GS-9 Geological investigations in the Manasan Falls area, Thompson Nickel Belt, Manitoba (part of NTS 63P12)

by C.G. Couëslan

Couëslan, C.G. 2011: Geological investigations in the Manasan Falls area, Thompson Nickel Belt, Manitoba (part of NTS 63P12); *in* Report of Activities 2011, Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, p. 86–93.

Summary

Mapping in the Manasan Falls area, located near the western margin of the Thompson Nickel Belt (TNB) southwest of Thompson, has revealed the presence of a supracrustal sequence that is likely Archean. The sequence consists of banded para-amphibolite or mafic metavolcaniclastic rock, siliceous metasedimentary rock, metagreywacke, and metapelite and metasemipelite. Other units in the area consist of Archean multicomponent gneiss, white quartzite of unknown affinity and an augen gneiss–granite gneiss suite, which is interpreted as Paleoproterozoic. The new findings at Manasan Falls, together with recent discoveries of Archean supracrustal rocks elsewhere in the TNB, suggest that some occurrences of supracrustal rocks have been misinterpreted as rocks of the Paleoproterozoic Grass River or Ospwagan groups, and that Archean supracrustal rocks may be more widespread than previously recognized.

Introduction

In July 2011, the water levels on the Burntwood River in Thompson were 4–5 feet below average levels (Manitoba Hydro, 2011). The low water levels allowed for the examination of extensive outcrops in the Manasan Falls area that are typically submerged or otherwise inaccessible. Previous work from diamond drillcore led to metamorphosed supracrustal rocks, tentatively identified as Grass River Group, being recognized in the Manasan Falls area (Macek et al., 2006; Zwanzig, pers. comm., 2011). Mapping of the area was conducted over several days at the end of July in an attempt to positively identify these rocks.

Geological overview

The TNB forms part of the northwestern Superior Boundary Zone of Manitoba. It is predominantly underlain by Archean gneiss of the Superior craton. The Archean gneiss is described as mostly felsic to intermediate orthogneiss (Bleeker, 1990); however, work along the eastern side of the TNB has revealed the presence of belts of Archean metasedimentary rocks (Böhm, 2005; Couëslan, 2008, 2009). Prior to ca. 1.88 Ga, the Paleoproterozoic passive-margin sequence of the Ospwagan Group was deposited on exhumed Archean gneiss of the Pikwitonei Granulite Domain (Bleeker, 1990; Zwanzig et al., 2007). These rocks were deformed and metamorphosed during the Trans-Hudson orogeny (ca. 1.83–1.76 Ga), when the Superior craton collided with the adjacent arc-derived Kisseynew Domain of the Reindeer Zone. Initial collision (ca. 1.83–1.80 Ga) resulted in large-scale isoclinal to recumbent F_2 folds and the development of the regionally penetrative S_2 foliation (Ansdell, 2005; Burnham et al., 2009). Later transpressional movement (D_3, ca. 1.77–1.76 Ga) resulted in elongate chains of upright, doubly-plunging F_3 synforms and antiforms (Bleeker, 1990; Burnham et al., 2009). Mylonite zones with subvertical-stretching lineations parallel many of the F_3 fold limbs (Bleeker, 1990).

The Kisseynew Domain dominantly consists of Burntwood Group, a sequence of deeper-water metagreywacke and metamudstone (Zwanzig et al., 2007). The Grass River Group, a shallow-water equivalent to the Burntwood Group, occurs along the eastern margin of the Kisseynew Domain. The Grass River Group consists of polymictic metaconglomerate and layered felsic to mafic metasandstone (Zwanzig, 1998; Zwanzig et al., 2007). The adjacent, eastern Kisseynew Domain has a shared tectonic history with the TNB, beginning with initial collision at ca. 1.83 Ga.

The Manasan Falls area is located along the western edge of the TNB, near the fault-bounded contact with the adjacent Kisseynew Domain (Figure GS-9-1). The area is underlain by Archean gneiss and what has been tentatively identified from diamond drillcore as Grass River Group metasedimentary rocks (Macek et al., 2006; Zwanzig, pers. comm., 2011). The falls are situated on the eastern limb of an upright F_3 antiform.

Lithological units

Five main lithological units were identified in the Manasan Falls area (Figure GS-9-2). The majority of rocks are interpreted as Archean, the exceptions being the quartzite, which is of unknown affinity, and the augen gneiss, which may be Paleoproterozoic. The relative ages of individual units are not known due to the lack of exposed contacts and preserved way-up indicators in the metasedimentary rocks. The order in which the units are discussed here does not follow either their chronological or their stratigraphic order. Although all rocks have been subjected to at least upper-amphibolite–facies metamorphic conditions, the “meta-” prefix has been omitted in the following to improve readability.

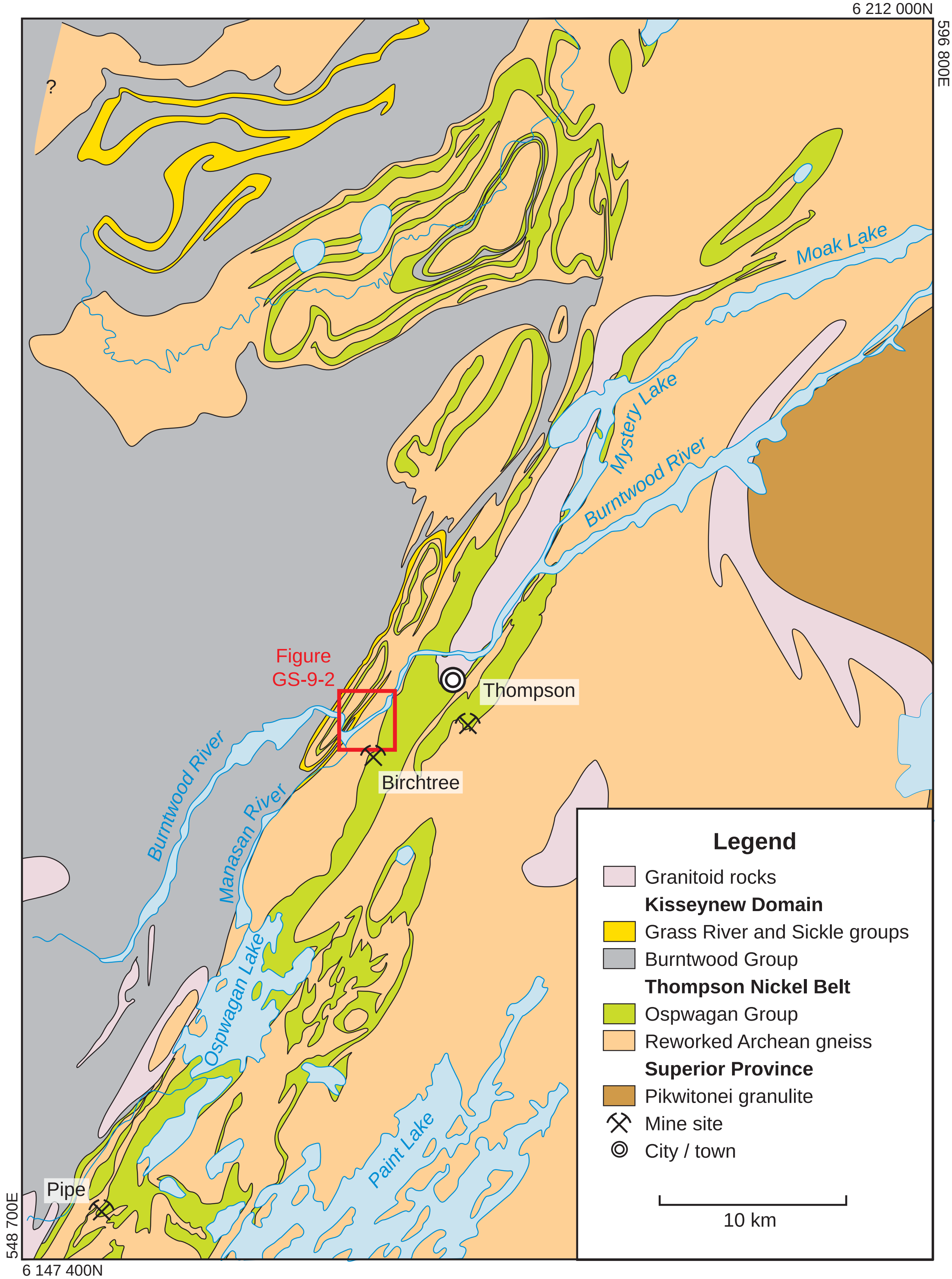

Figure GS-9-1: *Geology of the northern Thompson Nickel Belt and location of the study area at Manasan Falls, Manitoba (modified from Macek et al., 2006).*

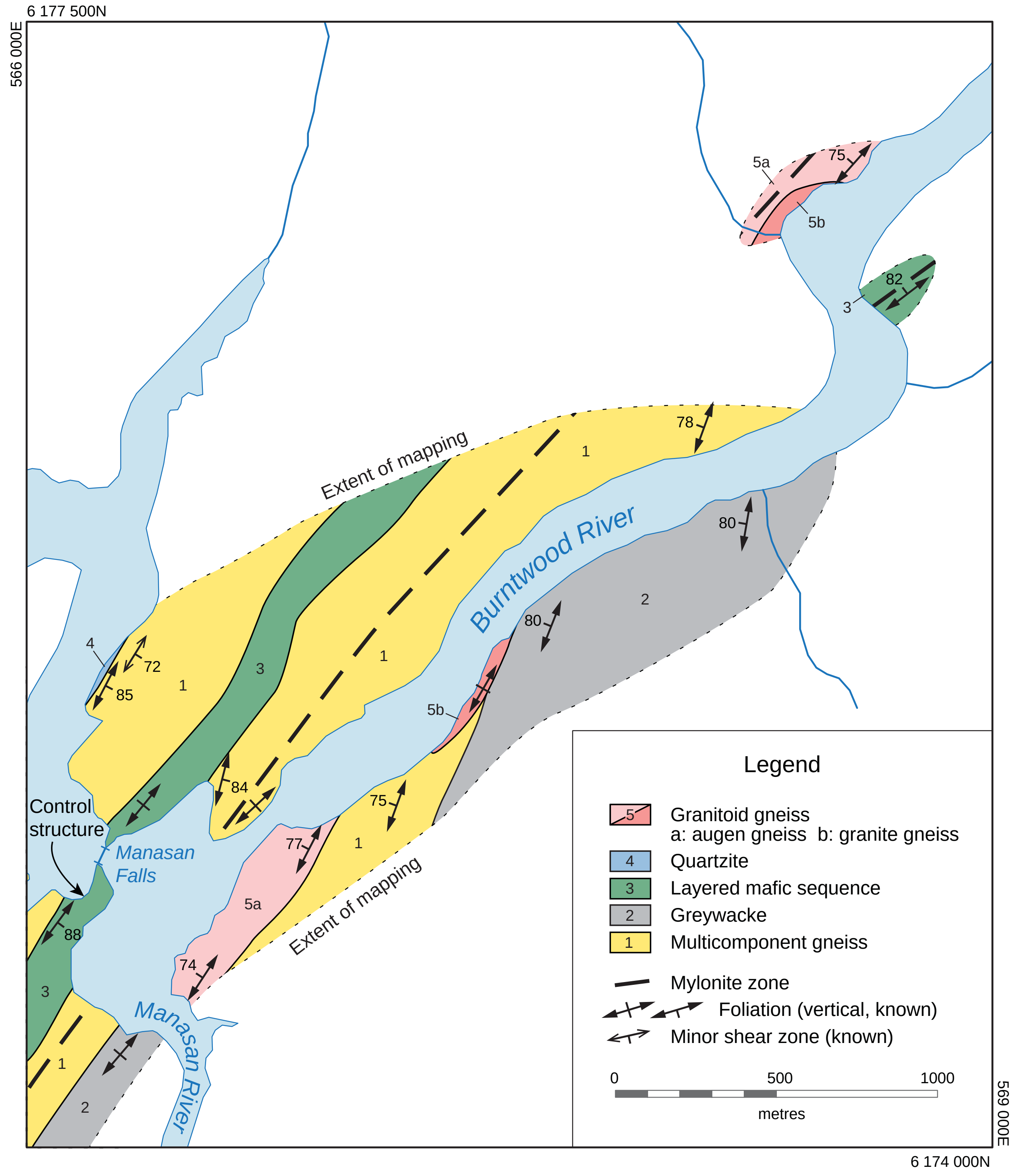

Figure GS-9-2: *Geology of the Manasan Falls area, Manitoba.*

Multicomponent gneiss

Outcrops of multicomponent gneiss, the dominant rock type in the Manasan Falls area (Figure GS-9-2), consist of either biotite- or hornblende-gneiss and typically include trace to 3% ultramafic schist, trace to 3% calcsilicate, 3–25% pegmatite and 7–20% plagioclase amphibolite. Rare lenses of iron formation, psammite and clinopyroxenite also occur. Multicomponent gneiss is light grey to pinkish grey, medium- to coarse-grained and migmatitic (Figure GS-9-3a); its composition varies from tonalitic to granodioritic, with 10–20% biotite and/or hornblende. Amphibolite occurs as disaggregated bands up to 3 m thick that are commonly boudinaged. Local boudins of calcsilicate (3–30 cm thick) and ultramafic schist (up to 1 m thick) occur along discrete horizons. Pegmatite dikes are generally subparallel to the foliation,

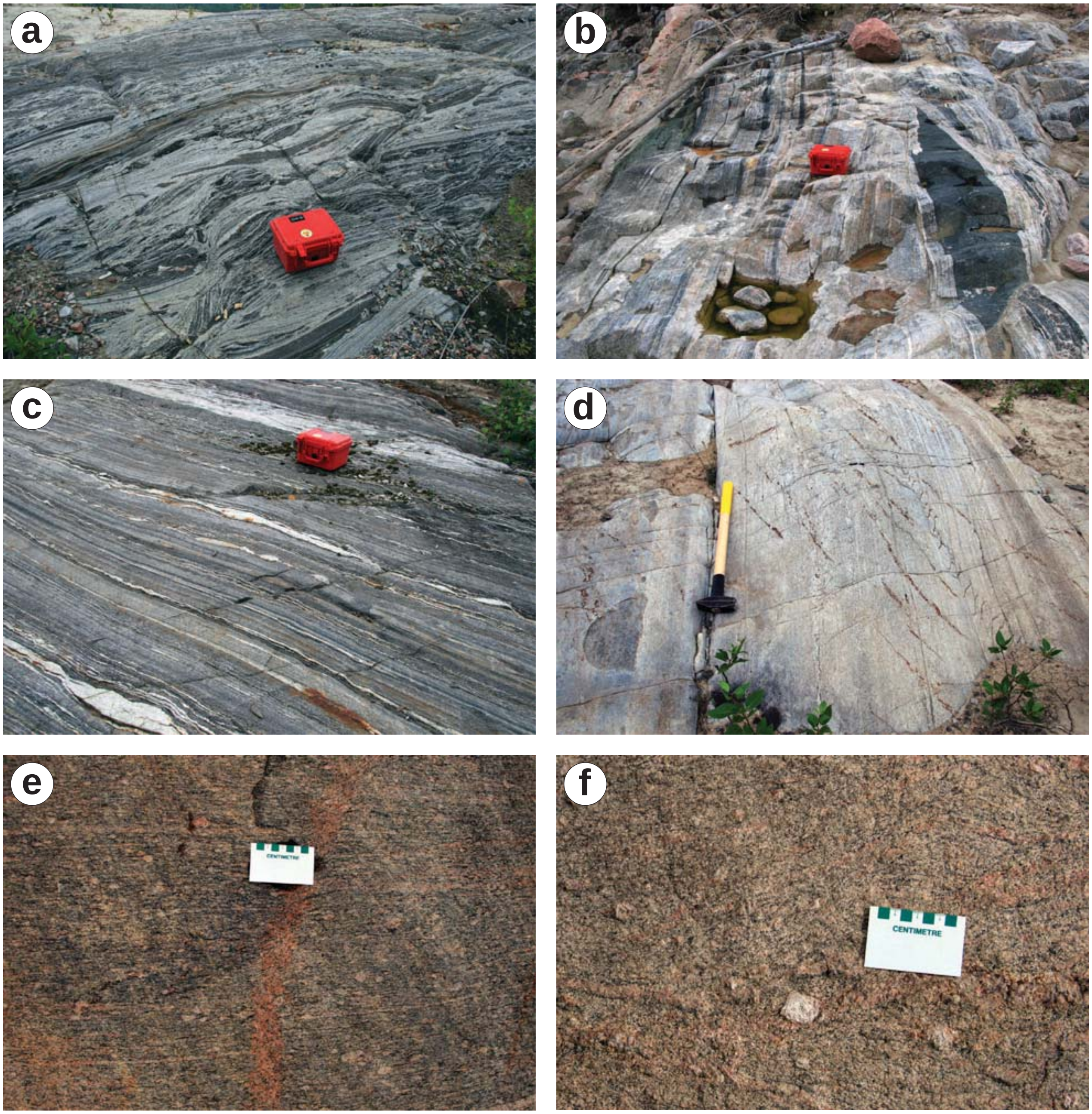

Figure GS-9-3:** Outcrop photographs in the Manasan Falls area, Manitoba:* ***a) *multicomponent gneiss with discontinuous bands of plagioclase amphibolite;* ***b)*** *mylonitized multicomponent gneiss located just east of Manasan Falls, Manitoba;* ***c)*** *greywacke with veins of leucosome that are subparallel to bedding;* ***d)*** *white quartzite of unknown affinity located upstream of Manasan Falls;* ***e)*** *a typical example of the augen gneiss;* ***f)*** *weakly foliated porphyritic granodiorite. Scale card is in centimetres.*

but also occur as irregular intrusions, and are variably foliated. Outcrops of multicomponent gneiss located directly east of the falls are mylonitic (Figure GS-9-3b) and locally intensely folded.

Greywacke

Greywacke is most common along the eastern side of the Burntwood River (Figure GS-9-2). It locally contains intercalations of psammite (centimetre- to decimetre-scale) and iron formation (up to 50 cm), discontinuous bands of plagioclase amphibolite (up to 1 m) and rare boudinaged layers of calcsilicate (up to 1 m). The greywacke forms a light grey, medium-grained paragneiss with centimetre- to decimetre-scale bands. It is typically quartz-rich (40–50%) and contains plagioclase (20–30%), biotite (10–30%), garnet (5–15%) and, rarely, sillimanite. Outcrops typically contain millimetre- to centimetre-scale bedding-parallel veins of leucosome, which are characterized by pinch-and-swell structures

(Figure GS-9-3c). Directly south of the falls, a contact between the multicomponent gneiss and greywacke is visible in outcrop; the contact consists of intercalations of greywacke and multicomponent gneiss within a zone roughly 2 m wide. It is not clear if this interleaving is the result of tectonic or sedimentary processes. A sedimentary origin would imply that the multicomponent gneiss at some locations is derived from an arkosic rock.

Quartzite

A small outcrop of white quartzite, located in a quarry upstream of the falls, is in sharp contact with the multicomponent gneiss (Figure GS-9-3d). The quartzite is interbedded with local protoquartzite horizons up to 40 cm thick and contains bands of plagioclase amphibolite up to 20 cm wide. The quartzite is medium grained and, in addition to quartz, contains minor plagioclase (7–10%), biotite (1–2%) and trace amounts of sulphide. The absence of additional field relations does not allow the quartzite to be directly correlated with other supracrustal rocks in the TNB.

Augen gneiss and granite gneiss

Several outcrops of pinkish grey augen gneiss are present along the Burntwood River (Figure GS-9-3e). The composition varies from granitic to granodioritic and the gneiss is characterized by K-feldspar augen up to 4 cm across. Discontinuous bands of amphibolite up to 1 m in length are present, along with pegmatite dikes up to 40 cm wide. Weakly foliated porphyritic granodiorite observed at one location contains 3–5% biotite and euhedral K-feldspar phenocryst up to 2 cm across; it is interpreted as a relatively undeformed equivalent of augen gneiss (Figure GS-9-3f). The existence of relatively undeformed exposures of K-feldspar porphyritic granite to granodiorite could imply a Paleoproterozoic intrusive age. The northernmost exposure of augen gneiss becomes increasingly sheared towards the southwest, where augen gneiss grades into granite gneiss over several metres (Figure GS-9-2). Veins of mylonite and pseudotachylyte are locally present. Local sheared amphibolitic bands and pegmatite dikes give the gneiss an appearance very similar to the multicomponent gneiss described above.

Granite gneiss is present at two localities along the Burntwood River; it is light pink to reddish pink, biotite-bearing and relatively homogeneous, except for local pegmatitic veins up to several centimetres thick. The gradational relationship with the augen gneiss suggests that the two rocks may be related as a gradationally zoned intrusion.

Layered mafic sequence

Extensive outcrops of a layered mafic sequence are exposed at the falls and the adjacent control structure (Figure GS-9-2). The mafic sequence consists dominantly of banded amphibolite, which grades into siliceous sedimentary rock and pelite towards the northwest, and which is interlayered with greywacke, semipelite and calcareous rocks towards the southeast. All phases within the layered mafic sequence appear migmatitic. Veins of pseudotachylyte occur locally in central portions of the outcrop.

Banded amphibolite

Banded amphibolite is a compositionally variable, layered sequence roughly 40 m thick; it is dark grey to greenish grey and banded on a centimetre- to decimetre-scale (Figure GS-9-4a). The rock is hornblende-rich with variable proportions of plagioclase, biotite and up to 30% quartz. Local calcsilicate bands (2–20 cm) contain green amphibole and/or diopside in place of hornblende and biotite (Figure GS-9-4b). Local siliceous bands (1–10 cm wide), similar to the siliceous sediment described below, are ubiquitous. The banded amphibolite grades from a hornblende-rich rock into a siliceous, biotite-bearing sedimentary rock over a roughly 15 m interval.

Siliceous sedimentary rock

Brownish grey siliceous sedimentary rock (Figure GS-9-4c) forms a section, measuring approximately 20 m in width, of the layered mafic sequence. It is compositionally banded on a centimetre-scale and typically contains trace amounts of magnetite and hornblende, minor biotite and plagioclase, and up to 80% quartz. Local laminations may contain up to 20% biotite. Quartz-rich, leucocratic segregations are common and locally contain coarse-grained, stubby hornblende porphyroblasts. Sillimanite-bearing bands up to 3 cm thick occur within a few metres of the contact with the adjacent pelite.

Pelite

A horizon of pelite 1–2 m wide occurs immediately adjacent to the control structure at Manasan Falls (Figure GS-9-4d). The pelite is dark brownish grey and contains 5–7% sillimanite, 10–12% garnet and 20–30% biotite in a matrix of quartz and feldspar. Local beds of greywacke up to 15 cm thick are present within the pelite horizon.

Interbanded amphibolite and sedimentary rocks

The eastern side of the layered mafic sequence consists of an interval of interbanded amphibolite (50–60%), greywacke (20–30%), semipelite (20–30%) and calc-silicate (5–7%) 20 m thick. Amphibolite is similar to that described above; it forms horizons that are internally banded and typically greater than 2 m thick. Garnet occurs locally along discrete layers. One relatively homogeneous layer, possibly a dike, contains porphyroblasts

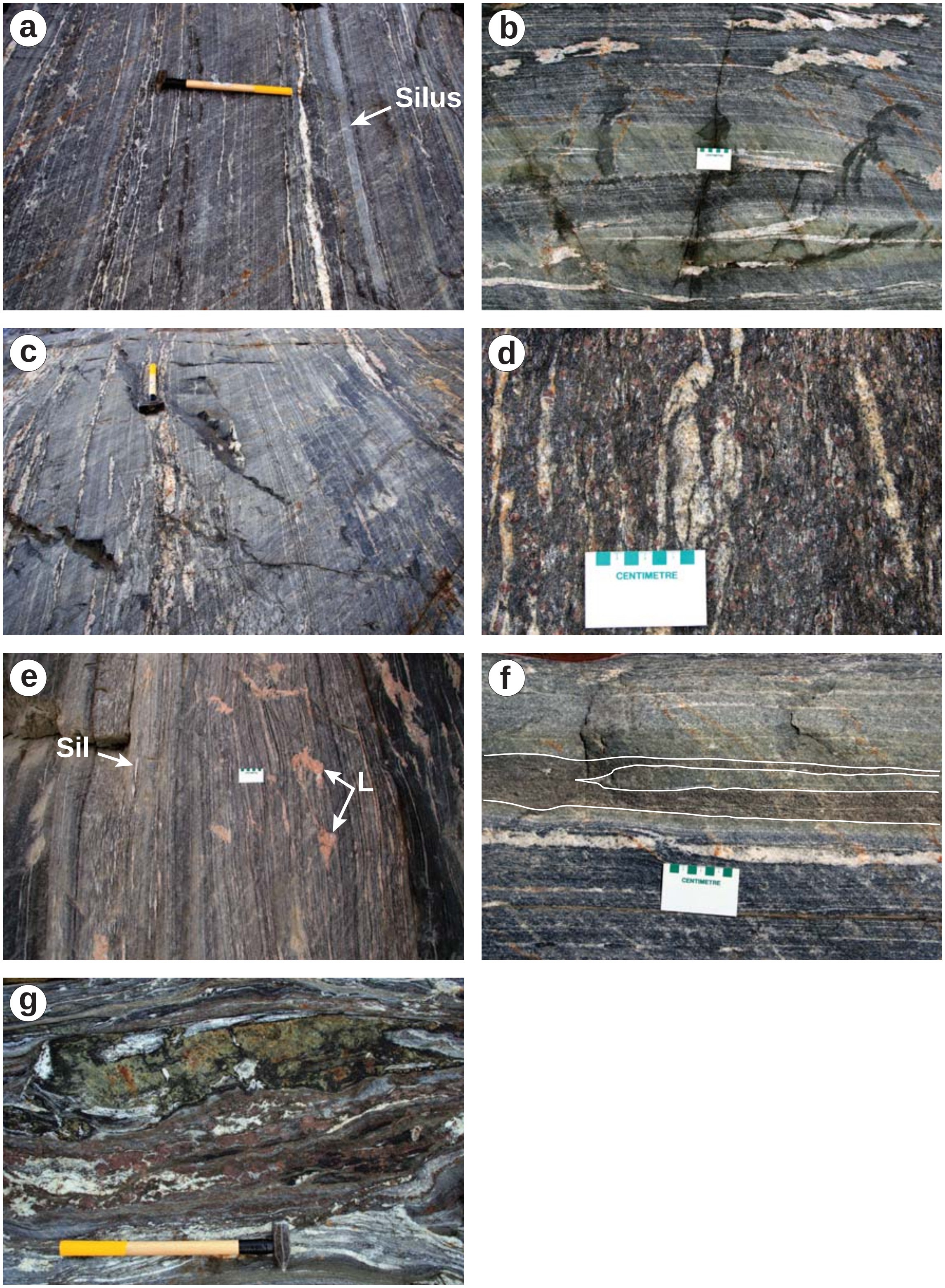

Figure GS-9-4: *Outcrop photographs of a layered mafic sequence in the Manasan Falls area of Manitoba show:* ***a)*** *a typical example of banded amphibolite with local siliceous bands;* ***b)*** *green calcsilicate bands within banded amphibolite;* ***c)*** *siliceous sedimentary rock, which grades into banded amphibolite over roughly 15 m;* ***d)*** *pelite immediately adjacent to siliceous sedimentary rock;* ***e)*** *sillimanite-bearing semipelite (left) grading into hornblende-bearing semipelite with leucosome (right), with amphibolite bounding both sides of the semipelite;* ***f)*** *impure marble horizon (outlined in white) within a calcsilicate band in banded amphibolite;* ***g)*** *possible hybridized zone, located between banded amphibolite and greywacke, characterized by diopside-rich boudins and garnet-rich rock. Scale card is in centimetres. Abbreviations: L, leucosome; Sil, sillimanite; Silus, siliceous horizon.*

of hornblende. Contacts between the amphibolite horizons and sedimentary rocks are typically sharp.

Horizons of greywacke and semipelite are typically less than 1.5 m thick. Greywacke is as previously described. The semipelite is light grey, medium- to coarse-grained and strongly foliated; it contains 1–2% garnet, 7–10% K-feldspar, 10–20% biotite, 10–20% plagioclase, 20–30% sillimanite and 30–40% quartz. Semipelite grades into a less aluminous, hornblende-bearing rock that contains 5–10% biotite, 10–20% hornblende, 10–20% plagioclase, 10–20% K-feldspar and 40–50% quartz. The hornblende-bearing rock is characterized by ubiquitous incipient pools of leucosome (Figure GS-9-4e).

Calcsilicate horizons are similar to those described in the banded amphibolite subsection but can form internally layered horizons up to 1.5 m thick. A single layer of impure marble, roughly 10 cm thick, was observed at the core of a calcsilicate horizon (Figure GS-9-4f). A boudinaged, diopside-rich layer is present at the contact between greywacke and amphibolite. The boudins are enclosed by a strongly deformed garnet- and quartz-rich rock (Figure GS-9-4g). The protolith of the diopside-, garnet- and quartz-rich rock is unclear; it may represent a form of hybridized rock between the amphibolite and greywacke.

Structure and metamorphism

The majority of rocks from the Manasan Falls area are highly strained and characterized by a pervasive, subvertical foliation, which parallels the compositional layering. This strong foliation correlates with the regional S_2 foliation in the TNB trending roughly 030°. A prominent, foliation-parallel mylonite zone is present just east of Manasan Falls, within the multicomponent gneiss (Figure GS-9-3b). The northeasternmost outcrops of the layered mafic sequence, along the Burntwood River, are also highly strained and contain quartz-rich leucocratic segregations forming rootless folds in the siliceous sedimentary rock. Sense of movement has not been determined for the mylonite zone, but mylonitic deformation is likely related to the D_3-D_4 events established in the TNB (Bleeker, 1990; Burnham et al., 2009). The presence of K-feldspar–bearing leucosome and sillimanite in pelite and semipelite suggests upper-amphibolite–facies metamorphic conditions.

Discussion

Several lines of evidence suggest that the layered mafic sequence in the Manasan Falls area represents a volcaniclastic rock or para-amphibolite unrelated to similar rocks in the Grass River Group. At the southeastern end of the sequence, amphibolite layers are interbedded with clastic sedimentary rocks and rare marble. At the northwestern end of the sequence, the banded amphibolite grades into siliceous sediment over a 15 m interval. In addition, calcsilicate and siliceous layers are present throughout the sequence. Although volcaniclastic rocks are present in the lower members of the Grass River Group (Zwanzig et al., 2007), the absence of conglomeratic and arkosic rocks suggests the layered mafic sequence is not correlative with this group. In addition, marble layers have not been reported from the Grass River Group and are not likely to occur in the fluvial-alluvial environment inferred for the Grass River Group.

The associated greywacke is petrographically similar to that described at Paint Lake, which is interpreted as part of an Archean supracrustal sequence (Couëslan, 2008, 2009). Layered mafic rocks are also present at Paint Lake and were previously interpreted as layered mafic intrusions consisting of metagabbro and an anorthositic or leucocratic metagabbro phase (Macek and Russell, 1978; Charbonneau et al., 1979; Couëslan, 2008). The layered mafic rocks at Paint Lake are typically quartz-bearing. Portions described as leucocratic metagabbro regularly contain up to 20% quartz (Couëslan, 2008) and the most leucocratic layers locally contain up to 60 % quartz, suggestive of a sedimentary protolith. However, the metagabbro at Paint Lake is characterized by abundant garnet porphyroblasts, which are rare at Manasan Falls. This may be related to the higher metamorphic grade at Paint Lake rather than bulk composition. In addition, calcareous bands have not been identified in the layered metagabbro at Paint Lake. More work is required for any direct correlation to be made of the Paint Lake layered metagabbro with the layered mafic sequence at Manasan Falls, but the latter does appear to be part of an Archean supracrustal sequence.

Economic considerations

In the TNB, ultramafic intrusive bodies in Ospwagan Group supracrustal rocks have a greater potential for forming magmatic nickel deposits than ultramafic bodies hosted by Archean gneiss (Bleeker and Macek, 1996). Because rocks of the Ospwagan Group are routinely targeted during mineral exploration it is important that they be readily differentiated from other supracrustal rocks of lower potential for hosting Ni-deposits. Archean gneiss is traditionally considered to be mainly orthogneiss; however, authors of recent studies have suggested that supracrustal rocks may compose a significant portion of Archean gneiss in the eastern TNB (Böhm, 2005; Couëslan, 2009). This study suggests that supracrustal rocks in Archean gneiss may also be significantly more widespread than previously recognized along the western edge of the exposed TNB. It is important that the nature of Archean supracrustal rock sequence(s) be documented so that it/they can be differentiated from the Ospwagan Group supracrustal rocks of greater economic importance.

Acknowledgments

The author thanks A. Piotrowski for providing enthusiastic field assistance, as well as N. Brandson and

E. Anderson for logistical support. J. Macek is thanked for suggesting an investigation of the outcrops around Manasan Falls.

References

Ansdell, K.M. 2005: Tectonic evolution of the Manitoba–Saskatchewan segment of the Paleoproterozoic Trans-Hudson Orogen, Canada; Canadian Journal of Earth Sciences, v. 42, p. 741–759.

Bleeker, W. 1990: Evolution of the Thompson Nickel Belt and its Nickel Deposits, Manitoba, Canada; PhD thesis, University of New Brunswick, Fredericton, 400 p.

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.

Böhm, C.O. 2005: Bedrock geology of northern and central Wintering Lake, Manitoba (parts of NTS 63P5 and 12); *in* Report of Activities 2005, Manitoba Industry, Economic Development and Mines, Manitoba Geological Survey, p. 32–39.

Burnham, O.M., Halden, N., Layton-Matthews, D., Lesher, C.M., Liwanag, J., Heaman, L., Hulbert, L., Machado, N., Michalak, D., Pacey, M., Peck, D.C., Potrel, A., Theyer, P., Toope, K. and Zwanzig, H. 2009: CAMIRO Project 97E-02, Thompson Nickel Belt: final report March 2002, revised and updated 2003; Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, Open File OF2008-11, 1 CD-ROM.

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 Energy and Mines, 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: 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.

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 Energy and Mines, Mineral Resources Division, p. 43–46.

Macek, J.J., Zwanzig, H.V. and Pacey, J.M. 2006: Thompson Nickel Belt geological compilation map, Manitoba (parts of NTS 63G, J, O, P, and 64A and B); Manitoba Science, Technology, Energy and Mines, Manitoba Geological Survey, Open File Report, OF2006-33, digital map, 1 CD-ROM.

Manitoba Hydro 2011: Thompson Seaplane Base: historical water levels & current year actuals (August 25, 2011); Manitoba Hydro website, URL <http://www.hydro.mb.ca/corporate/water_regimes/gif/seaplane4.gif> [September 15, 2011].

Zwanzig, H.V. 1998: Structural mapping of the Setting Lake area (parts of NTS 63J/15 and 63O/1, 2); *in* Report of Activities 1998, Manitoba Energy and Mines, Geological Services, p. 40–45.

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.