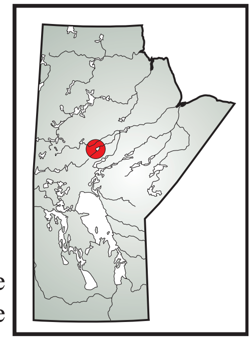
GS-10 Progress report of geological mapping at Paint Lake, Manitoba (parts of NTS 63O8, 9, 63P5, 12)

by C.G. Couëslan



Couëslan, C.G. 2009: Progress report of geological mapping at Paint Lake, Manitoba (parts of NTS 63O8, 9, 63P5, 12); *in* Report of Activities 2009, Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, p. 108–117.

Summary

This report follows the second summer of geological mapping in the Paint Lake area with the purpose of improving the understanding of the Archean basement to the Thompson Nickel Belt (TNB). The area is underlain predominantly by multicomponent gneiss with significant exposures of enderbitic gneiss and layered mafic rocks along the west side of the lake. A sequence of possibly Archean supracrustal rocks, consisting dominantly of metagreywacke and metapsammite with minor iron formation, metapelite and metavolcanic rocks, is present as disrupted bands along the east and west shores, and as a relatively continuous belt through the central islands of the lake. A variably metasomatized melasyenite intrusion with dikes of alkali-feldspar granite has been identified in the southwest corner of the lake. A carbonatite dike swarm identified in the previous year has been extended along strike for over 21 km and may continue north of the currently mapped area. The dominant structures in the area consist of upright, shallowly to moderately plunging isoclinal folds that have deformed the regional foliation. Significant shear zones are manifested by metre-scale zones of mylonite to ultramylonite along the east shore of the lake.

Similarities exist between the Archean supracrustal rocks and the nickel deposit–hosting Ospwagan Group supracrustal rocks. This could create additional difficulty for exploration in the region, with the potential for mistaken identification of Ospwagan Group rocks in areas of low nickel potential. The presence of carbonatite dikes introduces the potential for additional magmatic and hydrothermal deposit types in the area.

Introduction

Remapping of the geology in the Paint Lake area was initiated in the summer of 2008 (Couëslan, 2008), 30 years after the last mapping projects in the late 1970s (Macek and Russell, 1978; Charbonneau et al., 1979), with the goal of improving our understanding of the nature of the Archean basement to the Thompson Nickel Belt (TNB). This new phase of mapping identified a package of possibly Archean metasedimentary rocks and a swarm of carbonatite dikes. Summer field activities in 2009 have expanded the areal extent of these units and have also resulted in several new findings.

Geological overview

Paint Lake occurs along the eastern edge of the TNB (Figure GS-10-1). It is largely underlain by Archean gneisses, derived from the Pikwitonei Granulite Domain, which were variably retrogressed and structurally overprinted during the Trans-Hudson orogeny (Hubregtse, 1980; Russell, 1981; Bleeker and Macek, 1996). The Archean gneisses are interpreted to have undergone two major tectonometamorphic events during the Kenoran orogeny accompanied by isoclinal folding and culminating in granulite-grade metamorphism during the Archean D_2/M_2 event (Hubregtse, 1980; Mezger et al., 1990).

During the Trans-Hudson orogeny, the Archean gneisses and overlying Paleoproterozoic rocks were affected by three main events (Bleeker and Macek, 1996). The Hudsonian D_1 and D_2 events resulted in east-verging, recumbent and isoclinal folds. The S_2 fabrics were later folded into northeast-trending, upright, isoclinal F_3 folds. Extensive post-F_3 mylonitization occurs in shear zones that parallel the limbs of the F_3 folds. Peak Hudsonian metamorphism is interpreted as accompanying the D_2 event, but may have continued into early D_3. The Paint Lake area attained at least upper-amphibolite–grade metamorphic conditions and may have locally reached lower-granulite grade during the Trans-Hudson orogeny (Couëslan et al., 2007).

Lithological units

The descriptions provided here are summarized from Couëslan (2008), with the addition of new observations made during the 2009 field season. New units not previously described will also be discussed in greater detail. The units described below appear on preliminary map PMAP2009-3 (Couëslan, 2009).

Archean rocks

Multicomponent gneiss (unit 1)

Multicomponent gneiss is the dominant rock type in the Paint Lake area. It consists of varying proportions of hornblende gneiss, biotite gneiss, plagioclase amphibolite, leucogranodiorite, granodiorite, aplite, pegmatite and assorted ultramafic blocks and boudins (Figure GS-10-2). Rare bands of enderbitic gneiss, layered mafic rock and iron formation can also be present. These rock types occur as intermixed, highly attenuated, centimetre- to metre-scale bands. Hornblende and biotite gneisses are generally

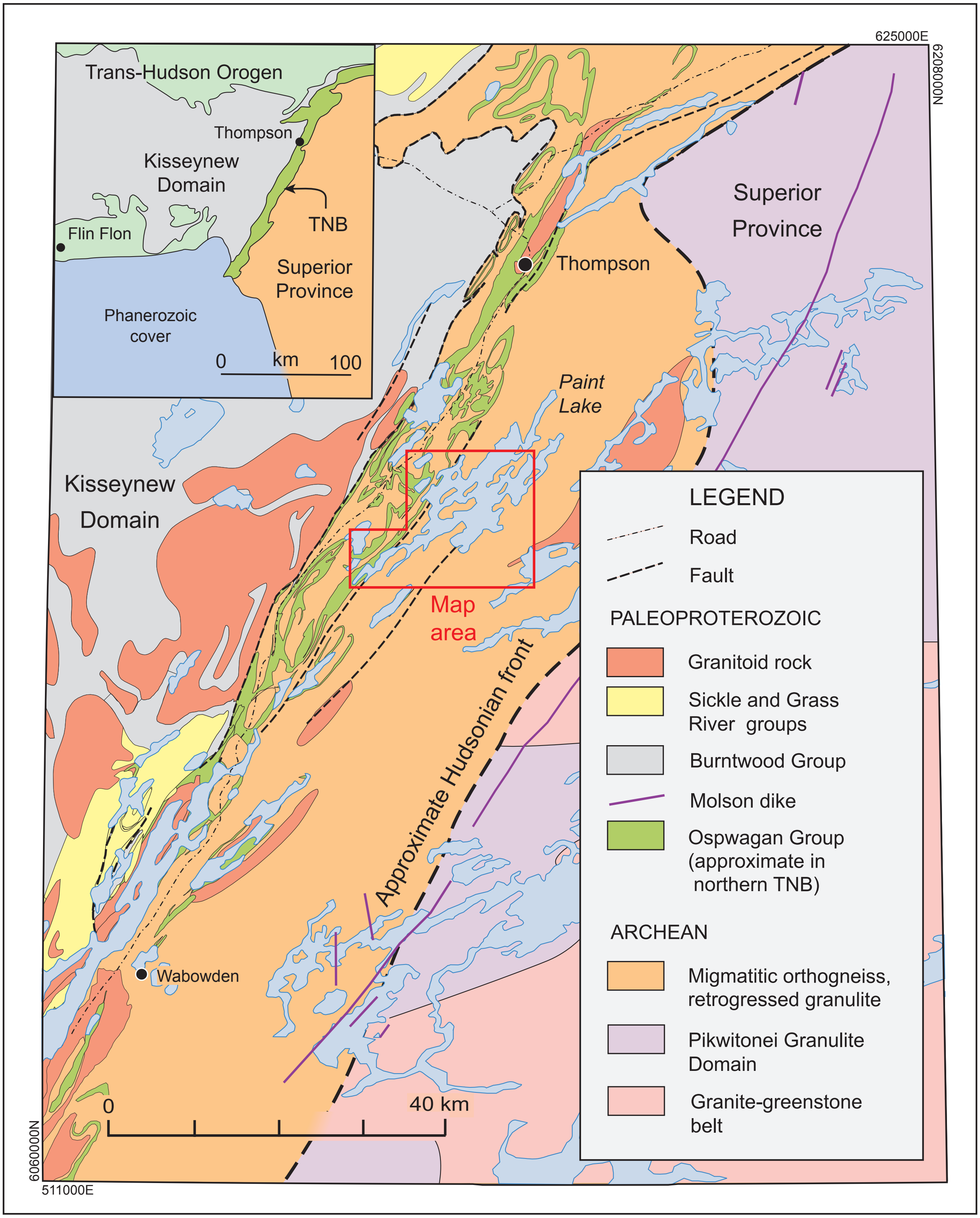


***Figure GS-10-1**: Simplified geology of the Thompson Nickel Belt and location of the map area at Paint Lake, Manitoba.*

__Figure GS-10-2:__ Multicomponent gneiss consisting of dominantly hornblende gneiss with narrow bands and rotated blocks of plagioclase amphibolite and sheared-in pegmatitic material. Scale card is in centimetres.

tonalitic to granodioritic and the majority of phases within the multicomponent gneiss are considered to be orthogneiss. It is locally highly strained and intensely folded.

The character of the multicomponent gneiss changes where it is associated with large volumes of pegmatite and towards the western edge of the map area, especially where it is spatially associated with Ospwagan Group metasedimentary rocks. The individual components of the gneiss become increasingly difficult to identify, the mafic content is reduced and hornblende and plagioclase generally become subordinate to biotite and potassium feldspar, respectively.

Enderbitic gneiss (unit 2)

Variably retrogressed enderbitic gneiss underlies much of the westernmost islands and the shoreline of Paint Lake. Two main varieties of enderbitic gneiss were observed: a biotite-rich variety (subunit 2a) and hornblende-rich variety (subunit 2b). The two varieties of enderbite are spatially associated, with the hornblende enderbite generally occurring along the periphery of the biotite enderbite. This association may reflect a compositional zonation of the original igneous body. Two-pyroxene enderbitic gneiss (subunit 2c) is a relatively minor phase that occurs as patches within the biotite enderbite.

Layered mafic rocks (unit 3)

Layered mafic rocks occur throughout the Paint Lake area; however, the largest bodies occur in the north-central part of the map sheet. The layered mafic rocks consist of layered metagabbro (subunit 3a) and a layered leucocratic metagabbro (subunit 3b). Metagabbro is compositionally and texturally heterogeneous and layered on a centimetre to decimetre scale. It contains varying proportions of clinopyroxene, orthopyroxene, garnet, hornblende, plagioclase and minor quartz. Leucocratic metagabbro is also compositionally heterogeneous. It is composed of variable proportions of orthopyroxene, garnet, hornblende, quartz, plagioclase and minor clinopyroxene and magnetite. The mafic mineral content of the leucocratic metagabbro is less than 50% and can be as low as 15%.

Rocks of uncertain age

Supracrustal rocks (unit 4)

Supracrustal rocks consist dominantly of metagreywacke and metapsammite, with subordinate iron formation, metapelite and possible metavolcanics. They occur in disrupted belts along both the east and west shores of Paint Lake, and as a relatively continuous belt through the central islands of the lake. The belts strike subparallel to the regional fabrics/structure. The local presence of orthopyroxene-bearing leucosome in the metagreywacke indicates the supracrustal rocks have been subjected to granulite-grade metamorphism and are potentially Archean.

Metagreywacke (subunit 4a) is characterized by alternating, centimetre-thick layers of more siliceous and more aluminous compositions. It generally contains 15–30% mafic minerals, 30–50% quartz, and plagioclase. Weathered surfaces are characterized by a light gossan stain, suggesting trace to minor amounts of sulphide is typically present. Mafic minerals consist of variable proportions of biotite, garnet and orthopyroxene, and typically the amount of orthopyroxene is inversely proportional to the amount of garnet. Orthopyroxene is generally absent in the westernmost occurrences of metagreywacke. It remains unclear whether the presence of garnet relative to orthopyroxene is a factor of metamorphic grade/retrogression or the composition of the protolith. Local semipelitic layers contain up to 20% garnet and 50% biotite, with trace amounts of hercynite. Metagreywacke commonly contains centimetre- to decimetre-thick beds of metapsammite and iron formation, and rare metapelite.

Metagreywacke and metapsammite are locally gradational into one another.

Metapsammite (subunit 4b) is layered on a centimetre scale. It contains 5–15% mafic minerals, 30–70% quartz, and plagioclase. Mafic minerals consist of varying proportions of garnet, orthopyroxene and biotite. Similar to the greywacke, the amount of orthopyroxene present is inversely proportional to the amount of garnet present. Centimetre- to metre-scale beds of metagreywacke are not uncommon. Outcrops of metapsammite are locally interbedded with centimetre-thick layers and lenses of metapelite. In rare instances, metapelite can form more extensive units up to several metres thick. Metapsammite contains rare concretions that are composed of 10–15% garnet, quartz and minor carbonate. Concretions have so far been observed only in outcrops with interbeds of metapelite. Rare examples of calcareous metapsammite are also present on Paint Lake in which the psammite contains diopside- and tremolite-rich laminations.

Iron formation (subunit 4c) is dominantly silicate facies with varying proportions of biotite, pyrrhotite, hornblende, magnetite, orthopyroxene, garnet, quartz and minor feldspar. Rare oxide facies iron formation is present, containing up to 30% magnetite and variable proportions of quartz and garnet. Iron formation varies from massive to well-laminated with alternating ferruginous and chert-rich layers. Weathered surfaces are generally gossan stained. Iron formation forms local centimetre- to metre-scale bands in metagreywacke and isolated lenses up to 10 m thick in the multicomponent gneiss.

Metapelite (subunit 4d) occurs as lenses and layers up to 30 cm thick, interbedded with metapsammite (Figure GS-10-3). Rare metre-scale, mappable units also occur with interbedded layers of metapsammite up to 10 cm thick. Metapelite is typically coarse-grained and strongly foliated. It is composed of 2–5% sillimanite, 5–30% garnet, 20–40% biotite, and quartz and feldspar. Locally the pelite contains up to 20% sillimanite and 50% biotite. The easternmost occurrence of metapelite, which is also the largest, is very coarse grained, containing garnet up to 7 cm across and 3–5% cordierite.

A discrete banded gneiss unit enclosed in metapsammite was identified at two locations along strike in east-central Paint Lake. It consists of gradational, alternating mafic, intermediate and felsic bands that are laterally continuous and of a uniform thickness at outcrop scale (Figure GS-10-4), and is tentatively interpreted as metavolcanic (subunit 4e). The metavolcanic rocks are banded on a centimetre to decimetre scale and consist of approximately equal proportions of felsic and intermediate bands with subordinate mafic bands. Felsic bands are honey yellow and consist largely of plagioclase with 20–40% quartz and minor biotite, hornblende and orthopyroxene. Intermediate bands are pale yellowish grey and are composed of plagioclase with minor orthopyroxene, hornblende and quartz, with trace amounts of biotite. Mafic bands are dark green–grey and contain plagioclase with 40–50% hornblende and 10–20% clinopyroxene. Laterally continuous beds of metapsammite up to 30 cm thick are locally present within the package of metavolcanics.

Plagioclase amphibolite (unit 5)

Large masses, discontinuous bands, and boudins of plagioclase amphibolite are ubiquitous in the Paint Lake area, occurring in almost all outcrops. The amphibolite bodies vary from centimetres to tens of metres in size and range from rather homogeneous to strongly gneissic. They are likely derived from mafic rocks of various ages, including Paleoproterozoic Molson dikes.

Granitoid rocks (unit 6)

Granitoid rocks consist of small dikes and larger bodies of granodiorite and leucogranodiorite. The intrusive bodies are generally subparallel to the regional foliation. The granitoid rocks are likely of a variety of ages;

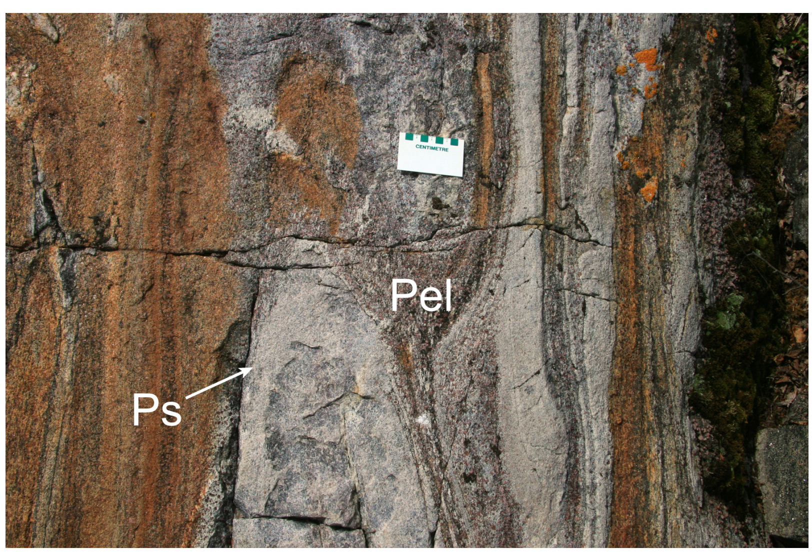


Figure GS-10-3: *Interbedded metapelite and metapsammite. Scale card is in centimetres. Abbreviations: Pel, metapelite; Ps, metapsammite.*

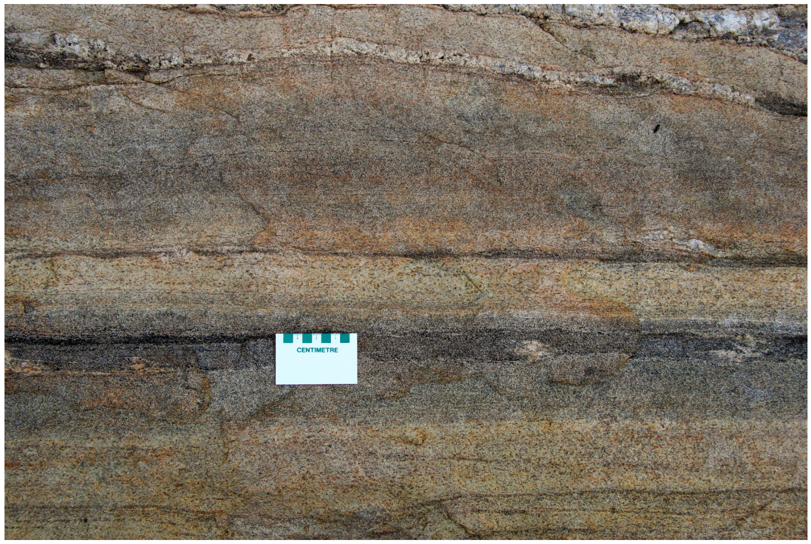


__Figure GS-10-4:__ Gradationally banded gneiss interpreted as metavolcanic rocks. Scale card is in centimetres.

however, they are interpreted to be dominantly Paleoproterozoic.

Granodiorite (subunit 6a) occurs in all portions of the map area, ranging from centimetre-thick dikes to large elongate bodies hundreds of metres thick and greater than 1 km long. It is foliated and crude centimetre-scale metamorphic banding is common. It contains 7–15% mafic minerals consisting of hornblende and/or biotite and is locally porphyritic.

Leucogranodiorite (subunit 6b) forms centimetre- to metre-scale dikes throughout the map area and a larger elongate body approximately 600 m thick and 5 km long in the southeast portion of the lake. Leucogranodiorite is white to light grey, medium- to coarse-grained, foliated and moderately magnetic. It contains plagioclase with 30–40% quartz, 7–20% potassium feldspar and less than 7% mafic minerals. The mafic minerals consist of nearly equal proportions of garnet, magnetite and biotite. Diffuse, anomalously siliceous patches with 40–50% quartz are common and patches with up to 80% quartz have been observed.

Paleoproterozoic rocks

Ospwagan Group (unit 7)

A narrow band of Ospwagan Group metasedimentary rocks occur along the western side of the lake. They consist of Manasan Formation quartzite (M1 member) and semipelite (M2 member) with minor siliceous sediment fragments and calcsilicate boudins of Thompson Formation (Figure GS-10-5). The M1 quartzite is laminated to finely layered and contains trace garnet, trace to 5% biotite, 5–10% feldspar, and quartz. The overlying M2 semipelite contains trace to 1% garnet, 20–30% biotite, 30–40% quartz, and a greater proportion of potassium feldspar than plagioclase. At the southwest corner of the lake, semipelite is diatexitic and all evidence of primary sedimentary structures is erased. The Thompson Formation calcsilicate occurs as boudins hosted by the M2

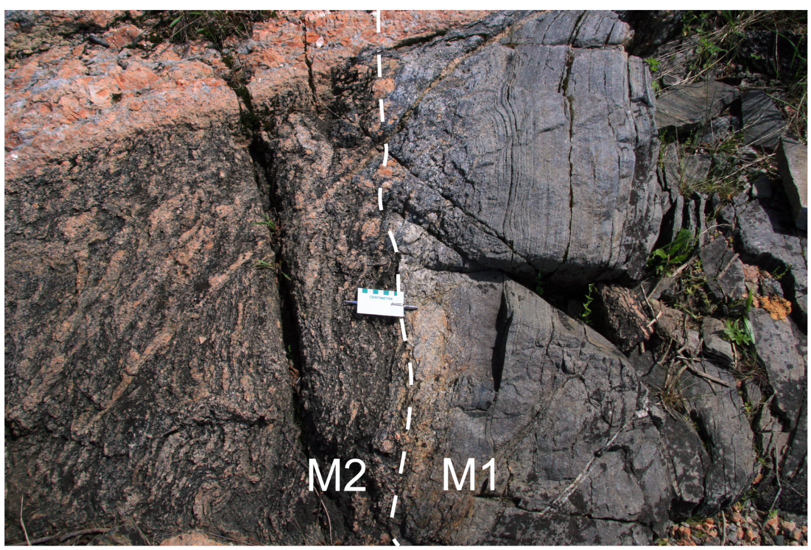


__Figure GS-10-5:__ Ospwagan Group metasedimentary rocks consisting of Manasan Formation M1 quartzite and M2 semipelite. The M2 semipelite is a diatexite with little or no sedimentary structures remaining. Scale card is in centimetres.

semipelite. The calcsilicate consists dominantly of diopside with minor hornblende, biotite, quartz, feldspar and local carbonate. The remainder of the Ospwagan Group sequence has either been truncated or is not exposed. The metasedimentary rocks are steeply dipping to vertical and facing towards the east.

Metapyroxenite (unit 8)

Although ultramafic blocks and boudins are ubiquitous in the Paint Lake area, they are rarely large enough to form mappable units. An outcrop of metapyroxenite is located in the southwest corner of Paint Lake. Metapyroxenite is dark green, coarse- to very coarse grained and weakly foliated. It contains trace to minor amounts of phlogopite, 7–10% quartz, 10–15% amphibole, and orthopyroxene. The rock appears relatively homogeneous with the exception of quartz- and plagioclase-bearing pockets with up to 12% felsic minerals. The metapyroxenite is found spatially associated with the melasyenite (subunit 9a); however, this does not necessarily infer a genetic relationship.

Melasyenite complex (unit 9)

An elongate body of melasyenite is present in the southwest corner of the map area. It is up to 700 m thick and greater than 7 km long. The majority of melasyenite outcrops are characterized by some degree of metasomatism and the presence of alkali-feldspar granite dikes.

Melasyenite (subunit 9a) is dark brown, weakly foliated and characterized by very coarse grained, dark grey to black potassium feldspar phenocrysts up to 3 cm long in a medium- to coarse-grained matrix of reddish brown biotite, hornblende, and honey brown potassium feldspar with less than 5% quartz (Figure GS-10-6a). Trace to minor amounts of orthopyroxene, apatite and zircon are also present in the groundmass. The phenocrysts commonly display Carlsbad twinning and locally have pale yellow cores. Hornblende forms less abundant phenocrysts up to 2 cm across.

In the vicinity of alkali-feldspar granite dikes, the melasyenite becomes variably metasomatized (Figure GS-10-6b). The colour can vary from dark purplish grey to dark pinkish brown to brick red, and the rock becomes foliated to locally mylonitic. Potassium feldspar phenocrysts become rounded and the dark grey to black colouration becomes progressively replaced by pink to red. The groundmass of the metasomatized syenite consists of trace amounts of apatite, up to 10% quartz, and variable amounts of biotite, hornblende and green amphibole with generally either biotite or hornblende dominating.

Alkali-feldspar granite (subunit 9b) occurs as dikes up to 1 m thick hosted by the melasyenite. It is reddish pink to orangey pink, medium- to coarse-grained and foliated. The granite generally contains minor clinopyroxene or amphibole, 15–30% quartz, and potassium feldspar; however, it locally contains up to 3% titanite and 30% clinopyroxene, and larger dikes commonly contain less than 5% quartz.

The melasyenite complex lies along strike with the carbonatite dike swarm. The lack of nepheline-bearing or other strongly alkaline rocks in the complex is not suggestive of a cogenetic relationship between the carbonatite and melasyenite. No carbonatite dikes or other carbonate-bearing magmatic phases were observed as far south as the melasyenite complex. It is possible the melasyenite and carbonatite dike swarm used the same zone of crustal weakness as a conduit for magma emplacement.

Carbonate-rich dikes (unit 10)

A swarm of small carbonate-rich dikes is present through the central islands of the lake over a strike length of greater than 21 km, with a width of up to 500 m. The dikes are foliated and strike subparallel to the regional structures, cutting the gneissosity of the Archean country rock at a low angle. The age of the dikes is interpreted

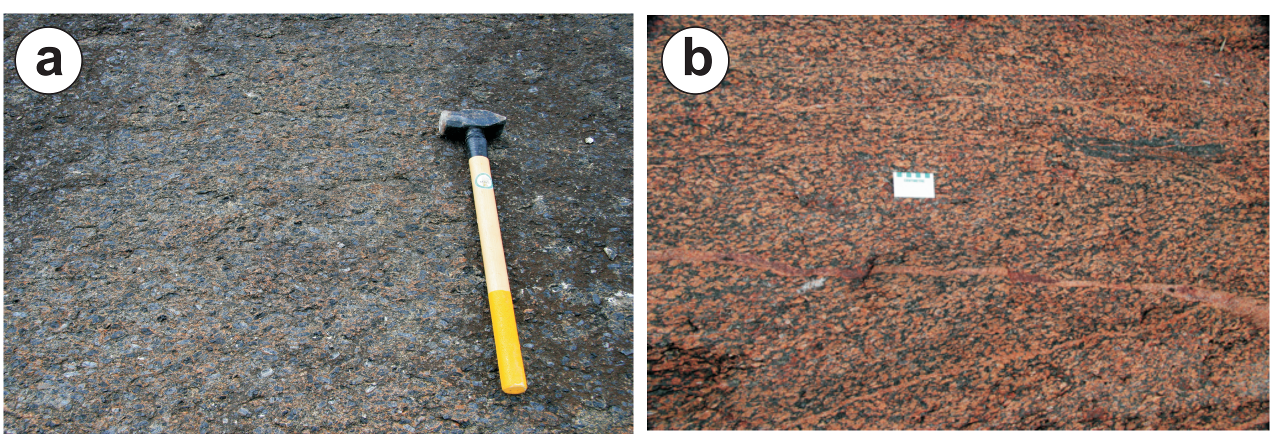


Figure GS-10-6: a) *Melasyenite with dark grey to black potassium feldspar; hammer for scale.* ***b)*** *Brick-red metasomatized melasyenite with narrow crosscutting dikes of alkali-feldspar granite. Scale card is in centimetres.*

as Proterozoic. They are observed crosscutting, and being cut by, pink pegmatite dikes, which are likely Proterozoic. The dikes are associated with alkali metasomatism of the surrounding rocks. Field observations and preliminary laboratory investigations suggest there may be two varieties of carbonate-rich dikes: a dolomitic, grey silicate-carbonate rock, and pink carbonatite (see Chakhmouradian et al., GS-11, this volume). Carbonatite dikes have been observed right to the northern edge of the map area.

Grey silicate-carbonate dikes (subunit 10a) are present along the northern half of the swarm's strike length. They are medium- to coarse-grained, foliated, equigranular and moderately to strongly magnetic. The dikes typically have a dark-grey weathered surface and are up to 1 m thick (Figure GS-10-7a). Grey silicate-carbonate dikes typically contain trace to minor amounts of phlogopite, magnetite, titanite, and apatite with 20–30% serpentinized olivine, and white to grey carbonate. Apatite locally comprises up to 15% of the rock. Veinlets of chrysotile and magnetite are common. A dike of this variety with red, oxide-stained apatite was interpreted as a metasedimentary marble during the 2008 field season (Couëslan, 2008; subunit 4d).

Pink carbonatite dikes (subunit 10b) occur along the entire strike length of the dike swarm. They are fine- to very coarse grained, foliated, strongly magnetic in places and form dikes up to 2.75 m thick. The weathered surfaces are typically covered by an earthy yellow-orange coating (Figure GS-10-7b). Pink carbonatite is composed of trace to minor amounts of sulphide, magnetite, biotite, titanite, cancrinite/scapolite, allanite and up to 25% apatite, 30% green clinopyroxene and/or amphibole, and pink to white carbonate. The dikes locally contain up to 25% magnetite. Metasomatized xenoliths of country rock are common.

Pegmatite and aplite (unit 11)

Two varieties of pegmatite are present in the Paint Lake area. Simple, quartz-feldspar pink pegmatite is ubiquitous and dikes are present in almost all outcrops. Plagioclase-rich white pegmatite is found spatially associated with carbonatite dikes.

Pink pegmatite (subunit 11a) occurs as centimetre- to metre-scale dikes and large bodies greater than 1 km thick. It is coarse- to very coarse grained, and massive to mylonitic. The foliated to mylonitic dikes are most common and generally trend subparallel to the regional foliation. Massive dikes are less common and typically cut across the regional foliation at a high angle. Aplitic dikes are locally present and can be frequently traced into coarser-grained pegmatitic units. It is likely that some of the earliest, most intensely deformed pegmatite is related to the Archean Kenoran orogeny. Pink pegmatite generally contains minor biotite, 10–30% plagioclase, 20–30% quartz, and potassium feldspar. Magnetite, garnet and a

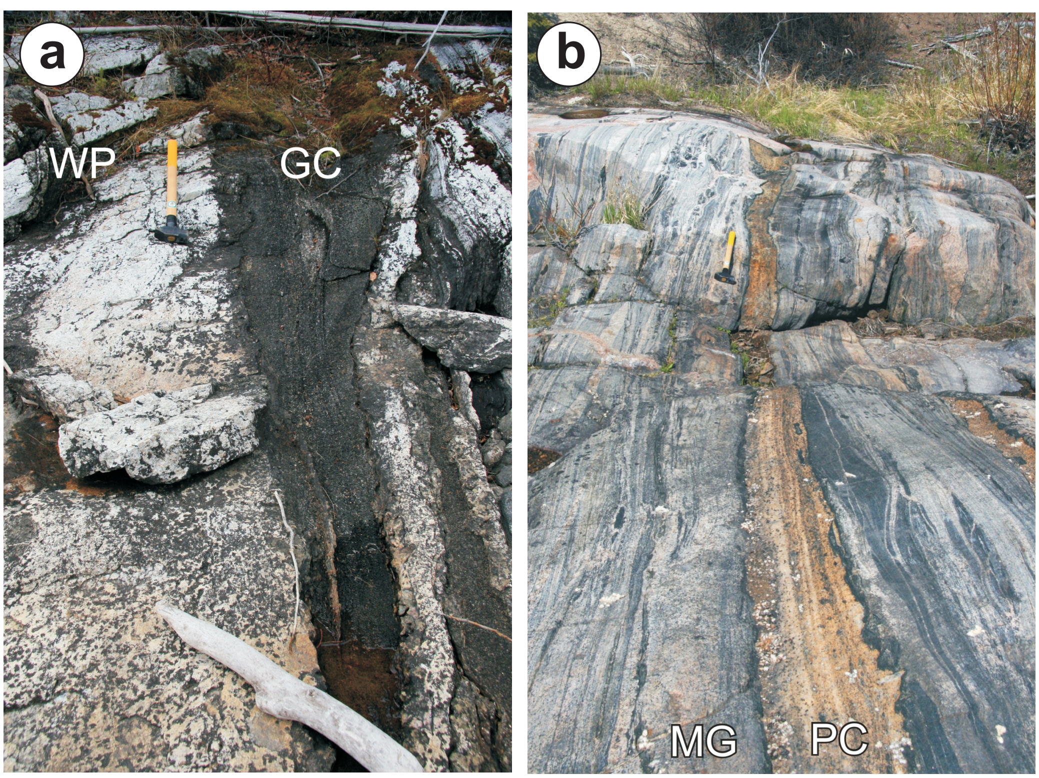


***Figure GS-10-7**: **a)** Grey silicate-carbonate dike hosted in plagioclase-rich white pegmatite; hammer for scale. **b)** Pink carbonatite dike intruding metasomatized multicomponent gneiss; hammer for scale. Abbreviations: GC, grey silicate-carbonate rock; MG, metasomatized multicomponent gneiss; PC, pink carbonatite; WP, plagioclase-rich white pegmatite.*

brown metamict mineral, tentatively identified as allanite, are locally present. Allanite is most common in strongly foliated and mylonitic dikes, and along late anastomosing fractures. Although allanite is strongly associated with these shear zones, it generally forms euhedral prisms up to several centimetres long indicating late- to postkinematic growth.

Rare plagioclase-rich white pegmatite dikes up to 4 m thick occur spatially associated with the carbonate-rich dikes (subunit 11b; Figure GS-10-7a). The dikes are medium- to very coarse grained and massive to foliated. They contain minor apatite, up to 20% mafic minerals, white plagioclase and typically less than 5% quartz. The mafic minerals consist of biotite, hornblende or clinopyroxene. When clinopyroxene is present, it is commonly rimmed by hornblende. Quartz can locally make up 20% of the rock. It is not known if a genetic relationship between the carbonate-rich dikes and white pegmatite exist; however, the plagioclase-rich nature of the rock makes this unlikely. The spatial association of the white pegmatite with carbonate-rich dikes may be a function of contamination or metasomatism of the pegmatite.

Structure and metamorphism

Evidence for both Archean and Proterozoic deformation and metamorphism are observed at most locations. Gneissic components within the multicomponent gneiss typically display complex internal fold patterns. The dominant regional structures in the Paint Lake area are upright, shallow to moderately plunging isoclinal folds with axial trends of roughly 045°. These folds are related to the Hudsonian D_3 event of Bleeker and Macek (1996). The dominant regional foliation was folded around these structures and also has a general trend of approximately 045°. Towards the southeast corner of the lake, these regional trends rotate closer to the east-west trends observed in the Superior Province, becoming approximately 075°. In the northwest portion of the map area, the regional structures are rotated closer to typical TNB orientations of 025°.

The majority of rocks in the Paint Lake area are highly strained, and straight gneisses are relatively common. Competent layers are typically boudinaged and single, isolated boudins of ultramafic and calcsilicate rocks are not uncommon in outcrops. Several discrete mylonitic to ultramylonitic zones were observed along the east side of the lake, marking fairly significant shear zones. The shear zones are generally oriented with trends of approximately 030–045° and dips greater than 60° to the east and west. They display dominantly sinistral movement; however, both east-side-up and west-side-up kinematic indicators have been tentatively identified at different exposures. Late brittle faults, locally with pseudotachylite and/or fault gouge, have also been observed at various locations. The later faults are generally striking 070–090° with dips greater than 60° to the south. The brittle faults are typically associated with localized epidotization, and potassic and hematitic alteration.

Evidence for Archean granulite-grade metamorphism is prevalent. Orthopyroxene-bearing leucosome interpreted as Archean is present in enderbitic gneisses, layered mafic rocks and metagreywacke. Groundmass orthopyroxene is also commonly present in these rocks, as well as in metapsammite and metavolcanics, and locally in the multicomponent gneiss. The presence of hercynite in semipelitic layers of metagreywacke is also suggestive of granulite-grade metamorphism. Orthopyroxene is commonly less abundant or absent in outcrops adjacent to large pegmatite bodies, Ospwagan Group rocks or with numerous pegmatitic injections. It is inferred that fluids emanating from Hudsonian pegmatitic melts and Paleoproterozoic supracrustal rocks caused hydration/metamorphic retrogression in adjacent Archean protoliths.

Metapelite mineral assemblages typically consist of sillimanite, garnet, biotite, plagioclase, potassium feldspar and quartz in the presence of leucosome. This assemblage is typical for upper-amphibolite–grade metamorphism (Figure GS-10-8). The addition of cordierite to this assemblage in the easternmost outcrop of metapelite is typical of granulite-grade metamorphism (Pattison et al., 2003).

Economic considerations

In the TNB, ultramafic bodies intruded in Ospwagan Group metasedimentary rocks have greater potential for forming magmatic nickel deposits than ultramafic bodies hosted by Archean gneiss (Bleeker and Macek, 1996). The recognition of a potential Archean supracrustal sequence in some portions of the TNB basement that has similarities to the Ospwagan Group presents an additional complicating factor in an area already made challenging for mineral exploration by the intense deformation and high metamorphic grade. Similarities of the supracrustal rocks at Paint Lake with rocks of the Ospwagan Group include

- calcsilicate-bearing siliceous units, which could be confused with certain horizons of the Thompson Formation;
- sillimanite- and garnet-rich horizons of metapelite similar to the Pipe Formation P2 member;
- silicate-facies iron formation similar to the Pipe Formation; and
- concretion-bearing quartzite interbedded with metapelite similar to the Setting Formation.

Alternatively, the presence of sulphide-bearing iron formation and metagreywacke in Archean supracrustal sequences could potentially make for new exploration targets. Ultramafic bodies intruding into these sulphide-bearing metasedimentary rocks could use the available sulphur to fractionate nickel sulphides. This is similar to the model interpreted for the nickel deposit–hosting

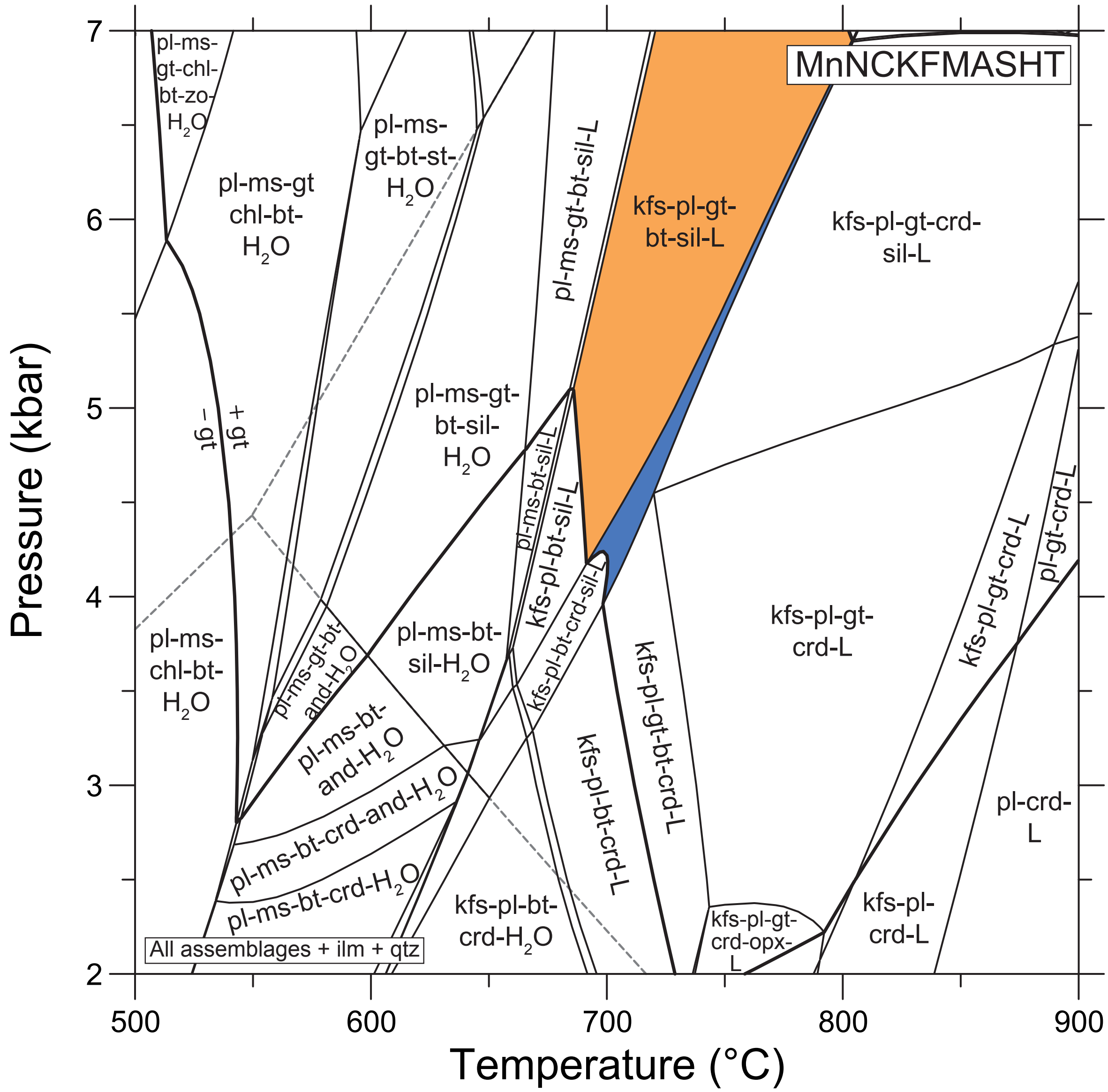


Figure GS-10-8: *Isochemical phase diagram for the average Nelson pelite (Pattison and Vogl, 2005) which is a close approximation of the average worldwide pelite. The mineral assemblage sillimanite–garnet–biotite–plagioclase–potassium feldspar–quartz–melt is indicated by the orange field, while the assemblage cordierite–sillimanite–garnet–biotite–plagioclase–potassium feldspar–quartz–melt is marked by the blue field. The aluminosilicate stability fields are indicated by grey dashed lines. The phase diagram was constructed using Theriak-Domino phase equilibria modelling software (Biino and de Capitani, 1995) in the system MnNCKFMASHT and calculated using the Holland and Powell (1998) thermodynamic dataset* as modified by *Pattison and Tinkham (2009). Abbreviations: and, andalusite; bt, biotite; chl, chlorite; crd, cordierite; gt, garnet; kfs, potassium feldspar; L, melt; ms, muscovite; opx, orthopyroxene; pl, plagioclase; sil, sillimanite; st, staurolite; zo, zoisite.*

ultramafic bodies emplaced in Ospwagan Group rocks elsewhere in the TNB.

The occurrence of carbonatite intrusions suggests the potential for additional magmatic and hydrothermal deposit-types in the region. Carbonatite and related rocks are important sources of Nb, Fe, P, rare earth elements (REE) and other commodities. Another Manitoba carbonatite located at Eden Lake has been explored as a REE-U prospect (Rare Earth Metals Corporation, 2006). Grey silicate-carbonate rock could have other implications for nickel exploration in the region. It can be mistaken for metasedimentary marble and, if similar intrusions exist elsewhere in the belt, it could be responsible for the misidentification of Ospwagan Group ‘ghost sequences’ (Zwanzig et al., 2007) where none exist.

Acknowledgments

The author thanks J. Dutka for providing enthusiastic field assistance in a summer filled with somewhat less than optimal weather conditions, and N. Brandson for providing logistical support. C. Böhm, A. Chakhmouradian, T. Corkery and J. Macek are thanked for their discussions and input, both on the outcrop and in the office.

References

Biino, G.C. and de Capitani, C. 1995: Equilibrium assemblage calculations: a new approach to metamorphic petrology; *in* Studies on Metamorphic Rocks and Minerals of the Western Alps: A Volume in Memory of Ugo Pognante, B. Lombardo, (ed.); Bollettino del Museo Regionale di Scienze Naturali di Torino, v. 13, p. 11–53.

Bleeker, W and Macek, J. 1996: Evolution of the Thompson Nickel Belt, Manitoba: setting of Ni-Cu deposits in the western part of the Circum Superior Boundary Zone; Geological Association of Canada—Mineralogical Association of Canada, Joint Annual Meeting, Winnipeg, Manitoba, May 27–29, 1996, Field Trip Guidebook A1, 45 p.

Charbonneau, R., Scoates, R.F.J. and Macek, J.J. 1979: Thompson Nickel Belt project (parts of 63O8, 9 and 63P5, 12); *in* Report of Field Activities 1979, Manitoba Department of Mines, Natural Resources and Environment, Mineral Resources Division, p. 20–23.

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.

Couëslan, C.G. 2009: Bedrock geology of the Paint Lake area, Manitoba (parts of NTS 63O8, 9, 63P5, 12); Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, Preliminary Map PMAP2009-3, scale 1:20 000.

Couëslan, C.G., Pattison, D.R.M. and Macek, J.J. 2007: Hudsonian regional metamorphism in the Thompson Nickel Belt, Manitoba (parts of 63J15, 16, 63O1, 2, 8, 9, 16, 63P12, 13, 64A4); *in* Report of Activities 2007, Manitoba Science, Technology, Energy and Mines, Manitoba Geological Survey, p. 91–97.

Holland, T.J.B. and Powell, R. 1998: An internally consistent thermodynamic data set for phases of petrological interest; Journal of Metamorphic Geology, v. 16, p. 309–343.

Hubregtse, J.J.M.W. 1980: The Archean Pikwitonei granulite domain and its position at the margin of the northwestern Superior Province (central Manitoba); Manitoba Department of Energy and Mines, Mineral Resources Division, Geological Paper GP80-3, 16 p.

Macek, J.J. and Russell, J.K. 1978: Thompson Nickel Belt project (parts of 63O8, 9 and 63P5, 12); *in* Report of Field Activities 1978, Manitoba Department of Mines, Resources and Environmental Managements, Mineral Resources Division, p. 43–46.

Mezger, K., Bohlen, S.R. and Hanson, G.N. 1990: Metamorphic history of the Archean Pikwitonei Granulite Domain and the Cross Lake Subprovince, Superior Province, Manitoba, Canada; Journal of Petrology, v. 31, p. 483–517.

Pattison, D.R.M., Chacko, T., Farquhar, J. and McFarlane, C.R.M. 2003: Temperatures of granulite-facies metamorphism: constraints from experimental phase equilibria and thermobarometry corrected for retrograde exchange; Journal of Petrology, v. 44, p. 867–900.

Pattison, D.R.M. and Tinkham, D.K. 2009: Interplay between equilibrium and kinetics in prograde metamorphism of pelites: an example from the Nelson aureole, British Columbia; Journal of Metamorphic Geology, v. 27, p. 249–279.

Pattison, D.R.M. and Vogl, J.J. 2005: Contrasting sequences of metapelitic mineral-assemblages in the aureole of the tilted Nelson Batholith, British Columbia: implications for phase equilibria and pressure determination in andalusite–sillimanite-type settings; The Canadian Mineralogist, v. 43, p. 51–88.

Rare Earth Metals Corporation 2006: Rare Earth Metals Announces Eden Lake Drill Results; Rare Earth Metals Corporation, News Release, May 19, 2006, URL <http://www.vmsventures.com/newsroom/NRG079a.asp> [August 26, 2009].

Russell, J.K. 1981: Metamorphism of the Thompson Nickel Belt gneisses: Paint Lake, Manitoba; Canadian Journal of Earth Sciences, v. 18, p. 191–209.

Zwanzig, H.V., Macek, J.J. and McGregor C.R. 2007: Lithostratigraphy and geochemistry of the high-grade metasedimentary rocks in the Thompson Nickel Belt and adjacent Kisseynew Domain, Manitoba: implications for nickel exploration; Economic Geology, v. 102, p. 1197–1216.