman, GS-25, this volume). Hulbert et al. (1994) reported an U-Pb zircon age of 1864 +6/-4 Ma for a gabbroic unit from the Winnipegosis Komatiite Belt.

Ultramafic intrusions in the TNB are predominantly olivine cumulates and, therefore, do not provide direct estimates of their parental magma compositions. Accordingly, residual mafic liquids must have developed concurrently with these Mg-rich ultramafic cumulates. However, ultramafic intrusions in the TNB rarely contain significant volumes of mafic rock. Conversely, several of the predominantly mafic dykes and volcanic sequences in the TNB contain ultramafic components (see below and Peredery, 1979; Paktunc, 1984; Theyer and Freund, GS-11, this volume). A correlation tool is required to determine the temporal and genetic relationships between mafic and ultramafic rocks in the TNB. Furthermore, although it is well established that a fundamental genetic relationship exists between ultramafic intrusions and Ni sulphide deposits in the TNB, it is not known whether any of the more mafic intrusions contain, or can be used to delineate, new magmatic sulphide deposits. Existing data suggest that one "pulse" of mafic-ultramafic magmatism generated all of the major Ni deposits in the Thompson area (R. Somerville, INCO Technical Services Ltd., written communication, 1998).

This report presents preliminary field observations from the first year of a four year geological investigation of mafic and mafic-ultramafic intrusions and volcanic sequences in the TNB (part of the Canadian Mining Industry Research Organization (CAMIRO) TNB Project; see Peck, GS-7, this volume) The objectives of the current investigation are to: (1) provide additional field observations relating to the contacts and stratigraphic context of the dykes and volcanic rocks with the Ospwagan Group metasedimentary sequences and the mineralized ultramafic bodies; (2) document the internal petrologic variations in the dykes and volcanic suites; and (3) carry out geochemical and geochronological investigations of mafic and ultramafic igneous rocks in the TNB.

Related geochronological, metamorphic and structural studies are underway (see, in this volume: Theyer and Freund, GS-11; Peck, GS-7; Kraus et al., GS-14). The current study focuses on the exposed parts of the TNB and immediately adjacent "Pikwitonei-type" Archean crust (within the eastern part of the Churchill-Superior Boundary Zone). The principal study areas (see Fig. GS-12-1 for locations) are: (1) volcanic suites (north to south): Moak Lake, Liz Lake, Mid Lake, Ospwagan Lake (see Theyer and Freund, GS-11, this volume), Velde Lake, Soab Mines - Grass River, Bah Lake, Halfway Lake - South Jonas Road and Setting Lake - Four Mile Lake (Zwanzig, GS-10, this volume); and, (2) mafic and mafic-ultramafic intrusions (north to south): Thompson South Pit (see Kraus et al., GS-14, this volume), Taylor River, Highway 6 between Soab North Mine and Joey Lake, Grass River lineament and Bah Lake. Here we discuss preliminary field observations for these areas.

Ultimately, the results of this investigation will be integrated with new data from the CAMIRO TNB project in order to better constrain the tectonomagmatic and metallogenic evolution of the TNB and the Churchill-Superior Boundary Zone.

MAFIC AND ULTRAMAFIC VOLCANIC SEQUENCES

1. Moak Lake

Altered, massive metabasalt is associated with oxide facies banded iron formation in an area located between Mystery and Moak lakes (Fig. GS-12-1). Here, prevalent S_0 fabrics are east-northeast trending, as opposed to north-northeast trending, as observed in other parts of the TNB. The basalts are cut by numerous, irregular vein networks of quartz and/or carbonate. Some of the veins contain chlorite, and sericite alteration is locally observed. Linear, narrow (<1 m) pyritic bands that contain minor to semi-massive pyrite ± pyrrhotite and trace chalcopyrite, are developed in altered basalts in association with intense quartz and carbonate veining. The sulphide veins are believed to be syn-volcanic because they have irregular orientations and are cut by later penetrative foliations and fractures. Unaltered, massive basalt and associated gabbro sills were sampled for geochemical analysis.

In one area, flow contacts in the basalt sequence are conformable with bedding in an adjacent oxide facies (chert-magnetite) banded iron formation (younging directions were not established). To the north of this contact, oxide facies iron formation is highly altered and some or all of the magnetite is replaced by pyrite and pyrrhotite (Fig. GS-12-2). This sulphidation is locally expressed as a narrow (<1 cm) aureole adjacent

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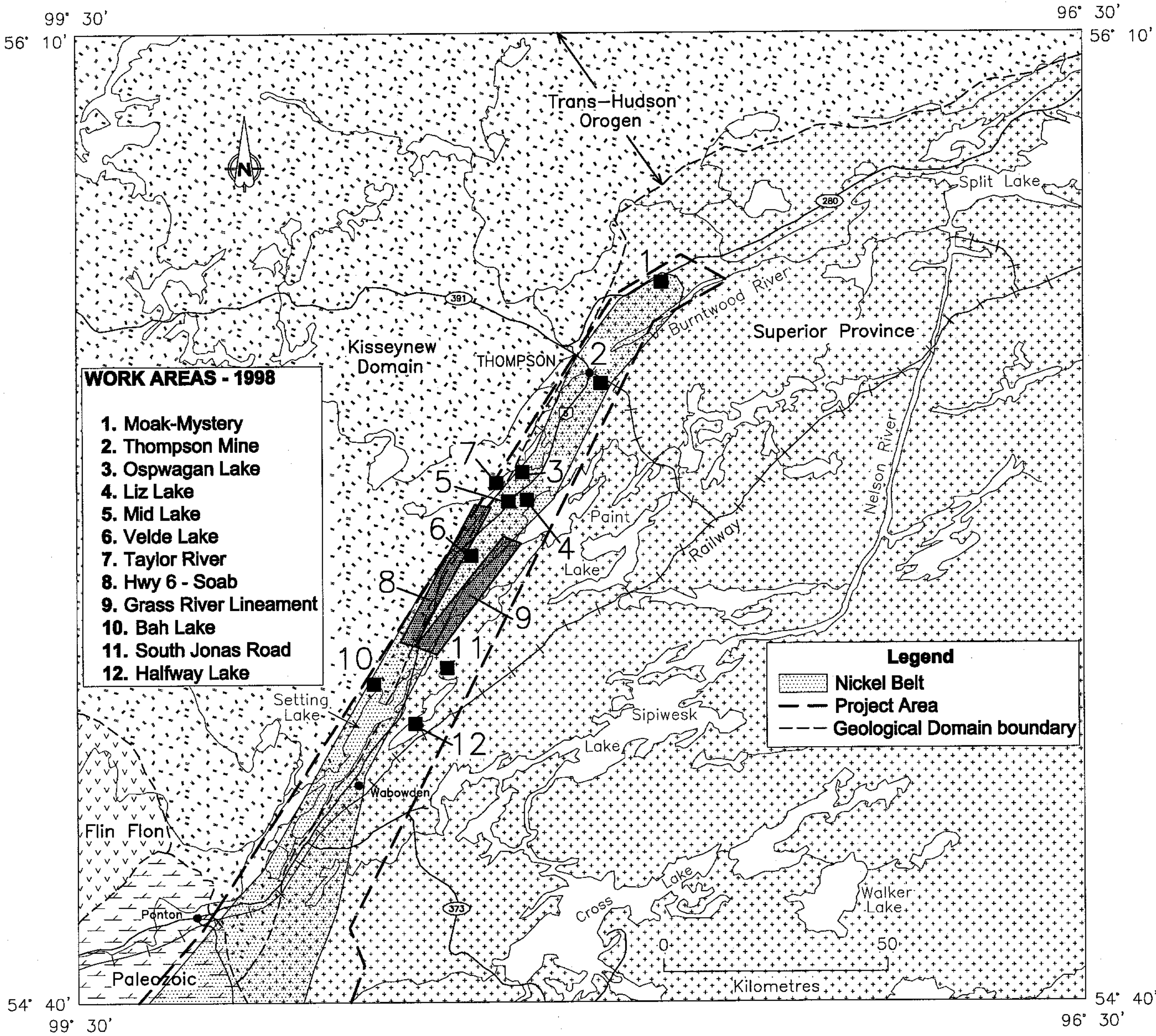
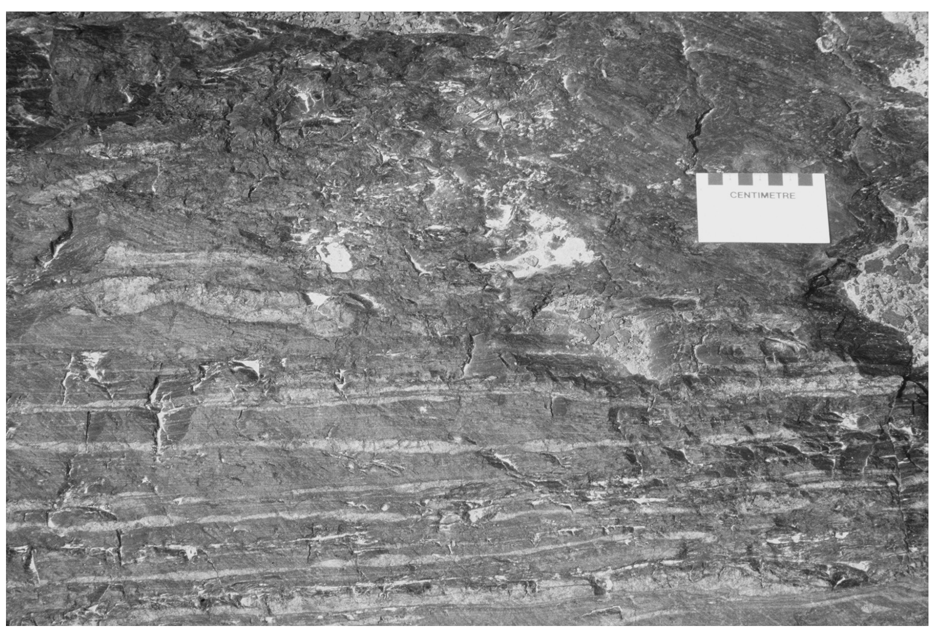


Figure GS-12-1: Location of the mafic and mafic-ultramafic intrusive and volcanic suites investigated, within the northern (exposed) part of the Thompson Nickel Belt.

Figure GS-12-2: Oxide facies banded iron formation affected by sulphur metasomatism. Original magnetite beds (dark beds in lower and middle parts of the photo) are partially to completely replaced by pyrite and pyrrhotite. Photo from an outcrop located ca. 2 km to the east of Mystery Lake, along the Moak railbed.



to irregular fractures that cut the iron formation. More commonly, the sulphidation is expressed as complete replacement of magnetite laminae by pyrite ± pyrrhotite. Based on the interpreted presence of volcanogenic sulphides in the adjacent basalts, it is proposed that an exhalative origin for the sulphides in the iron formation is possible.

2. Liz Lake

Foliated, equigranular metabasalt crops out along the western shoreline of Liz Lake and is intercalated with a more magnesian "picritic" basalt (Macek and Russel, 1978a). Several samples of basalt and "picritic" basalt were collected for lithogeochemical analyses. No primary flow features or contact relationships were observed. The "picritic basalts", as is the case with similar units observed from Ospwagan Lake (Theyer and Freund, GS-11, this volume) and the Grass River (below), are likely olivine poikiloblastic metaperidotite flows and/or sills.

3. Mid Lake

A pillow basalt sequence is exposed in a series of small outcrops ca. 1 km south of Mid Lake and 50 m east of Highway 6. The pillow basalts are typically highly flattened, but pillow structures are well preserved in the hinge region of a north-northeast trending fold. The pillowed flows are locally interlayered with coarse-grained gabbro (thick flows or sills). At the south end of the exposure, pillow basalt is in contact with <2 m thick units of sulphidic argillite and pyritic quartzite (sulphide facies banded iron formation) in which the sulphide component may be volcanic-exhalative in origin. This interpretation is based on the observed silica and carbonate alteration and pyrite veining in the vicinity of the sulphidic sedimentary units and adjacent basalts. The basalt - sulphidic argillite contacts are interpreted to be conformable with bedding in impure quartzites that occur directly to the south and west. A mafic dyke, <20 cm wide, cuts the quartzites. The interpretation of the relative ages of the units is complicated by the north-northeast-trending folds and the lack of facing indicators. Preserved pillow structures and the interpreted upward transition from altered basalt to sulphidic (exhalative) sedimentary rocks suggest that the supracrustal sequence is, on the scale of this exposure, south to southwest facing and that sedimentation was coeval with volcanism.

4. Ospwagan Lake

Mapping at a scale of ca. 1:16 000, together with local, detailed mapping, was completed on a well exposed sequence of pillow basalt, komatiitic basalt and olivine poikiloblastic Mg-rich basalt ("picrite" - see Macek and Russel, 1978b) on Upper Ospwagan Lake (Theyer and Freund, GS-11, this volume). The volcanic rocks appear to be consistently northwest facing and, in the eastern part of Upper Ospwagan Lake, are in faulted contact with quartzites interpreted to be part of the Manasan Formation (Theyer and Freund, GS-11, this volume). Geochemical and geochronological studies of the volcanic rocks and associated mafic sills have been initiated.

5. Velde Lake

A single outcrop of foliated metabasalt occurs on the northwest shoreline of Velde Lake. No primary volcanic structures were observed. A single sample was collected for geochemical analysis.

6. Soab Mines - Grass River

A large area, extending from the western side of the Soab South Mine to the Grass River between Pisew Falls and Insole Lake, is underlain by mafic metavolcanic rocks. This volcanic sequence is one of the largest in the TNB (Coats et al., 1972). A preliminary investigation of the Soab area volcanic rocks was carried out in the vicinity of the Soab South Mine and along the Grass River between Phillips Lake and Pisew Falls (Fig. GS-12-1). The rocks comprise fine-grained metabasalt that locally displays relict pillow structures. Several samples were collected for geochemical analysis from massive flows and associated gabbro to melagabbro intrusions from the Soab South Mine area.

The volcanic rocks exposed along the west shoreline of the Grass River were observed, at one location, to have been intruded by a layered, mafic-ultramafic "dyke", herein referred to as the Grass River intrusion. Field observations (see below) suggest that the Grass River intrusion is developed more or less continuously along the Grass River lineament. The latter feature is a major fault that, in this part of the TNB, separates the Archean portion of the Churchill-Superior Boundary Zone in the east from Proterozoic supracrustal rocks belonging to the Ospwagan Group in the west.

Variably preserved orthopyroxene + clinopyroxene + plagioclase +/- garnet assemblages are observed in irregular veins of leucosome in the metabasalt sequence along the west shoreline of the Grass River near the entrance to Phillips Lake (Fig. GS-12-3). This assemblage is widespread and suggests that the basalts were affected by granulite facies metamorphism (i.e., a Proterozoic granulite facies event). In the same area, peak metamorphic grades recorded by Archean gneisses on the east side of the Grass River lineament appear to be lower (amphibolite grade). This observation indicates significant burial and, subsequently, significant uplift of the TNB along the Grass River lineament.

In addition to lithogeochemical analyses, several geochronological analyses (conventional U-Pb zircon procedure) will be carried out on basalt and associated gabbro, pyroxenite and peridotite samples collected along the Grass River.

7. Bah Lake

Abundant exposures of mafic metavolcanic rocks occur directly to the north of Setting Lake and west of an area underlain by Archean orthogneisses (Fig. GS-12-1). Recent mapping in the Setting Lake area (see Zwanzig, GS-10, this volume) has demonstrated that these metavolcanic rocks, which principally comprise pillowed and massive basalt flows, can be traced to the south along or immediately adjacent to the western shoreline of Setting Lake. The basalts reach their maximum

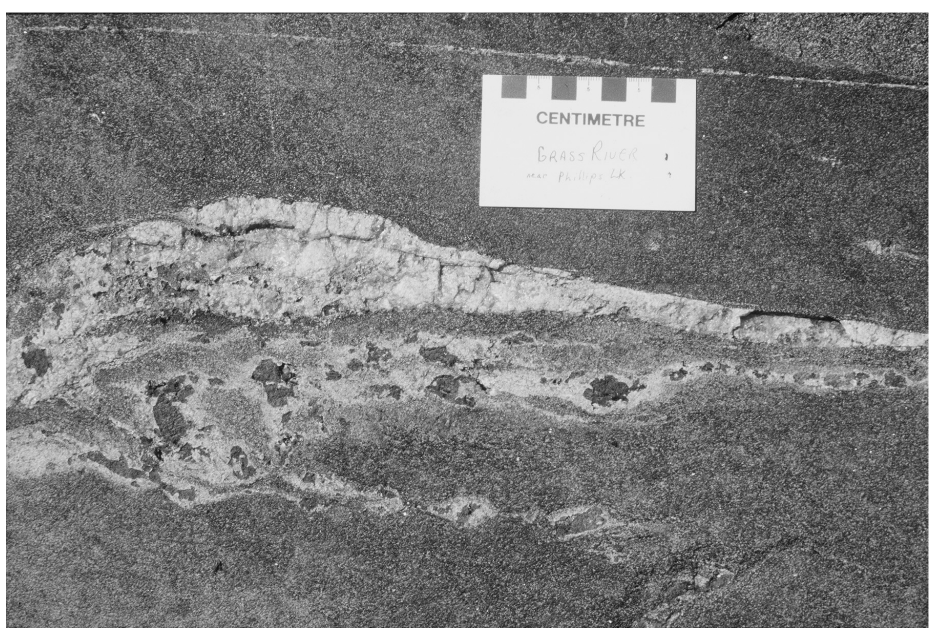


Figure GS-12-3: Irregular leucosome in metabasalt, from the western shoreline of the Grass River opposite the channel leading to Phillips Lake. The leucosome apparently records granulite facies (Paleoproterozoic ?) meta- basalt, as indicated by the presence of coarse-grained orthopyroxene por-phyroblasts (large, dark, idiomorphic crystals in the centre of the photograph) in association with plagio-clase (white part of leucosome) and, locally, clino-pyroxene and garnet (not shown). These leucosome veins are typically cut by younger granitic veins, such as that shown in the upper part of the photograph.

aerial extent immediately to the north of Setting Lake and east of Bah Lake and here, are referred to as the Bah Lake volcanics. These rocks are in tectonic contact with younger metasedimentary rocks that belong to the Grass River Group (Zwanzig, GS-10, this volume) and are well exposed in the hinge area of a major fold immediately to the southeast of Bah Lake (Zwanzig, GS-10, this volume.).

The geology and geochemistry of the Bah Lake volcanics will be investigated as part of an ongoing B.Sc. thesis project (C. Chandler, Brandon University). The field portion of this thesis project involved a three week study of the mafic volcanic rocks located to the south and east of Bah Lake. Field work included mapping of the volcanic rocks along the Setting Lake road at a general scale of 1:5000 and, where required, at a scale of 1:500. The geology of a plagioclase megacrystic layered gabbro intrusion in the basalts was also documented, as was the contact between the volcanic rocks and the Grass River Group sedimentary rocks. An attempt was made to develop a stratigraphy for the volcanic sequence, but most of the rocks are massive basalt and few petrologic differences were observed.

Concurrently, sampling was completed for an ongoing geochemical study of the basalt sequence and the megacrystic gabbro intrusion. Two samples were collected from the plagioclase megacrystic gabbro intrusion for U-Pb zircon geochronology. The planned geochemistry study will attempt to characterize the mantle source characteristics and inter-relationships between the basalt sequence and the megacrystic gabbro intrusion. The data will provide an additional tool for correlating the Bah Lake mafic rocks with those observed to the south, on and adjacent to, Setting Lake.

8. Halfway Lake and South Jonas Road

Retrogressed granulites of the Pikwitonei Domain that comprise tectonically overprinted orthogneiss of tonalitic to dioritic composition, are exposed in the Halfway Lake area and along the northeast-trending South Jonas forestry road (Fig. GS-12-1). Small remnants of mafic metavolcanic sequences are locally preserved as metre- to decametre-scale boudins and fault-bounded blocks within the orthogneisses. The age of the mafic metavolcanic rocks is unknown and, given their proximity to the TNB, it is possible that some of them may be correlative with the TNB volcanic sequences. In order to test this hypothesis, a preliminary suite of samples was collected from the southern end of Halfway Lake and from outcrops along the South Jonas Road for petrological and geochemical anaylsis.

Most of the mafic rocks examined from this area represent complexly deformed (e.g., two or more foliations) boudins of fine-grained basalt or gabbro. Textures in these rocks are typically annealed, such that polygonal grain boundaries have formed between amphibole and plagioclase. Preliminary structural observations made along a 50 km section of the South Jonas Road revealed that a penetrative foliation developed in the orthogneisses and the mafic boudins is north-northeast trending adjacent to Highway 6, but to the east, progressively changes to an east-west orientation. This trend may reflect the progressive overprinting of the predominant Archean fabrics (easterly) by north-northeast-trending structures during the ca. 1.8 Ga collisional orogoeny involving the Superior Province and the Trans-Hudson Orogen.

MAFIC AND ULTRAMAFIC DYKES IN THE THOMPSON NICKEL BELT

1. Thompson South Pit

An ca. 40 m thick mafic intrusion (South Pit gabbro) occurs along the Archean-Proterozoic unconformity on the west side of the Thompson Mine South Pit. Several other dyke-like mafic intrusions are recognized in the Thompson Mine, both underground and from the open pits (INCO Ltd., unpublished mapping; Bleeker, 1990). The petrology, stratigraphy, geochemistry and age of the South Pit gabbro is currently being investigated as part of a structural study of the South Pit. Preliminary results of this study are given by Kraus et al. (GS-14, this volume). Of relevance here is the fact that the geometry and layering of the South Pit gabbro reflects emplacement as a nearly horizontal, sill-like body, prior to any significant deformation in the host Ospwagan Group units (Manasan Formation). This interpretation, if correct, suggests that some of the mafic intrusions in the TNB developed prior to the F_1 nappe structures that have been proposed by Bleeker (1990). A maximum age for the first major deformation in the Ospwagan Group can therefore be obtained if a crystallization age can be determined for the South Pit gabbro (ongoing studies; L.H., University of Alberta; W. Bleeker and others, Geological Survey of Canada.).

2. Taylor River

Stephenson (1974) mapped a >20 km long mafic dyke along the Taylor River that resides within/along the major tectonic boundary between Burntwood Group paragneisses in the Trans-Hudson orogen and paragneisses and metavolcanic rocks assigned to the Ospwagan Group (see Macek and Russel, 1978a, b). This boundary is a major lithotectonic feature, in the same manner that the Grass River lineament has major tectonic significance on the eastern side of the TNB. The Taylor River intrusion (our nomenclature) was observed in outcrops as far south as the Pipe Mine and as far north as the northwest end of Lower Ospwagan Lake.

The intrusion (or intrusions ?) is not well exposed, but was observed in a few small outcrops along the east shoreline of the Taylor River and in the northwest part of Lower Ospwagan Lake. These outcrops comprise medium- to coarse-grained gabbro and leucogabbro. In one location, serpentinized peridotite was observed within 30 m of an area of gabbro outcrops. It is not known whether the peridotite and gabbro are cogenetic, but geochemical and geochronological studies (ongoing) should help in this regard. Locally, the Taylor River intrusion is intensely foliated (north-northeast-trending fabric) and has a faulted contact with arkosic sedimentary rocks of unknown affinity. Arkose of similar appearance crops out along the western shoreline of the Taylor River in several locations, where it is locally interlayered with semi-pelitic paragneiss that may be part of the Burntwood Group (Stephenson, 1974) or the recently defined Grass River Group (Zwanzig, GS-10, this volume).

3. Highway 6 between Soab North Mine and Joey Lake

Numerous road cuts and outcrops exposed on both sides of Highway 6 and along the abandoned railbed between the Pipe Mine and the Soab South Mine were examined in order to document the many occurrences of mafic (gabbroic and/or basaltic) rocks in the area. A large number of <1 to >10 m wide gabbroic units were recognized in this area, locally accounting for 30 - 40% of the exposed geology. Most of these bodies are interpreted to be deformed dykes or sills that were emplaced along, or adjacent to, the contact between presumed Archean orthogneisses to the east and paragneisses, that appear to correlate with parts of the Ospwagan Group, to the west. Some of the gabbroic units display rhythmic, cm-scale modal layering (Fig. GS-12-4) and many are conformable with bedding in the enclosing paragneisses. There is an almost ubiquitous association between the gabbroic bodies and a sedimentary sequence that comprises quartzite or impure quartzite, semi-pelitic gneiss and derived migmatite, and biotite-rich sulphidic schist. Less commonly, the gabbroic rocks form boudins, up to several metres long, within tonalitic gneiss and derived migmatite of probable Archean age. In the Archean rocks, it is unclear whether the external margins of the mafic boudins are intrusive or tectonic. In contrast, many chilled margins are observed from the gabbros developed in the sedimentary sequences. We believe that the large volume of mafic rocks in the Soab Mines - Joey Lake segment of the TNB reflects the existence of another major north-northeast-trending structure that is not as well preserved as the major lineaments along the Taylor and Grass rivers. Field observations suggest that the mafic rocks in the Soab Mine - Joey Lake area are not linked to a single, large intrusion, but rather reflect a confluence of smaller mafic intrusions into the Ospwagan Group and, to a lesser degree, the Archean orthogneisses.

A large mafic intrusion (herein referred to as the Soab dyke) is exposed on a road cut immediately to the north of the Soab North Mine access road that adjoins Highway 6. The dyke is also exposed in an abandoned quarry ca. 50 m to the west of this road cut. Although it appears to be relatively undeformed in the road cut, the dyke is clearly deformed by north-northeast-trending large scale folds (F_3 ?; Bleeker, 1990) in the quarry. The Soab dyke displays a chilled margin against adjacent quartzites (to the north and west) and mafic metavolcanic rocks (to the south and east). An abrupt, but irregular, contact is observed between fine- and medium-grained gabbro layers that have similar modal compositions (Fig. GS-12-5). Small droplet-like inclusions of the coarser-grained gabbro are present in the immediately overlying fine-grained gabbro that locally fills tube-like scours along this contact (Fig. GS-12-5). These features are indicative of liquid-liquid contacts and suggest that this intrusion was fed by two batches of compositionally similar magma. A xenolith of sulphide-bearing metapyroxenite is also present in the Soab dyke. Several samples were collected from the Soab dyke and some of the smaller gabbroic intrusions in the Soab Mines - Joey Lake area for detailed petrochemical and preliminary

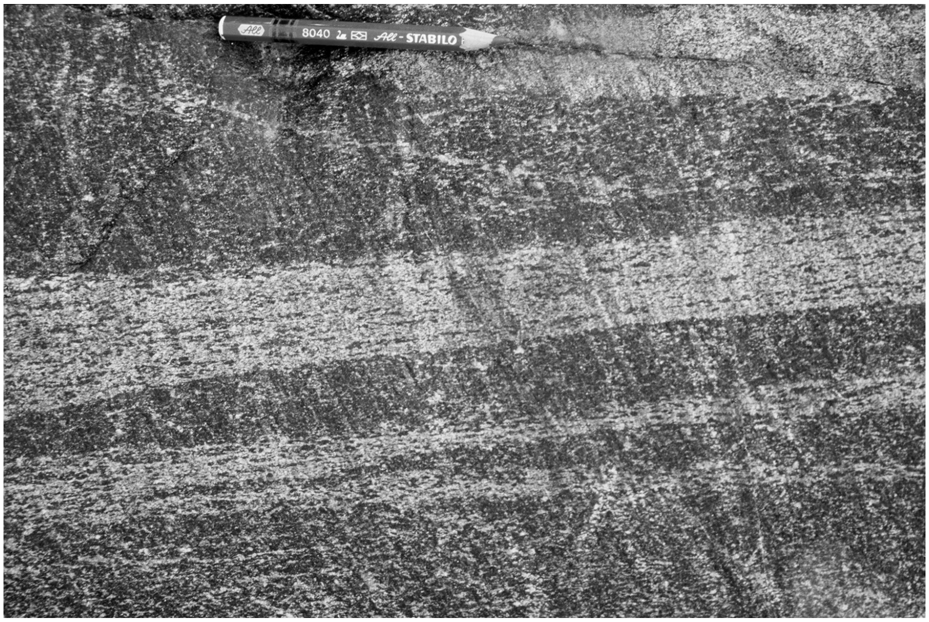


Figure GS-12-4: Centimetre-scale modal layering involving leucogabbro and gabbro in a >10 m wide mafic intrusion emplaced into Ospwagan Group metasedimentary rocks, in the Joey Lake - Soab Mines area, east of Highway 6 (see Fig. GS-12-1). The rocks have been recrystallized and contain a penetrative, metamorphic foliation (S_1) has developed.

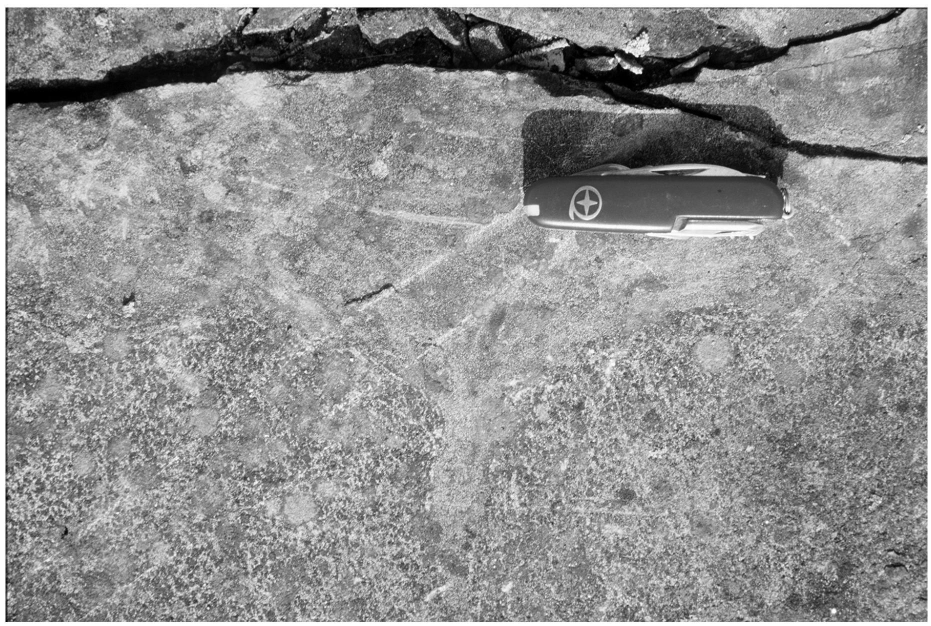


Figure GS-12-5: Abrupt contact (defined by grain size) between compositionally similar gabbro layers in the Soab dyke, exposed along a road cut on Highway 6 near the Soab North Mine. Note the tube-like scour-fill structure in the older, coarser-grained gabbro layer (bottom of photograph). The knife is ca. 9 cm long.

geochronological analysis.

4. Grass River Lineament

The Grass River intrusion, as mentioned previously, appears to occupy a major fault zone that, in the Pisew Falls - Phillips Lake area, separates Archean orthogneisses in the east from Ospwagan Group supracrustal rocks in the west. The intrusion is only exposed in a few small outcrops along the western shoreline of the Grass River, directly opposite to, or southwest of, the channel leading to Phillips Lake. The outcrops consist of centimetre- to decimetre-scale layered gabbro, melagabbro, pyroxenite, olivine pyroxenite and olivine poikiloblastic peridotite (Fig. GS-12-6). The intrusion may extend as far north as the southwestern end of Paint Lake, where similar olivine poikiloblastic peridotite and pyroxenite are exposed. Peridotite, exposed on Soab Creek a few km to the west of the Grass River intrusion, was sampled in order to investigate potential genetic relationships.

Granulite facies mineral assemblages were observed in gabbro layers from the Grass River intrusion, in the same area that granulite facies leucosome occurs in metabasalts. The age of the granulite metamorphism will be investigated by Dr. N. Machado (l'Université du Québèc à Montréal) and colleagues (see Peck, GS-7, this volume). Deformation recorded by the Grass River intrusion includes a weak to strong north-northeast-trending penetrative foliation and north-north-east-trending asymmetric minor folds. In many areas, the intrusion is relatively massive and preserves primary layering features and megascopic igneous textures.

5. Bah Lake.

As described above, a plagioclase phyric to megacrystic layered gabbro intrusion occurs north of Setting Lake, within the central part of the Bah Lake volcanic sequence, ca. 6 km to the west of Highway 6 (Fig. GS-12-1). The contacts between the intrusion and adjacent pillowed and massive basalt flows are poorly exposed. The dyke is composed of alternating layers of dm-thick aphyric and plagioclase phyric medium-grained gabbro, melagabbro and leucogabbro (Fig. GS-12-7). Similar plagioclase phyric gabbroic rocks occur as far as 20 km to the south, along the eastern shoreline of Setting Lake. A well exposed example is located at the boat launch and camp ground on Setting Lake opposite the Wabowden turn off from Highway 6.

Figure GS-12-6: Relict coarse-grained olivine poikiloblastic or porphyritic peridotite layer (middle of photograph) interlayered with thinner, medium-grained olivine pyroxenite layers (base and top of photograph), from an outcrop along the western shoreline of the Grass River near Phillips Lake. Note that all of the primary, igneous minerals have been pseudomorphed by amphiboles and serpentine-group minerals. The knife is ca. 9 cm long.

Figure GS-12-7: Centimetre-scale modal layering between plagioclase "phyric" and aphyric gabbro within a >20 m wide dyke-like intrusion emplaced into the Bah Lake volcanic sequence, ca. 6 km to the west of Highway 6 and Sasagiu Rapids. The plagioclase phenocrysts locally attain diameters of 15 cm, and are interpreted to represent entrained xenocrysts rather than phenocrysts.

DISCUSSION

The principal observation that arises from our initial study of mafic magmatism in the TNB, and the one most relevant to mineral exploration, is that most of the gabbroic dykes and sills (+/- interlayered ultramafic rocks) occur along major north-northeast-trending structures. The significance of this observation, known to INCO geologists for some time, remains to be determined and awaits additional field work and related geochemical and geochronological investigations. Based on the available field data, it appears likely that these north-northeast trends reflect the pre-collisional configuration of the TNB. We now know that some of the ultramafic rocks in the TNB are coeval with the 1.883 Cuthbert suite of dykes from the adjacent parts of the Western Superior Province (see above). Most of these north-northeast-trending "dykes" were emplaced as multiple intrusions of similar, Mg-rich magmas and locally developed modal layering involving gabbroic to peridotitic layers. The Cuthbert dykes (Scoates and Macek, 1978), based on the type locality at Cuthbert Lake, are not nearly as primitive as the ultramafic bodies in the TNB, but show a very similar range in composition to the Grass River intrusion. The proximity of large "Molson dykes" (such as the Cuthbert Lake intrusion(s)) to the TNB "dykes", and the similarity of their compositions and orientations, provides evidence that they may be coeval and cogenetic.

Large continental dyke swarms are known from both marginal and intracratonic parts of the Superior Province (e.g., Mackenzie vs. Matachewan swarms). The major lineaments in the TNB that contain large volumes of mafic and ultramafic intrusive rocks may record the early stages of continental rifting. The age of the rifting is unknown, but is likely coincident with the emplacement of some of the "Molson dykes" in the Superior Province. In this model, the lineaments represent initial extensional features that were later affected by the collisional orogeny that involved the Trans-Hudson Orogen and the Superior craton. The largest mafic-ultramafic intrusions in the TNB, such as the Taylor River and Grass River intrusions, appear to retain their original strike direction with respect to the Superior craton margin. This feature is problematic if, as seems likely, the intrusions predated the F_1 to F_3 compressional structures. These large dykes occupy major lineaments that may have originated as rifts along the Superior margin and, subsequently, became strain-hardened owing to the mechanical homogeneity of the dykes in comparison to adjacent Archean orthogneisses and Ospwagan Group sedimentary rocks. The prevalent interference patterns that result from polyphase folding of the Ospwagan Group within the TNB (e.g., Coats et al., 1972) do not appear to have had a significant affect on the orientations of these large, dyke-like mafic-ultramafic intrusions. In contrast, smaller mafic intrusions throughout the exposed parts of the TNB are strongly deformed during the F_3 folding. We believe that the larger dyke-like intrusions in the TNB escaped much of the strain induced during the collisional orogeny and may provide constraints on the age and style of rifting and related magmatism on the western margin of the Superior craton.

We also hope to test the idea that the larger "dyke-like" intrusions were at one time contiguous with some of the ultramafic sills developed in the Ospwagan Group sedimentary sequences. The absence of mafic residual rock types in the ultramafic sills could reflect escape of the mafic liquids into these large, linear magma conduits. Therefore, the composition of the "dykes" could potentially provide an important exploration tool. There is also a critical need for new age determinations for the mafic and ultramafic rocks in the TNB, particularly in relation to the age of the major deformational events. Similarly, it is important to establish the relative ages of major mafic-ultramafic bodies and the various S-bearing metasedimentary rocks in the TNB. As we have documented, sulphidation of oxide facies iron formations (e.g., Moak Lake area, see above) locally occurred during volcanism in the northern parts of the TNB. Although we are not aware of any large mafic-ultramafic sills that were emplaced into these sulphidic sequences, there is a preliminary indication that some of the TNB mafic-ultramafic magmatism was at least coeval with, if not younger than, some of the mafic volcanism.

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