GS2024-13

Investigation of volcanic rocks along the eastern margin of the sub-Phanerozoic Thompson nickel belt, central Manitoba (part of NTS 63J3)

by C.G. Couëslan

In Brief:

- Four drillcores were relogged to determine the affinity of volcanic rocks reported by Hudson Bay Exploration and Development during the early 2000s
- A correlation with the Ospwagan group or the Winnipegosis komatiite belt would imply a potential for magmatic Ni-Cu deposits, while a juvenile-arc affinity could suggest a potential for VMS Cu-Zn
- Preliminary observations are largely inconclusive and samples will be submitted for further analytical work

Citation:

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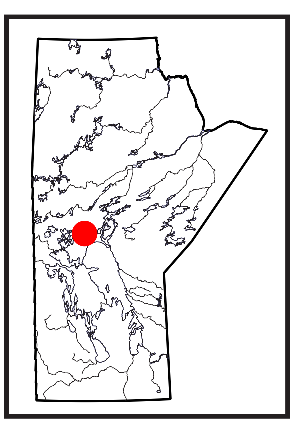

Summary

The geology of Precambrian rocks below the Phanerozoic strata of the Western Canada Sedimentary Basin remains poorly constrained in Manitoba. Several occurrences of volcanic rocks were reported by Hudson Bay Exploration and Development Company Limited (now HudBay Minerals Inc.) geologists during exploration for magmatic nickel-copper deposits along the eastern margin of the sub-Phanerozoic Thompson nickel belt in the early 2000s. The affinity of these volcanic rocks remains unknown. They could be related to the Ospwagan group of the Thompson nickel belt, the volcanic rocks of the Winnipegosis komatiite belt, or juvenile volcanic-arc rocks similar to those of the Tower deposit (located approximately 16 km to the south-southwest). Four drillcores were relogged to determine the affinity of the volcanic rocks. Preliminary observations are largely inconclusive. Samples will be submitted for petrographic thin sections, whole-rock lithogeochemistry, and Sm-Nd isotope geochemistry to help determine their affinity. A correlation with the Ospwagan group or the Winnipegosis komatiite belt would imply a potential for magmatic nickel-copper deposits, whereas a juvenile-arc affinity could suggest a potential for volcanogenic massive sulphide copper-zinc deposits.

Introduction

Exploration of the Precambrian basement underlying the Phanerozoic Western Canada Sedimentary Basin (sub-Phanerozoic) is exceedingly difficult. Exploration methods are entirely dependant on geophysical surveys and diamond drilling. There have been many successes with deposits discovered in the sub-Phanerozoic Flin Flon domain, Kisseynew domain, and Thompson nickel belt (TNB), which include magmatic nickel-copper (Ni-Cu; e.g., Minago and Namew Lake) and volcanogenic massive sulphide (VMS) copper-zinc (Cu-Zn; e.g., Limestone, Reed Lake, Talbot, Tower; Figure GS2024-13-1). Despite these successes, the geology of the sub-Phanerozoic Precambrian remains poorly constrained, with the extent and boundaries of the Flin Flon and Kisseynew domains, and TNB remaining a contentious issue (cf. NATMAP Shield Margin Project Working Group, 1998; Macek et al., 2006; McGregor, 2012; Reid, 2022). In addition, the Tower deposit, which is located along the eastern margin of the sub-Phanerozoic TNB, appears to share affinity with juvenile volcanic-arc rocks of the Trans-Hudson orogen. This suggests that juvenile rocks of the Reindeer zone could be thrust a significant distance east of the current Superior craton margin (Couëslan, 2018).

Several occurrences of volcanic rocks were reported by Hudson Bay Exploration and Development Company Limited (now HudBay Minerals Inc.) geologists during exploration for magmatic Ni-Cu deposits along the eastern margin of the sub-Phanerozoic TNB (Assessment Files 72992, 73174, 73553, 73648 and 94423, Manitoba Economic Development, Investment, Trade and Natural Resources, Winnipeg). The affinity of these volcanic rocks remains unknown. They could be related to the Bah Lake assemblage of the Ospwagan group of the TNB, the volcanic rocks of the Winnipegosis komatiite belt (WKB), or juvenile-arc rocks similar to those of the Tower deposit. A shared affinity with the Bah Lake assemblage or the WKB would imply a potential for magmatic Ni-Cu deposits, whereas a juvenile-arc affinity could suggest a potential for VMS Cu-Zn deposits. Three complete and one partial drillhole from the HudBay Minerals Inc. archives were relogged to determine the affinity of the volcanic rock occurrences. Twenty-two samples were collected for later petrographic, geochemical, and isotopic studies.

Regional geology

The investigated drillholes were collared near the boundary between the TNB and the WKB, and approximately 16 km north-northeast of the Tower deposit (Figure GS2024-13-1).

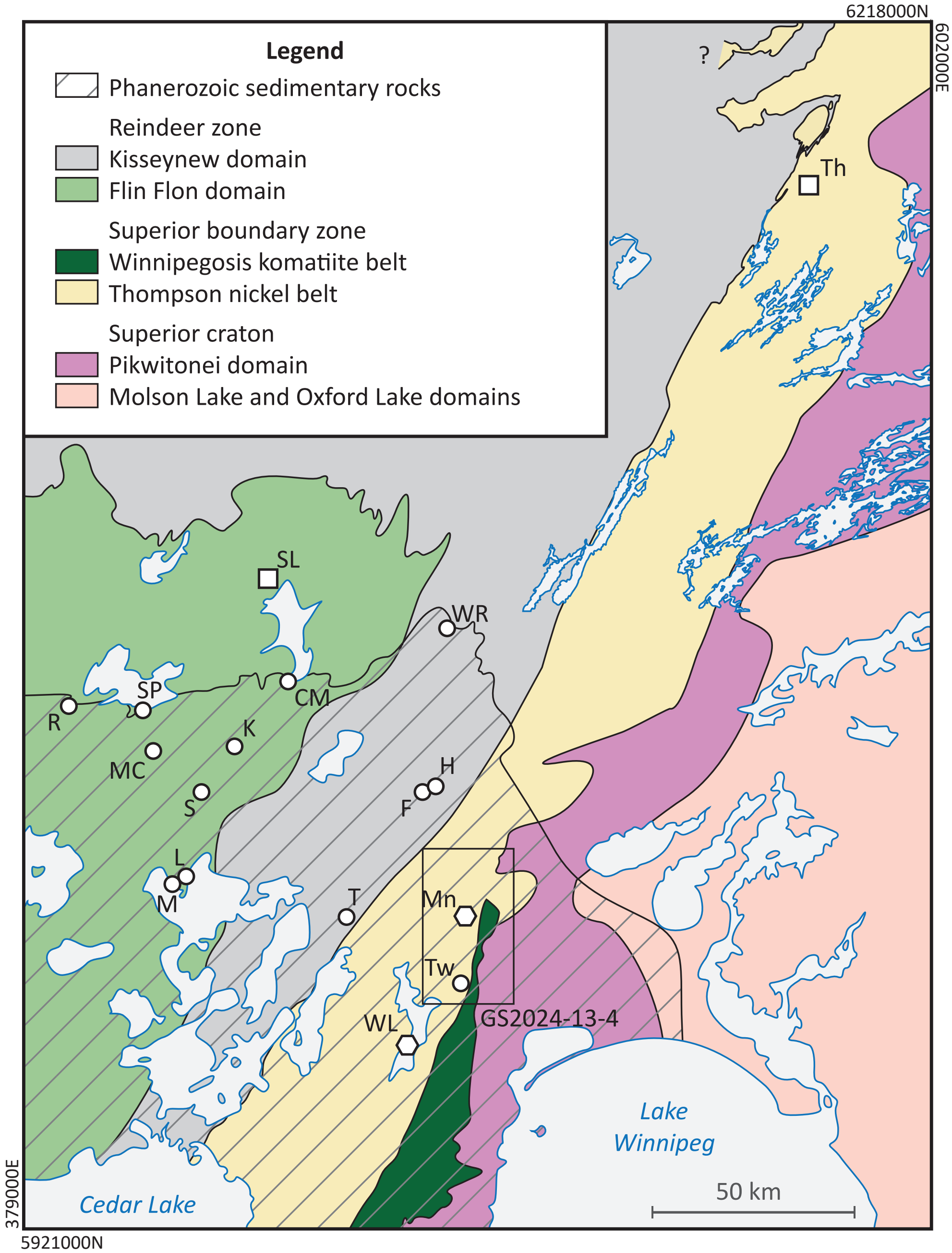

Figure GS2024-13-1: *Geological domains along the Superior boundary zone, central Manitoba (modified from Couëslan, 2020). Squares indicate the locations of towns/cities; circles and hexagons indicate the locations of sub-Phanerozoic volcanogenic massive sulphide deposits and magmatic nickel-copper deposits and occurrences, respectively. Box outlined in black shows location of Figure GS2024-13-4. Abbreviations: CM, Copperman; F, Fenton; H, Harmin; K, Kofman; L, Limestone; M, Moose; MC, McClarty; Mn, Minago; R, Reed; S, Sylvia; SL, Snow Lake; SP, Spruce Point; T, Talbot; Th, Thompson; Tw, Tower; WL, William Lake; WR, Watts River. All co-ordinates are in UTM Zone 14, NAD83.*

Thompson nickel belt (TNB)

The TNB forms a segment of the Superior boundary zone in Manitoba. In the sub-Phanerozoic, it is flanked to the northwest by the Kisseynew domain of the Reindeer zone of the Trans-Hudson orogen, and to the southeast by the WKB of the Superior boundary zone and the Pikwitonei domain of the Superior craton (Figure GS2024-13-1). The TNB is underlain largely by reworked Archean gneiss of the Pikwitonei domain, which is typically quartzofeldspathic, with enclaves of mafic to ultramafic rock. It is commonly migmatitic and characterized by complex internal structures that are the result of multiple generations of Archean and Paleoproterozoic deformation and metamorphism; clearly recognizable paragneiss is rare. The granulites of the Pikwitonei domain were exhumed and unconformably overlain by the Paleoproterozoic supracrustal rocks of the Ospwagan group (TNB) prior to intrusion of the Molson dike swarm and associated Ni-bearing ultramafic intrusions at ca. 1883 Ma (Bleeker, 1990; Zwanzig et al., 2007; Heaman et al., 2009; Scoates et al., 2017).

The Archean basement gneiss and Ospwagan group were subjected to multiple generations of deformation and metamorphic conditions, ranging from middle-amphibolite to lower-granulite facies, during the Trans-Hudson orogeny (Bleeker, 1990; Burnham et al., 2009; Couëslan and Pattison, 2012).

The dominant phase of penetrative deformation is D_2, which affected the Ospwagan group and ca. 1883 Ma magmatic rocks. This deformation phase resulted in the formation of F_2 nappe structures, which incorporated the underlying Archean gneiss. The nappe structures have been interpreted as either east verging (Bleeker, 1990; White et al., 2002) or southwest verging (Zwanzig et al., 2007; Burnham et al., 2009). The recumbent folds are associated with regionally penetrative S_2 fabrics. The D_2 phase of deformation is interpreted as the result of ca. 1830 to 1800 Ma convergence between the Superior craton margin and the Reindeer zone, and was accompanied, and outlasted, by prograde to peak regional metamorphism. The D_3 phase of deformation resulted in isoclinal folds with vertical to steeply southeast-dipping axial planes (Bleeker, 1990; Burnham et al., 2009). Mylonite zones with subvertical stretching lineations parallel many of the regional F_3 folds. Tightening of D_3 structures continued during D_4 deformation, and is characterized by localized retrograde greenschist metamorphism along northeast-striking, mylonitic, and cataclastic shear zones that commonly record southeast-side-up sinistral movement (Bleeker, 1990; Burnham et al., 2009).

Ospwagan group stratigraphy

The following summary of the Ospwagan group is sourced largely from Bleeker (1990) and Zwanzig et al. (2007). The Paleoproterozoic Ospwagan group unconformably overlies Archean basement gneiss in the TNB (Figure GS2024-13-2). The lowermost unit of the Ospwagan group is the siliciclastic Manasan forma-

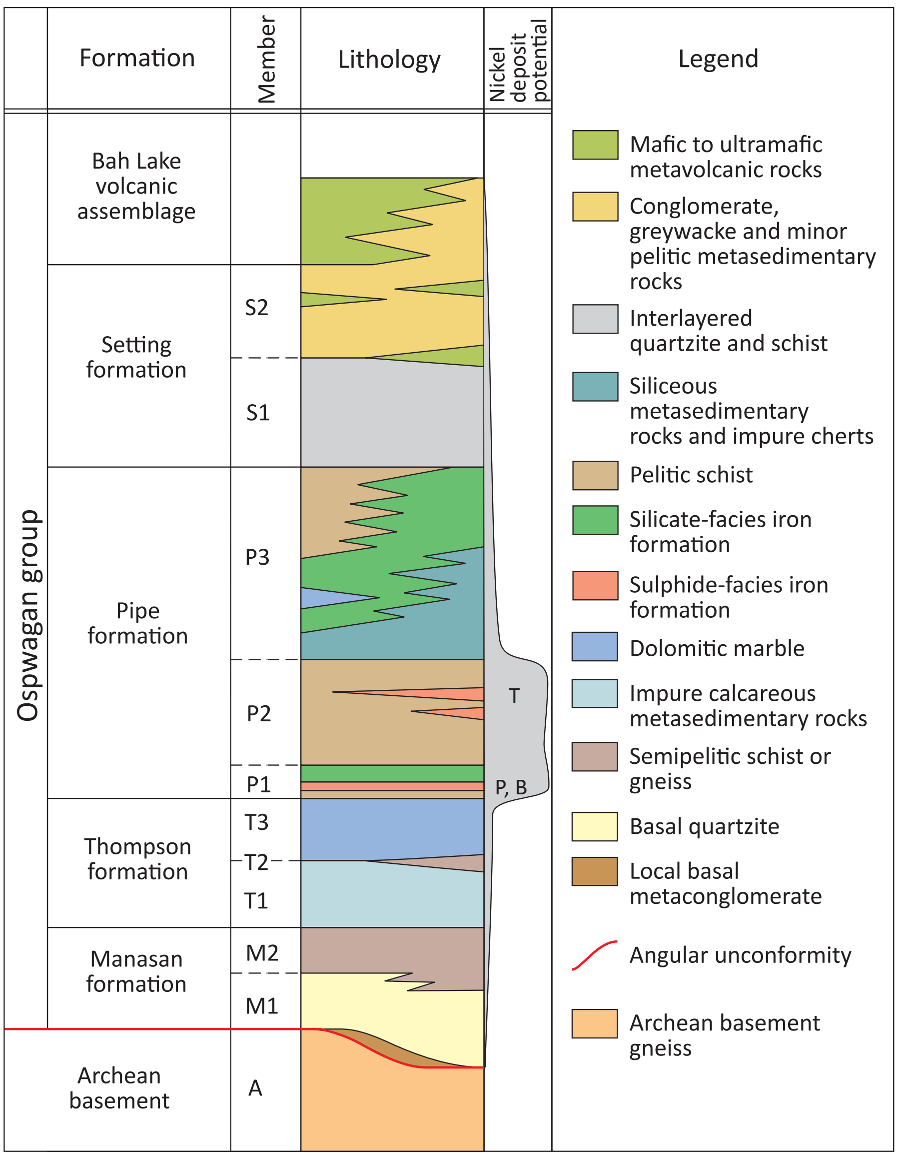

Figure GS2024-13-2: *Schematic lithostratigraphic section of the Ospwagan group (modified from Bleeker, 1990). Abbreviations: B, stratigraphic location of the Birchtree orebody; P, stratigraphic location of the Pipe II orebody; T, stratigraphic location of the Thompson orebody.*

tion, which fines upward from quartzite at the base to semipelite at the top. This siliciclastic system grades into the overlying calcareous sedimentary rocks of the Thompson formation. The Thompson formation consists of a variety of calcareous–siliceous rocks including chert, calcsilicate, and impure marble. It becomes increasingly calcareous toward the top and represents a transition from a siliciclastic-dominated to a carbonate-dominated system. The Manasan and Thompson formations are interpreted to represent a passive-margin sequence along the margin of the Superior craton.

The Pipe formation consists of a variety of pelitic and chemical sedimentary rocks including chert, iron formations, calcsilicate, and marble. Sulphidic rocks within the Pipe formation are the locus of the ore bodies at the Pipe II, Birchtree, and Thompson mines. The Pipe formation represents a mix of chemical sediments and fine to very fine siliciclastics that were deposited in either an open-marine environment (Zwanzig et al., 2007) or during the development of a foredeep basin (Bleeker, 1990).

The Setting formation represents a return to coarser clastic deposits. It consists of rhythmically interbedded quartzite and pelitic schist, thickly layered greywacke, and local beds grading from conglomeratic at the base to pelitic at the top. The Setting formation is interpreted to have been deposited by turbidity currents in a relatively deep marine environment, and may represent axial sedimentation within a foredeep basin (Bleeker, 1990) or possibly the onset of active tectonism and shallowing of the basin (Zwanzig et al., 2007).

At the top of the Ospwagan group is the Bah Lake assemblage, which consists of mafic to ultramafic volcanic rocks dominated by massive to pillowed basalt flows, with local picrite and minor synvolcanic intrusions. The Bah Lake assemblage is dominated by a high-Mg suite (similar to normal mid-ocean–ridge basalt; N-MORB) that occurs throughout much of the main TNB, and an incompatible-element–enriched suite (similar to enriched mid-ocean–ridge basalt; E-MORB) that occurs in the northwestern Setting Lake area and along the margin of the Kisseynew domain (Zwanzig, 2005). The enriched suite is interpreted to overlie the high-Mg suite; however, it is uncertain if this represents a stratigraphic or tectonic relationship. The Bah Lake assemblage could represent the onset of active rifting in the TNB (Zwanzig, 2005; Zwanzig et al., 2007) or magmatic activity within the foredeep (Bleeker, 1990).

Winnipegosis komatiite belt (WKB)

The WKB occurs along the eastern side of the sub-Phanerozoic Superior boundary zone in the Lake Winnipegosis–Cedar Lake area (Figure GS2024-13-1). It forms a 150 by 30 km greenstone belt adjacent to the TNB and occurs under 150–500 m of Phanerozoic cover (Hulbert et al., 1994; Pearson, 1996). Initially misidentified as Ospwagan group rocks, the mafic to ultramafic volcanic rocks of the WKB are distinctly younger (ca. 1870 Ma) than the volcanic rocks of the Ospwagan group (ca. >1890 Ma; Zwanzig, 2005; McGregor, 2012; Waterton et al., 2017). The WKB is subdivided into three volcanic packages: the western upper tholeiite suite, the central Winnipegosis komatiite suite, and the eastern Grand Island tholeiite suite (Figure GS2024-13-3; Lin et al., 1998; McGregor, 2012). Contacts between the three suites were initially interpreted as thrust faults; however, the contact between the Grand Island tholeiite suite and the Winnipegosis komatiite suite was later interpreted as stratigraphic by Cominco Ltd. geologists (Lucas et al., 1996). Little is known about the two tholeiite suites, which are characterized by indistinguishable MORB-like trace-element profiles. They could represent separate sequences derived from a similar magmatic source or they could represent thrust repetitions (Carlson, 2017).

The three supracrustal suites form a west-facing homoclinal sequence that rests unconformably on weathered Superior craton tonalite to granodiorite (Lin et al., 1998; McGregor, 2012). The sequence consists of a thin, discontinuous interval of tonalite-derived basal conglomerate and sandstone (Lucas et al., 1996; Waterton et al., 2017). This is overlain by a package of Fe-tholeiite flows <1 km thick, with thick sulphidic argillite interflow horizons (Grand Island tholeiite suite). The tholeiites are overlain by a sequence of clastic and chemical sedimentary rocks <500 m thick, which are dominantly carbonate at the base and become increasingly shale rich at the top, indicating a subsiding basin. The sedimentary rocks are overlain by a thick succession (<1 km) of komatiite that varies from thin sheet flows to ponded cumulate horizons (Winnipegosis komatiite suite). One drillhole intersected a basaltic sequence along the western margin of the WKB, which is referred to as the upper tholeiite suite. Gabbro and peridotite–dunite bodies intrude all of the above units (Pearson, 1996; McGregor, 2012). The overall stratigraphy of the WKB remains largely unknown.

Rocks of the WKB are characterized by subgreenschist- to greenschist-facies metamorphic assemblages (Waterton et al., 2017) and appear to extend northward to where komatiites of similar low-metamorphic grade are recognized east of the William Lake area (Lin et al., 1998). Recent studies suggest the komatiitic magmas were generated by a mantle plume deflected toward the margins of the Superior craton by a thick lithospheric keel and were emplaced within an evolving rift environment (Ciborowski et al., 2017; Waterton et al., 2017). The nature of the boundary between the TNB and WKB remains uncertain, but is assumed to be a fault (Lin et al., 1998).

Tower deposit

The following summary of the Tower deposit is sourced from Couëslan (2018). Tower is a juvenile-arc–hosted VMS deposit situated along the eastern margin of the sub-Phanerozoic TNB, close to the boundary with the WKB (Figure GS2024-13-1). The deposit is hosted in a sequence of variably altered mafic to felsic metavolcanic rocks, now represented by a variety of amphibolites, gneisses, and schists with middle-amphibolite–facies

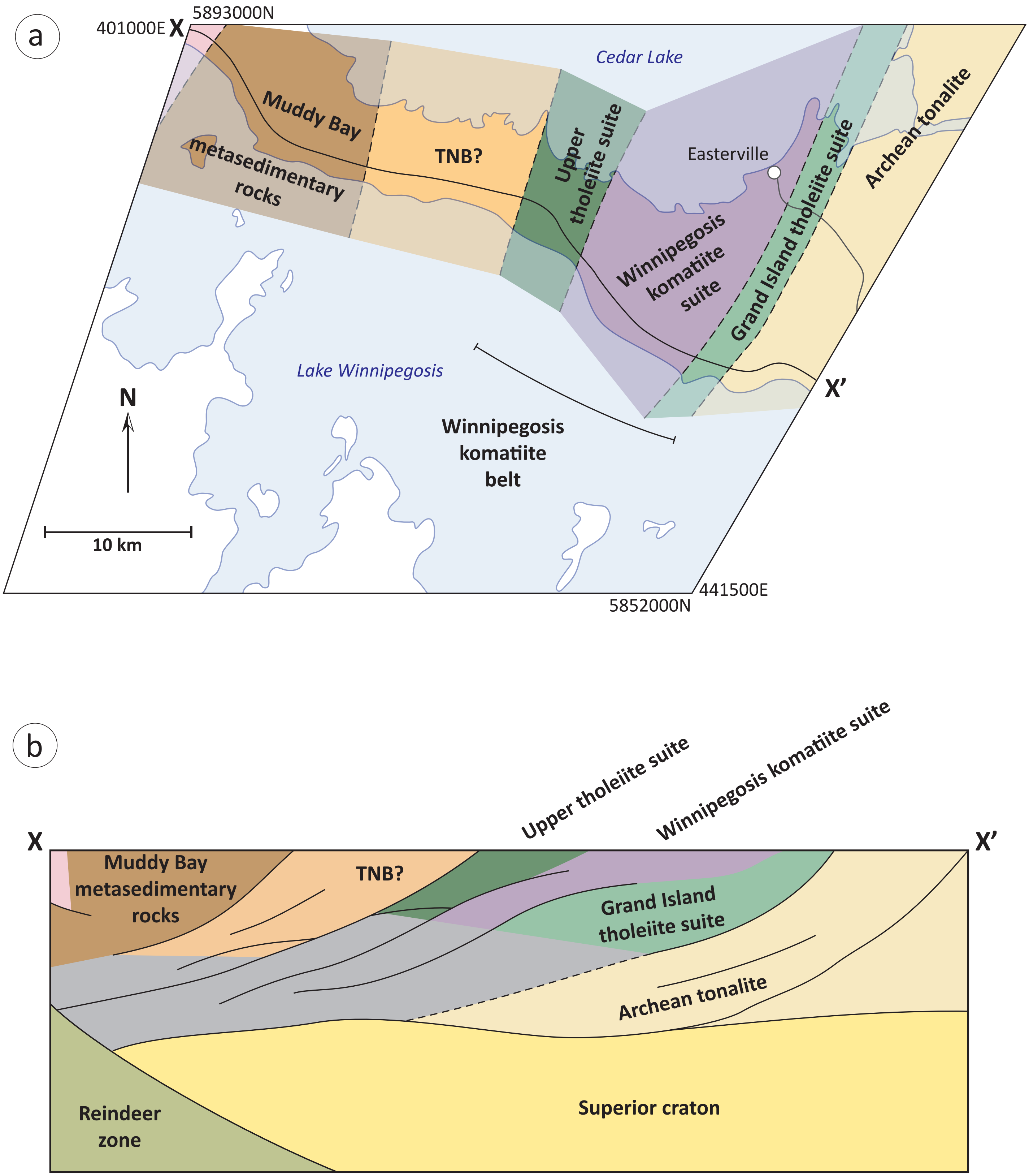

Figure GS2024-13-3: *Interpreted geology of the sub-Phanerozoic Superior boundary zone in the Lake Winnipegosis–Cedar Lake area of central Manitoba:* ***a)*** *map modified from Lucas et al. (1996);* ***b)*** *schematic interpretation of seismic data from LITHOPROBE transect S3B (line X–X'; adapted from Lucas et al., 1996; White et al., 2002). All co-ordinates are in UTM Zone 14, NAD83.*

assemblages. Lithogeochemistry suggests the sequence is dominantly mafic, with subordinate intermediate and felsic rocks. Zones of intense VMS-related hydrothermal alteration occur as muscovite-biotite, biotite-garnet, cummingtonite, and heterogeneous chlorite schists. The stratigraphy is intruded by mafic to ultramafic intrusions, and a juvenile granodiorite intrusion is present in the structural hangingwall to the deposit. The presence of felsic volcanic rocks with FII–FIIIa rhyolite geochemistry, local mafic rocks with boninitic affinity, and ultramafic rocks is suggestive of a rifted-arc environment. The rocks hosting the Tower deposit likely formed in an island-arc environment, within the Manikewan Ocean basin, at an unknown distance from the Superior craton margin. These juvenile-arc rocks were likely thrust onto the Superior craton during the Trans-Hudson orogeny and preserved as a klippe, or erosional remnant, approximately 30 km east (inboard) of the present-day craton margin.

Drillcore

Three complete drillholes and one partial drillhole that were collared near the boundary between the TNB and WKB, and roughly 16 km along strike from the Tower VMS deposit, were relogged. The drillholes were located on the compilation map of Macek et al. (2006) as an initial screening of the geological setting (Figure GS2024-13-4). Drillhole MRO-005 is interpreted to be within the TNB, in a region underlain by undivided Archean and Ospwagan group rocks. Farther north within the TNB, drillhole NIM-068 may be underlain by rocks of the Bah Lake volcanic assemblage. Drillholes MRO-006 and MRO-007 are located within the WKB, in a region underlain by mafic to ultramafic volcanic rocks and ultramafic intrusions. Thicknesses presented below are intersection widths, not true thickness. All Precambrian rocks in the drillcore are metamorphosed; however, the 'meta' prefix has been omitted for clarity.

Thompson nickel belt

MRO-005

The top of the Precambrian rocks in drillhole MRO-005 consists of 19 m of variably weathered ultramafic schist, which consists largely of clay, carbonate, chlorite, and pale green amphibole (Figure GS2024-13-5a). This is underlain by a 59 m intersection of interlayered pelite and iron formation (Figure GS2024-13-5b). The pelite forms beds <19 m thick, which are typically strongly foliated and well laminated. Local dark laminations are likely carbonaceous. Peak metamorphic assemblages contain quartz, plagioclase, muscovite, biotite, garnet, and staurolite, which is typical of the middle-amphibolite facies; however, much of the interval is retrogressed to weathered, with mafic minerals replaced by chlorite, clays, and iron oxides, and plagioclase replaced by epidote and clays. The pelite grades into a muscovite- and biotite-bearing siliceous sediment toward the bottom 5 m of the interval. The iron formation forms beds <8 m thick that are well layered to laminated and vary from strongly magnetic oxide- to nonmagnetic silicate-facies assemblages. Although garnet is typically well preserved, the remainder of iron-rich silicates are typically retrogressed to dark green chlorite or altered to brown clays. Preserved grunerite is relatively rare.

The pelite-iron formation package is underlain by a 3 m layer of graphitic and sulphidic schist (black shale). This is followed by 55 m of mafic volcanic rocks interbedded with subordinate impure chert and black shale (Figure GS2024-13-5c). The mafic volcanic rocks consist of relatively homogeneous amphibolite layers that likely represent massive flows or dikes, alternating with biotite-bearing, laminated beds that likely represent mafic tuff or possibly sheared flows. The impure chert occurs as well-laminated beds <4.5 m thick. It ranges from hornblende and biotite rich, with minor grunerite and garnet, to very siliceous, with minor amphibole and biotite. Although tentatively identified as impure chert, this unit could alternatively represent intermediate to felsic tuffaceous material. The black shale can occur as discrete layers within the basalt or in association with, and grading into, the impure chert.

The stratigraphy in MRO-005 could be interpreted as Pipe formation pelite and iron formation followed downhole by Bah Lake volcanic assemblage rocks, which would require that the stratigraphy is overturned (Figure GS2024-13-2). However, in this scenario Setting formation rocks are absent and seemingly replaced by black shale, which would indicate a detritus-starved basin. This would be in contrast with the high rates of sedimentation interpreted for the turbidite-derived Setting formation in the exposed parts of the TNB. In addition, the presence of interflow impure chert (or intermediate to felsic tuff) and black shale units is not typical of Bah Lake volcanic assemblage rocks in the exposed portions of the TNB. Black shale, or sulphidic argillite, is reported as thick interflow units associated with Fe-tholeiitic basalt in the Grand Island suite (McGregor, 2012). Iron formation and 'argillite' were also reported from a drillhole in the southern WKB, along strike from the Grand Island suite (Lin et al., 1998). However, the sequence in MRO-005 is metamorphosed to much higher grades than reported elsewhere for the WKB (typically subgreenschist to greenschist facies).

NIM-068

The Precambrian stratigraphy in drillcore NIM-068 begins with 9 m of variably weathered mafic volcanic rocks, followed by 155.5 m of basalt, with rare granitic pegmatite intrusions <1 m wide. The basalt varies from dark green and hornblende rich (Figure GS2024-13-5d) to grey-green, with minor hornblende and abundant tremolite and anthophyllite (Figure GS2024-13-5e). The lighter coloured layers become more abundant downhole and likely represent more magnesian bulk compositions. Local layers of well-laminated, biotite-bearing mafic tuff occur at the bottom of the interval and are <5 m thick. A 1.5 m mylonite zone is present approximately 110 m into the interval.

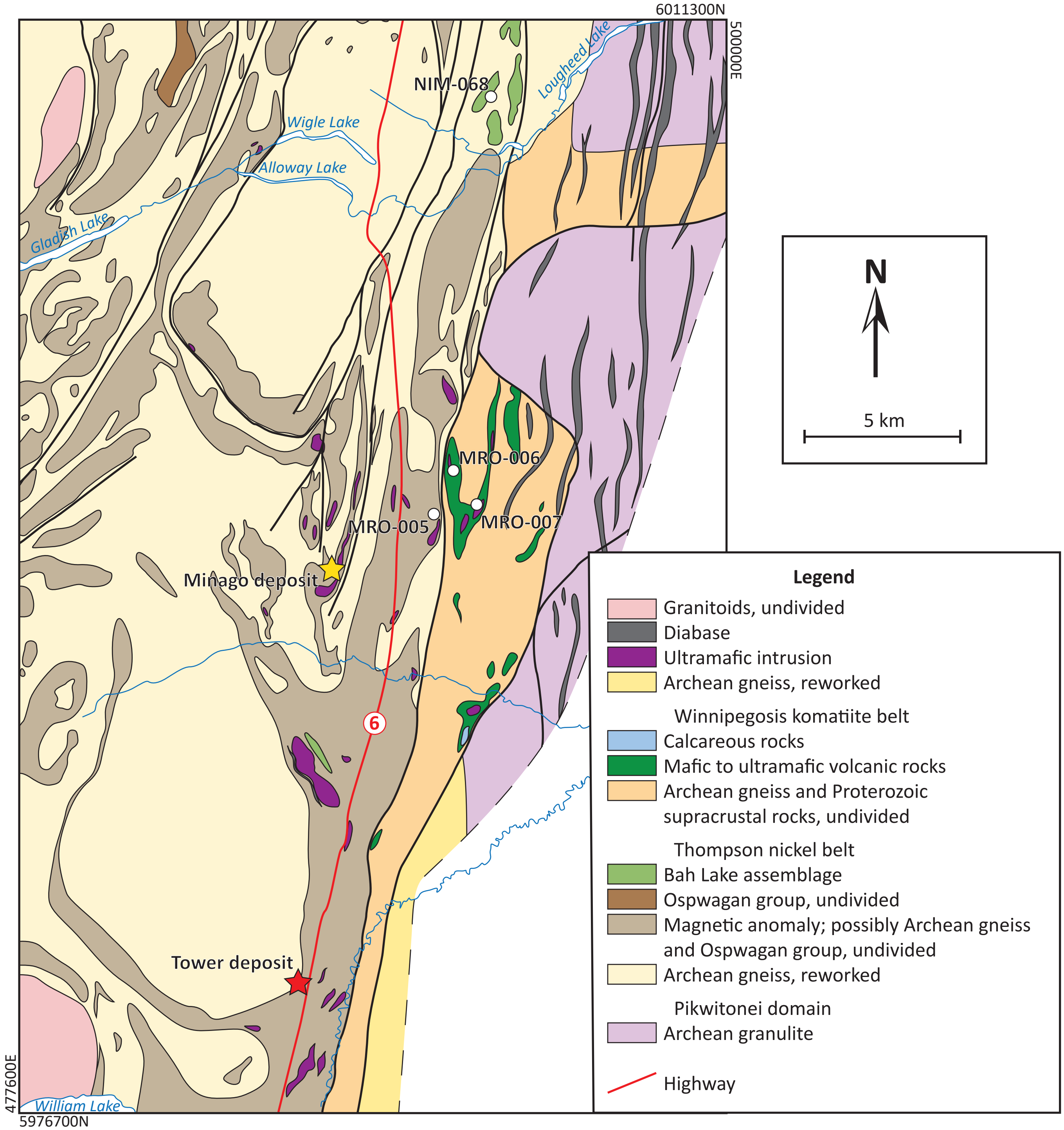

Figure GS2024-13-4: *Geology of the sub-Phanerozoic Thompson nickel belt in the Minago River area (modified from Macek et al., 2006). Circles indicate the locations of drillholes from this study; the red star indicates a volcanogenic massive sulphide deposit and the yellow star indicates a magmatic-nickel deposit. All co-ordinates are in UTM Zone 14, NAD83.*

The basalt is followed by a 15 m interval of peridotite that consists dominantly of serpentine, with minor anthophyllite and magnetite (Figure GS2024-13-5f). The peridotite contains local zones of ultramafic schist <2.5 m wide. The ultramafic schist typically consists of anthophyllite, with minor phlogopite; however, it can grade toward almost solid phlogopite. The peridotite is followed by 31 m of basalt grading into high-Mg basalt and mafic tuff toward the end of the interval. This is followed by a 4 m interval of graphite breccia, which consists of mafic tuff clasts in a matrix of graphite±subordinate pyrrhotite. The breccia varies from clast supported to matrix supported.

Underlying the breccia is an 18 m interval of picrite and mafic tuff interlayered on a scale <1.5 m (Figure GS2024-13-5g). The picrite is similar to the high-Mg basalt, but it is characterized

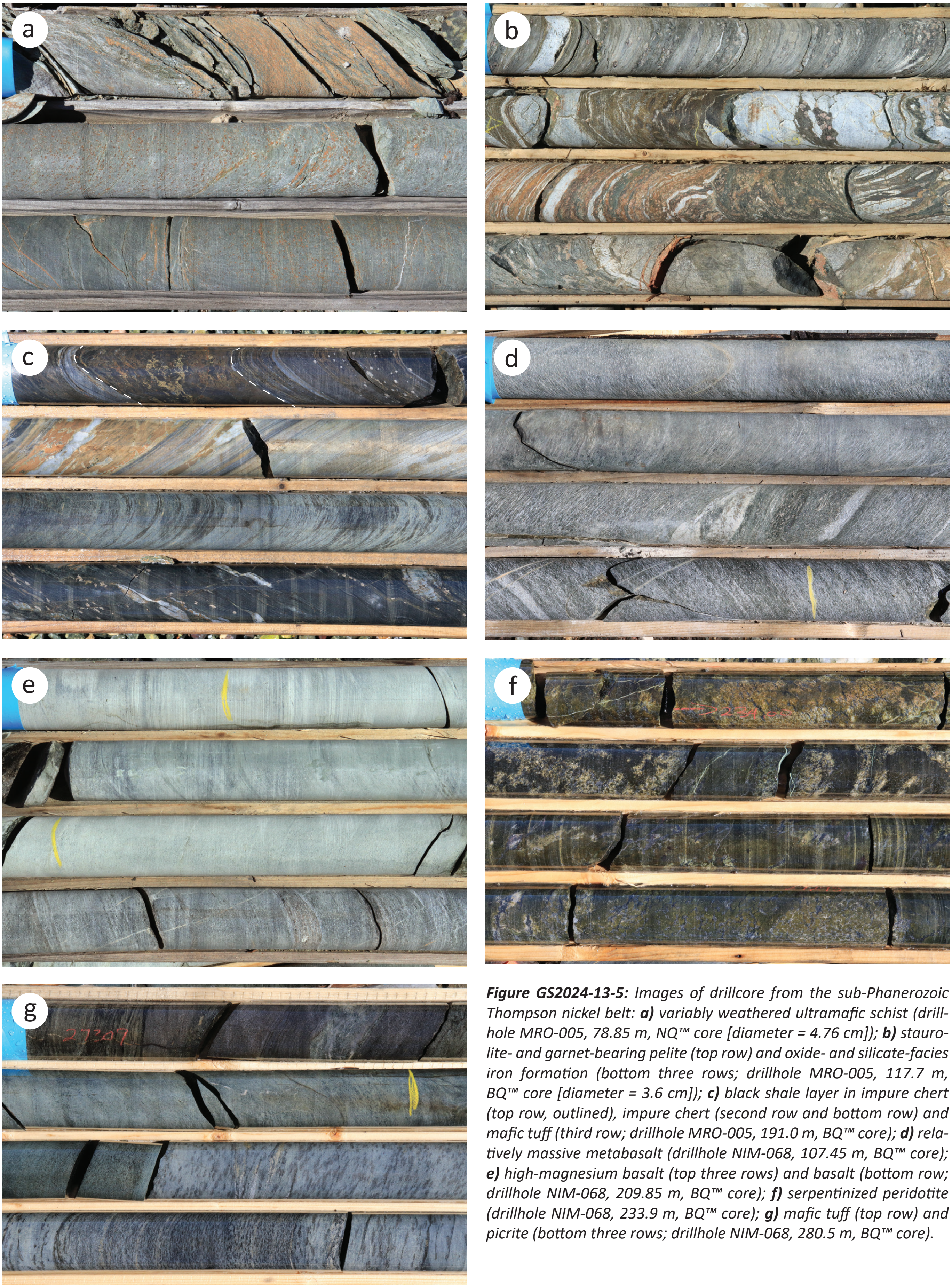

Figure GS2024-13-5: *Images of drillcore from the sub-Phanerozoic Thompson nickel belt:* ***a)*** *variably weathered ultramafic schist (drillhole MRO-005, 78.85 m, NQ™ core [diameter = 4.76 cm]);* ***b)*** *staurolite- and garnet-bearing pelite (top row) and oxide- and silicate-facies iron formation (bottom three rows; drillhole MRO-005, 117.7 m, BQ™ core [diameter = 3.6 cm]);* ***c)*** *black shale layer in impure chert (top row, outlined), impure chert (second row and bottom row) and mafic tuff (third row; drillhole MRO-005, 191.0 m, BQ™ core);* ***d)*** *relatively massive metabasalt (drillhole NIM-068, 107.45 m, BQ™ core);* ***e)*** *high-magnesium basalt (top three rows) and basalt (bottom row; drillhole NIM-068, 209.85 m, BQ™ core);* ***f)*** *serpentinized peridotite (drillhole NIM-068, 233.9 m, BQ™ core);* ***g)*** *mafic tuff (top row) and picrite (bottom three rows; drillhole NIM-068, 280.5 m, BQ™ core).*

by abundant flattened porphyroblasts of serpentinized olivine <5 mm across. This interval is intruded by a 4.5 m dike of grey, medium-grained biotite granite that contains trace amounts of garnet. The drillcore terminates in a 16 m interval of similar granite; however, it varies from grey to pink and contains local pegmatitic zones <40 cm thick.

The stratigraphy of drillcore NIM-068 consists almost entirely of mafic volcanic rocks, which makes interpreting the affinity difficult from hand sample observations alone. It is tentatively correlated with the Bah Lake assemblage, which is known to contain similar picritic rocks.

Winnipegosis komatiite belt

MRO-006

The top of the Precambrian rocks in drillcore MRO-006 consists of 32 m of relatively pure, grey to beige quartzite. The quartzite is foliated to mylonitic and contains trace amounts of oxide(s), minor amounts of intensely weathered feldspar, and minor zones of hematite staining (Figure GS2024-13-6a). The quartzite is relatively homogeneous, with local dark layers <5 cm thick that contain trace amounts of sulphide and biotite or chlorite. The quartzite is underlain by 106 m of dark green and variably sheared basalt (Figure GS2024-13-6b). The basalt is actinolite rich, with subordinate feldspar and local biotite. It is discontinuously layered on a scale <20 cm. Several metasomatized and sheared zones <2 m wide consist of a strongly foliated to protomylonitic, biotite-rich rock with local veinlets of quartz±feldspar (Figure GS2024-13-6c). Regularly spaced biotite-rich layers in lower strain basalt could represent pillow selvages. Toward the bottom of the interval, the basalt contains wispy epidote+quartz pods <2 cm thick and local carbonate veins <2 cm thick.

Strongly sheared granite intervals <26 m thick intrude the basalt and the basalt-quartzite contact. The granite is grey-brown to orange-green, protomylonitic to mylonitic, and consists of 30–40% quartzofeldspathic fragments <2 cm thick in a fine-grained biotite+quartz+feldspar matrix. The sheared granite contains local zones of hematization and chloritization, and (Fe-?) carbonate alteration. A single 14 m interval of sheared, garnet-bearing and biotite-rich quartzofeldspathic rock occurs toward the middle of the Precambrian section, and is bounded on both sides by sheared granite (Figure GS2024-13-6d). The rock is relatively homogeneous and could represent an interval of wacke, or possibly metasomatized basalt.

The affinity of the stratigraphy of drillcore MRO-006 is difficult to constrain because of its limited variability. The presence of quartzite in contact with mafic volcanic rocks could correlate with the Setting formation–Bah Lake assemblage transition in the Ospwagan group (Figure GS2024-13-2); however, the Setting formation quartzite is typically interlayered with pelite, which is not observed. Hornblende was not identified in hand sample, which could indicate greenschist-facies metamorphic assemblages typical of the WKB; however, confirmation of this observation requires further petrographic studies. Pure quartzite is not described from any part of the WKB stratigraphy.

MRO-007

The top of the Precambrian stratigraphy in drillcore MRO-007 consists of 11 m of regolith and intensely weathered basalt. This is followed by 58 m of ultramafic schist, with minor peridotite as intersections <7.5 m thick. The schist is silvery grey-brown and contains tan-weathering carbonate±serpentine pseudomorphs of olivine in a fine-grained groundmass of talc±anthophyllite (Figure GS2024-13-6e). The peridotite consists of serpentine with minor anthophyllite. Relict cumulate textures are locally preserved. Both the schist and the peridotite are strongly magnetic, with very fine-grained magnetite occurring in their respective groundmass.

The ultramafic rocks are followed by 150 m of basalt. The basalt occurs as fine-grained heterogeneous amphibolite that is plagioclase and actinolite rich, with minor hornblende. Local, coarse-grained homogeneous zones <9.5 m thick likely represent gabbro intrusions (Figure GS2024-13-6f). Sparse homogeneous zones grade into fine-grained amphibolite, which suggests they could represent massive flows. The amphibolite is discontinuously layered to laminated in places. The bottom 3.5 m of the unit is well laminated, which suggests it could represent a mafic tuff or strongly sheared basalt. The upper 3 m of the basalt, immediately below the ultramafic rocks, is brecciated, with locally intense veining of orange-weathering carbonate with or without a black acicular mineral that could be tourmaline.

The basalt is followed by 3 m of silicate-facies iron formation (Figure GS2024-13-6g). The iron formation is layered to laminated, with local chert beds up to 10 cm thick. Ferruginuous layers are grunerite and biotite rich, with minor magnetite and trace amounts of sulphide. Below the iron formation is a 43 m interval of white to light grey quartzite. The quartzite is relatively pure, with trace amounts of muscovite, biotite, sulphide, and <7% feldspar. The rock is massive to thickly bedded, with local pyrite-rich laminations and dark laminations that likely contain biotite±sulphide±graphite. The quartzite becomes interlaminated with pelite over the last 40 cm of the interval (Figure GS2024-13-6h). The pelite is muscovite rich, with local brown-pink garnets. The remaining 265 m of core from this drillhole was unavailable at the time of logging.

The stratigraphic sequence in drillcore MRO-007 of basalt to iron formation to quartzite does not correlate well with the Ospwagan group (Figure GS2024-13-2). Moreover, a sequence containing iron formation and relatively pure quartzite is not described from any part of the WKB stratigraphy. In addition, the presence of hornblende within the basalt suggests a metamorphic assemblage transitional into the amphibolite facies, which would represent a higher metamorphic grade than previously interpreted for the WKB. It should be emphasized that the

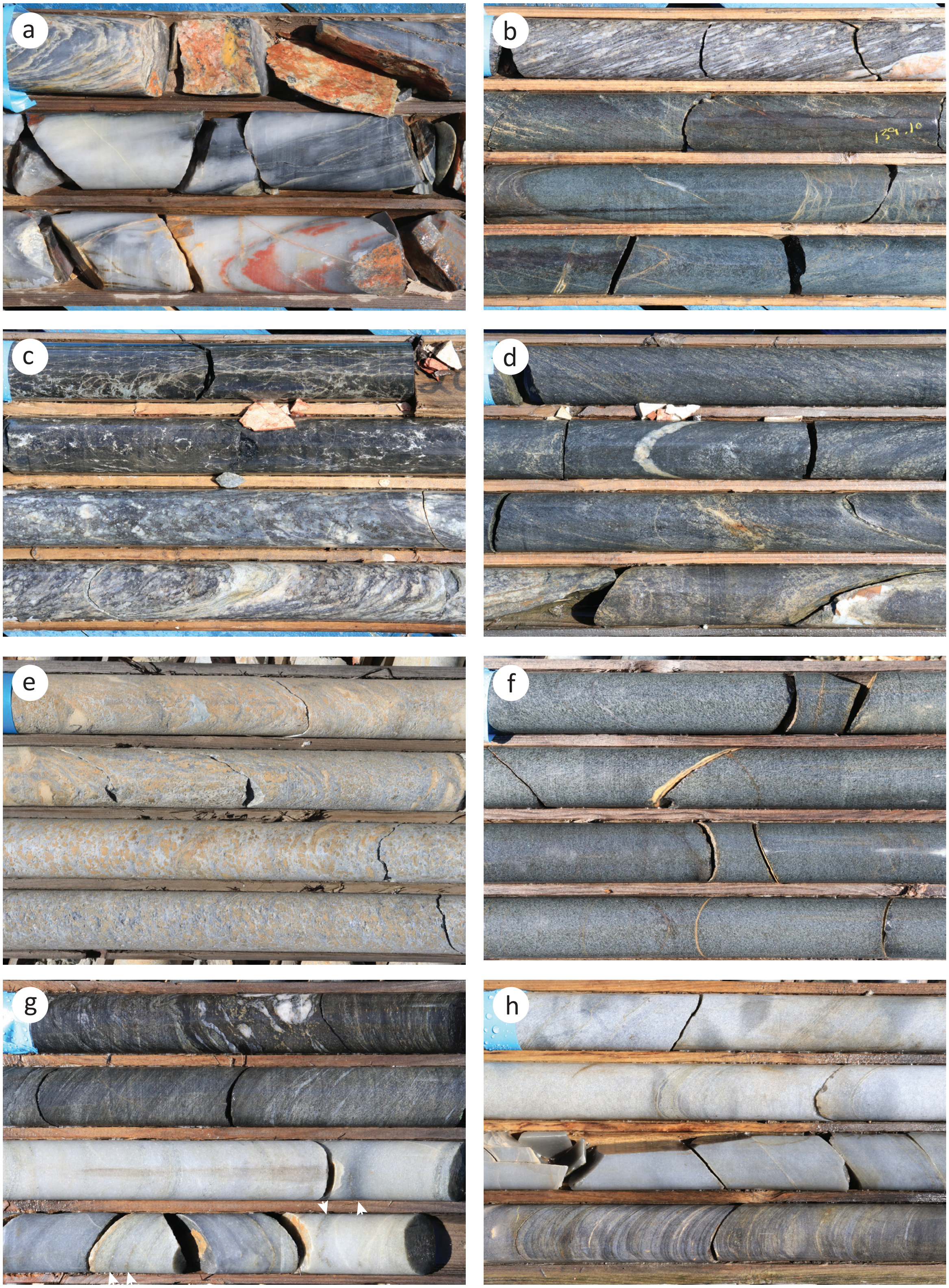

Figure GS2024-13-6: *Images of drillcore from the sub-Phanerozoic Winnipegosis komatiite belt:* ***a)*** *locally sheared quartzite with hematite staining (drillhole MRO-006, 104.7 m, NQ™ core [diameter = 4.76 cm]);* ***b)*** *protomylonitic granite (top row) and basalt (bottom three rows; drillhole MRO-006, 137.35 m, BQ™ core [diameter = 3.6 cm]);* ***c)*** *biotite-rich metasomatized rock with veinlets of quartz±feldspar (top two rows) and protomylonitic granite (bottom two rows; drillhole MRO-006, 205.75 m, BQ™ core);* ***d)*** *protomylonitic garnet-bearing and biotite-rich rock could represent sheared wacke or metasomatized basalt (drillhole MRO-006, 183.3 m, BQ™ core);* ***e)*** *talc-rich ultramafic schist (drillhole MRO-007, 116.5 m, BQ™ core);* ***f)*** *gabbro or possibly massive basalt (drillhole MRO-007, 157.8 m, BQ™ core);* ***g)*** *silicate-facies iron formation (top two rows) and quartzite with local sulphidic laminations (arrows, bottom two rows; drillhole MRO-007, 292.05 m, BQ™ core);* ***h)*** *quartzite (top three rows) and quartzite interlayered with pelite (bottom row, drillhole MRO-007, 332.5 m, BQ™ core).*

presence of the hornblende was identified in hand sample and requires further verification.

Economic considerations

Very little is known about the geology of the sub-Phanerozoic Superior boundary zone. Although its potential to host magmatic Ni-Cu deposits has been recognized for decades (Assessment Files 91655, 91731, 92282), its potential to host polymetallic VMS deposits is a relatively recent development (Assessment File 63G13256). The stratigraphy of the Ospwagan group and its importance for hosting Ni-deposits in the TNB is well established (Bleeker, 1990; Zwanzig et al., 2007). In contrast, the stratigraphy of the WKB and that of the juvenile volcanic-arc rocks hosting the Tower deposit remain largely unknown (Lin et al., 1998; Couëslan, 2018).

Determining the affinity of the volcanic rocks encountered in this study could have major implications for exploration in the sub-Phanerozoic Superior boundary zone. If it is determined that they share affinity with either the Bah Lake volcanic assemblage of the Ospwagan group (TNB) or the mafic to ultramafic volcanic rocks of the WKB, it could suggest potential for magmatic Ni-Cu deposits. If the volcanic rocks are correlative with the juvenile rocks that host the Tower deposit, it could suggest potential for Cu-Zn-Ag-Au VMS deposits and extend the area of known arc-affinity rocks in the area.

No obvious felsic or intermediate volcanic rocks, or VMS-related hydrothermal alteration, was recognized in the drillcore to correlate it with stratigraphy at the Tower deposit. Moreover, none of the logged drillcore could be unambiguously placed within Ospwagan group (TNB) or WKB stratigraphy. It is presumed that whole-rock lithogeochemistry and Sm-Nd isotope geochemistry, in combination with thin-section petrography, will help determine the affinity of the rock units described in this study. It is hoped that additional information can also be gathered from logging other drillcore in the area, if it becomes available.

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