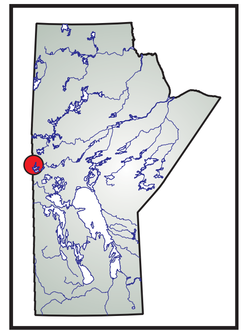
GS-5 Geology east and west of the Mandy Road Fault in the Schist Lake–Mandy mines area, Flin Flon, west-central Manitoba (part of NTS 63K12)



by Y.M. DeWolfe[1]

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Summary

The Schist Lake and Mandy deposits occur within the Paleoproterozoic Flin Flon Belt, which is part of the southeastern Reindeer Zone of the Trans-Hudson Orogen. They are located on the western edge of the Northwest Arm of Schist Lake in northwestern Manitoba, approximately 4 km southeast of the town of Flin Flon.

Detailed mapping (1:2000 scale) of the strata east and west of the Mandy Road Fault was the focus of fieldwork during the summer of 2011. Rocks west of the Mandy Road Fault have been correlated with those of the Hidden formation of the Flin Flon arc assemblage. However, rocks east of the Mandy Road Fault, which host the currently inactive Schist Lake and Mandy deposits, have thus far not been correlated with those of the Flin Flon Block to the west or the Hook Lake Block to the east.

Detailed mapping of the various volcanic facies, including their lateral and vertical distributions, as well as zones of alteration and structures in the area, has revealed that 1) the Mandy Road Fault represents a major shear zone across which there is a change in volcanic lithofacies; 2) an abrupt lateral change in volcanic lithofacies occurs from north to south and is interpreted to be the result of a fault, possibly the reactivation of a synvolcanic fault; 3) near this synvolcanic fault is a pervasive chlorite and pyrite alteration zone that hosts a massive sulphide stringer zone exposed at surface near the Schist Lake mine shaft and indicates the presence of an active hydrothermal system during the emplacement of these rocks; and 4) major early structures, such as the massive sulphide stringer zone and interpreted synvolcanic fault, have been transposed into the dominant northwest-striking foliation in the area. It remains unclear whether 1) the Mandy Road Fault has juxtaposed two entirely unrelated strata, or 2) the rocks east of the faults can be correlated with those of the Flin Flon Block.

The interpreted synvolcanic fault may have acted as a pathway for both magma and fluid while accommodating movement associated with both primary subsidence, related to volcanism, and movement during later deformation. Thus, this structure is essential in reconstructing the environment in which the Schist Lake and Mandy deposits formed, as well as in understanding the physical controls on mineralization, since it is close to the chlorite-pyrite alteration, the massive sulphide stringer zone at surface and both the Schist Lake and Mandy orebodies, if extended to depth.

Introduction

Paleoproterozoic volcanic rocks of the Flin Flon Belt contain more than 27 known volcanogenic massive sulphide (VMS) deposits (Syme et al., 1996). Located within 5 km of the town of Flin Flon are six current (Callinan, Triple 7 and Trout Lake) and past-producing (Flin Flon, Schist Lake and Mandy) VMS deposits (Figures GS-5-1 and -2). Totalling more than 90 million tonnes, these deposits constitute one of the largest massive sulphide districts in the Proterozoic (Bailes and Syme, 1989; Syme et al., 1999; Devine et al., 2002; Devine, 2003; Gibson et al., 2003).

The Schist Lake and Mandy deposits are hosted by rocks that lie just east of the Mandy Road Fault and were interpreted by Bailes and Syme (1989) to be part of the Flin Flon Block (Figure GS-5-2). However, more recent work in the Schist Lake–Mandy mines area (Simard, 2006; Simard and Kremer, 2007) has led Simard and Kremer to propose that the strata hosting the Schist Lake and Mandy deposits could also be part of the Hook Lake Block to the east (Figure GS-5-2). This summer's mapping marked the third summer of a project that is building upon the work done by Simard (2006), Simard and Kremer (2007) and Cole et al. (2007, 2008) in the Schist Lake–Mandy mines area. This project concentrated on mapping the volcanic rocks east and west of the Mandy Road Fault with the goal of reconstructing the volcanic environment of the deposits to aid exploration in the area. This report summarizes the results of a six-week bedrock mapping and sampling program that took place during the summer of 2011 in the Schist Lake–Mandy mines area. Mapping focused on strata east and west of the Mandy Road Fault that were not mapped as a part of this project in the summers of 2008 and 2009 (Figure GS-5-3).

Objectives and methodology

Mapping at 1:1000 and 1:2000 scales of the strata that structurally overlie the rocks that host the Schist Lake

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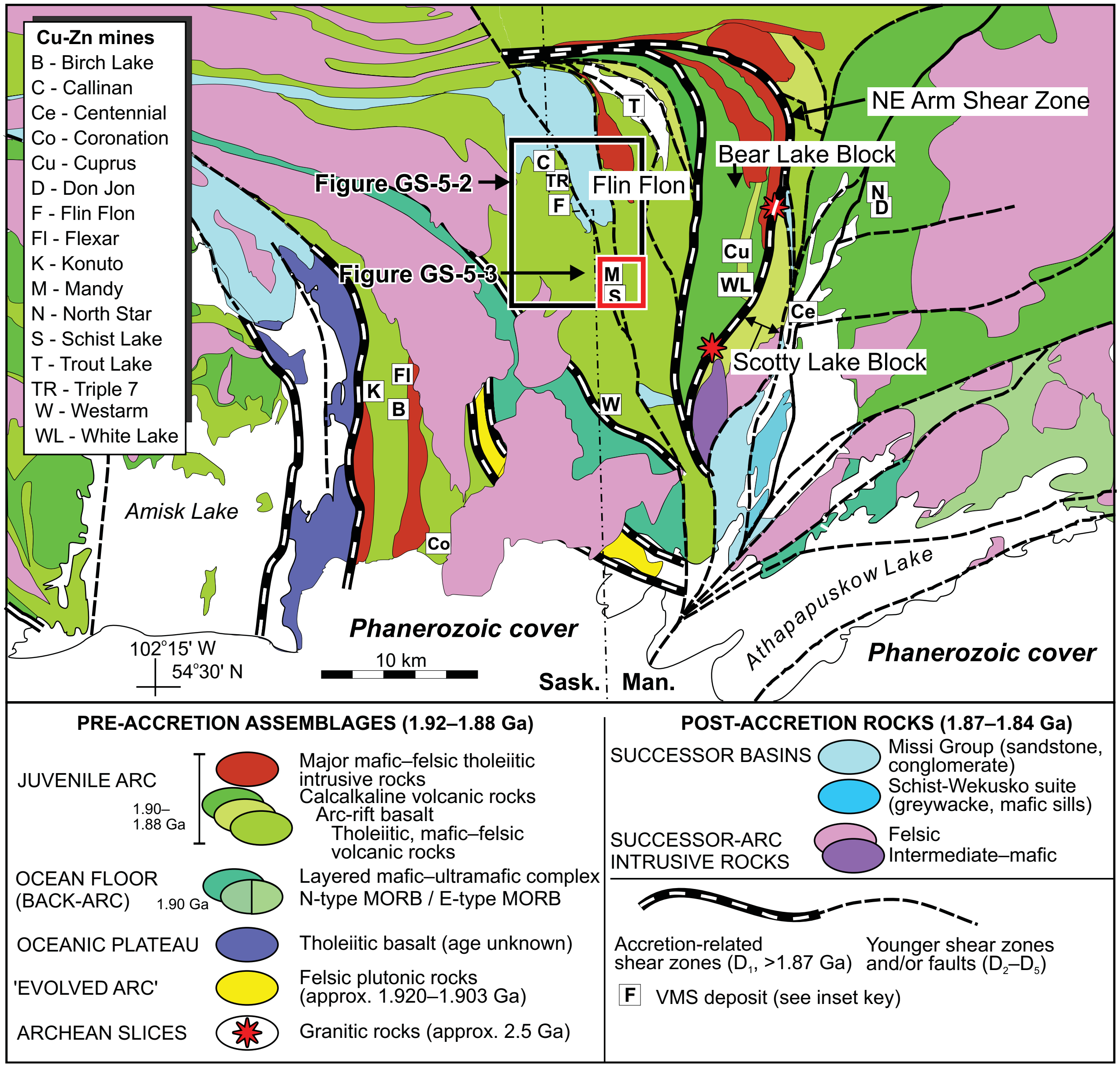

Figure GS-5-1. *Geology of the Flin Flon Belt, showing the locations of known volcanogenic massive sulphide (VMS) deposits (modified from Syme et al., 1999); black and red boxes indicate the areas covered by Figures GS-5-2 and -3, respectively.*

and Mandy deposits has formed the basis of this three-year research study and will be augmented with drillcore logging, petrography, trace and rare earth element analysis and geochronology.

Objectives of this three-year project that are addressed in this report include

- establishing a detailed litho- and chemostratigraphy for the rocks that host the Schist Lake and Mandy deposits and the structurally overlying sequence of Hidden formation west of the Mandy Road Fault;
- determining if the Mandy Road Fault has significantly affected the strata in the Schist Lake–Mandy mines area (i.e., has the fault structurally juxtaposed two different strata?); and
- reconstructing the volcanic environment and emplacement/depositional history of these strata, including the location of synvolcanic faults (building on the observations of Simard, 2006).

Regional geology

The Flin Flon Belt is part of the southeastern Reindeer Zone of the Trans-Hudson Orogen. The belt consists of a series of 1.91–1.84 Ga juvenile-arc, back-arc, ocean-floor and evolved-plutonic-arc tectonostratigraphic assemblages (Bailes and Syme, 1989; Stern et al., 1995; Lucas et al., 1996, 1997; Bailes and Galley, 1999; Stern et al., 1999). The Flin Flon and Snow Lake juvenile-arc

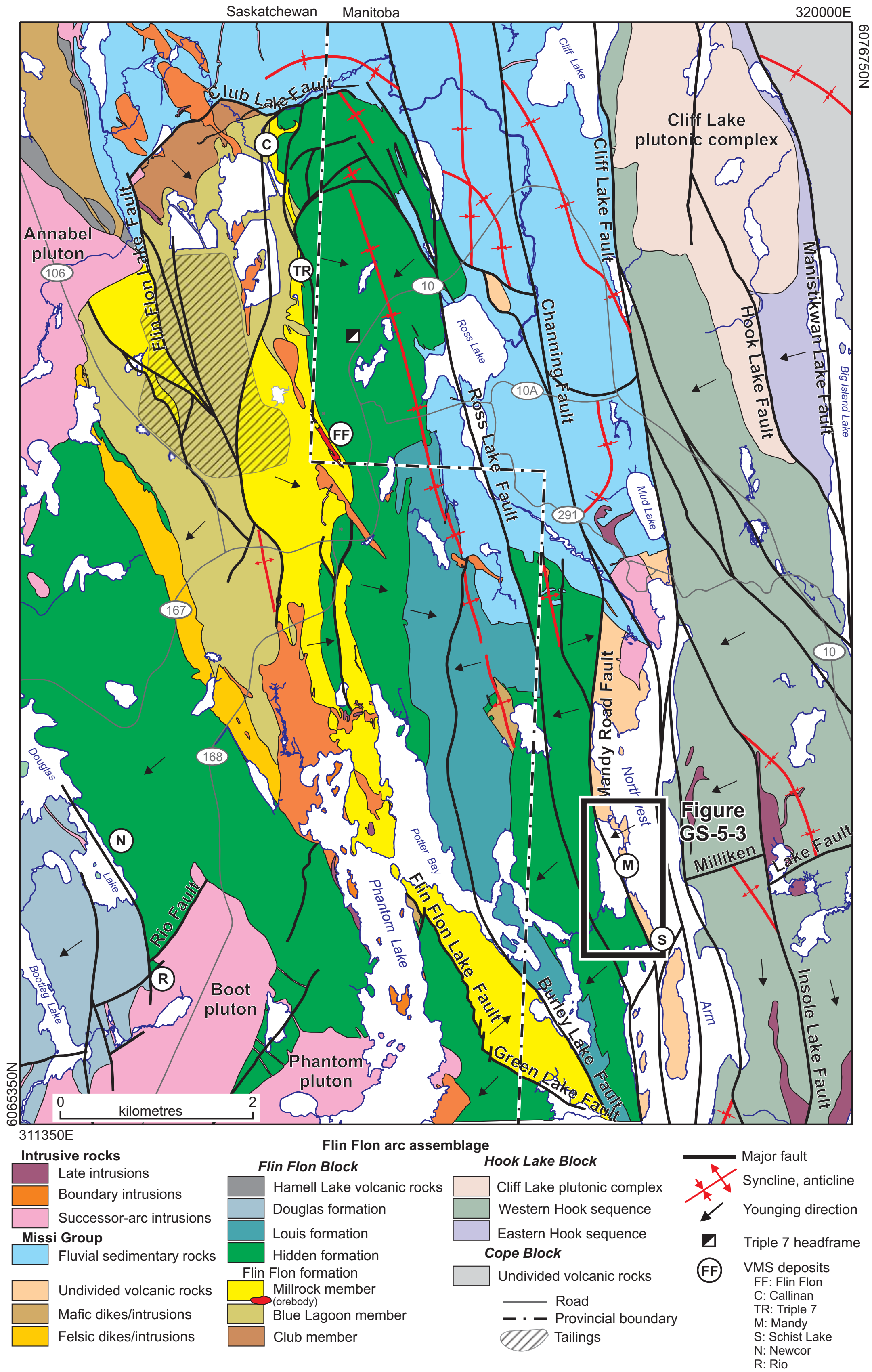

Figure GS-5-2. *Simplified geology of the Flin Flon area, showing the major stratigraphic units and structures (modified from Simard et al., 2010); box indicates the area covered by Figure GS-5-3.*

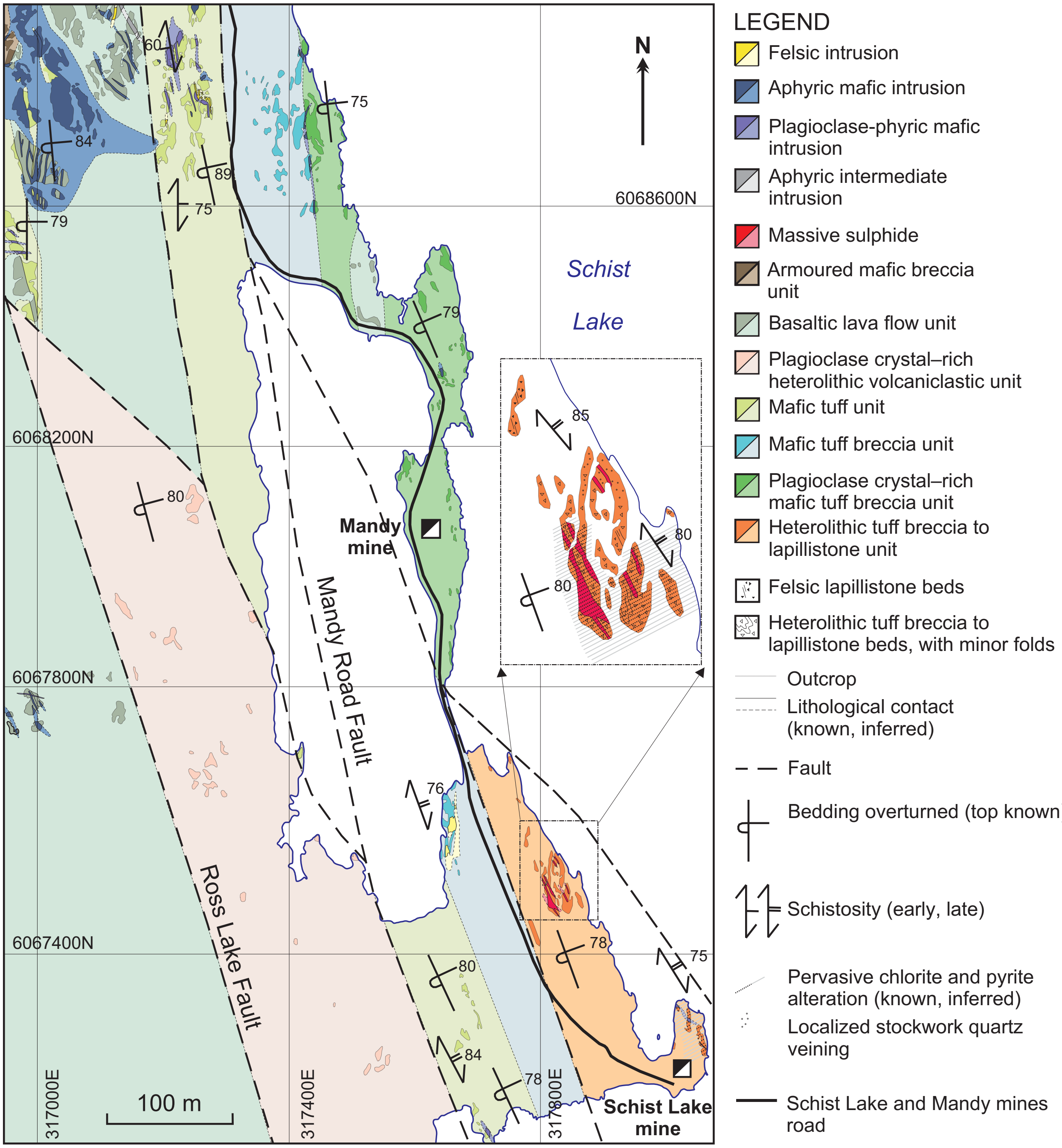

Figure GS-5-3: *Bedrock geology of the Schist Lake–Mandy mines area, Flin Flon, Manitoba.*

assemblages contain the majority of the VMS deposits in the Reindeer Zone (Syme et al., 1999).

The study area is located within the rocks of the Flin Flon arc assemblage, southeast of the town of Flin Flon (Figure GS-5-2). The Flin Flon arc assemblage is composed of juvenile metavolcanic rocks (1.91–1.88 Ga) that are unconformably overlain by younger fluvial sedimentary rocks of the Missi Group (ca. 1.84 Ga; Bailes and Syme, 1989; Stern et al., 1995; Lucas et al., 1996). Rocks of the Flin Flon arc assemblage are interpreted to have been erupted and emplaced in an island-arc–back-arc setting and consist of basalt, basaltic andesite flows and breccia, and lesser rhyolitic flows (Bailes and Syme, 1989). The Flin Flon, Callinan and Triple 7 VMS deposits, which total more than 92.5 million tonnes grading 2.21% Cu, 4.25% Zn, 2.11 g/t Au and 27.22 g/t Ag (numbers include NI 43-101–compliant data for proven, probable and inferred resources; K. Proctor, HudBay Minerals Inc., 2008), are interpreted to have formed during a period of localized rhyolitic volcanism in a synvolcanic subsidence structure, or cauldron, within a much larger, dominantly basaltic, central volcanic complex (Bailes and Syme, 1989; Syme et al., 1999). The Schist Lake (1.8 million tonnes grading 4.3% Cu, 7.27% Zn, 1.3 g/t Au and 37 g/t Ag; Mineral Inventory File 660, Manitoba Innovation, Energy and Mines, Winnipeg) and Mandy (0.13 million tonnes grading 7.3% Cu, 12.9% Zn, 2.8 g/t Au and 57 g/t Ag; Mineral Inventory File 662, Manitoba Innovation, Energy and Mines, Winnipeg) deposits are hosted by a quartz-phyric rhyolite unit lithologically similar to that which hosts the Flin Flon, Callinan and Triple 7 VMS deposits. They are overlain by mafic flows, sills and volcaniclastic rocks, which occur on both sides of the Mandy Road Fault and are similar to the rocks overlying the main Flin Flon VMS deposits (Figure GS-5-3; Simard, 2006; DeWolfe, 2009, 2010).

Geology of the Hidden formation in the Schist Lake–Mandy mines area

Strata in the Schist Lake–Mandy mines area trend north, dip steeply to the east or west, and young to the west (Figure GS-5-3). To the north, they are in unconformable contact with the younger sedimentary rocks of the Missi Group (Figure GS-5-2).

These rocks could constitute the hangingwall strata to the Schist Lake and Mandy deposits, depending on the offset along the Mandy Road Fault and other faults present in the area. West of the Mandy Road Fault, rocks consist of aphyric to plagioclase-phyric basalt flows, intercalated with mafic and heterolithic volcaniclastic rocks. Basaltic flows are the dominant lithofacies in the northern part of the area, whereas volcaniclastic rocks are the dominant lithofacies to the south (Simard, 2006; DeWolfe, 2009). East of the Mandy Road Fault, rocks consist of mafic and heterolithic volcaniclastic rocks with minor basaltic flows. This report focuses on the volcaniclastic rocks east of the Mandy Road Fault, and on the area west of the Mandy Road Fault dominated by volcaniclastic lithofacies (Figures GS-5-2, -3).

In these descriptions, a nongenetic terminology for volcaniclastic rocks is used because distinguishing primary and resedimented volcaniclastic deposits in the field is difficult. The deposits are described using the nongenetic, granulometric names ‘tuff’, ‘lapilli tuff’, ‘lapillistone’ and ‘tuff breccia’, which only reflect the percentage and size of the components (Fisher, 1961; Gibson et al., 1999; White and Houghton, 2006). In this terminology, tuff represents particles <2 mm, lapilli are 2–64 mm, and blocks and bombs are >64 mm. Peperite is “a genetic term applied to a rock formed essentially in situ by disintegration of magma intruding and mingling with poorly consolidated, typically wet sediments” (White et al., 2000).

Structures in the Schist Lake–Mandy mines area

The dominant structure in the Schist Lake–Mandy mines area is the Mandy Road Fault, so named because it is located along the Schist Lake and Mandy mines road (Figure GS-5-3). It has been referred to in previous publications as the East Mandy Road Fault, and the splay to the west as the West Mandy Road Fault (Simard, 2006). Since these faults are interpreted to join to the south and there is another splay to the east of the East Mandy Road Fault, this paper refers to the Mandy Road Fault as the main fault that is located near the Schist Lake and Mandy mines road and that has both west and east splays.

The rocks in the area display two foliations, defined primarily by the alignment of chlorite: a first fabric strikes approximately north and dips steeply to the east, whereas a second, more dominant foliation strikes 325–340º and dips steeply (75–85º) to the east. The elongation of clasts within the volcaniclastic units defines a stretching lineation that trends 110–150° and plunges 48–55°. These foliations and the stretching lineation have been identified in previous work and were observed to increase in intensity in proximity to the Mandy Road Fault (Cole et al., 2007). Cole et al. (2007) noted that the second foliation (a mylonitic S-fabric) is rotated counterclockwise as it approaches the plane of the north-striking foliation (C-fabric), indicating sinistral east-side-up shear parallel to the lineation.

Sulphide stringers exposed at surface near the old Schist Lake headframe strike 340º and dip steeply (85–87º) to the east, oriented parallel to the dominant, mylonitic S-fabric foliation in the area.

Stratigraphy of the Hidden formation in the Schist Lake–Mandy mines area

This report focuses on rocks located both east and west of the Mandy Road Fault from north of the Mandy deposit to the Schist Lake deposit in the south (Figure GS-5-3). The area is dominated by volcaniclastic lithofacies with minor lava flows. The lithofacies have been previously recognized as highly variable along strike in this area (Simard, 2006; DeWolfe, 2009, 2010). Figure GS-5-4 shows two simplified stratigraphic columns for rocks in the Schist Lake–Mandy mines area, one for the south and one for the north.

Heterolithic tuff breccia to lapillistone unit

This unit is exposed on the western shore of Schist Lake, where it has a maximum exposed thickness of 220 m, is continuous along strike for approximately 310 m north from the shaft of the former Schist mine and hosts a sulphide stringer zone exposed at surface (Figure GS-5-3). The unit is clast supported and crudely bedded, with beds ranging from 1 to 10 m. It is dominated by beds containing 60% pale brown, rounded, quartz-feldspar–phyric (quartz, 1%, ≤1 mm; feldspar, 5%, ≤1 mm) rhyolite

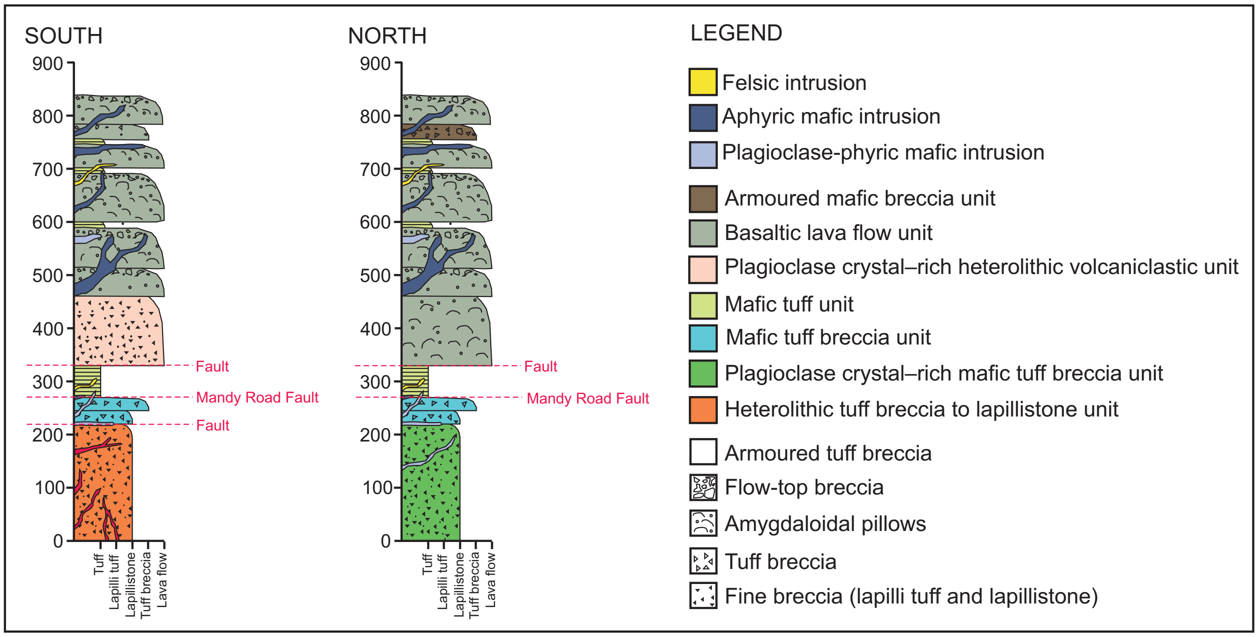

Figure GS-5-4: *Simplified stratigraphic columns for the Schist Lake–Mandy mines area shown in Figure GS-5-3.*

lapilli; 5–10% juvenile, dark grey, aphyric basalt lapilli; and 5% dark grey, aphyric, quartz-amygdaloidal basalt lapilli and blocks. The matrix is dark green, strongly chloritized tuff (Figure GS-5-5a). The contact with the overlying mafic tuff breccia unit is not exposed.

Felsic lapillistone beds

Locally, the heterolithic tuff breccia to lapillistone unit contains two felsic lapillistone beds, each approximately 10 m thick (Figure GS-5-3). The beds are dominantly massive, but the upper bed shows a change to smaller clast sizes to the west. The unit is composed of 60–70% pale brown, subrounded rhyolite lapilli and blocks in a dark green, strongly chloritized matrix. Locally, the lapilli show pumiceous textures within a rusty, sericitized matrix. The top of the lower lapillistone bed contains a block (measuring 60 by 10 cm) of laminated tuff.

Sulphide stringer zone

Approximately halfway between the Mandy and Schist Lake mines, a sulphide-stringer zone is exposed at surface (Figure GS-5-3). The massive sulphide stringers range from 0.1 to 3.5 m in width and have a general orientation of 340º (Figure GS-5-5b). They are strongly weathered, making identification of primary sulphide minerals in outcrop difficult; however, the presence of malachite suggests the weathering of copper sulphide minerals. Each sulphide stringer has an associated alteration zone of intense chloritization (1–3 m) and quartz-stockwork veining (randomly oriented quartz veins, each 1–5 cm in width) in the surrounding hostrocks.

Localized chlorite and pyrite alteration zone

In the southernmost portion of the study area, along the western shore of Schist Lake near the old Schist Lake mine (Figure GS-5-3), the unit displays strong chlorite and pyrite alteration. Here the unit contains 40% pale brown, rounded, strongly silicified basalt or rhyolite blocks and lapilli; 10% grey, subrounded, aphyric, quartz-amygdaloidal (5%, 1–5 mm) basalt blocks and lapilli; and 5% rusty, rounded blocks and lapilli. The matrix is green, strongly chloritized tuff. The unit is also strongly pyritized in this area, with euhedral pyrite (20%, 1–5 mm) overprinting all clast types and matrix material. Future petrographic work will determine if the silicified clasts are basalt or rhyolite, and provide details on the mineralogy of the ‘rusty’ clasts.

Plagioclase crystal–rich, mafic tuff breccia unit

This unit has a maximum thickness of 100 m and a strike length of approximately 520 m extending north from the shaft of the former Mandy mine. It is massive, monolithic and clast supported. The unit contains 60% blocks and 35% lapilli in a tuff matrix. It consists of beds containing 25% purple, subrounded to subangular, plagioclase-phyric (<5%, ≤1 mm) basalt blocks and lapilli; and 45% green, rounded to subrounded, plagioclase-phyric (<10%, ≤1 mm), quartz-amygdaloidal (20%, ≤1 mm) basalt blocks and lapilli (Figure GS-5-5c). The matrix is green and composed of subhedral, seldom-broken plagioclase crystals (≤ 40% of the matrix) and tuff-sized basalt clasts (Figure GS-5-5d). The contact with the overlying mafic tuff breccia unit is locally intruded by a plagioclase-phyric mafic sill; where the sill is not present,

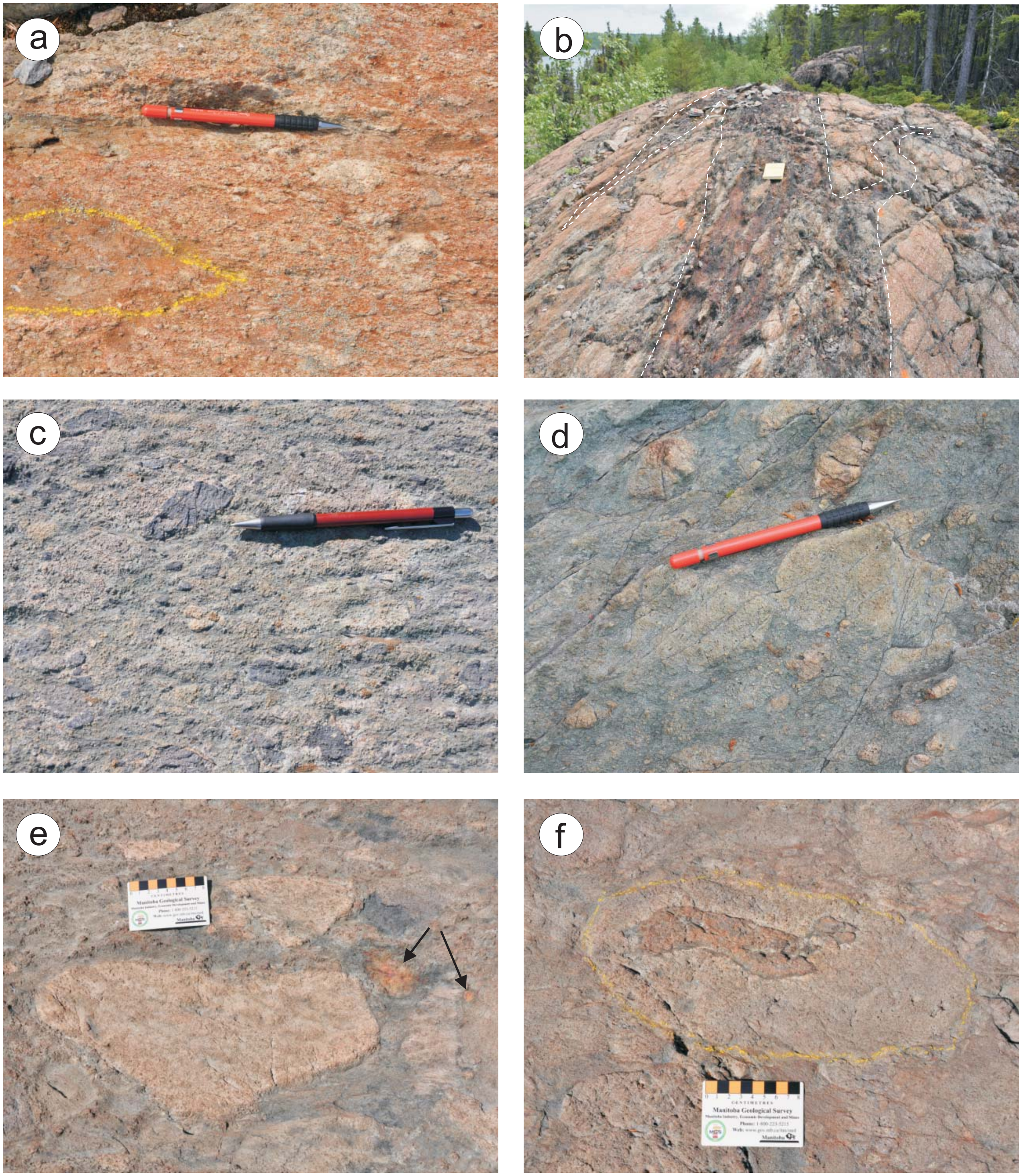

Figure GS-5-5: *Outcrop photographs of rocks in the Schist Lake–Mandy mines area:* ***a)*** *quartz-amygdaloidal basalt block in a lapillistone dominated by rhyolite lapilli;* ***b)*** *massive sulphide stringer (dashed white outline) hosted by heterolithic tuff breccia to lapillistone;* ***c)*** *purple and greenish-brown plagioclase-phyric basalt lapilli in plagioclase crystal–rich mafic tuff breccia;* ***d)*** *greenish-brown plagioclase-phyric basalt lapilli in a plagioclase crystal–rich matrix within plagioclase crystal–rich mafic tuff breccia;* ***e)*** *pinkish-brown, aphyric basalt blocks and rusty block and lapilli (arrows) in mafic tuff breccia;* ***f)*** *dark reddish-brown, 'juvenile', aphyric basalt block rimmed by aphyric, quartz-amygdaloidal basalt.*

the contact is sharp and irregular, marked by the sudden disappearance of plagioclase crystals in the matrix.

Mafic tuff breccia unit

This unit has a maximum thickness of 30 m and strike length of approximately 1 km. It is dominated by mafic tuff breccia beds but also contains a 2 m thick tuff bed that is characterized by intercalated, finely laminated (<10 cm thick) beds separated by coarser, massive tuff beds (<30 cm) containing <5% basalt blocks and <10% basalt lapilli. Scour structures and crosslaminations within the tuff bed indicate younging to the west. The tuff breccia beds are 1–6 m thick and contain 50% blocks and 30% lapilli in a tuff matrix. Clast types include 1) 30% grey, angular to subrounded, aphyric to weakly plagioclase-phyric (<5%) and quartz-amygdaloidal (5–10%, <1 mm) basalt (Figure GS-5-5e); 2) 25% purple to brown, rounded to subrounded, plagioclase-phyric (10–20%, 1–2 mm), vesicular (1–20%, <2 mm) basalt; 3) grey-brown, subrounded, aphyric, quartz-amygdaloidal (25%, ≤1 mm) basalt; 4) 15%, pink to pale brown, rounded to subangular, aphyric, quartz-amygdaloidal (25–30%, <1 mm) basalt; 5) 5% dark grey, fluidal basalt with very fine grained chilled margins (2–10 mm) that are seldom mantled by aphyric basalt (Figure GS-5-5f), display quartz-epidote–altered cores and commonly have a ropy or banded texture; and 6) 1% rounded, very fine grained, oxidized (rusty) clasts (Figure GS-5-5e). The matrix for the tuff breccia is composed of dark green tuff-sized particles of unknown composition and <5% plagioclase crystals. The contact with the overlying mafic tuff is not exposed.

Mafic tuff unit

This unit has a maximum thickness of 90 m and strike length of approximately 1 km. It is present on both sides of the Mandy Road Fault (Figure GS-5-3). The unit is dominated by parallel-laminated tuff beds (seldom crosslaminated) that are <50 cm thick. These tuff beds are intercalated with ≤ 1 m thick plagioclase crystal–rich (10–50%, 1–5 mm, rounded to subrounded) beds. Crosslaminations in the tuff beds (Figure GS-5-6a) and normal grading within the plagioclase crystal–rich beds (Figure GS-5-6b) indicate younging to the west. Massive, <3 m thick lapillistone beds are rare.

Mafic tuff is locally intruded by plagioclase-pyroxene–phyric mafic sills that commonly display peperitic margins. It is overlain by aphyric, pillowed basalt flows to the north and plagioclase crystal–rich, heterolithic volcaniclastic rocks to the south; in each case, the upper contact is not exposed.

Plagioclase crystal–rich, heterolithic volcaniclastic unit

This unit has a maximum thickness of 130 m and a strike length of 650 m, and is dominated by massive lapillistone beds (<1 to 6 m thick). These beds contain 50–70% white, rounded quartz (<2%, ≤1 mm)-feldspar (<1%, ≤1 mm)–phyric rhyolite lapilli, and 20% angular to rounded plagioclase crystals (2–8 mm) in a matrix containing white plagioclase crystals (angular, broken, <2 mm) and green, volcanic rock fragments (<2 mm, composition unknown; Figure GS-5-6c). The lapillistone beds are interbedded with plagioclase crystal–rich, massive, mafic tuff beds containing ≤5% basalt lapilli (aphyric, weakly quartz amygdaloidal, plagioclase phyric) and plagioclase-free, pale to dark grey, planar-laminated, mafic tuff beds (20–65 cm thick; Figure GS-5-6d).

Scour structures observed locally within this unit indicate younging to the west. The contact with the overlying basalt unit is not exposed, but the Ross Lake Fault is interpreted to be along the contact (Figure GS-5-3; Stockwell, 1960; Simard et al., 2010).

Basaltic lava flow unit

This unit occurs at the top of the exposed strata overlying the Schist Lake ore horizon. It has a maximum thickness of 640 m and strike length of approximately 1 km. The unit consists of a series of dark green, aphyric, quartz-amygdaloidal (5–20%, 1–5 mm), pillowed and massive lava flows (5–30 m thick) with silicified flow-top breccias (Figure GS-5-6e, -6f). The unit is also characterized by dark green, aphyric, quartz-amygdaloidal (5–20%, 1–5 mm) mafic sills with irregular but sharp chilled margins that crosscut, at a very low angle (<10º), the basalt flows and tend to intrude near flow contacts. Planar-laminated tuff beds seldom separate the basalt lava flows.

Summary and discussion

The volcanic lithofacies are highly variable along strike in the Schist Lake–Mandy mines area, changing from a flow-dominated regime in the north to a volcaniclastic-dominated regime in the south (Simard, 2006; DeWolfe, 2009).

Detailed mapping of the volcaniclastic-dominated regime in the south shows that the contact between the mafic tuff breccia unit and the overlying mafic tuff unit is not exposed, but the Mandy Road Fault is interpreted to lie along this contact (Figure GS-5-3). The amount of offset along the Mandy Road Fault remains unknown. Consequently, depending on the amount of offset along the fault, the rocks that host the Schist Lake and Mandy orebodies may be a part of the Flin Flon Block, as previously proposed by Bailes and Syme (1989) for the case of little offset, or may be a part of the Hook Lake Block, as proposed by Kremer and Simard (2007).

The mafic tuff unit is overlain by aphyric pillowed basalt flows to the north and a plagioclase crystal–rich heterolithic volcaniclastic unit to the south. In each case, the upper contact is not exposed, but they are interpreted

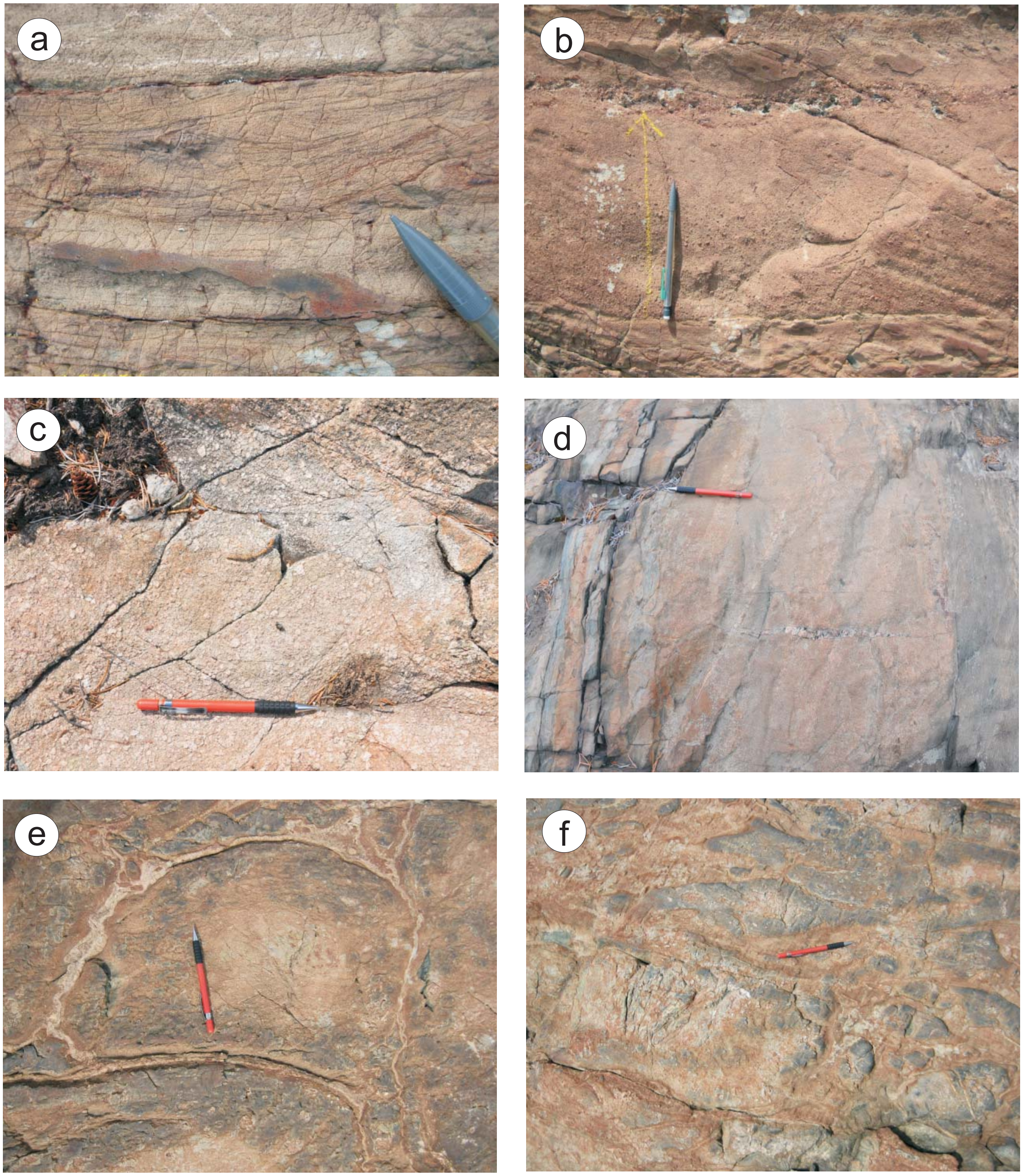

***Figure GS-5-6:** Outcrop photographs of rocks in the Schist Lake–Mandy mines area: **a)** crosslaminated mafic tuff (top towards top of photo); **b)** normal grading in a plagioclase crystal–rich tuff bed (top towards top of photo); **c)** plagioclase crystal–rich lapillistone bed, dominated by quartz-plagioclase–phyric rhyolite lapilli, within plagioclase crystal–rich heterolithic volcaniclastic rocks; **d)** massive plagioclase crystal–rich tuff bed overlain (to left) by planar-laminated mafic tuff beds; **e)** aphyric, quartz-amygdaloidal, pillowed basalt flow; **f)** amoeboid flow-top breccia of pillowed flow shown in (a).*

to be along the western splay of the Mandy Road Fault to the north and the Mandy Road Fault to the south (Figure GS-5-3).

North of the Mandy mine shaft, the strata consist of (from oldest to youngest) a plagioclase crystal–rich mafic volcaniclastic unit, a mafic tuff breccia to tuff unit, and basalt lava flows (Figure GS-5-4). South of the Mandy mine shaft, the strata consist of (from oldest to youngest) a heterolithic volcaniclastic unit, a mafic tuff breccia to tuff unit, a plagioclase crystal–rich heterolithic volcaniclastic unit and basalt lava flows (Figures GS-5-3, -4). This change in the youngest unit from a plagioclase crystal–rich mafic volcaniclastic unit in the north to a heterolithic volcaniclastic unit in the south is interpreted to be the result of faulting, possibly the reactivation of a younger synvolcanic fault. This synvolcanic fault would have separated synvolcanic depositional basins in the area, allowing for the deposition of the heterolithic volcaniclastic unit to the south in a basin separate from the plagioclase crystal–rich mafic volcaniclastic unit to the north (Figure GS-5-3). Such synvolcanic faulting would also allow for the deposition of the thick sequences of volcaniclastic rocks that are observed in the Schist Lake–Mandy mines area.

Similarly, the plagioclase crystal–rich heterolithic volcaniclastic unit that occurs in the stratigraphy south of the Mandy shaft is interpreted to be separated from the basaltic lava flow unit to the north by a fault (Figure GS-5-3). Alternatively, this north to south transition may represent a lateral facies change.

It is important to note that the interpreted synvolcanic fault between the plagioclase crystal–rich mafic volcaniclastic unit in the north and the heterolithic volcaniclastic unit in the south is just one of many that have been suggested for the Schist Lake–Mandy mines area from recent detailed mapping observations (Simard, 2006; DeWolfe, 2009, 2010). Also, the synvolcanic fault interpreted to lie between the Schist Lake and Mandy deposits is located within 100 m of the Schist Lake orebody and massive sulphide stringer zone exposed at surface, indicating that it may have acted as a hydrothermal fluid pathway during massive sulphide mineralization at Schist Lake and Mandy mines (Figure GS-5-3).

Of course, all primary features or structures in the area have been deformed due to shearing along the Mandy Road Fault, and many have been transposed parallel to the dominant foliation. As such, the orientation of the interpreted synvolcanic fault would be subparallel to the dominant foliation in the area. Similarly, the massive sulphide stringers, which would have formed more or less perpendicular to stratigraphy in a VMS-type setting, are interpreted to have been transposed into the plane of the dominant 340º foliation.

The intense, pervasive chlorite alteration and pyritization that occurs in the Schist Lake mine area (Figure GS-5-3) is interpreted to represent a disconformable zone of hydrothermal alteration that is commonly observed in the footwall to VMS deposits (Franklin et al., 1981). It should also be noted that the rocks structurally overlying these strongly chlorite-altered and mineralized rocks also show evidence of hydrothermal alteration, as defined by the occurrence of strong, patchy epidote-quartz alteration within the flows and volcaniclastic rocks west of the Mandy Road Fault. Similar epidote-quartz alteration in intermediate to mafic volcanic rocks has been attributed to relatively high temperature (>300°C, <400°C), evolved seawater-rock interaction within semiconformable hydrothermal alteration zones associated with some VMS deposits (Galley, 1993; Gibson and Kerr, 1993).

Economic considerations and future work

The amount of structural offset of strata along the Mandy Road Fault is still unclear. Thus, the ore horizon for the Schist Lake and Mandy deposits may be the time-stratigraphic equivalent to the main ore-hosting stratigraphy in Flin Flon (i.e., Flin Flon, Callinan and Triple 7), as originally proposed by Bailes and Syme (1989), or the strata east and west of the fault may be unrelated if there is significant offset along the Mandy Road Fault.

Additional economic considerations stemming from this summer's mapping include the potential recognition of synvolcanic structures in the Schist Lake–Mandy mines area, and associated synvolcanic depositional basins. Such structures provide more evidence, in addition to that given in Simard (2006) and DeWolfe (2009, 2010), that key conditions required to form a VMS deposit are observed in the rocks overlying the Schist Lake and Mandy VMS deposits. Such conditions include

- synvolcanic faults (required for cross-strata permeability and to act as magma and hydrothermal-fluid pathways), as evidenced by the abrupt change in volcaniclastic lithofacies along strike;
- synvolcanic grabens (provide evidence of rifting or thinning of crust needed for high heat flow), as evidenced by the thick succession of volcaniclastic rocks that overlies the Schist Lake and Mandy deposits and the fact that they change abruptly along strike (indicating different depositional basins);
- hydrothermal alteration (evidence of an active, synvolcanic hydrothermal system), as defined by the occurrence of locally strong, semiconformable, pervasive chlorite alteration within the volcaniclastic rocks east of the Mandy Road Fault and conformable, quartz-epidote alteration within the lava flows and volcaniclastic rocks west of the Mandy Road Fault; and
- a hiatus in effusive volcanism (allowing for the concentration of mineralization along a specific stratigraphic horizon), as evidenced by the large volume of volcaniclastic rocks in the Schist Lake–Mandy mines area.

Continued work with the data generated through this project will attempt to characterize the ore-forming environment in the Schist Lake–Mandy mines area, and to relate the interpreted subsidence structures in this area to those in the main Flin Flon camp (DeWolfe, 2009, 2010; DeWolfe et al., 2009).

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