GS2023-5

Logging of archived drillcore and re-interpretation of stratigraphy from the Halfway Lake area, Thompson nickel belt, central Manitoba (parts of NTS 63O1, 2)

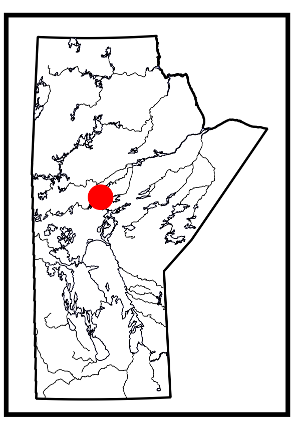
by C.G. Couëslan

In Brief:

- Archived drillcore from industry and government core libraries was relogged to help constrain the extent and affinity of metasedimentary rocks at Halfway Lake
- A compiled lithologic section correlates well with Ospwagan group stratigraphy
- A working stratigraphic section has been created to aid exploration efforts in the Halfway Lake area

Citation:

Couëslan, C.G. 2023: Logging of archived drillcore and re-interpretation of stratigraphy from the Halfway Lake area, Thompson nickel belt, central Manitoba (parts of NTS 63O1, 2); *in* Report of Activities 2023, Manitoba Economic Development, Investment, Trade and Natural Resources, Manitoba Geological Survey, p. 27–39.



Summary

This report details the continuation of a bedrock mapping project at Halfway Lake in the Thompson nickel belt, which was initiated in 2022. During the winter and summer of 2023, archived drillcore from industry and government core libraries was relogged to help determine the extent and affinity of metasedimentary rocks in the area. A lithological section was compiled across four diamond-drill holes in the east-central Halfway Lake area. The section consists of orthogneiss, mylonite, calcareous and sulphidic metasedimentary rocks, and interbedded quartzite and metapelite. The lithological section correlates well with Ospwagan group stratigraphy. It implies Archean basement gneiss is in sheared contact with calcareous rocks of the Thompson formation, which is overlain by pelitic and sulphidic rocks of the P2 member of the Pipe formation, and interbedded quartzite and pelite with rare iron formation of the P3 member. Setting formation rocks likely overlie the last iron formation of the P3 member. Although not present in the lithological section, Bah Lake assemblage volcanic rocks occur along strike and are interpreted to overlie the Setting formation rocks.

Ultramafic rocks occur near the Thompson formation–Pipe formation transition and are locally in close spatial association with P2 member sulphidic rocks, which correlates with the ore horizon at the Thompson mine. Mineralized ultramafic rocks in this vicinity were the focus of previous exploration activity. A similar structural regime as that of the Thompson mine area implies that exploration efforts targeting F_3 fold structures for thickened zones of sulphide in hinge zones and mineralization hosted by metasedimentary rocks rather than by intrusions could be viable strategies in the Halfway Lake area.

Introduction

A mapping project at Halfway Lake was initiated in the summer of 2022 (Couëslan, 2022a). Mapping was conducted along the lakeshore at a scale of 1:20 000 utilizing the stratigraphic framework for the Thompson nickel belt (TNB). The goal of the project was to update the mapping with respect to the Ospwagan group stratigraphy and to characterize the mafic rocks of the southeastern Halfway Lake area, which are believed to be correlative with the Bah Lake assemblage. In addition, a search was made for possible Paint sequence rocks (Couëslan, 2016, 2022b) misidentified as Archean basement gneiss or as 'ghost successions' of the Ospwagan group (cf. Zwanzig et al., 2007).

Mapping revealed the extent of metasedimentary rock exposures on Halfway Lake to be significantly less than indicated by previous compilation work (Figure GS2023-5-1; Macek et al., 2006). Two metasedimentary rock packages were identified: a calcsilicate-semipelite assemblage, tentatively correlated with the Thompson formation of the Ospwagan group, and a quartzite-pelite assemblage of uncertain affinity. Archived drillcore from industry and government core libraries was relogged during the winter and summer of 2023 to help constrain the extent, and help determine the affinity of, the metasedimentary rocks at Halfway Lake. For a review of the regional and local geology, the reader is referred to Couëslan (2022a).

New results

Drillcore archived by the Manitoba Geological Survey, CaNickel Mining Ltd. and Vale Canada Ltd. was relogged in an effort to better constrain the geology of the Halfway Lake area. The drillcore was especially useful in determining the affinity of the sedimentary packages as well as the stratigraphic relationship between the calcsilicate-semipelite and quartzite-pelite assemblages. A lithological section believed to be representative for the Halfway Lake area was compiled using data from several drillholes located in the east-central Halfway Lake area. All rocks discussed in the text were metamor-

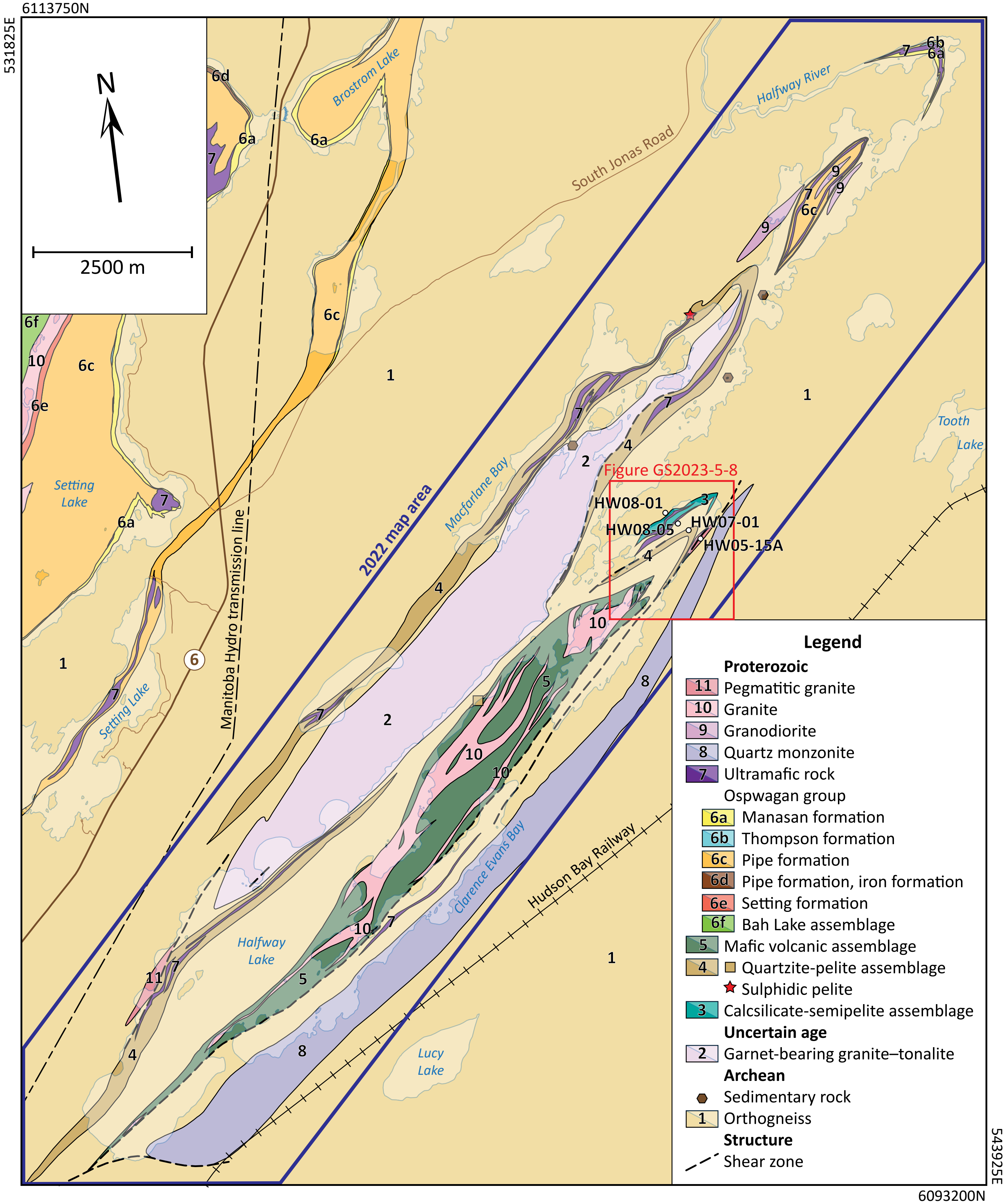


Figure GS2023-5-1: *Bedrock geology of the Halfway Lake area, central Manitoba (modified from Couëslan, 2022c). Lighter shade of colour indicates a body of water. White circles in the east-central Halfway Lake area indicate the location of drill collars used to construct the lithological section (Figure GS2023-5-2). Geology outside of the 2022 map area is from Macek et al. (2006). The red outline shows the location of Figure GS2023-5-8. All co-ordinates are in UTM Zone 14, NAD83.*

phosed to amphibolite-facies conditions; however, to improve the readability of the text, the 'meta-' prefix has been omitted from rock names.

Stratigraphic section from the east-central Halfway Lake area

A lithological section has been compiled across drillholes HW08-01, HW08-05, HW07-01 and HW05-15A (Figure GS2023-5-2; Assessment Files 74270, 74504, 74607; Manitoba Economic Development, Investment, Trade and Natural Resources, Winnipeg). These holes are arrayed across strike and define a northwest to southeast section through what is interpreted as a fold structure in the east-central Halfway Lake area. Drillhole HW08-01 is collared in Archean gneiss and directed southeast toward the calcsilicate-semipelite assemblage presented in Couëslan (2022a), whereas drillhole HW05-15A is collared in

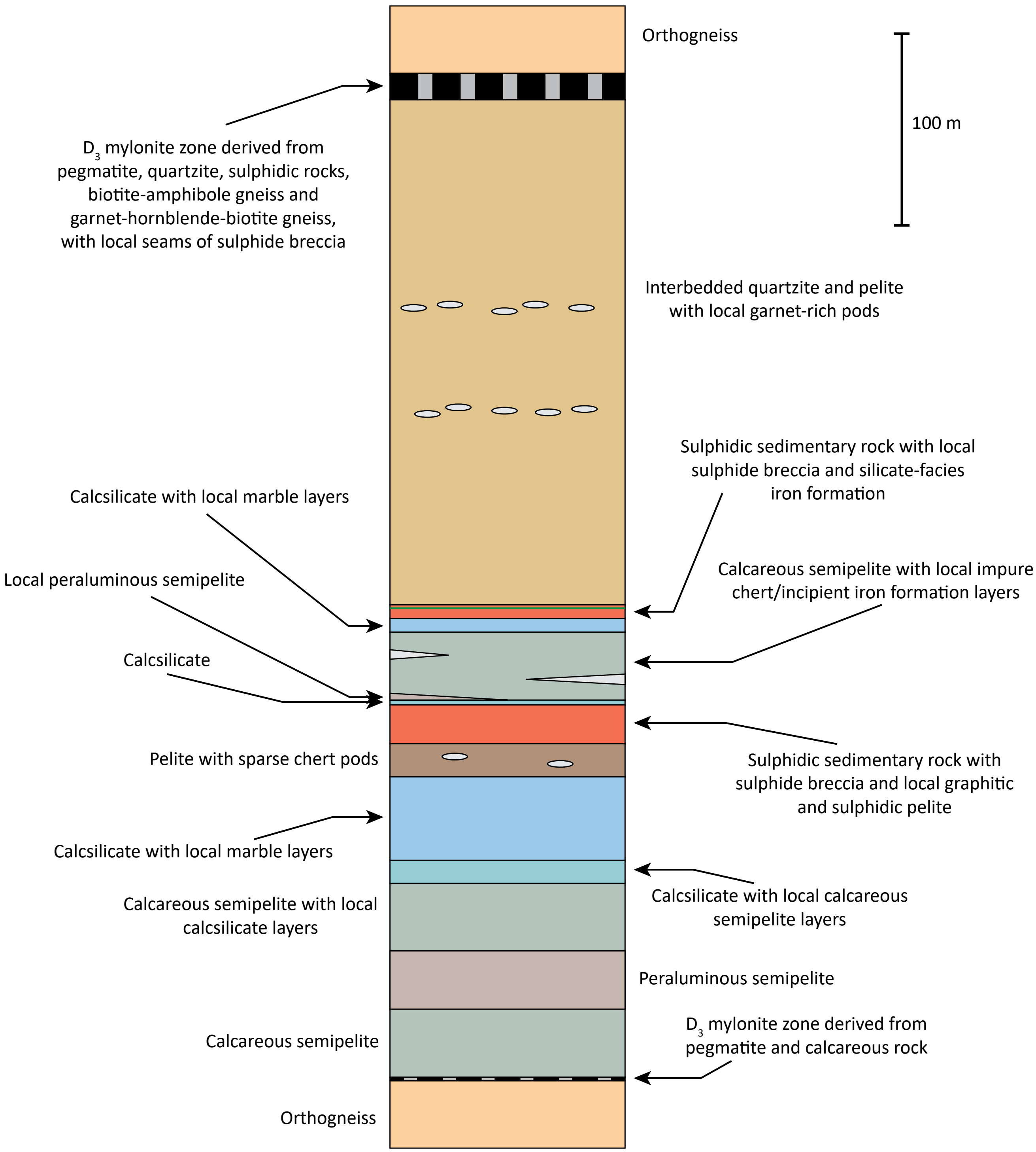


Figure GS2023-5-2: *Schematic lithological section compiled from drillcores HW08-01, HW08-05, HW07-01 and HW05-15A from the Halfway Lake area.*

Archean gneiss and directed northwest toward the quartzite-pelite assemblage. Drillholes HW08-05 and HW07-01 are collared between the previous two drillholes and are both directed toward the northeast.

Although the descriptions below are specific to this section, similar units and relationships were noted throughout the Halfway Lake area. The approximate true thickness is given for each lithological unit; however, the thickness of many units has been disrupted by granitic, mafic and ultramafic intrusions. Unit thicknesses are also expected to vary along strike because of isoclinal folding and attenuation and thickening along regional fold limbs and fold hinges, respectively. All units contain variable amounts of plagioclase amphibolite as metre- to centimetre-scale intersections. The plagioclase amphibolite is interpreted as mafic rock derived at least in part from the Molson dike swarm. Variable amounts of granitic pegmatite are present in all units with intrusions varying from centimetres to tens of metres in scale.

Orthogneiss

Drillhole HW08-01 is collared in grey orthogneiss (Figure GS2023-5-3a). The gneiss is tonalitic to granodioritic, with 7–10% biotite and trace to minor amounts of hornblende. The biotite content locally increases to 10–20%. The mafic minerals typically define gneissic laminations; however, the gneissosity is locally more diffuse. The gneiss shows signs of increasingly higher strain upsection, with local protomylonitic zones.

Shear zone

The Archean orthogneiss is in contact with a mylonitic zone 1.7 m wide. This zone appears to consist of sheared pegmatite and calcareous rocks (Figure GS2023-5-3b). Multiple seams of mylonitized carbonate rock <15 cm thick are present, along with one intersection of less deformed carbonate rock 5 cm thick.

Calcareous semipelite

Juxtaposed against the shear zone is a package of calcareous semipelite 100 m thick (Figure GS2023-5-3c). The calcareous semipelite is grey, medium- to coarse-grained, foliated to strongly foliated and nonmagnetic. It forms a poorly layered diatexite, with 10–20% biotite and a quartzofeldspathic groundmass. Calcic mineral content ranges from 3–5% hornblende in less calcareous zones to 10–12% diopside and/or tremolite in more calcareous compositions. The semipelite locally contains up to 5% pyrrhotite. It becomes increasingly calcareous upsection, where it becomes interlayered with local beds of calcsilicate <5 m thick.

Toward the middle of the calcareous semipelite package is an interval of peraluminous semipelite 30 m thick that is disrupted by abundant pegmatite, which makes up 60–70% of the core (Figure GS2023-5-3d). The semipelite forms a diatexite, with 10–30% biotite and trace amounts of sulphide and garnet in a quartzofeldspathic groundmass. It is locally more aluminous, with 5–7% garnet, or sulphidic, with 5–7% pyrrhotite.

Calcsilicate and marble

The calcareous semipelite grades over approximately 12 m into a sequence of calcsilicate and marble 35–50 m thick. This unit becomes increasingly calcareous upsection. Lower in the section, it consists of calcsilicate interlayered with minor calcareous semipelite beds <30 cm thick, whereas higher in the section, it consists of approximately equal proportions of calcsilicate and impure marble interlayered on a scale of <2 m.

The calcsilicate is green, coarse grained, foliated to massive and nonmagnetic (Figure GS2023-5-3e). It ranges from relatively quartzofeldspathic, with 10–20% biotite, 20–30% diopside and minor sulphide, to nearly solid diopside. Local layers contain minor amounts of a nonmagnetic, black, opaque mineral tentatively identified as spinel or possibly darkly coloured titanite. The calcsilicate ranges from well laminated to poorly layered on a scale of <1.5 m.

The marble is beige to greenish white, medium to coarse grained and foliated (Figure GS2023-5-3f). The composition varies from 20–30% phlogopite and carbonate, to 2–3% phlogopite, 3–5% diopside, 20–30% serpentinized olivine and carbonate. The marble ranges from relatively homogeneous to poorly layered on a scale of <10 cm.

Pelite

Upsection from the calcsilicate and marble package is a package of pelite 13–20 m thick (Figure GS2023-5-3g). The contact between the pelite and the previous calcareous metasedimentary rocks is obscured by pegmatite. The pelite is grey-brown, medium to coarse grained and strongly foliated. It forms a quartzofeldspathic diatexite, with 20–30% biotite, minor sillimanite and pink-violet garnet, and trace to minor amounts of sulphide. Sparse siliceous pods contain 10–20% fine-grained garnet and may represent nodules or discontinuous layers of chert. The pelite is intruded by pervasive pegmatite, which can be locally protomylonitic and brecciated. The brecciated zones locally contain veins and blebs of sulphide <1 cm thick.

Sulphidic sedimentary rock

Following the pelite is a unit of sulphidic sedimentary rock 12–27 m thick, with significant zones of sulphide breccia up to 3.3 m thick (Figure GS2023-5-3h). The sulphidic rocks are intruded by large volumes of pegmatite that make up 50–60% of the core. The sulphidic sedimentary rock is grey, medium grained, foliated to strongly foliated and magnetic. It is quartzofeldspathic, with 5–7% pyrrhotite and 10–20% biotite, and locally pelitic, with minor amounts of graphite, garnet and sillimanite.

The sulphide breccia is brown bronze, medium to coarse grained, foliated to brecciated and strongly magnetic. It consists

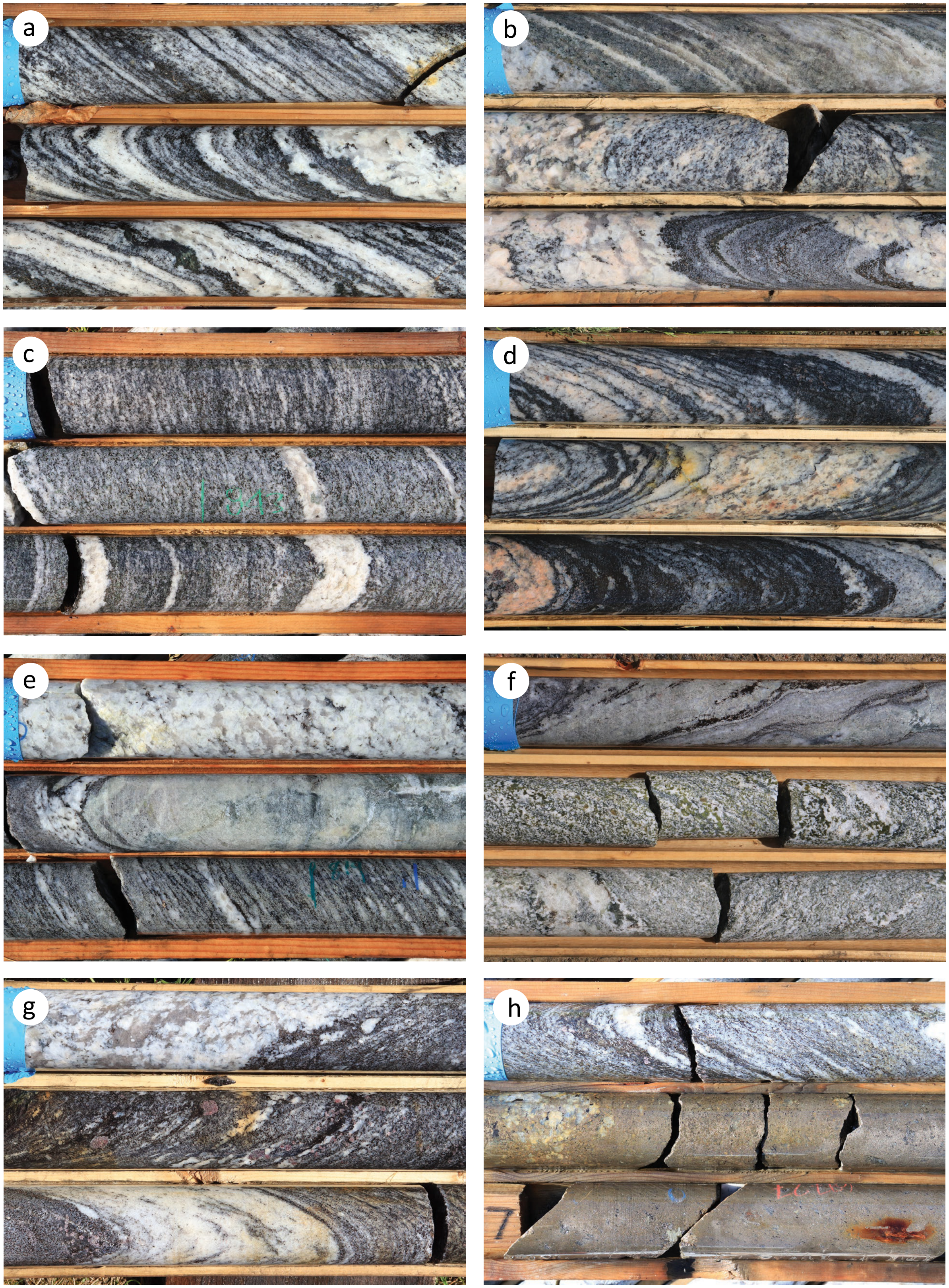


Figure GS2023-5-3: *Diamond-drill core images from the east-central Halfway Lake area:* ***a)*** *tonalitic orthogneiss (drillhole HW07-01, 571.6 m);* ***b)*** *mylonitic calcareous rock (top row) and pegmatite with semipelitic schlieren and xenoliths (bottom two rows; drillhole HW08-01, 94.2 m);* ***c)*** *calcareous semipelite with local pegmatitic injections and/or leucosome (drillhole HW05-15A, 816.0 m);* ***d)*** *peraluminous semipelite disrupted by pegmatitic injections (drillhole HW08-01, 163.4 m);* ***e)*** *pegmatite (top row) and calcsilicate (bottom two rows; drillhole HW05-15A, 816 m);* ***f)*** *calcsilicate (top row) and marble with serpentinized olivine (bottom two rows; drillhole HW08-05, 186.1 m);* ***g)*** *sillimanite- and garnet-bearing pelite with pegmatitic injections and/or leucosome (drillhole HW08-01, 403.1 m);* ***h)*** *sulphidic pelite (top row) and sulphide breccia (bottom two rows; drillhole HW05-15A, 674.0 m). The drillcore is NQ™ (diameter = 4.76 cm).*

of near solid pyrrhotite, with 10–20% biotite, 30–40% rounded to irregular fragments of quartzofeldspathic material <3 cm across, and minor graphite and garnet. Graphite is locally more abundant and can make up 10–12% of the breccia. Assay results reveal that the sulphidic rocks are not mineralized in Ni or Cu (Assessment Files 74270, 74504, 74607).

Calcareous semipelite

The sulphidic sedimentary rocks are followed respectively by a thin (2.5 m) layer of calcsilicate and an interval of calcareous semipelite 30–40 m thick. The semipelite is poorly layered on a scale of <1 m and is quartzofeldspathic, with 10–20% biotite and 3–5% hornblende or 5–7% diopside. It contains local siliceous layers <40 cm thick that contain abundant hornblende and red-burgundy garnet, which could be derived from impure chert or incipient iron formation (Figure GS2023-5-4a). The start of the semipelite interval is locally more aluminous, with 5–7% garnet and no hornblende or diopside.

Calcsilicate and marble

The calcareous semipelite grades into 5–10 m of calcsilicate, with minor marble layers <20 cm thick. The calcsilicate is light green and diopside rich, with minor biotite in a groundmass of quartz and feldspar. Sparse blebs of carbonate can be present. The calcsilicate ranges from poorly layered to well laminated and locally grades toward more biotite-rich compositions.

The marble varies from pinkish to greenish grey, and is coarse grained and foliated. It consists of white to pink carbonate, with abundant serpentinized olivine and minor to trace amounts of diopside, tremolite and phlogopite. The marble varies from poorly layered to well laminated.

Sulphidic sedimentary rock

The calcsilicate grades over 2 m into an interval of sulphidic sedimentary rock 7 m thick. The sulphidic sedimentary rock is locally more siliceous than previously described and can contain 20–30% biotite. It contains local seams of sulphide breccia <40 cm thick. In the upper part of the interval, a thin (20–35 cm) bed of silicate-facies iron formation grades upward into sulphide breccia (Figure GS2023-5-4b). The purplish grey-green iron formation is laminated, locally magnetic and contains 20–30% ferrosilite, 30–40% garnet and minor pyrrhotite in a siliceous groundmass. Assessment Files show this package to be barren of Ni and Cu mineralization.

Interbedded quartzite and pelite

Upsection from the sulphidic rocks is a package of quartzite and pelite 260 m thick. The quartzite and pelite are interlayered on a scale of <7 m. The quartzite is light grey to beige and contains minor to trace amounts of biotite, pink-violet garnet and pyrrhotite. The quartzite can grade toward protoquartzite, with 2–3% garnet, 7–10% biotite and an increased feldspar content (Figure GS2023-5-4c). The quartzite can be internally layered to laminated on a scale of <15 cm and beds of quartzite are commonly separated by thin pelitic laminations.

The pelite is brown grey, strongly foliated and weakly magnetic in places. It typically forms a quartzofeldspathic diatexite, with 20–30% biotite, minor sillimanite and pink-violet garnet, and trace amounts of pyrrhotite and graphite (Figure GS2023-5-4d). It can grade toward more semipelitic compositions, with no sillimanite and decreased biotite and garnet content, or toward more aluminous compositions, with 5–7% sillimanite and 30–40% biotite.

The interbedded quartzite-pelite sequence also contains at least two varieties of sparse, garnet-bearing pods <5 cm thick that vary from pink to green. The pink variety is garnet and quartz rich with subordinate feldspar. The green variety is quartz rich, with an abundant green mineral that could be either clinozoisite or amphibole and subordinate very pale pink garnet. Both varieties can be zoned with white, feldspar-bearing siliceous rims <2 cm thick (Figure GS2023-5-4e). These pods may represent impure chert nodules or layers and/or calcareous concretions.

Shear zone

The quartzite-pelite package terminates at a shear zone. The shear zone consists of an interval of protomylonitic to mylonitic rock 14 m thick that appears to be derived from pegmatite, quartzite, sulphidic gneiss, biotite-amphibole gneiss and garnet-hornblende-biotite gneiss, along with lenses of strongly foliated plagioclase amphibolite and local seams of sulphide breccia (Figure GS2023-5-4f).

Orthogneiss

Drillhole HW05-15A is collared in orthogneiss, which grades from foliated to protomylonitic with proximity to the above shear zone. The orthogneiss is grey, medium to coarse grained and nonmagnetic. It is tonalitic to granodioritic, with 10–20% biotite and trace amounts of red-burgundy garnet (Figure GS2023-5-4g). The orthogneiss locally contains minor hornblende.

Ultramafic rocks

Peridotite intrusions occur within the calcsilicate and marble package, and in contact with the sulphidic sedimentary rocks. The peridotite is serpentine-rich, with 10–20% anthophyllite and trace to minor amounts of sulphide and magnetite (Figure GS2023-5-4h). It locally grades in composition to dunite and pyroxenite. The peridotite contains local zones of ultramafic schist, typically in close spatial association with pegmatite intrusions. The ultramafic schist typically contains variable amounts of anthophyllite, chlorite and biotite. The schist can locally grade into monomineralic rocks consisting of any one of these three minerals. Although not part of this study, intersections of mineralized peridotite in the vicinity have yielded assays of 1.38%

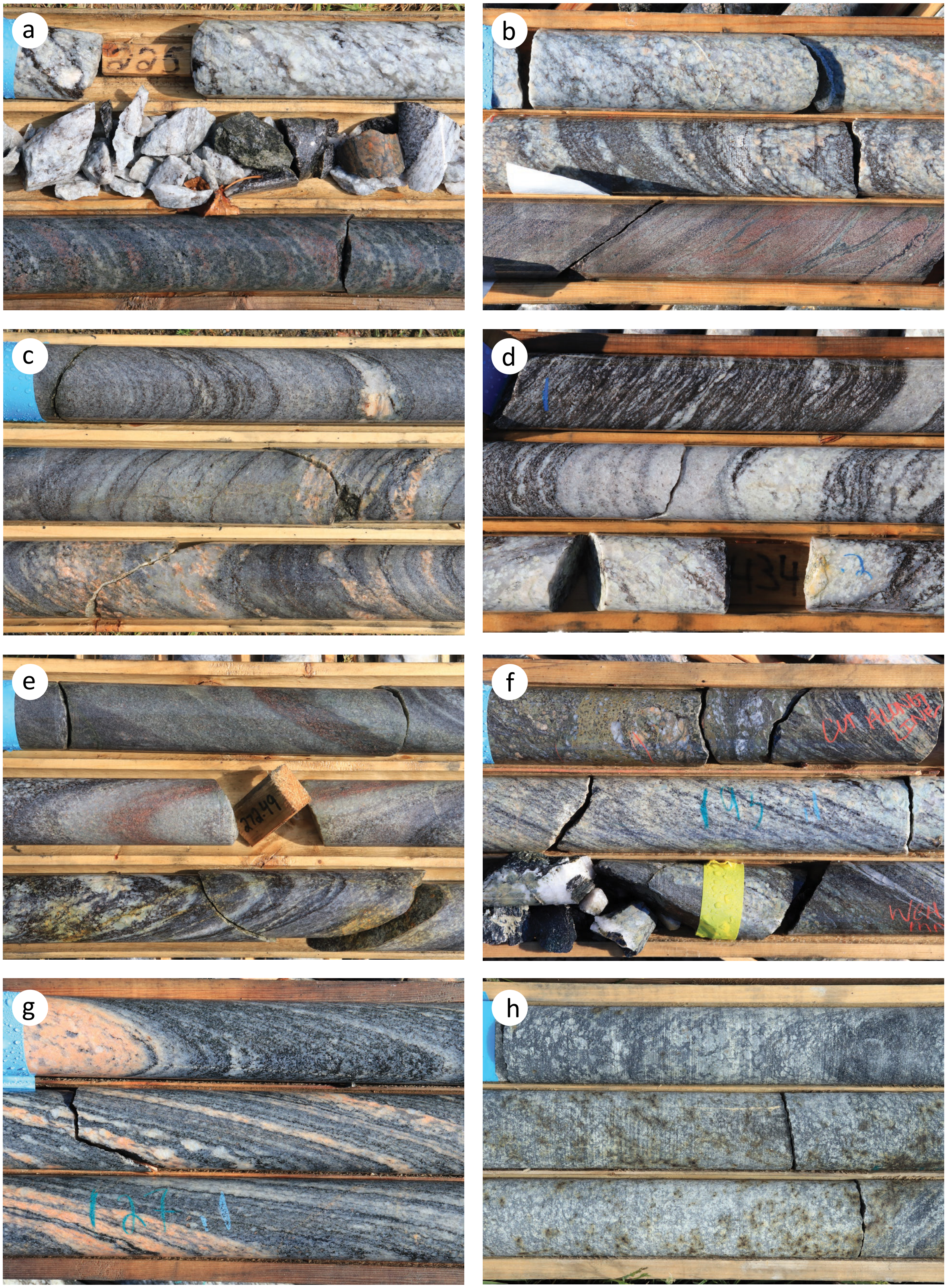


Figure GS2023-5-4: *Diamond-drill core images from the east-central Halfway Lake area:* ***a)*** *pegmatite (top two rows) and impure chert or incipient iron formation (bottom row; drillhole HW07-01, 224.9 m);* ***b)*** *pegmatite with schlieren and xenoliths of sulphidic sedimentary rock (top two rows) and silicate-facies iron formation (bottom row; drillhole HW05-15A, 575.5 m);* ***c)*** *protoquartzite with pelitic layers and laminations, and pegmatite injections (drillhole HW07-01, 91.7 m);* ***d)*** *pelite interlayered with quartzite and intruded by local pegmatite (drillhole HW05-15A, 431.0 m);* ***e)*** *zoned, garnet-rich concretions in quartzite (top two rows), and interlayered pelite and quartzite (bottom row; drillhole HW08-08, 271.0 m);* ***f)*** *protomylonite derived from biotite gneiss, pegmatite, and sulphidic and semipelitic rocks (drillhole HW05-15A, 91.5 m);* ***g)*** *garnet-bearing orthogneiss with sheared pegmatitic injections (drillhole HW05-15A, 24.2 m);* ***h)*** *peridotite (top row) grading into sulphide-bearing olivine pyroxenite (bottom two rows; drillhole HW05-15A, 751.4 m). Drillcore is NQ™ (diameter = 4.76 cm), except for (e), which is BQTK™ (diameter = 4.07 cm).*

Ni over 17.55 m (drillhole HW95-05; Assessment File 72905) and 1.58% Ni over 13.03 m (drillhole HW08-02; Assessment File 74607).

Correlations with 2022 mapping and regional stratigraphy

Two sedimentary rock assemblages were defined from geological mapping in 2022: the calcsilicate-semipelite assemblage and the quartzite-pelite assemblage (Couëslan, 2022a). Although the two assemblages were found in relatively close proximity in the east-central Halfway Lake area, it remained uncertain if they were part of a continuous stratigraphic sequence. From the lithological section described above, it appears that the calcareous semipelite and calcsilicate with marble packages correlate with the calcsilicate-semipelite assemblage of Couëslan (2022a), whereas the interlayered quartzite and pelite package correlates with the quartzite-pelite assemblage. The continuous, and locally gradational, nature of the units in the section implies that the two assemblages represent parts of a single continuous sedimentary rock succession. The sulphidic and graphitic pelite that was assigned to the quartzite-pelite assemblage in Couëslan (2022a) likely correlates to one of the two sulphidic sedimentary rock units observed in the drillcore section described above.

The wide variations in sedimentary lithologies observed in the Halfway Lake rocks do not match the relatively restricted range of compositions observed to date in the Paint sequence (Couëslan, 2016, 2022b). The drillcore section outlined above appears to be a better match for Ospwagan group stratigraphy (Figure GS2023-5-5).

Toward the base of the Ospwagan group is a substantial thickness of semipelite, which forms the M2 member of the Manasan formation (Figure GS2023-5-2). This could be correlative with

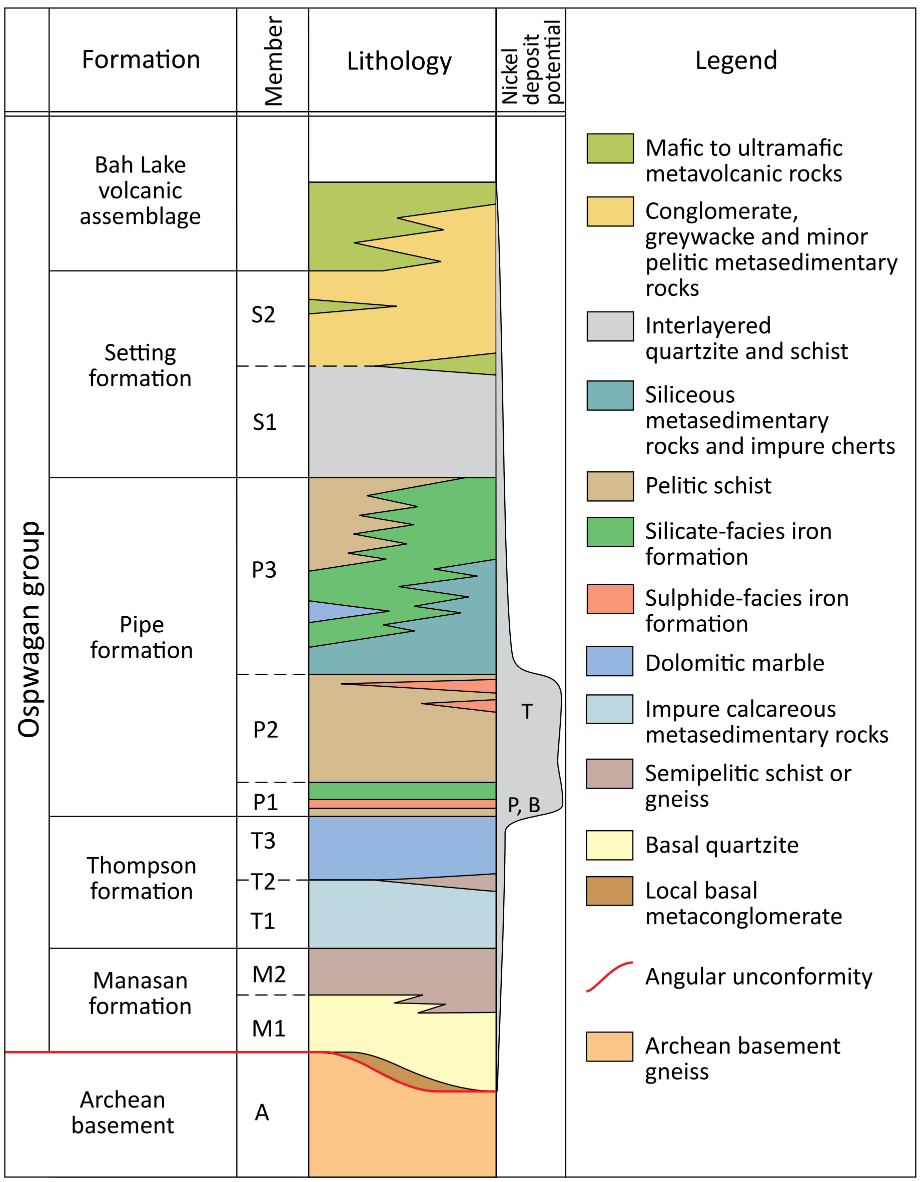


Figure GS2023-5-5: *Schematic lithostratigraphic section of the Ospwagan group (modified from Bleeker,1990). Abbreviations: B, stratigraphic location of the Birchtree orebody; P, stratigraphic location of the Pipe II orebody; T, stratigraphic location of the Thompson ore body.*

the calcareous semipelite near the base of the lithological section described above. However, this would require the input of a calcareous component not seen in the M2 member, which is typically peraluminous and muscovite or sillimanite bearing. In addition, the Ospwagan group stratigraphy as defined by Bleeker (1990) and updated by Zwanzig et al. (2007), assigned all calcareous rocks from the lower part of the Ospwagan group to the overlying Thompson formation. Therefore, by definition, both the calcareous semipelite and calcsilicate-marble units should be part of the Thompson formation. The calcareous semipelite likely represents a more clastic-rich portion of the T1 member or possibly a rather thick example of the semipelitic T2 member, which to date has only been documented as a thin (1–4 m), discontinuous layer at the Thompson mine (Bleeker, 1990; Zwanzig et al., 2007). The calcsilicate-marble unit is more typical of the Thompson formation, especially the T3 member.

The calcareous rocks of the Thompson formation are overlain by the Pipe formation of the Ospwagan group (Figure GS2023-5-5; Bleeker, 1990; Zwanzig et al., 2007). The P1 member at the base of the Pipe formation consists of graphitic and sulphidic schist or sulphide-facies iron formation. The P1 member sulphide-facies iron formation is overlain by silicate-facies iron formation 0.5–5 m thick, followed by cherts or siliceous schists, which become increasingly pelitic as they grade into the overlying P2 member pelite. This is in contrast with the Halfway Lake lithological section, where the calcareous rocks of the Thompson formation appear to be succeeded by pelitic schist, with sparse chert pods followed by sulphidic sedimentary rocks, which is analogous to the P2 member of the Pipe formation. Zwanzig et al. (2007) recognized that not all stratigraphic units are necessarily present at a given location, but could be attenuated or pinched out. It is therefore possible that the P1 member is missing from the section in the east-central Halfway Lake area.

The sulphidic rocks are followed by a return to calcareous sedimentation. The sulphidic rocks are overlain by 2.5 m of calcsilicate, followed by 30–40 m of calcareous semipelite and 5–10 m of calcsilicate, with minor marble. The calcsilicate and marble grade into an overlying unit of sulphidic sedimentary rock 7 m thick that is characterized by a thin silicate-facies iron formation near the top. There are at least three possibilities for this repeating sequence of sulphidic to calcareous and back to sulphidic rocks:

- There could be a cryptic, early D_2 thrust fault above the first sulphidic horizon. This would explain the repetition of broadly similar stratigraphy, where calcareous rocks appear to transition into sulphidic rocks twice within the same sequence (Figure GS2023-5-6a).
- Alternatively, the repeated sequence could represent an attenuated isoclinal fold. In this interpretation, the two sulphidic horizons are a repetition of the P2 member; however, attenuation has led to the pinching-out of the pelitic schist. Similarly, the Thompson formation rocks have been attenuated, such that the peraluminous semipelite pinches out, and the calcsilicate and marble unit after the first sulphidic horizon is attenuated to only 2.5 m (Figure GS2023-5-6b).
- A third alternative would require a sedimentary facies change from the classical Ospwagan group stratigraphy. In this scenario, the pelitic rocks and first sulphidic horizon would correlate to the P1 member of the Pipe formation. This would place the overlying calcareous rocks in the stratigraphic position of the upper P1 and/or P2 members, which consist of silicate-facies iron formation and pelitic schist in the classical Ospwagan group stratigraphy (Bleeker, 1990; Zwanzig et al., 2007). The second sulphidic horizon would then correlate with sulphide-facies iron formation at the top of the P2 member. The P2 member pelite at the Pipe II mine contains local, discontinuous calcsilicate layers, which indicates the deposition of some calcareous rocks at this time. Therefore, it is conceivable that the above discrepancy is the result of a facies change, where the typical P2 member pelite grades laterally into a package of more calcareous sedimentary rocks. This may be supported by the presence of local peraluminous semipelite near the base of the unit and the apparently gradational nature of the contact between the calcsilicate and marble, and the second sulphidic horizon. The local chert/incipient iron-formation layers within this calcareous semipelite unit in the Halfway Lake area is a shared feature with the P2 pelite at the Pipe II mine (Figure GS2023-5-6c; Bleeker, 1990).

The second scenario is tentatively the favoured interpretation as isoclinal folding is relatively common in the stratigraphy of the TNB; however, each of the three interpretations is potentially viable.

The P3 member of the Pipe formation at the Thompson mine consists largely of interbedded impure quartzite and pelite with subordinate iron formation (Bleeker, 1990). This correlates well with the interbedded quartzite-pelite package in the Halfway Lake area; however, iron formation is exceedingly rare. Although iron formation was not recognized in the four drillcores used to construct the lithological section, silicate-facies iron formations and chert layers were recognized in three nearby drillholes within the same fold structure (W118-23, Assessment File 93977; HW95-04, Assessment File 72905; HW96-10, Assessment File 73104). The iron formations can be up to 9 m thick, but rarely exceed 1 m. They vary from well laminated to almost massive and are typically garnet and quartz rich, with subordinate ferrosilite and minor biotite and sulphide. Hornblende and magnetite can be present in trace amounts.

The Setting formation is defined as all clastic rocks between the last iron formation of the Pipe formation and the mafic to ultramafic volcanic rocks of the overlying Bah Lake assemblage (Bleeker, 1990; Zwanzig et al., 2007). The clastic rocks of the S1 member commonly occur as interbedded quartzite and pelite similar to those described above. The relative scarcity of iron for-

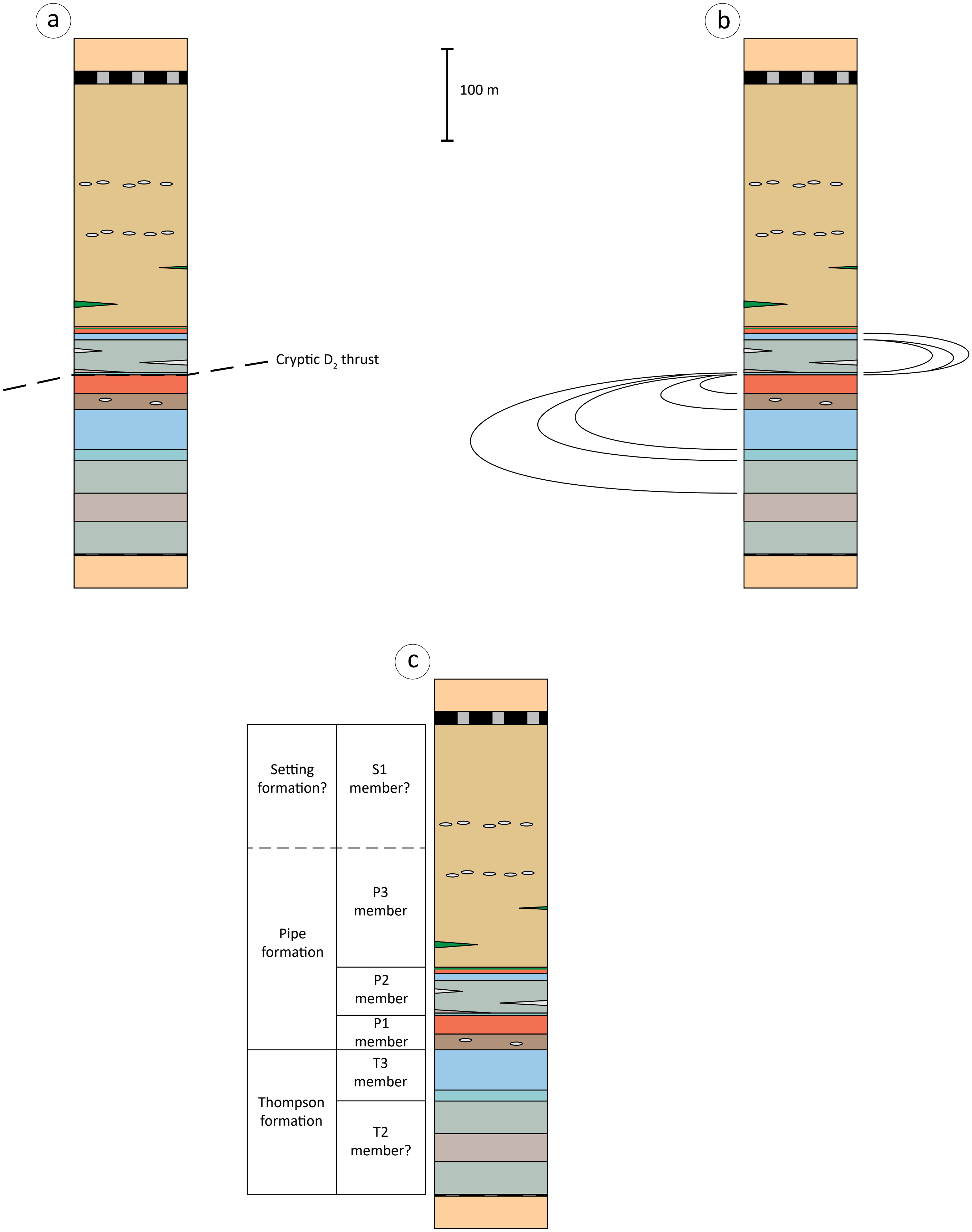


Figure GS2023-5-6: *Three possible interpretations for the lithological section of the east-central Halfway Lake area outlined in the text:* ***a)*** *cryptic D_2 thrust placing Thompson formation on P2 member rocks;* ***b)*** *isoclinal folding of Thompson and Pipe formation rocks;* ***c)*** *sedimentary facies change of the P2 member.*

mation within the interbedded quartzite-pelite package in the Halfway Lake area makes discriminating the boundary between the P3 member of the Pipe formation and the Setting formation difficult. Although Bah Lake assemblage rocks were not intersected along the lithological section, mafic volcanic rocks do occur toward the southwest in the core of the fold structure and are likely correlative.

The upper and lower contacts of the lithological section are truncated by D_3 mylonitic shear zones. The mylonite zones juxtapose the sedimentary rocks with orthogneiss and are interpreted as the sheared contact between the Ospwagan group and Archean basement. The lower shear zone appears to be derived from calcareous rocks and pegmatite, which implies that rocks below the Thompson formation (Manasan formation) are either tectonically removed, or mylonitized and attenuated, and can no longer be recognized. The upper shear zone is derived from a wider range of protolith including calcareous, sulphidic, semipelitic and siliceous sedimentary rocks. This could imply that the entire stratigraphic sequence below the P3 member is sheared and attenuated within the mylonite zone, which effectively represents a highly attenuated fold limb.

A stratigraphic column and new geological map of the east-central bay on Halfway Lake has been generated based on the above correlations (Figures GS2023-5-7, -8). The updated map was compiled using field observations from 2022, combined with the new drillcore observations from this summer. It indicates that, in many places, the lower part of the Ospwagan group sequence has either been tectonically removed or attenuated beyond the resolution of the map scale, such that only Pipe formation rocks are recognized. Additional data collected from archived drillcore will be used to update the geology for the remainder of the Halfway Lake area.

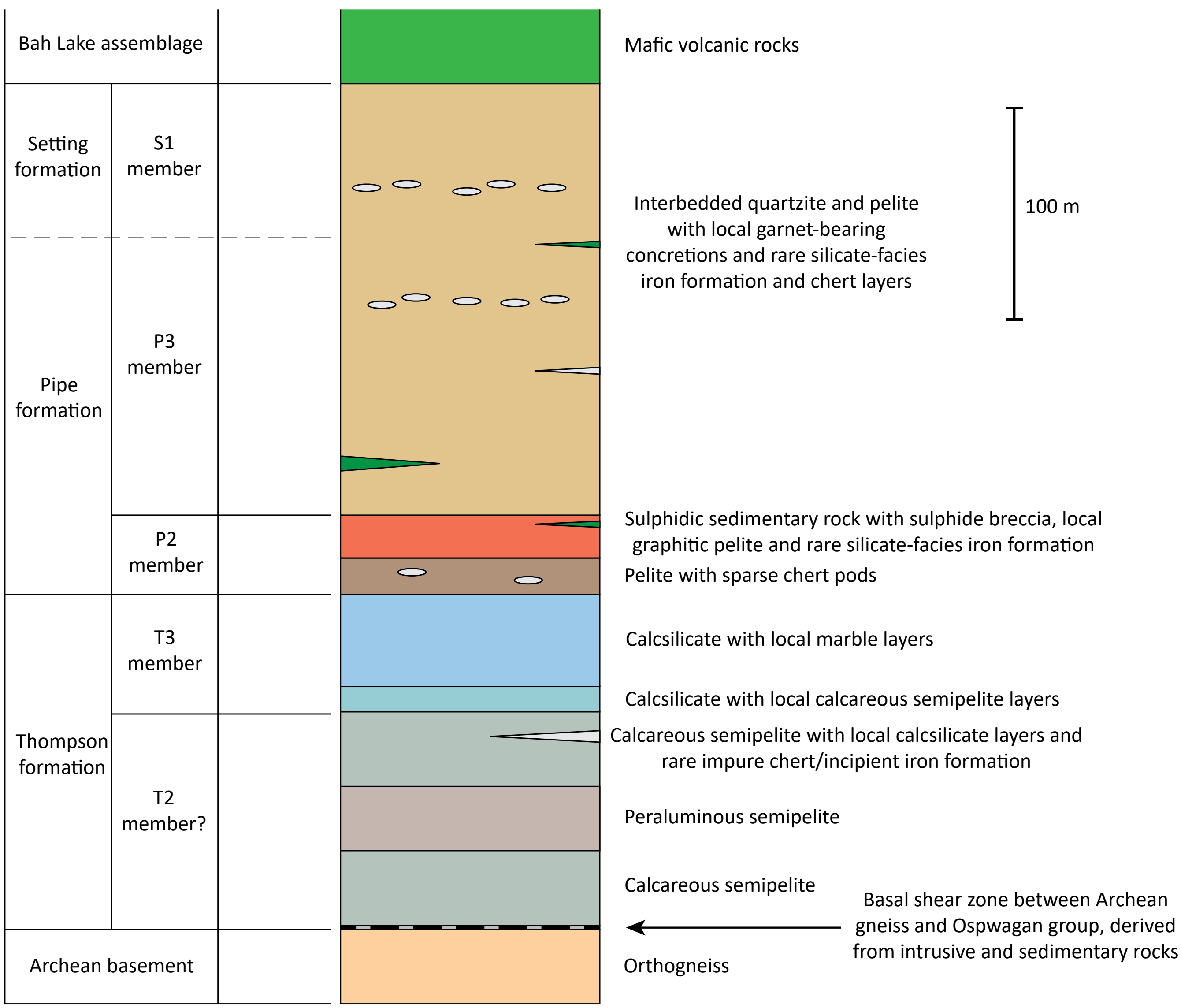


Figure GS2023-5-7: *Schematic stratigraphic section of the Ospwagan group rocks in the east-central Halfway Lake area.*

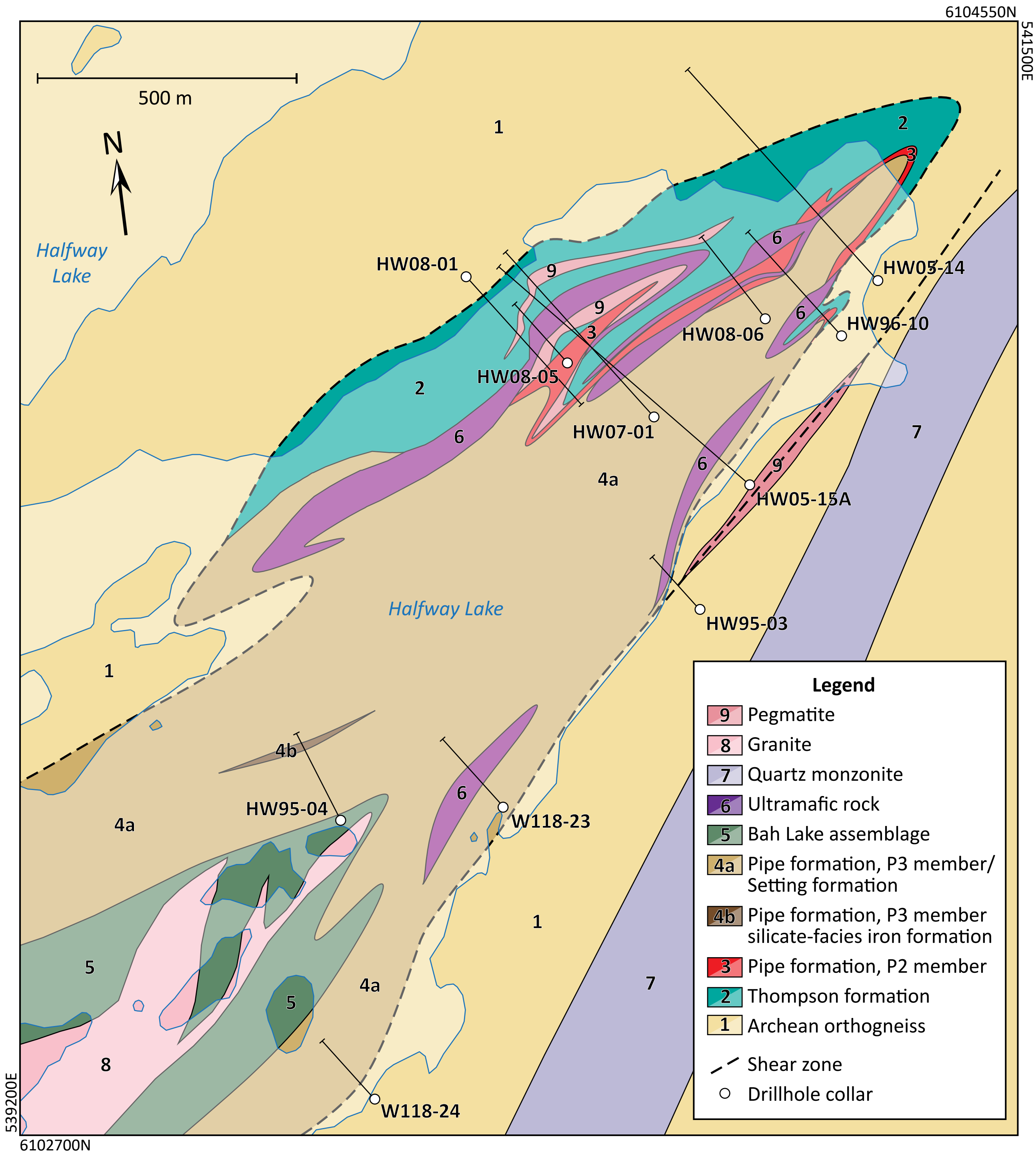


Figure GS2023-5-8: *Revised bedrock geology of the east-central Halfway Lake area. The plotted drillholes were those used for compilation of the geology. Lighter shade of colour indicates a body of water. All co-ordinates are in UTM Zone 14, NAD83.*

Economic considerations

The most widely accepted model for generating Ni-Cu deposits in the TNB invokes the intrusion of ultramafic magmas into sulphide-rich horizons of the Pipe formation of the Ospwagan group (Figure GS2022-3-5; Bleeker, 1990; Zwanzig et al., 2007). There the magmas scavenged sulphide from the host sedimentary rocks, leading to sulphur saturation of the melt and the precipitation and concentration of sulphides enriched in Ni and Cu. As a result, ultramafic bodies occurring in Pipe formation rocks are considered the most likely to host mineralization and are prime exploration targets in the TNB (Bleeker, 1990; Layton-Matthews et al., 2007; Zwanzig et al., 2007).

Relogging of archived drillcore has confirmed the presence of Ospwagan group rocks in the Halfway Lake area and has led to the creation of a working stratigraphic section that can be used to guide exploration activities. This revised stratigraphy has identified sulphide-rich horizons, which likely correlate to the P2 member of the Pipe formation, in the east-central Halfway Lake area. This is the same stratigraphic level as the ore horizon at the Thompson mine (Bleeker, 1990; Lightfoot et al., 2017). A mineralized ultramafic body in this part of the lake was the focus of exploration for Falconbridge Ltd. (now Glencore Canada Corporation) and Crowflight Minerals Inc. (now CaNickel Mining Ltd.) between 1992 and 2008. The best mineralized intersections to date include 1.38% Ni over 17.55 m (drillhole HW95-05; Assessment File 72905) and 1.58% Ni over 13.03 m (drillhole HW08-02; Assessment File 74607). Additional sulphidic horizons are identified in outcrop and drillcore throughout the Halfway Lake area (Macek et al., 2006; Couëslan, 2022a).

Intersections of Ni mineralization in the Halfway Lake area include ultramafic-hosted disseminated and net-textured sulphide, similar to mineralization in much of the Thompson belt, as well as metasedimentary-hosted semisolid to solid sulphide, similar to mineralization at the Thompson mine (Assessment Files 74504, 74607). The metamorphic grade in the Halfway Lake area is comparable to that of the Thompson mine, which implies a similar ductile structural regime, with sulphides deforming in a plastic or viscous manner. A considerable portion of the Thompson orebody is contained within an F_3 hinge zone, with mineralization also associated with parasitic F_3 fold structures along one of the limbs (Lightfoot et al., 2017). Although it occurs at the same stratigraphic level as a train of ultramafic bodies, most of the Ni ore at the Thompson mine is hosted by Pipe formation rocks (Bleeker, 1990; Lightfoot et al., 2017).

Future exploration at Halfway Lake might consider targeting F_3 fold structures to look for thickened zones of sulphide plunging along hinge lines. The mineralized ultramafic body mentioned in the previous paragraph occurs along the western limb of an F_3 fold, not far from the hinge zone. Additional fold hinges and spatially associated sulphidic rocks are interpreted to occur throughout the Halfway Lake area. It should also be remembered that sulphide could have remobilized under high-grade metamorphic conditions and need not be directly associated with ultramafic bodies. Exploration at the same stratigraphic level as ultramafic bodies could reveal the presence of mineralization that is hosted by sedimentary rocks rather than by the intrusion.

Acknowledgments

The author thanks M. Friesen (University of Manitoba) and M. Kaan (University of Winnipeg) for providing excellent field assistance as well as C. Epp and P. Belanger for logistical support. Discussions with J. Macek helped formulate interpretations of the Halfway Lake stratigraphy; M. Nicolas and T. Martins reviewed earlier drafts of the report. Special thanks to K. Zhu, S. Anthony and C. Ducharme of CaNickel Mining Ltd.; and S. Kirby, S. Nicholson and D. Hanson of Vale Canada Ltd. (Manitoba Operations) for providing access to drillcore from Halfway Lake, which provided valuable insight into the geology of the Halfway Lake area.

References

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

Couëslan, C.G. 2016: Geology of the Paint and Phillips lakes area, Thompson nickel belt, central Manitoba (parts of NTS 63O1, 8, 9, 63P5, 12); Manitoba Growth, Enterprise and Trade, Manitoba Geological Survey, Geoscientific Report GR2016-1, 44 p., 1 map at 1:50 000 scale.

Couëslan, C.G. 2022a: Bedrock mapping in the Halfway Lake area, Thompson nickel belt, central Manitoba (parts of NTS 63O1, 2); *in* Report of Activities 2022, Manitoba Natural Resources and Northern Development, Manitoba Geological Survey, p. 12–24.

Couëslan, C.G. 2022b: Characterization of ultramafic-hosting metasedimentary rocks and implications for nickel exploration at Phillips Lake, Thompson nickel belt, central Manitoba (part of NTS 63O1); Manitoba Natural Resources and Northern Development, Manitoba Geological Survey, Geoscientific Paper GP2022-1, 33 p., 4 appendices.

Couëslan, C.G. 2022c: Bedrock geology of the Halfway Lake area, central Manitoba (parts of NTS 63O1, 2); Manitoba Natural Resources and Northern Development, Manitoba Geological Survey, Preliminary Map PMAP2022-1, scale 1:25 000.

Layton-Matthews, D., Lesher, C.M., Burnham, O.M., Liwanag, J., Halden, N.M., Hulbert, L. and Peck, D.C. 2007: Magmatic Ni-Cu-platinum-group element deposits of the Thompson Nickel Belt; *in* Mineral Deposits of Canada: a Synthesis of Major Deposit Types, District Metallogeny, the Evolution of Geological Provinces and Exploration Methods, W.D. Goodfellow (ed.), Geological Association of Canada, Mineral Deposits Division, Special Publication no. 5, p. 409–432.

Lightfoot, P.C., Stewart, R., Gribbin, G. and Mooney, S.J. 2017: Relative contribution of magmatic and post-magmatic processes in the genesis of the Thompson Mine Ni-Co sulfide ores, Manitoba, Canada; Ore Geology Reviews, v. 83, p. 258–286.

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 on CD, URL <https://manitoba.ca/iem/info/libmin/OF2006-33.zip> [August 2023].

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.