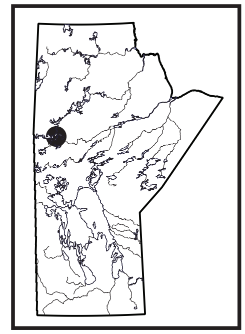
GS-6 Examination of exploration drillcore from the Reed Lake area, Flin Flon belt, west-central Manitoba (parts of NTS 63K7, 8, 9, 10)

by S. Gagné



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Summary

Two weeks were spent examining recent and historical exploration drillcore from the Reed Lake area and the sub-Phanerozoic basement immediately to the south. A total of 21 drillcores were examined, documented and sampled to complement a set of 53 drillcores examined previously (2010–2015). This work is a component of a larger project aimed at updating the geology of the Reed Lake area. Key observations from this summer include recognition of intense pervasive silica alteration and narrow graphite-sulphide–bearing sedimentary intervals within the volcanic-arc sequence in the northern part of Reed Lake. Intrusive and extrusive rocks of intermediate and felsic composition, of possible arc to arc-rift origin, were identified in what was previously interpreted as a homogeneous ocean-floor sequence in eastern Reed Lake, and may indicate tectonic interleaving of the ocean-floor and volcanic-arc sequences in this area. Drillcores from the Fourmile Island area confirmed the presence of altered felsic volcanic and volcaniclastic rocks on both flanks of the island. Aside from late intrusions, the sub-Phanerozoic basement south of Reed Lake consists predominantly of bimodal volcanic and volcaniclastic rocks locally intercalated with narrow sequences of wacke and graphitic and sulphidic mudstone. Metamorphic grade in most of the Reed Lake region is low and varies from lower- to upper-greenschist facies. However, the rocks from Cooper Lake to McClarty Lake have mineral assemblages indicative of low- to mid-amphibolite–facies metamorphism, perhaps indicating the presence of a fault-bounded structural panel. The presence of bimodal volcanic and volcaniclastic rocks, moderate to intense alteration, and local sulphide mineralization suggests that all of the areas examined to date, including the eastern portion of Reed Lake, have potential for volcanogenic massive sulphide (VMS) deposits.

Introduction

Paleoproterozoic rocks in the Reed Lake area are a component of a larger tectonic collage of volcano-plutonic and sedimentary rocks that was assembled during the closure of an ancient ocean (ca. 1.9–1.8 Ga) and is collectively termed the Flin Flon belt (FFB; Figure GS-6-1). The Flin Flon belt contains numerous base-metal VMS deposits and is among the world`s most prolific VMS districts.

The Flin Flon belt in the Reed Lake area, and its extension to the south under a thin cover of Phanerozoic sedimentary rocks, has significant potential to host additional VMS deposits. Despite the presence of several significant economic deposits, including the currently producing Reed Cu-Zn deposit (Figure GS-6-2), the geological setting of VMS deposits in the Reed Lake area is generally not well understood. Previous workers (Stern et al., 1995a) recognized that significant stratigraphic, geochemical and isotopic differences exist between arc-volcanic rocks in the Flin Flon (Amisk collage) and Snow Lake areas, suggesting that these two segments of the FFB formed in distinct tectonic settings (Lucas et al., 1996). The Reed Lake area represents a critical bridge between these two segments, as it lies at the boundary between the Amisk collage *sensu stricto* and the Snow Lake segment (Figure GS-6-1). One of the key geological units of the Reed Lake area, the Fourmile Island assemblage (FIA), is a bimodal succession of volcanic and volcaniclastic rocks of arc or arc-rift affinity that is known to host several VMS deposits.

In order to gain a better understanding of the geological framework and mineral potential of the Reed Lake area, a multiyear field-mapping and compilation project was initiated in 2013. To complement data acquired through geological mapping, a drillcore examination and sampling component was added to the project in 2015. The drillcores provide essential information in areas that lack surface exposure. Previous geological work (Leclair et al., 1997) and geophysical data show that arc-affinity rocks extend south of Reed Lake beneath the Phanerozoic cover for a distance of more than 50 km. Therefore, a better understanding of the exposed and sub-Phanerozoic geology of the Reed Lake area has important implications for base-metal exploration in this complex and challenging area.

Previous work

Reconnaissance mapping of Reed Lake was completed at 1:50 000 scale during a joint Manitoba Geological Survey–Geological Survey of Canada project in the summer of 1995 (Syme et al., 1995a), and the results of follow-up geochemical and structural studies were presented by Syme and Bailes (1996). Prior to 1995, supracrustal rocks at Reed Lake were subdivided into mafic volcanic, volcaniclastic and sedimentary types (e.g.,

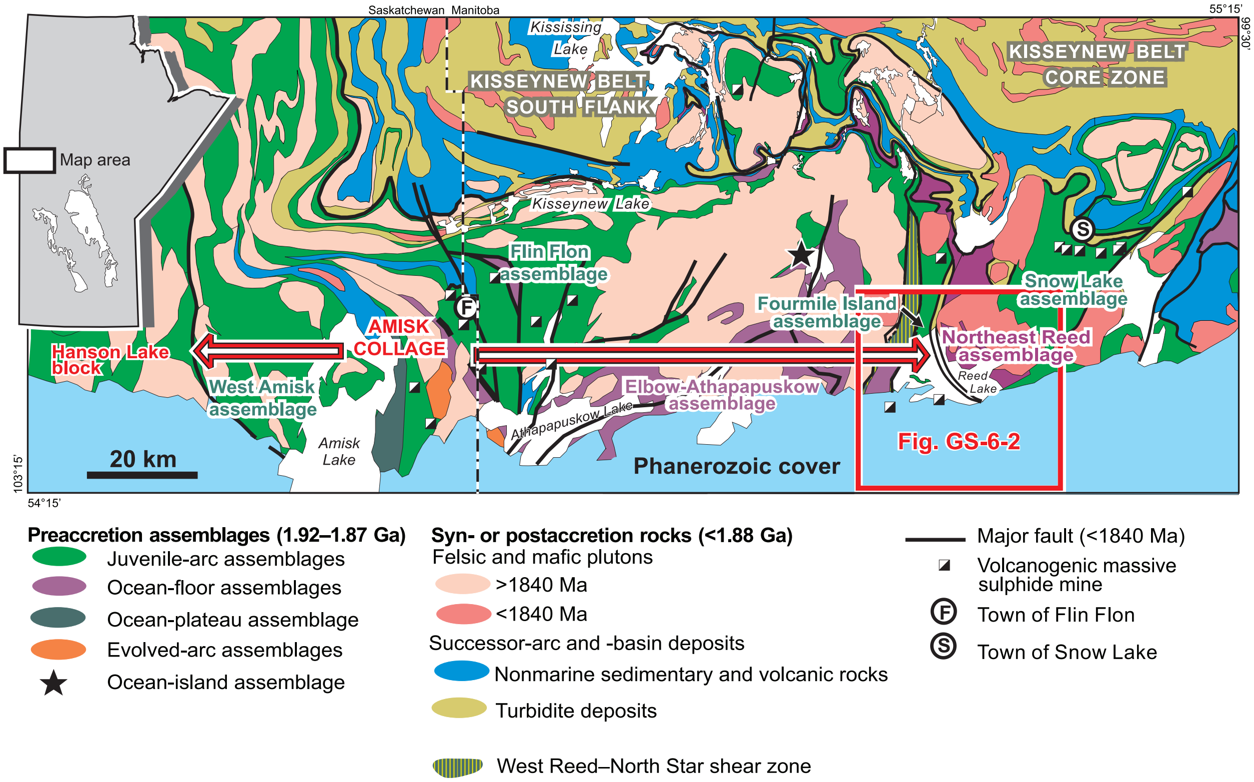

Figure GS-6-1: *Geology of the Flin Flon belt, showing major tectonostratigraphic assemblages, plutons and volcanogenic massive sulphide deposits (modified from NATMAP Shield Margin Project Working Group, 1998). The box outlined in red indicates the location of the Reed Lake study area.*

Stanton, 1945; Rousell, 1970). Preliminary Map 1995F-1 (Syme et al., 1995b) was compiled from older maps, including those of Rousell (1970) and Stanton (1945), and new data from the 1995 field season, resulting in a significantly improved understanding of the local geology. Morrison and Whalen (1995) reported the results of mapping of granitoid rocks in the NTS 63K10 area, west of Reed Lake; a simplified version of their map was included in Preliminary Map 1995F-1 (Syme et al., 1995b) and their complete work was presented in Morrison et al. (1996). In 2013, the northwestern Reed Lake area, including Rail, Sewell and Prieston lakes, was mapped at 1:10 000 scale (Gagné, 2013a, b) and the inland area west of Reed Lake was subsequently mapped in 2014 at 1:20 000 scale (Gagné and Anderson, 2014a, b).

The southern shore of Reed Lake coincides with the northern extent of Phanerozoic platformal sedimentary rocks, which unconformably overlie the Precambrian basement and increase from a few metres to 30 m in thickness in the area immediately south of Reed Lake. Despite geophysical discoveries of significant base-metal mineralization in the sub-Phanerozoic basement in the 1960's and 1970's, the geology of this area remained poorly understood. During NATMAP, the first regional map of the sub-Phanerozoic portion of the FFB was produced, by integrating high-resolution aeromagnetic and gravity data with drillcore information (Leclair et al., 1997; Leclair and Viljoen, 1997). In the course of that project, only a small number of drillcores from the area south of Reed Lake were examined. However, the recent discovery of the Reed VMS deposit has resulted in renewed interest in the sub-Phanerozoic geology south of Reed Lake.

To address this interest, an initial 53 drillcores were examined and sampled from the Reed Lake area (Simard et al., 2010; Gagné, 2015). This report presents the preliminary results from the examination and sampling of an additional 21 drillcores from this area. A new companion project is focused on the sub-Phanerozoic basement immediately east of the Reed Lake area, south of Wekusko Lake (Reid and Gagné, GS-7, this volume).

Geological framework of the Reed Lake area

The exposed portion of the FFB at Reed Lake contains several distinct fault-bounded panels of rocks assigned to the juvenile-arc assemblage; some of these panels also contain rocks assigned to the ocean-floor assemblage, younger sedimentary rocks of the Burntwood group and plutonic rocks (Figure GS-6-1). The juvenile-arc assemblages are internally complex due to faulting and folding (e.g., Bailes and Syme, 1989), and include a wide range of typical bimodal, arc-related volcanic, volcaniclastic and synvolcanic intrusive rocks (e.g., Bailes and Syme, 1989;

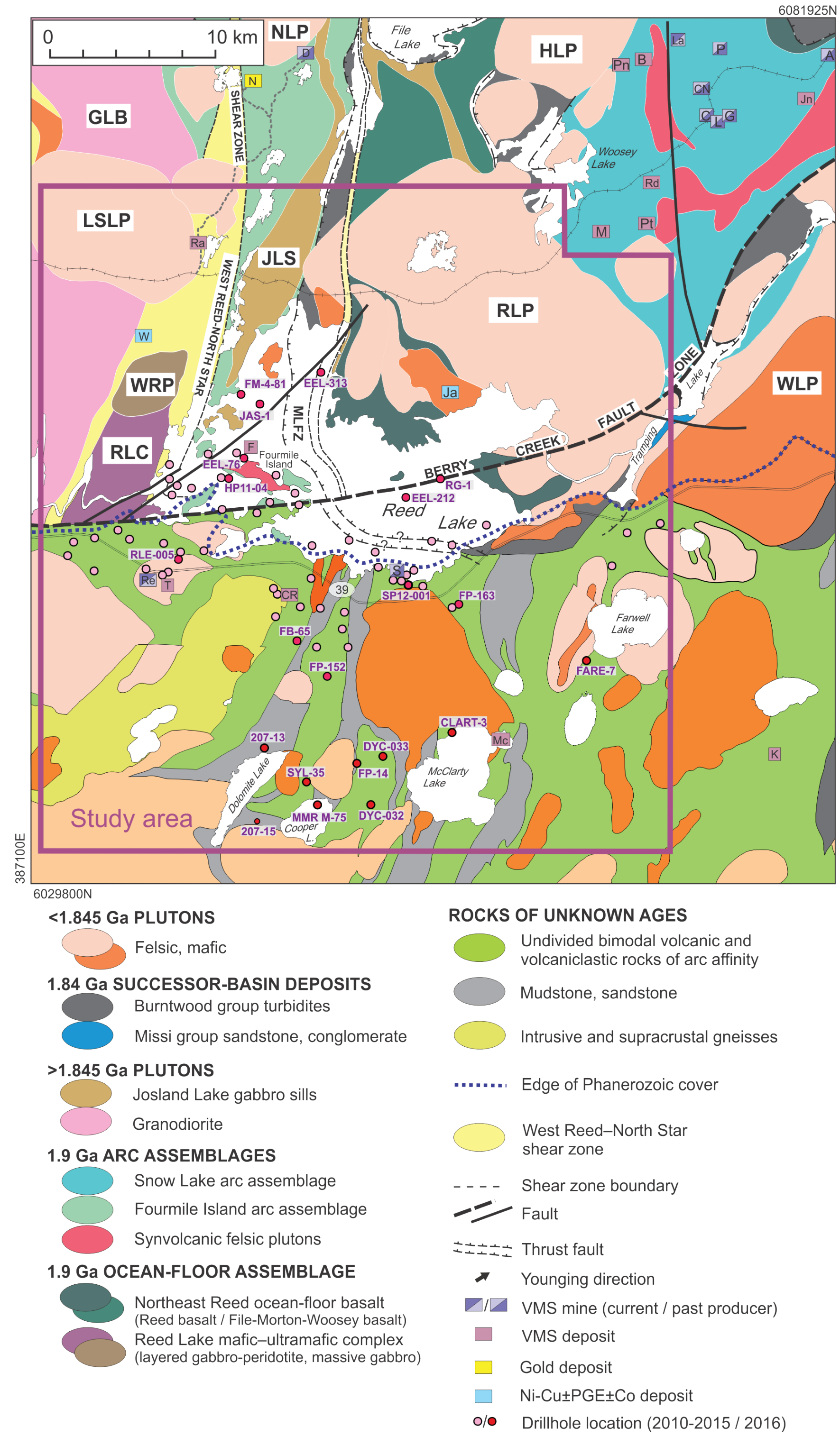

Figure GS-6-2: *Generalized geology of the Reed Lake area (after Syme et al., 1995b) including the geology of the sub-Phanerozoic basement (Leclair and Viljoen, 1997; NATMAP Shield Margin Project Working Group, 1998) and the locations of the drillcores examined during this study. Intrusive rocks: GLB, Gants Lake batholith; HLP, Ham Lake pluton; JLS, Josland Lake sills; LSLP, Little Swan Lake pluton; NLP, Norris Lake pluton; RLC, Reed Lake mafic–ultramafic complex; RLP, Reed Lake pluton; WLP, Wekusko Lake pluton; WRP, West Reed pluton. Structural feature: MLFZ, Morton Lake fault zone. Mines (active or closed) and deposits: A, Anderson; B, Bomber; C, Chisel; CN, Chisel North; CR, Cowan River zone; D, Dickstone; F, Fourmile Island; G, Ghost; Ja, Jackfish; Jn, Joannie; K, Kofman; L, Lost; La, Lalor; M, Morgan; Mc, McClarty; N, North Star; P, Photo; Pn, Pen; Pt, Pot; Ra, Rail; Rd, Raindrop; Re, Reed; S, Spruce Point; T, Tower; W, Wine. Other: PGEs, platinum-group elements; VMS, volcanogenic massive sulphide.*

Syme and Bailes, 1993; Stern et al., 1995a; Lucas et al., 1996; Bailes and Galley, 2007). Ocean-floor assemblages primarily consist of mid-ocean–ridge basalt and related kilometre-scale, layered, mafic–ultramafic intrusions (Syme and Bailes, 1993; Stern et al., 1995b). Voluminous successor-arc plutons and coeval volcanic and sedimentary rocks (1.88—1.83 Ga) occur throughout the Reed Lake area and include the Missi group and the Burntwood group. The Missi group is characterized by thick packages of fluvial-alluvial conglomerate and sandstone, whereas the basinal-marine Burntwood group comprises turbiditic greywacke, mudstone and rare conglomerate.

The western Reed Lake area includes a regionally extensive (kilometres wide) north-trending zone of tectonite referred to as the West Reed–North Star (WRNS) shear zone, which was previously thought to juxtapose rocks of ocean-floor affinity on the western side of the zone with rocks of juvenile-arc affinity (FIA) on the eastern side (Syme et al., 1995a, b). Rocks east of the WRNS shear zone are further divided into two domains separated by the Morton Lake fault zone: the FIA in the footwall, and the Northeast Reed assemblage, Reed Lake pluton and Snow Lake arc assemblage in the hangingwall (Figure GS-6-2; Syme et al., 1995a, b; Syme and Bailes, 1996). The fault zone includes a narrow panel of Burntwood group rocks. The Berry Creek fault zone (BCFZ), a major east-trending fault, transects the southern part of Reed Lake near the northern limit of the Phanerozoic cover (Figure GS-6-2).

Syme et al. (1995a) proposed that the exposed volcanic stratigraphy south of the BCFZ can be related in a general sense to that which lies to the north. However, direct correlation of units across the BCFZ is hampered by poor exposures at Reed Lake, Phanerozoic cover farther south, and the uncertainty surrounding the sense and magnitude of its displacement.

The Phanerozoic cover in the Reed Lake area typically consists of 1–2 m of Ordovician quartz-rich sandstone (Winnipeg formation) overlain by 12–25 m of Ordovician dolomitic limestone (Red River formation), atop of which generally sit several metres of unconsolidated glacial sediments and organic material. The Precambrian rocks beneath the Ordovician cover are weathered to depths ranging from 5 to 30 m.

Drillcore logging

This paper provides a summary of observations made on drillcore in 2016. In addition to the examination of 21 drillcores, a total of 181 samples have been collected for whole-rock chemistry, thin section petrography, Sm-Nd isotopic analysis and U-Pb radiometric dating.

The examined drillcores have been subdivided into two groups based on geographic location: 1) Reed Lake, and 2) the sub-Phanerozoic basement south of Reed Lake. The VMS deposit located north of Fourmile Island under Reed Lake is herein referred to as the 'Fourmile Island deposit' to avoid confusion with the Reed deposit, which is currently in production.

Mineral assemblages in the study area indicate lower-greenschist– to mid-amphibolite–facies metamorphism. However, in the interest of brevity, the prefix 'meta-' is not used in this report and the rocks are described in terms of their protoliths.

Reed Lake area

Seven drillholes from the immediate Reed Lake area were selected for examination and sampling in 2016.

Northern Reed Lake

Drillcore from three drillholes in the northern Reed Lake area were examined. Two short drillholes, FM-4-81 and JAS-1, were collared into an area shown on the map by Syme et al. (1995b) to be dominated by andesitic rocks. Rocks encountered in drillcore FM-4-81 were almost exclusively mineralized graphitic mudstone and minor wacke, except for two narrow (<2 m) dikes of quartz porphyry and massive dacite (Figure GS-6-3). The sequence of mineralized argillite does not contain graded beds or distinct sandy intervals, as is typical of the Burntwood group, but is similar to sequences of sedimentary intervals observed in drillholes through the volcanic sequence on the northern and southern flank of Fourmile Island. A thick, homogeneous sequence of mostly massive, amygdaloidal andesite with a few intervals of strong silicification (Figure GS-6-4a) 3–5 m thick was observed in drillcore JAS-1. Drillhole EEL-313 was collared in a narrow package of Burntwood group turbidites that are bound between ocean-floor rocks to the east and arc rocks of the FIA to the west (Figure GS-6-2). The drillcore contains centimetre-thick beds of mudstone interbedded with thicker intervals of wacke.

This is similar to outcrop observations made on an island 800 m to the northwest, where metre-thick graded beds of wacke did not contain mud-rich intervals. All outcrops of Burntwood group rocks visited along the northern shoreline of Reed Lake have mineral assemblages that indicate peak metamorphic conditions of greenschist facies were attained; however, the metasedimentary rocks of drillcore EEL-313 contain abundant andalusite in the more pelitic beds (Figure GS-6-4b). Their coarseness (3–15 mm) and lack of preferential orientation suggest that the alumino-silicate porphyroblasts result from contact metamorphism. A few small islands of Burntwood group rocks in the northeastern bay of Reed Lake (~5 km northeast of RG-1) were also affected by contact metamorphism of the composite Reed Lake pluton and contain metamorphic mineral assemblages that include biotite, garnet and sillimanite.

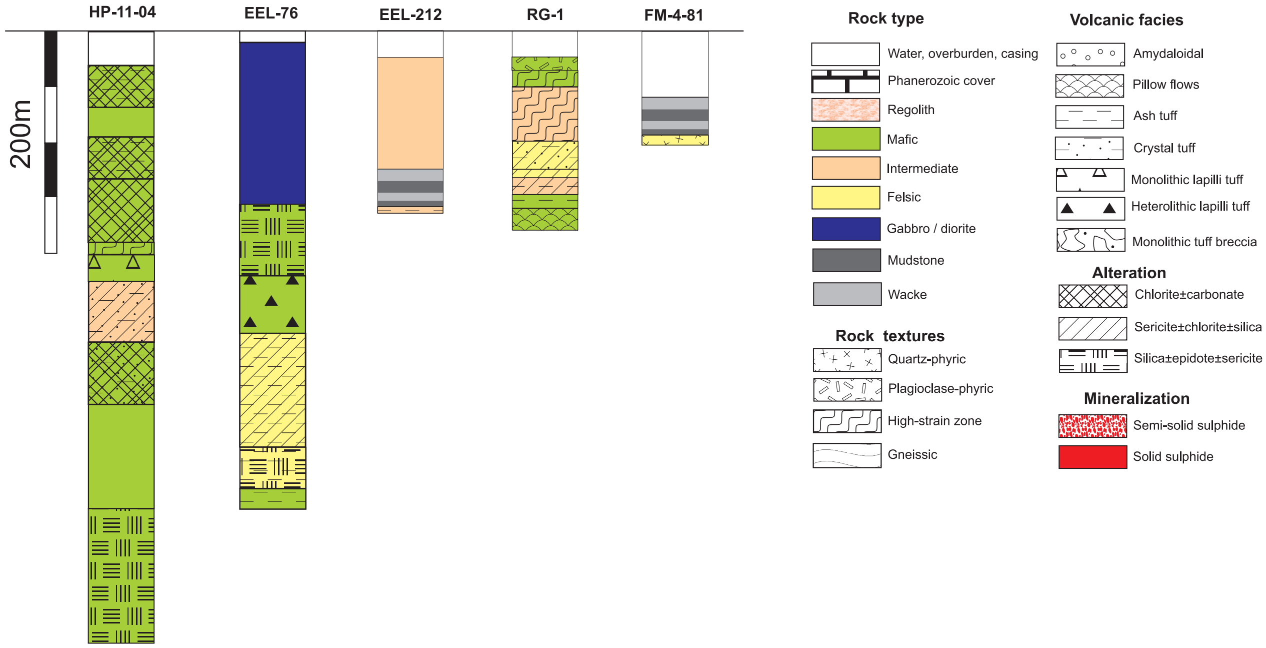

***Figure GS-6-3:** Schematic logs of the examined drillcores from the Reed Lake area. All logs are drawn to the same scale.*

Fourmile Island

Two drillholes, EEL-76 and HP-11-04, were examined in order to further refine the stratigraphy of the Fourmile Island deposit (Figure GS-6-2). On the northern flank of Fourmile Island, drillhole EEL-76 intersected a downhole succession of medium-grained gabbro, weakly to strongly silicified andesite, mafic lapilli tuff, felsic ash tuff and minor sericitized aphyric felsic flows (Figures GS-6-3 and -4c), and terminates with a short interval of mafic ash tuff. On the southern side of Fourmile Island, drillcore HP-11-04 shows a thick succession of dominantly mafic flows and minor volcaniclastic facies, which are separated by quartz-phyric crystal tuff of intermediate composition (Figure GS-6-3 and -4d) ~50 m thick. The upper portion of the drillhole shows several intervals of chlorite-carbonate alteration, whereas sericite alteration affects rocks of intermediate composition (Figure GS-6-3). The lower portion of the drillcore only contains domains of silica±epidote alteration (Figure GS-6-3).

Eastern Reed Lake

Outcrop over a large area of eastern Reed Lake consists of homogeneous basaltic pillowed flows with minor massive flows and rare autoclastic facies (Northeast Reed assemblage; Syme et al., 1995a). Two short drillholes from this area (EEL-212 and RG-1; Figure GS-6-2) were selected based on their log descriptions being inconsistent with outcrop observations. Drillhole EEL-212 was described as a sequence of massive aphyric dacite. Drillcore confirmed a featureless, aphyric, massive light grey rock of intermediate composition (Figure GS-6-3), distinct from the medium to dark green basaltic rocks exposed on nearby islands, with minor graphitic mudstone and intermediate ash tuff. The composition of the rock appears to be very close to the andesite-dacite limit and a definitive identification will require whole-rock geochemical data. Felsic, intermediate and mafic volcanic and volcaniclastic rocks with domains of high strain were observed in drillcore RG-1 (Figure GS-6-3). Intermediate ash tuff and sericite-altered quartz-phyric felsic crystal tuff and minor lapilli tuff form the bulk of the sequence (Figure GS-6-4e).

Sub-Phanerozoic basement

Fourteen drillcores that penetrate the Phanerozoic cover and intersect basement rocks south of Reed Lake were examined and sampled (Figure GS-6-2). The basement consists mostly of bimodal volcanic and volcaniclastic rocks intruded by late gabbroic and granitic intrusions, and also includes the Reed deposit. Drillcores around the Reed, Spruce Point and Cowan River VMS deposits were specifically selected to provide an increased density of geological information in these key areas. In addition, several drillcores to the south provide geological constraints for prospective volcanic rocks that extend to the Dolomite and McClarty lakes area (Figure GS-6-2).

Reed deposit

Drillhole RLE-005, located near the Reed deposit (Figure GS-6-2), intersected a succession of massive aphyric andesite and terminated in rhyolite and quartz porphyry. The andesite is weakly affected by chlorite and

Figure GS-6-4: *Photos of drillcore from the Reed Lake area:* ***a)*** *JAS-1; massive andesitic flow with moderate to strong pervasive silica alteration; intervals in photo show a progression from moderate (medium grey-green at bottom) to strong silica alteration (light grey colour at top; BQ core; 68.6–85.3 m [225–280 ft]);* ***b)*** *EEL-313, turbidites of the Burntwood group showing centimetre-thick planar beds of greywacke and mudstone with light grey, randomly-oriented porphyroblasts of andalusite (BQ core; 89.3 m [293 ft]);* ***c)*** *EEL-76, aphyric felsic flow and felsic tuff showing bleached areas that represent zones of moderate to strong pervasive silica alteration (BQ core, 376.1–385.3 m [1234–1264 ft]);* ***d)*** *HP-11-04, quartz-phyric intermediate crystal tuff with moderate sericite alteration (NQ core, 234 m);* ***e)*** *RG-1, quartz-phyric felsic lapilli tuff with weak to moderate sericite alteration (BQ core, 101.5–106.0 m [333–348 ft]);* ***f)*** *SP-12-01, basaltic amoeboid pillow breccia with narrow dark selvages on clasts and a fine matrix of biotite and chlorite (HQ core; 35.6 m). Drillcore diameter: BQ, 36.5 mm; HQ, 63.5 mm; NQ, 47.6 mm.*

carbonate alteration, whereas a narrow interval (<1 m) of near-solid sulphides (pyrite-pyrrhotite dominated) within the felsic volcanic rocks is characterized by domains of weak chlorite-sericite alteration.

Spruce Point mine–Cowan River deposit

Four drillcores from near the past-producing Spruce Point mine and Cowan River deposit (FB-65, FP-152, FP-163 and SP-12-01; Figure GS-6-2) penetrate potentially distinct rock packages. Drillhole FB-65 intersected a sequence dominated by intermediate to felsic volcaniclastic rocks with minor intervals of graphitic and sulphidic argillite. Drillhole FP-152 cut a sequence of volcanic and volcaniclastic rocks that ranges in composition from andesite to rhyolite (Figure GS-6-5) and includes a narrow interval (~1.5 m) of near-solid sulphides within the felsic volcanic rocks. Relatively weak domainal chlorite and sericite alteration affects the rocks in drillcore FP-152.

Drillhole SP-12-01, collared ~800 m south-southeast from the Spruce Point mine, cores through a sequence similar to that which hosts the deposit (Gagné, 2015). The hangingwall succession contains abundant andesite pillowed flows and minor amoeboid pillow breccia (Figures GS-6-5 and -4f), which are cut by gabbroic dikes and porphyritic shallow-level intermediate dikes. A thin sequence of aphyric rhyolitic fragmental rocks overlies the mineralized (mostly pyrite-pyrrhotite) horizon, which is hosted in strongly silicified and sericitized rhyolitic tuff breccia (Figure GS-6-6a) and interpreted as correlative to the hostrocks of the Spruce Point deposit.

Further to the southwest, drillcore from FP-163 contains a thick, monotonous sequence of andesitic pillowed flows with minor intervals of autoclastic breccia and mafic tuff. Vein-like and patchy alteration haloes are replaced by a metamorphic mineral assemblage of calcite-epidote-garnet and a biotite-hornblende-plagioclase mineral assemblage is observed in bedded mafic tuff, indicating slightly higher-grade metamorphic conditions. It is unclear whether the higher metamorphic grade is the result of regional metamorphism or if it is related to the large mafic intrusion immediately to the west (Figure GS-6-2).

Dolomite Lake–McClarty Lake area

Eight drillholes (CLART-3, DYC-032, DYC-033, FP-14, MMR M-75, SYL-35, 207-13 and 207-15; Figure GS-6-2) from the Dolomite Lake–McClarty Lake region were selected for examination. Drillholes 207-13 and 207-15 were picked to obtain more information on the metasedimentary sequence that passes through Dolomite Lake (Figure GS-6-2). Although it had been previously logged as consisting of sedimentary and volcanic rocks, re-examination of drillcore 207-13 showed that it is a multiphase gabbroic intrusion with medium-grained leucocratic gabbro as the dominant phase. Drillcore 207-15 intersected a bimodal sequence of chlorite-altered mafic tuff and mineralized (pyrite-pyrrhotite) sericite-altered felsic tuff.

Located 6.5 km south and almost along strike from FP-152, drillcore SYL-35 intersected interbedded felsic and mafic tuff in the upper portion of the drillhole, and a sequence of andalusite-bearing argillite intruded by

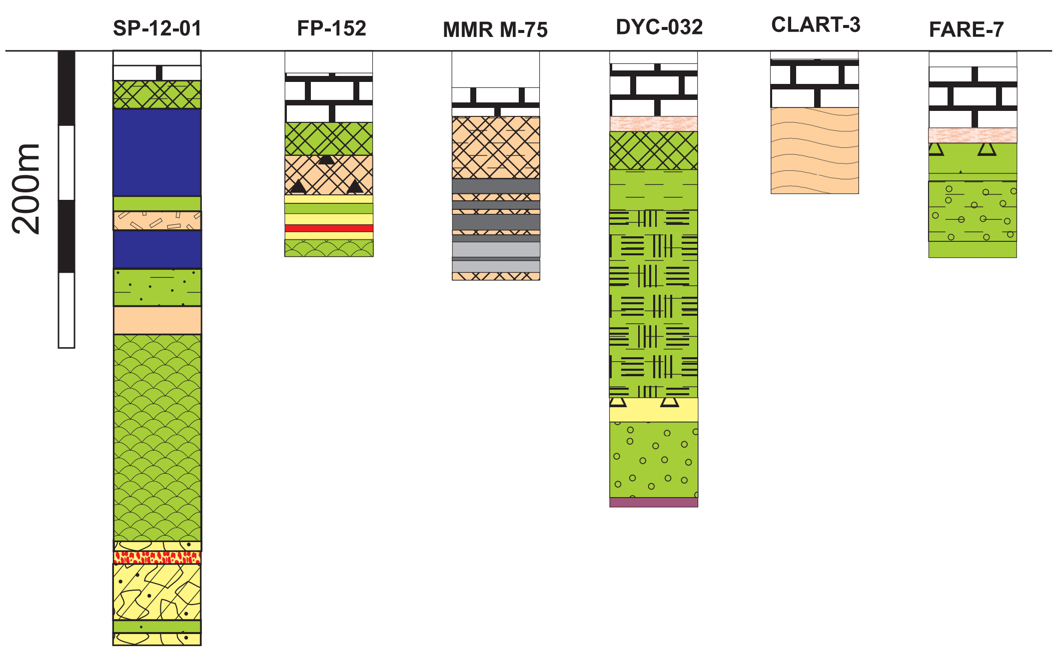

Figure GS-6-5: *Schematic logs of examined drillcore from the sub-Phanerozoic basement south of Reed Lake. Legend is the same as for Figure GS-6-3. All logs are drawn to the same scale.*

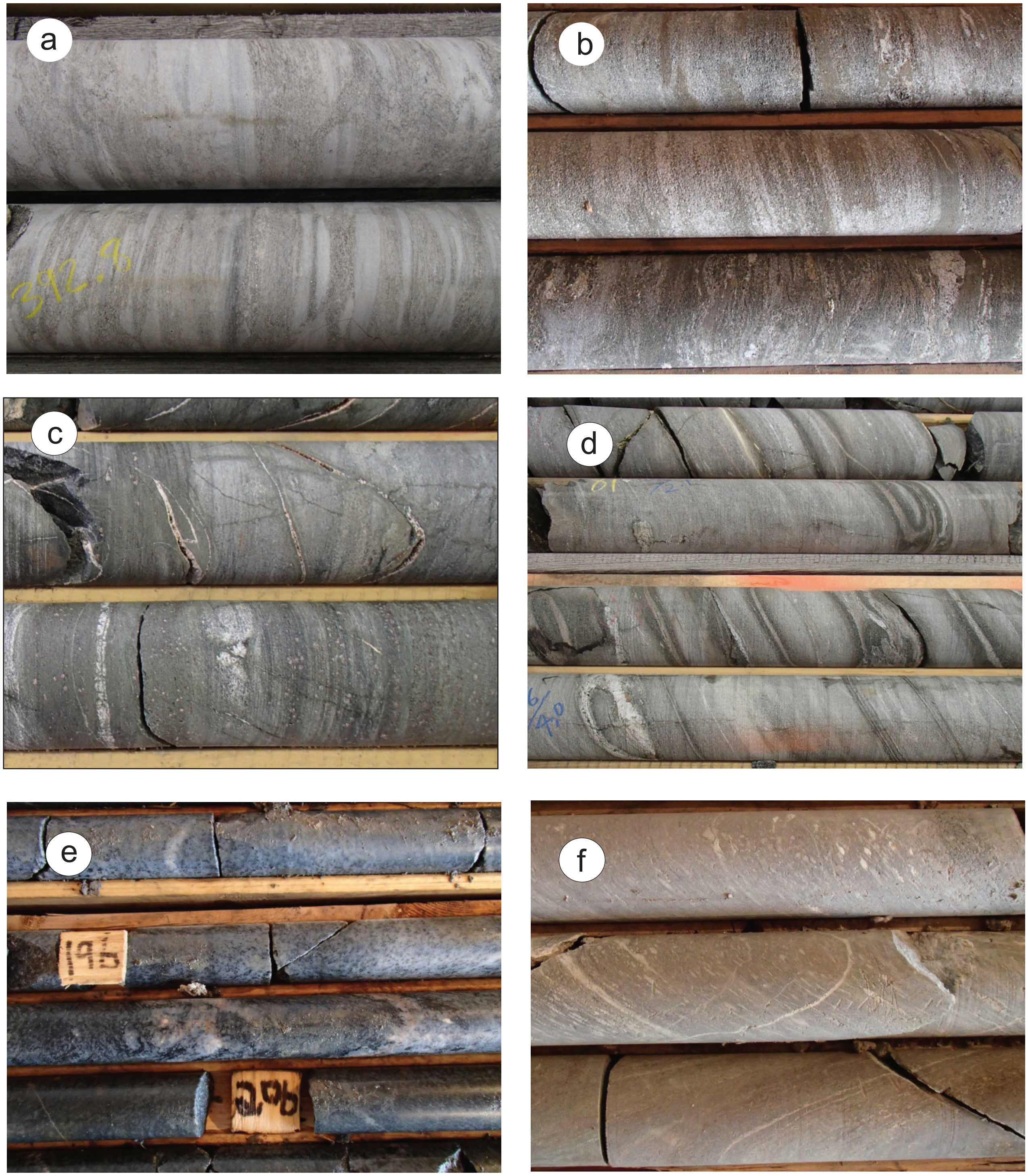

Figure GS-6-6: *Photos of drillcore from the sub-Phanerozoic basement south of Reed Lake:* ***a)*** *SP-12-01, matrix-supported monolithic tuff breccia with aphyric rhyolite fragments and sericite-altered matrix (HQ core, 392.8 m);* ***b)*** *FP-14, crudely bedded greywacke to feldspathic wacke containing the metamorphic assemblage biotite-hornblende-plagioclase-garnet-quartz (AQ-core, 82.9–86.0 m [272–282 ft]);* ***c)*** *DYC-032, massive to crudely bedded mafic ash tuff; metamorphic mineral assemblage includes biotite-hornblende-plagioclase-garnet-quartz; garnet is sporadic and forms small (1–2 mm) euhedral crystals (NQ core, 72 m);* ***d)*** *DYC-033, pillowed andesitic flows with thick dark selvage (3–6 mm) and minor interpillow material (NQ core, 80–84 m);* ***e)*** *CLART-3, medium-grained biotite-hornblende-plagioclase-quartz gneiss with crude compositional layering (BQ core, 58.2–62.8 m [191–206 ft]);* ***f)*** *FARE-7, plagioclase-phyric intermediate volcaniclastic rocks with 1–2% quartz amygdules, weakly altered to chlorite-sericite (BQ core, 63.7–67.1 m [209–220 ft]). Drillcore diameter: AQ, 27 mm; BQ, 36.5 mm; HQ, 63.5 mm; NQ, 47.6 mm.*

granodiorite in the lower portion. Drillcores MMR M-75 and FP-14 were both collared in the same north-trending package of volcano-sedimentary rocks, but are separated by a granitoid intrusion 2.6 km wide. The sequence intersected in drillcore MMR M-75 consists of interbedded graphitic and sulphide-bearing argillite with fine-grained, heterogeneous chlorite-biotite-muscovite schist and laminated siliceous beds (Figure GS-6-5). The siliceous horizons represent either altered dacite-rhyodacite tuffs or feldspathic mudstone, whereas the more schistose parts may be altered volcaniclastic or sedimentary rocks. Unfortunately, the slightly higher metamorphic grade and lack of diagnostic primary features hinders from identifying the protoliths. Drillcore FP-14 is composed mostly of volcaniclastic and fine-grained sedimentary rocks. The rocks are typically light to medium grey to dark grey-green, fine- to medium-grained, and layered (centimetre-scale layering; Figure GS-6-6b). Mineral assemblages identified include hornblende-biotite±chlorite and biotite±muscovite±chlorite.

Drillholes DYC-032 and DYC-033 were selected to document the volcanic and volcaniclastic rocks that straddle the area between Cooper Lake and McClarty Lake (Figure GS-6-2). The sequence of rocks encountered in drillcore DYC-032 (Figure GS-6-5) consists of massive amygdaloidal andesite with intervals of mafic to intermediate lapilli tuff and crystal tuff, and diorite. A few narrow intervals (<1.5 m) of sulphide mineralization (pyrite-pyrrhotite) were intersected and are typically hosted in sedimentary rocks and/or intermediate lapilli tuff. Common metamorphic mineral assemblages include biotite-hornblende-plagioclase-quartz. Altered mafic tuff also locally contains small euhedral garnets (Figure GS-6-6c). Drillcore DYC-033 includes a thick succession of sparsely amygdaloidal pillowed andesite (Figure GS-6-6d), several metre-thick intervals of bedded mafic and felsic ash/crystal tuff, and minor gabbro. Numerous narrow sulphide-mineralized (pyrite-pyrrhotite) intervals (<2 m) are mainly hosted in silicified tuff units.

Drillhole CLART-3, collared on the northwestern shore of McClarty Lake, contains compositionally layered intermediate to felsic biotite-hornblende-plagioclase-quartz gneiss (Figure GS-6-2, -5, and -6e). Metamorphic recrystallization and the absence of diagnostic primary features hinder from identifying the protolith. The McClarty VMS deposit is located on the northeastern shore of the eponymous lake about 2.8 km due east from CLART-3. No drillcore from this deposit has been examined for the purpose of this study, as a recent technical report by Kutluoglu and Bailes (2008) provided detailed descriptions of drillcore and thin sections. Mineral assemblages described in the report also indicated metamorphic conditions from lower- to mid-amphibolite facies.

Farwell Lake

Drillhole FARE-7 (Figure GS-6-2 and -5) intersects massive, fine-grained, well-foliated, amygdaloidal andesite, bedded mafic crystal tuff and ash tuff containing quartz amygdules and plagioclase phenocrysts, respectively (Figure GS-6-6f). A few narrow, fine-grained, mafic dikes cut these rocks.

Discussion

Drillcore examination has shown that graphitic and sulphidic argillite similar to that described from the southern and northern flank of Fourmile Island can also be found several kilometres to the north (e.g., FM-4-81). Tracing of this distinct sedimentary unit, which is easily recognizable in drillcore and has a good geophysical response, will be useful in refining the geological model of this area. Felsic volcanic and volcaniclastic rocks like those hosting the Fourmile Island deposit have been confirmed in EEL-76 (Figures GS-6-3 and -4c). Documentation and sampling of felsic volcanic rocks from the northern flank of Fourmile Island will allow comparisons with the better documented stratigraphy of the southern flank of the island (Syme et al., 1995a; Simard et al., 2010; Gagné, 2015), which will improve the current state of knowledge regarding the sequence hosting the Fourmile Island deposit.

The presence of felsic and intermediate volcanic and volcaniclastic rocks in the eastern bay of Reed Lake was also confirmed. The bimodal geochemistry and volcaniclastic character of rocks encountered in RG-1 and EEL-212 (Figure GS-6-2) suggest an arc/arc-rift setting (geochemical results are pending). These lithological units contrast with the monotonous pillowed basalt observed along the northeastern shoreline of Reed Lake, which has an ocean-floor trace-element signature (Syme et al., 1995a). The pillowed basalt directly overlying Spruce Point deposit has an ocean-floor trace-element geochemical signature (S. Gagné, unpublished data, 2015). In the Flin Flon belt, juxtaposition of arc/arc-rift rocks with ocean-floor rocks occurred late in the collisional history and often incorporated fault-bounded slices of Burntwood group rocks. Syme et al. (1995a) interpreted that the Northeast Reed assemblage (ocean-floor rocks) were intercalated with the arc/arc-rift rocks of the FIA along the Morton Lake fault zone. The presence of arc/arc-rift rocks in direct contact with ocean-floor rocks can be explained by the presence of an early discrete fault that predates the Morton Lake fault zone. Similar early discrete thrusts have recently been identified within the McLeod Road–Birch Lake thrust panel in the Snow Lake arc assemblage (Rubingh et al., 2013).

Metamorphic grade in most of the Reed Lake region is low, varying from lower- to upper-greenschist facies, but the rocks from the area between Cooper Lake to McClarty Lake show mineral assemblages indicative of lower- to mid-amphibolite–facies metamorphism. In contrast, surrounding rocks examined from the vicinity of Dolomite Lake and Farwell Lake (this study), as well as from the area of the Sylvia and Kofman deposits (Simard et al., 2010; Reid and Gagné, GS-7, this volume) show greenschist-facies metamorphic assemblages. The marked increase in metamorphic grade of the rocks from the Cooper Lake and McClarty Lake area may indicate that these volcano-sedimentary rocks define a fault-bounded panel, with the last significant displacement postdating regional peak metamorphism.

Economic considerations

Bimodal volcanic and volcaniclastic rocks recognized in drillcore throughout the Reed Lake area indicate that the host successions were deposited in arc or arc-rift settings. The presence of moderate to intense, pervasive alteration and local sulphide mineralization suggest that all volcanic-arc assemblages in the sub-Phanerozoic basement of the Reed Lake area have potential to host significant VMS mineralization. However, establishing the key criteria to target specific favourable horizons within these packages is the focus of ongoing work. From an economic perspective, the interleaving of arc/arc-rift volcanic rocks with ocean-floor rocks indicates that the under-explored northeastern and eastern portions of Reed Lake have the potential to contain VMS mineralization.

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