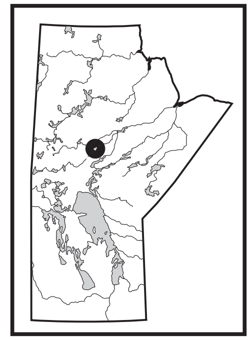
GS-9 Preliminary results from geological mapping of the west-central Paint Lake area, Manitoba (parts of NTS 63O8, 9, 63P5, 12)

by C.G. Couëslan[1]



Couëslan, C.G. 2008: Preliminary results from geological mapping of the west-central Paint Lake area, Manitoba (parts of NTS 63O8, 9, 63P5, 12); *in* Report of Activities 2008, Manitoba Science, Technology, Energy and Mines, Manitoba Geological Survey, p. 99–108.

Summary

This mapping project was initiated with the purpose of improving the understanding of the Archean basement to the Thompson Nickel Belt (TNB). Previous mappers recognized multicomponent migmatitic gneiss, layered mafic rocks, retrogressed enderbitic gneisses and Proterozoic granitoid rocks. New results also outline a package of Archean metasedimentary rocks that share some similarities with the Paleoproterozoic Ospwagan Group, which hosts the magmatic nickel-sulphide deposits of the TNB. The work has also identified a potential suite of alkaline igneous rocks that includes carbonatite-like dikes. Dominant structures in the area consist of upright, shallowly to moderately plunging folds that have deformed the regional foliation. From east to west, Archean granulite-grade assemblages were progressively overprinted by Hudsonian retrogression/hydration.

The recognition of an Archean metasedimentary sequence that exhibits some similarities to the Ospwagan Group has major implications for exploration in the belt. Specifically, it could allow for the mistaken identification of Ospwagan Group metasedimentary rocks in areas of low nickel potential. The possible suite of alkaline igneous rocks, which may include carbonatite, suggests potential for additional magmatic or hydrothermal deposit types in the area.

Introduction

Previous mapping of the Paint Lake area was conducted in the late 1970s by Macek and Russell (1978) and Charbonneau et al. (1979). Since that time, knowledge of the geology in the Thompson Nickel Belt (TNB) has grown significantly, especially in terms of structure, stratigraphy and tectonic setting. The aim of this project is to improve understanding of the Archean basement to the TNB by looking through the metamorphic overprints and interpreting protoliths, rather than using descriptive petrographic units.

Geological overview

Paint Lake is located along the Superior Boundary Zone, which separates the Archean Superior craton from the accreted Paleoproterozoic terranes of the Trans-Hudson Orogen. The lake is situated along the eastern side of the TNB (Figure GS-9-1). It is underlain dominantly by Archean gneiss, which is interpreted as deformed and variably retrogressed granulite, equivalent to the adjacent Pikwitonei Granulite Domain (PGD; Hubregtse, 1980; Russell, 1981; Bleeker and Macek, 1996). These gneissic units were reworked during the Trans-Hudson orogeny from approximately 1.82 to 1.72 Ga (Machado et al., 1990; Bleeker and Macek, 1996; Zwanzig et al., 2003).

The Archean rocks of the PGD are interpreted to have undergone three major tectonic events (Hubregtse, 1980). The first two events, D_1/M_1 (2700–2687 Ma) and D_2/M_2 (2660–2635 Ma), are Kenoran events that were followed by a Hudsonian overprint (D_3/M_3; 1820–1720 Ma; Hubregtse, 1980; Machado et al., 1990; Mezger et al., 1990; Bleeker and Macek, 1996). The D_1/M_1 event is evidenced by metamorphic banding (S_1) with local isoclinal folds, and was accompanied by amphibolite-grade metamorphism. The D_2/M_2 event strongly overprinted the D_1 structures, resulting in isoclinal folding of the S_1 fabric and the generation of S_2 banding that generally trends east. The D_2 event was accompanied by M_2 granulite-grade metamorphism that resulted in the formation of orthopyroxene- and hornblende-bearing leucosome. The D_3/M_3 event recognized by Hubregtse (1980) is likely a composite of the deformation events outlined by Bleeker and Macek (1996). Along the western edge of the PGD, this event is manifested by the reactivation of D_2 structures and the retrogression/hydration of the granulite- to amphibolite-grade gneiss. This hydration front denotes the eastern margin of the TNB. Continuing westward from the hydration front, the east-trending fabrics of the northwestern Superior craton were rotated to trend northeast during Hudsonian deformation.

The Hudsonian deformation in the TNB is again divided into three main events (Bleeker and Macek, 1996). The D_1 and D_2 events are evidenced by east-verging, recumbent and isoclinal folds. Peak metamorphism is interpreted to be coincident with, and possibly outlast, the D_2 event. The S_2 fabrics were later folded into upright, isoclinal D_3 folds with northeast-trending axial planes. Extensive mylonitization occurs post-F_3 and is confined to shear zones that parallel the steeply dipping limbs of the F_3 folds. Peak Hudsonian metamorphism in the TNB varies from middle amphibolite to granulite grade. Middle amphibolite–facies rocks generally occur in a long central trough that roughly parallels the belt, with higher grade

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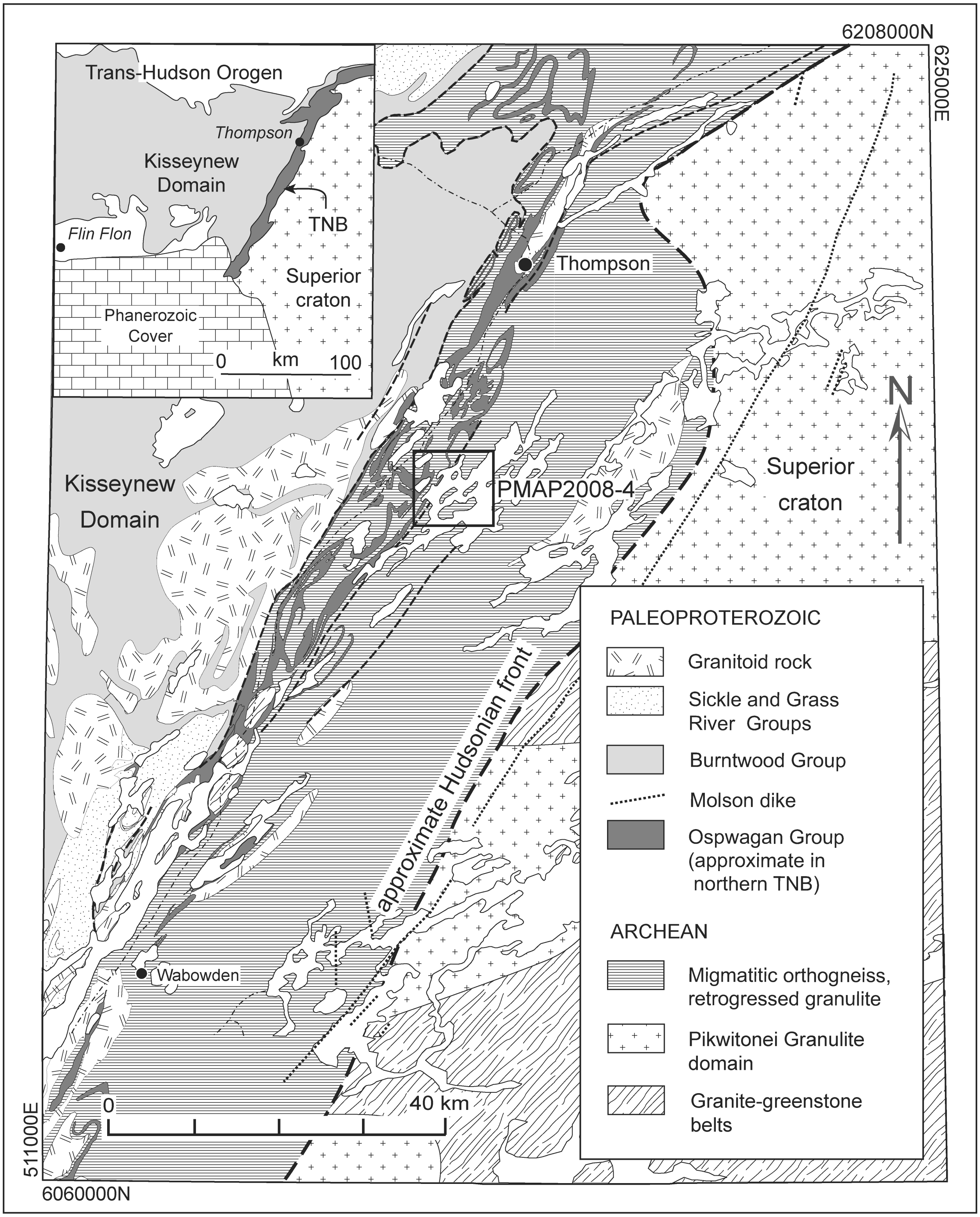

Figure GS-9-1: *Simplified geology of the Thompson Nickel Belt and location of the map area on Paint Lake.*

rocks to the west and east (Couëslan et al., 2007).

Previous work at Paint Lake outlined a layered mafic complex, consisting of metapyroxenite, layered metagabbro, layered anorthositic metagabbro and associated layered amphibolite, and large areas of retrogressed enderbitic gneiss in the western portions of the lake (Macek and Russell, 1978; Charbonneau et al., 1979). The eastern portions of the lake are dominantly underlain by complex migmatitic gneiss. The migmatite varies from outcrop to outcrop according to the number of components present, their composition and volume; however, the phases are generally quartzofeldspathic with variable amounts of biotite, hornblende, pyroxene, garnet and potassium feldspar. Ultramafic and mafic boudins are common. The migmatite is described as stromatic, folded, nebulitic and augen structured. The layered mafic rocks, enderbitic gneiss and migmatite are interpreted as Archean. Small dikes, sills and irregular bodies of aplite, pegmatite and other granitoid rocks occur throughout the area and are interpreted to be Hudsonian. Russell (1981) found the retrogression/hydration of the Archean rocks, from granulite to amphibolite grade, to be greatest in outcrops with larger proportions of these younger granitoid intrusions. Retrogression is also commonly accompanied by increased proportions of potassium feldspar. Although the Archean D_1/M_1 events of Hubregtse (1980) could not be positively identified at Paint Lake, Russell (1981) identified Archean D_2/M_2 events as well as Hudsonian effects.

Lithological units

The lithological units described below appear on Preliminary Map PMAP2008-4 (Couëslan, 2008). Many of the lithological units described by previous workers (Macek and Russell, 1978; Charbonneau et al., 1979) were also recognized during this summer's mapping program, including the layered mafic rocks, retrogressed enderbitic gneisses, multicomponent migmatite and various granitoid rocks of possible Proterozoic age. However, additional to these units is a large volume of Archean metasedimentary rocks in the central portions of the lake, and a suite tentatively identified as alkaline igneous rocks. The Ospwagan Group rocks outlined by Macek et al. (2006) were also identified and mapped.

Archean rocks

Multicomponent migmatite (unit 1)

The multicomponent migmatite consists of varying proportions of hornblende gneiss, biotite gneiss, plagioclase amphibolite, leucogranite, granodiorite, pegmatite and assorted ultramafic blocks and boudins (Figure GS-9-2). The various rock types occur as intermixed, highly attenuated, centimetre- to metre-scale bands and are not separated on Preliminary Map PMAP2008-4. Rare bands of enderbitic gneiss, layered mafic rock and iron formation are also present. The majority of components within the migmatite are considered to be orthogneiss.

Hornblende gneiss commonly forms the dominant component of the migmatite. It varies from pinkish grey to light grey, and is medium to coarse grained and foliated to strongly foliated. It generally contains 10–30% hornblende, 20–30% quartz, and plagioclase, but may also contain up to 2% garnet, 7% biotite and 20% potassium feldspar. Rarely, it contains up to 5% clinopyroxene and 15% orthopyroxene. It varies from crudely banded to strongly banded on a millimetre to centimetre scale and is locally highly strained and intensely folded. Rarely the gneiss contains orthopyroxene- or hornblende-bearing leucosome that is likely related to the M_2 metamorphic event of Hubregtse (1980).

The biotite gneiss is much less common than the hornblende variety. It is light grey to pinkish or brownish grey, medium to coarse grained and foliated to strongly foliated. It is composed of 2–5% hornblende, 10–30% biotite, 20–30% quartz, and plagioclase. Locally, it contains trace amounts of garnet, 3–5% orthopyroxene and up to 20% potassium feldspar. In places, the biotite gneiss

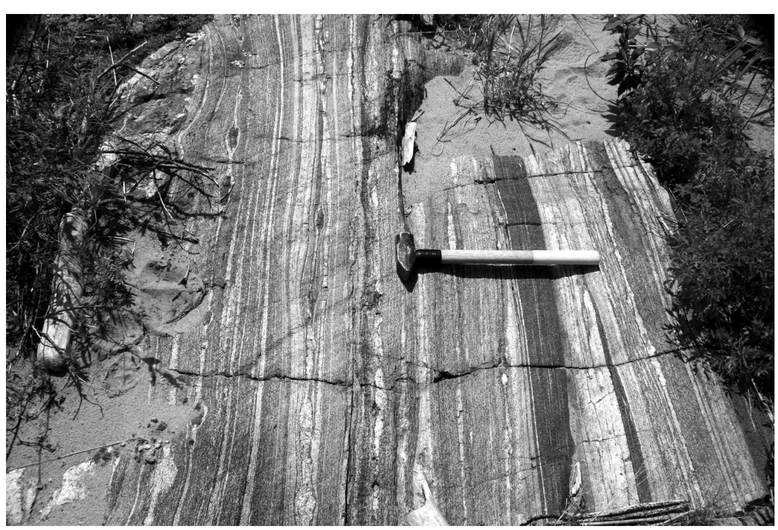

Figure GS-9-2: *Multicomponent migmatite consisting of several interbanded orthogneiss phases. The dominant feldspar is plagioclase.*

is texturally similar to the hornblende gneiss and varies from relatively homogeneous to strongly banded on a centimetre scale.

The ultramafic rocks generally constitute less than 2 % of a given outcrop but may occur as blocks or boudins up to 5 m across. They include clinopyroxenite, pyroxenite, ultramafic amphibolite and ultramafic schist. The most abundant type of ultramafic rock is clinopyroxenite, which commonly forms isolated boudins or discontinuous boudinaged layers less than 15 cm thick. The clinopyroxenite consists dominantly of clinopyroxene with variable but minor amounts of biotite, plagioclase, garnet, hornblende, quartz and carbonate. Individual boudins typically have selvages of hornblende up to 1 cm thick. Serpentine occurs rarely in the clinopyroxenite. The petrogenesis of the clinopyroxenite may include several possible origins. It is found in both the migmatite and the metasedimentary rocks, and it can be conformable or discordant. This suggests that both magmatic and metasedimentary clinopyroxenites are present. Locally, the clinopyroxenite contains up to 30% apatite as segregations or discontinuous layers within the boudins. This apatite-bearing clinopyroxenite may be genetically related to the suite of alkaline rocks as either disaggregated metasomatic veins or fragments of a magmatic ultramafic phase.

The migmatite typically takes on a different character towards the western edge of the map area, especially where it is found spatially associated with Ospwagan Group metasedimentary rocks or significant volumes of pegmatitic injection. The migmatite retains a strong gneissosity and is intensely folded; however, it becomes increasingly difficult to identify individual components within the rock. The mafic content is reduced and consists of trace–3% hornblende and 10–20% biotite, and the proportion of potassium feldspar is commonly equal to or greater than that of plagioclase (Figure GS-9-3).

Retrogressed enderbitic gneiss (unit 2)

As observed by Macek and Russell (1978), two varieties of enderbitic gneiss were identified: a biotite-rich variety and a hornblende-rich variety. A possible third variety consists of two-pyroxene enderbitic gneiss. The biotite enderbite makes up the largest volume of this unit. The hornblende enderbite occurs along the periphery, perhaps reflecting a compositional zonation in the original igneous body. All enderbitic phases contain pods of orthopyroxene- or hornblende-bearing leucosome that are attributed to the Archean M_2 event. The enderbitic gneiss underlies much of the western portion of the map area and forms a body tens of kilometres in length. Rare bands of enderbitic gneiss (potentially dikes) are observed within the multicomponent migmatite.

Retrogressed enderbitic biotite gneiss (subunit 2a)

The biotite enderbite is pinkish grey to brown-grey on the weathered surface and yellowish brown to greenish grey on the fresh surface, medium to coarse grained and foliated to strongly foliated. It is composed of trace–7% potassium feldspar, 2–10% orthopyroxene, 10–30% biotite, 20–30% quartz, and plagioclase. Locally the gneiss may contain 3–5% hornblende and up to 2% garnet, 3% clinopyroxene and 20% orthopyroxene. In general, the biotite content in the enderbite decreases as the amount of orthopyroxene increases. Rarely, pods of leucosome are clinopyroxene bearing. Local mafic clots composed dominantly of pyroxene were also observed.

Retrogressed enderbitic hornblende gneiss (subunit 2b)

The hornblende enderbite is light grey to pinkish grey, medium to coarse grained and foliated. It contains trace–5% biotite, 20–30% hornblende, 20–30% quartz, and plagioclase. The retrogressed enderbite locally contains 10–20% potassium feldspar. At the easternmost occurrence, the enderbite contains 7% hornblende

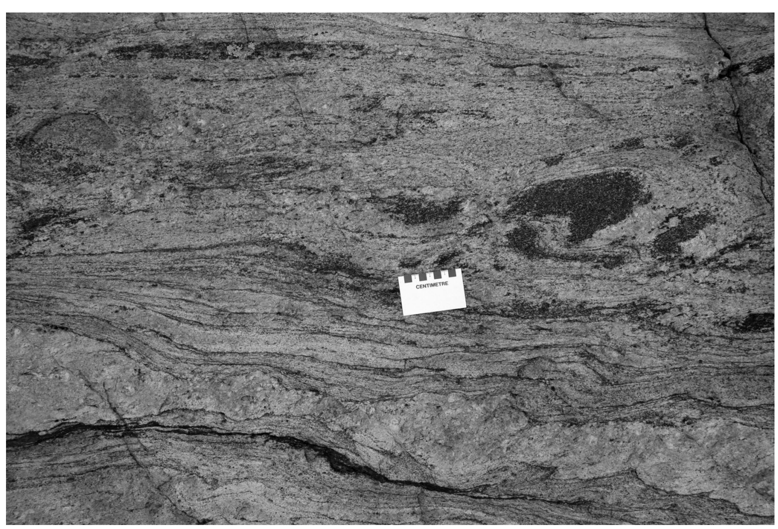

Figure GS-9-3: *Retrogressed multicomponent migmatite in which individual orthogneiss phases have become indistinct and the dominant feldspar is potassium feldspar. Nebulitic patches of amphibolite occur above and to the right of the scale card. Scale card is in centimetres.*

and 15% orthopyroxene. The hornblende enderbite hosts patches of leucosome containing stubby, poikiloblastic hornblende that may be a pseudomorphic replacement after orthopyroxene.

Two-pyroxene enderbitic gneiss (subunit 2c)

The two-pyroxene enderbite is light brownish grey on the weathered surface and green-grey to yellowish grey on the fresh surface. It contains 5–10% clinopyroxene, 5–15% orthopyroxene, 10–20% biotite, 20–30% quartz, and plagioclase. Up to 15% potassium feldspar is present as discrete segregations, which may represent incipient pools of leucosome. Pods of leucosome may contain 3–7% clinopyroxene and 10–20% orthopyroxene. The two-pyroxene enderbite occurs as discrete mappable patches within the biotite enderbite. It may represent masses of more pristine biotite or hornblende enderbitic gneiss, or may represent a third compositional phase of the enderbitic gneiss.

Layered mafic rocks (unit 3)

Macek and Russell (1978) divided the layered mafic rocks into four phases: metapyroxenite, layered metagabbro, layered anorthositic metagabbro and layered amphibolite. However, since the metapyroxenite and metagabbro are locally interlayered and exhibit a complete compositional gradation, these two rock types are merged into a single 'layered metagabbro' unit for the purpose of this report. The layered amphibolite is also included in the layered metagabbro unit, as it differs from the metagabbro only in that it contains little to no garnet. The layered anorthositic metagabbro unit was retained; however, due to the mafic content of the rock, it is renamed 'layered leucocratic metagabbro'. The two varieties of layered mafic rock are commonly spatially associated, and can form elongate bodies greater than 4 km long. The age relationship between the retrogressed enderbitic gneiss and the layered mafic rocks is not known.

Layered metagabbro (subunit 3a)

The layered metagabbro is greenish black to dark grey, medium to very coarse grained and weakly foliated to foliated. It is compositionally heterogeneous and layered on a centimetre to decimetre scale. The metagabbro consists of varying proportions of clinopyroxene, orthopyroxene, garnet, hornblende and plagioclase, with minor quartz. The composition of individual layers varies from metapyroxenite to leucocratic metagabbro. Quartz- and pyroxene-bearing, plagioclase-rich pegmatitic segregations occur locally within the metagabbro and appear to be primary igneous features. As a general rule, the abundance of hornblende in an outcrop generally decreases with increasing amounts of orthopyroxene. A similar relationship may also exist between orthopyroxene and garnet. Leucosome locally contains porphyroblasts of orthopyroxene. Leucosome also appears to have formed around porphyroblasts of garnet (Figure GS-9-4). Several metamorphic reactions appear to have taken place involving the minerals orthopyroxene, garnet, plagioclase, quartz and, presumably, hornblende. Poikiloblastic garnet that encloses orthopyroxene may, in turn, be rimmed by quartz and plagioclase. At some locations, garnet porphyroblasts appear to have been entirely consumed, replaced by knots of quartz and plagioclase. Garnet is also found in symplectic intergrowth with quartz and plagioclase.

Layered leucocratic metagabbro (subunit 3b)

The leucocratic metagabbro varies from dark pinkish grey to light grey on weathered surfaces and is dark honey brown on fresh surfaces. It is medium to very coarse grained and foliated. Layering occurs on a centimetre to decimetre scale and is manifested by changes in both composition and grain size. The leucocratic metagabbro is composed of variable proportions of orthopyroxene, garnet, hornblende, quartz and plagioclase. Magnetite and clinopyroxene may also be present in minor amounts. The mafic mineral content is less than 50% and may be as low

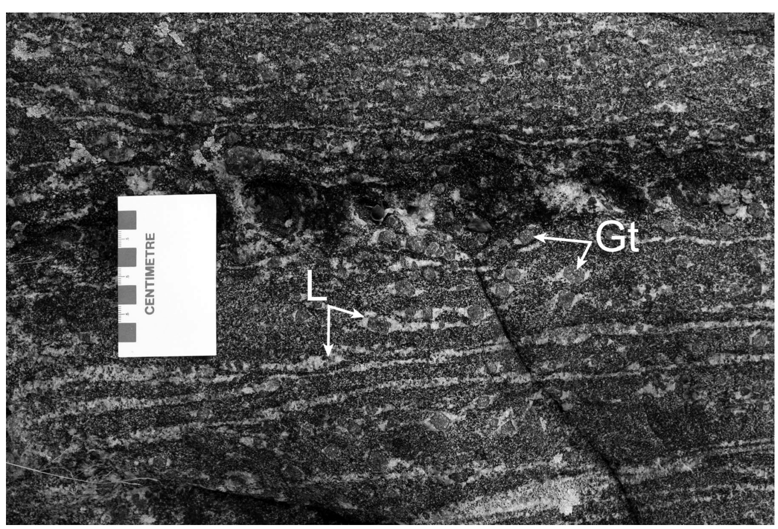

Figure GS-9-4: *Garnet-rich layered metagabbro, containing garnet porphyroblasts rimmed by quartz+plagioclase leucosome. Abbreviations: Gt, garnet; L, leucosome.*

as 20%. Quartz commonly forms up to 20% of the mode, indicating a composition approaching mafic tonalite. Patches of garnet-rich leucosome are common.

Rocks of uncertain age

Metasedimentary rocks (unit 4)

The metasedimentary rocks consist dominantly of metagreywacke and metapsammite, with subordinate metamorphosed iron formation and semipelite, and rare lenses of marble. These rocks may contain discontinuous bands of plagioclase amphibolite and granitoid injections, along with rare boudins and discontinuous layers of clinopyroxenite. They are found throughout the mapped area but are most common in the eastern portion.

Metagreywacke (subunit 4a)

The metagreywacke is light bluish grey to light brownish grey, medium grained and foliated to strongly foliated. It contains 5–15% garnet, 5–20% orthopyroxene, 10–30% biotite, 30–50% quartz, and plagioclase. In general, the amount of orthopyroxene is inversely proportional to the amount of garnet present, with garnet being most abundant towards the west and orthopyroxene towards the east. Orthopyroxene is often absent entirely in the western part of the map area. Outcrops with up to 30% orthopyroxene contain as little as 5% biotite. The metagreywacke locally contains minor amounts of graphite, iron sulphide, magnetite, hornblende and potassium feldspar. The metagreywacke is characterized by alternating, centimetre-thick layers of more psammitic and more aluminous compositions. Discontinuous layers and incipient pods of leucosome are common. The leucosome is generally potassium feldspar rich and becomes orthopyroxene bearing in the eastern part of the map area (Figure GS-9-5). The presence of orthopyroxene suggests that the leucosome is related to the Archean M_2 event. The absence of M_2 leucosome in these occurrences could be the result of Hudsonian retrogression and attenuation. It commonly contains centimetre- to decimetre-thick beds of metapsammite, iron formation and, more rarely, semipelite. The composition of the metagreywacke and metapsammite are gradational into one another.

The semipelite occurs as rare lenses and layers up to 20 cm thick in the metagreywacke and metapsammite. It is pinkish grey to grey, medium to very coarse grained and strongly foliated. The semipelite contains trace–7% sillimanite, 7–10% garnet, 30–50% biotite, and quartz and feldspar. Locally, it contains 1–2% iron sulphide and up to 20% garnet. No sillimanite is noted in semipelite from the eastern part of the map area; however, a subtle bluish tint to the rock may suggest the presence of groundmass cordierite. Abundant leucosome is present in most semipelite lenses. The leucosome is rich in potassium feldspar and locally orthopyroxene bearing.

Metapsammite (subunit 4b)

The metapsammite is white to light grey to pinkish grey, medium to coarse grained and foliated to mylonitic. It contains trace–7% garnet, 2–5% orthopyroxene, 2–10% biotite, 30–70% quartz, and plagioclase. Minor amounts of iron sulphide and graphite are locally present. Discrete layers contain up to 90% quartz. As with the metagreywacke, the amount of garnet and orthopyroxene are generally inversely proportional, with orthopyroxene more common towards the east and garnet towards the west. The metapsammite is generally layered on a centimetre scale and locally contains centimetre- to metre-thick beds of metagreywacke and, more rarely, semipelite. The metapsammite contains rare 'concretions' that are composed of 7–10% garnet and quartz with minor carbonate. These concretions are similar in composition and scale to those that characterize the Setting Formation of the Ospwagan Group (Zwanzig et al., 2007).

Iron formation (subunit 4c)

The iron formation is dark greenish grey to brownish red, fine to very coarse grained, foliated to strongly

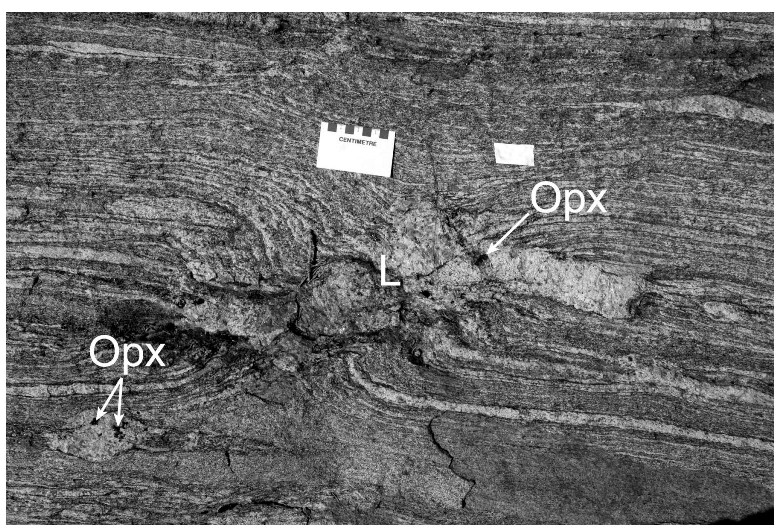

Figure GS-9-5: *Orthopyroxene-bearing leucosome in metagreywacke, interpreted as Archean M_2 leucosome. The leucosome was pooled in the extensional regime of a boudin neck. Scale card is in centimetres. Abbreviations: L, leucosome; Opx, orthopyroxene.*

foliated and, in places, strongly magnetic. The composition is generally that of silicate-facies iron formation with varying proportions of biotite, pyrrhotite, hornblende, magnetite, orthopyroxene, garnet and quartz, and minor feldspar. Rare oxide-facies iron formations were observed, containing up to 30% magnetite and quartz with minor feldspar. The iron formation is characterized by alternating, millimetre- to centimetre-scale siliceous and ferruginous layers, and intense gossan staining on weathered surfaces. It occurs as local bands, up to 3 m thick, in the metagreywacke and isolated lenses, up to 10 m thick, in the migmatite.

Marble (subunit 4d)

A single, 50 cm layer of marble is hosted by metagreywacke. It is dark grey on the weathered surface and greenish white on the fresh surface, medium to coarse grained and foliated to mylonitic. The marble contains 3–5% diopside, 30–40% serpentinized olivine, and carbonate. A deep red mineral, likely either a humite group mineral or garnet, makes up 2–3% of the rock. The abundance of serpentinized olivine and the presence of humite group minerals make it similar to marble in the Thompson Formation (T3 Member of the Ospwagan Group; Zwanzig et al., 2007). Although no visible magnetite or sulphide was noted, the rock is moderately magnetic in places, which may help differentiate it from marble of the Ospwagan Group.

The marble is separated from the metagreywacke by a rind of calcsilicate. The calcsilicate is green, coarse to very coarse grained and massive. It is composed of 5–7% tremolite, 80–90% diopside, and quartz and carbonate. Similar discontinuous layers and boudins of calcsilicate/clinopyroxenite, up to 20 cm thick, are common within the metagreywacke.

Plagioclase amphibolite (unit 5)

Plagioclase amphibolite occurs as large masses, discontinuous bands or boudins in almost every outcrop on Paint Lake. It is dark grey to dark green-grey, fine to medium grained and foliated. It is generally composed of trace–7% clinopyroxene, 50–70% hornblende, and plagioclase. Minor amounts of garnet may be present, and orthopyroxene locally accounts for up to 15% of the rock in the eastern part of the map area. Amphibolite bodies vary from centimetres to tens of metres in size and range from relatively homogeneous to strongly gneissic. It is likely that the plagioclase amphibolite is derived from mafic rocks of various ages, perhaps including Paleoproterozoic Molson dikes.

Granitoid rocks (unit 6)

Two granitoid rocks of uncertain age are present at Paint Lake: granodiorite and leucogranite. These granitoid rocks are tentatively interpreted as Proterozoic. They are observed as dikes and intrusive bodies in all Archean rock types; however, they have not been observed intruding known Proterozoic rocks. They are foliated and predate the Hudsonian D_3 folding event. These phases commonly occur as bands or dikes in the multicomponent migmatite. A previously sampled granitoid in multicomponent migmatite from Paint Lake yielded a Paleoproterozoic Sm-Nd model age (C. Böhm, pers. comm., 2008), indicating that Hudsonian granitic rocks are present.

Granodiorite (subunit 6a)

The granodiorite ranges from centimetre-thick dikes up to large elongate bodies hundreds of metres thick and greater than a kilometre long. It is light grey to pale pinkish grey, fine to medium grained and weakly foliated to foliated. It contains 10–20% potassium feldspar, 20–30% quartz, and plagioclase. The mafic mineral content is generally 10–15% and consists of hornblende and/or biotite. Up to 2% magnetite and 2% garnet may also be present. Centimetre-scale metamorphic banding is often present. Locally, the granodiorite is porphyritic with potassium feldspar phenocrysts up to 2 cm across. The phenocrysts are commonly rounded and are locally stretched parallel to the regional lineation. Granodiorite dikes occur in all portions of the map area and are generally subparallel to the regional foliation.

Leucogranite (subunit 6b)

The leucogranite is light pink to white, medium to coarse grained and foliated. It is composed of 2–7% biotite, 20–30% quartz, 20–40% plagioclase, and potassium feldspar. Magnetite and garnet locally occur in trace amounts. The mafic content of the leucogranite is generally less than 5%. The rock occurs as centimetre- to metre-scale dikes that are generally subparallel to the regional foliation.

Paleoproterozoic rocks

Ospwagan Group (unit 7)

Several outcrops of Ospwagan Group metasedimentary rocks were observed along the western margin of the map area that had been previously identified by Macek et al. (2006). They consist of Manasan Formation quartzite and semipelite with minor Thompson Formation calcsilicate (T1 Member). The interested reader is referred to Macek et al. (2006) and Zwanzig et al. (2007) for descriptions of these units.

Alkaline igneous suite (unit 8)

Two rocks of possible alkaline affinity were recognized. White pegmatite dikes lacking quartz were recognized in two locations, and a series of small carbonatite-like dikes were observed at a dozen locations. These rocks are interpreted as Proterozoic in age. They are commonly foliated but crosscut the gneissosity of the Archean country rock. Locally, the carbonatite-like dikes crosscut foliated pink pegmatite dikes. Additional petrographic and geochemical data are required to properly categorize these rocks.

White pegmatite (subunit 8a)

The two occurrences of white pegmatite form dikes up to 4 m across. The dikes are medium to very coarse grained and massive to weakly foliated. They consist of white feldspar with 3–5% apatite and 10–20% mafic minerals. The mafic minerals in one dike consist solely of biotite, while the other contains clinopyroxene with hornblende rims. The apatite occurs as blue-green prisms that can form clots up to 1 cm across and are strongly associated with the mafic mineral phase. Both occurrences of white pegmatite are accompanied by the presence of carbonatite-like dikes.

Carbonatite-like dikes (subunit 8b)

The carbonatite-like dikes range from centimetres up to 3 m in thickness (Figure GS-9-6). Although a few scattered occurrences of these dikes were observed, the majority lie along a 5 km trend that continues to the north-eastern edge of the map area. The dikes are rusty orange-brown to powdery yellow on the weathered surface and pink to white on the fresh surface. They are fine to very coarse grained, massive to foliated and, in places, strongly magnetic. Their composition is somewhat variable. They contain trace to minor amounts of pyrite, biotite, titanite and magnetite, up to 25% apatite, 30% clinopyroxene, and pink to white carbonate. Occasional magnetite-rich dikes may contain up to 25% magnetite as irregularly shaped grains up to 3 cm across. They typically contain abundant, randomly oriented xenolithic/xenocrystic material that has been entrained from the country rock (Figure GS-9-7). Xenoliths are characterized by a saccharoidal texture. The dikes are lined by selvages of clinopyroxene- and apatite-rich rock composed of 3–5% titanite and approximately equal proportions of clinopyroxene and apatite. The apatite commonly forms masses up to 5 cm across along dike margins.

Migmatitic gneiss and amphibolite country rock hosting the carbonatite-like dikes typically has a bleached appearance caused by alkali metasomatism (Figure GS-9-8): the hornblende is typically replaced by clinopyroxene, plagioclase appears to be at least partially replaced by alkali feldspar, quartz is reduced to only minor amounts or is absent, and trace to minor amounts of magnetite and titanite are added to the rock. Gneissic banding is generally preserved; however, the rock is typically granoblastic. Pink pegmatite dikes in these outcrops contain minor amounts of magnetite, 5–10% clinopyroxene and less than 15% quartz. It is not clear if this is the effect of metasomatism or a primary magmatic feature.

Pink pegmatite (unit 9)

Simple quartz-feldspar pegmatite is found throughout the map area. It occurs as centimetre- to metre-scale dikes and large bodies greater than 1 km thick. The pegmatite is coarse to very coarse grained and ranges from massive to mylonitic. It is composed of 10–30% plagioclase, 20–30% quartz, and potassium feldspar. Biotite is common and may constitute up to 12% of the mode. Up to 3% garnet may be present, especially when the dike is in close proximity to metasedimentary or layered mafic rocks. Three to five percent magnetite occurs as rare iridescent blue grains. Locally, the pegmatite contains up to 10% of a metamict mineral, also observed by Charbonneau et al. (1979). The mineral, tentatively identified as allanite, is dark brown and earthy on the weathered surface, and vitreous to resinous black on the fresh surface. It forms euhedral prismatic grains up to 1 cm across, even in mylonitized dikes. The allanite appears to be associated with late, anastomosing fractures.

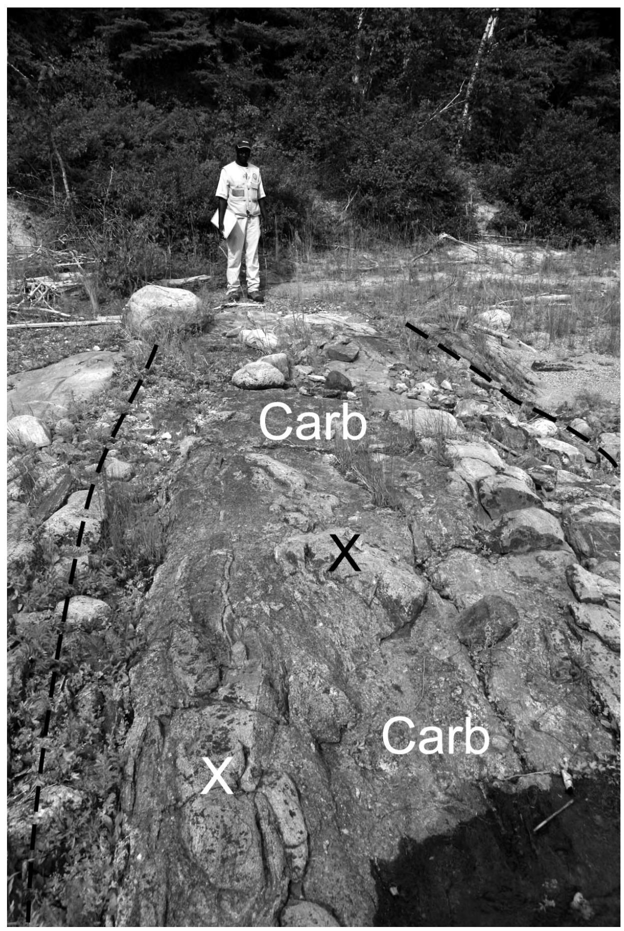

Figure GS-9-6: *Carbonatite-like dike approximately 3 m wide (dashed lines define the approximate dike boundary). Xenoliths consist dominantly of clinopyroxene-bearing pegmatite and metasomatized hornblende gneiss. Field assistant J. Duku for scale. Abbreviations: Carb, carbonate-rich matrix; X, xenolithic fragments of country rock.*

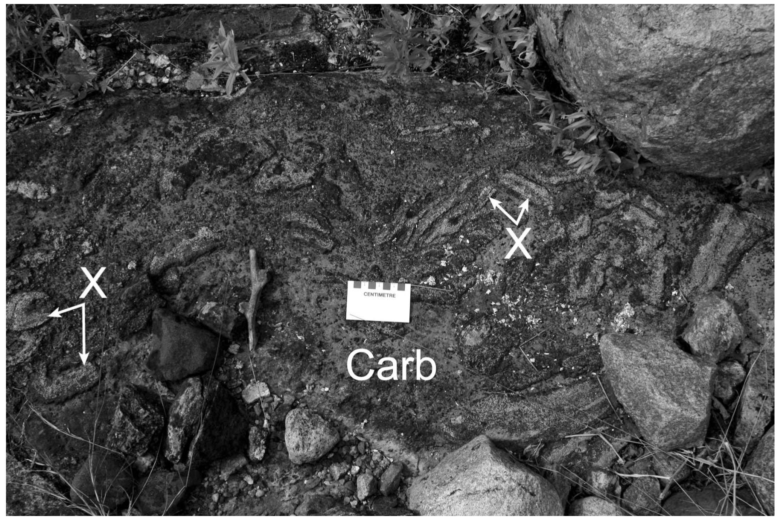

Figure GS-9-7: *Randomly oriented xenoliths in the carbonatite-like dike pictured in Figure GS-9-6. Xenoliths have a saccharoidal texture. Scale card is in centimetres. Abbreviations: Carb, carbonate-rich matrix; X, xenolithic fragments of country rock.*

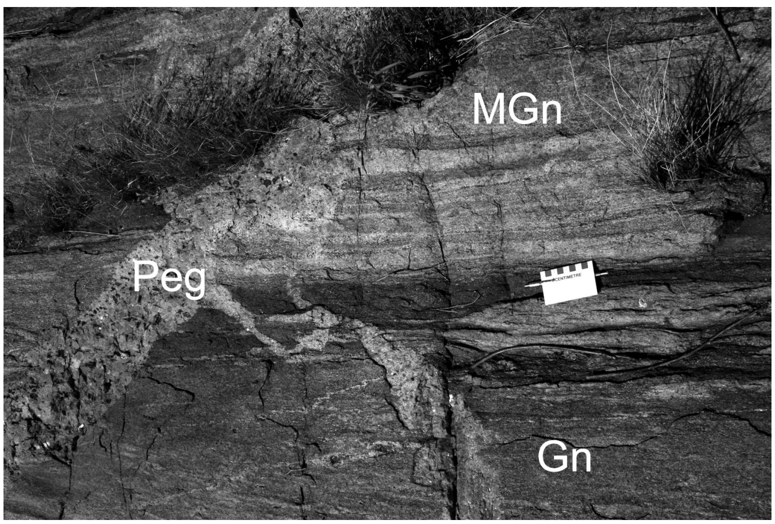

Figure GS-9-8: *Metasomatized and unmetasomatized hornblende gneiss cut by clinopyroxene-bearing pegmatite. The metasomatized gneiss consists dominantly of alkali feldspar and clinopyroxene. The unmetasomatized gneiss is composed dominantly of hornblende, quartz and plagioclase. Relict gneissic banding is preserved in the metasomatized gneiss. Scale card is in centimetres. Abbreviations: Gn, hornblende gneiss; MGn, metasomatized gneiss; Peg, pegmatite.*

Structure and metamorphism

The gneissic rocks of Paint Lake are highly strained and show evidence of both Archean and Hudsonian deformation and metamorphism. The dominant structures in the map area consist of upright, shallow to moderately plunging folds with axes trending roughly 045°. The folds are Hudsonian structures related to the D_3 event described by Bleeker and Macek (1996). The regional foliation has also been folded around these structures and has a general of trend of approximately 045° with a very steep dip. Along the western side of the map area, the orientation of these structures is rotated to approximately 025°. The majority of foliated pegmatite dikes have similar trends, roughly subparallel to the regional foliation. Massive pegmatite dikes however, are more randomly oriented.

The highly strained nature of the rocks can result in the migmatite and metasedimentary rocks having the appearance of straight gneiss. More competent layers are boudinaged in the majority of outcrops. Zones of mylonitization, locally accompanied by ultramylonite, indicate the positions of shear zones, likely coeval with or postdating Hudsonian D_3. Later brittle faults are also present and result in localized fracturing of the rocks, accompanied by hematization, chloritization and epidotization.

Archean structures have been largely overprinted by the Hudsonian deformation. Gneissic components within the migmatite commonly display complex internal fold patterns. Locally, Archean M_2 leucosome can be observed pooled in boudin necks created by the D_2 deformation (Figure GS-9-5).

The abundance of orthopyroxene in the enderbite, metasedimentary rocks and migmatite generally decreases from east to west across the map area. This indicates that Hudsonian retrogression/hydration progressively overprinted Archean granulite assemblages towards the west.

Economic considerations

The largest nickel deposits of the TNB are hosted by Ospwagan Group metasedimentary rocks; therefore, the recognition of Archean metasedimentary rocks with characteristics similar to those of the Ospwagan Group has important implications for exploration. Ultramafic bodies that have intruded Ospwagan Group metasedimentary rocks have much greater potential of forming magmatic nickel deposits than ultramafic bodies hosted by Archean gneiss. The recognition of an Archean metasedimentary sequence, including quartzite with garnet-bearing concretions, iron formations and olivine marble, presents an additional complicating factor in an area already made challenging for mineral exploration by the intense deformation and high metamorphic grade.

As mentioned by Charbonneau et al. (1979), molybdenite flakes occur as rare isolated lenses up to 3 cm long. No association could be established between the molybdenite and any one rock type. Three isolated knots of molybdenite were observed in migmatitic hornblende gneiss, metapsammite and metagreywacke. No associated metasomatism or trends were identified.

The possible presence of alkaline igneous rocks, including carbonatite, suggests additional potential for mineral deposits in the region, including Fe, Nb, rare-earth elements (REE) and other commodities. Mineralization of this type is present in the Eden Lake complex, an REE prospect along the southern margin of the Lynn Lake Belt where REE mineralization occurs in hydrothermal and carbothermal[2] rocks associated with carbonatite dikes (Mumin and Corriveau, 2004).

Acknowledgments

The author thanks J. Duku, B. Coyston, and T. Martins for their field assistance, as well as N. Brandson for logistical support. T. Corkery, J. Macek and C. Böhm are thanked for their discussions and advice in and out of the field.

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[2] defined by Mitchell (2005) as a "low temperature fluid derived from a fractionated magma dominated by CO_2 but also containing fluorine and H_2O in variable proportions."