

by K.D. Reid

In Brief:

- Bedrock geological mapping constrains the Stuart Bay fault to the south of Puella Bay and identifies mafic volcanic rocks previously not documented
- The McCafferty Lifter fault block is a northeasting-younging homoclinal volcanic sequence that is host to both gold and base-metal occurrences

Citation:

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Summary

A multiyear project examining the bedrock geology southeast of Wekusko Lake was initiated in the summer of 2019. Bedrock geological mapping was conducted at 1:20 000 scale over an area of 8.5 x 11 km in the Puella Bay area in 2019 and will be combined with another 8.5 x 11 km block to the north in 2020. The project area was selected because it lacks comprehensive mapping, and recent forestry activity (2008–2016) resulted in significant new rock exposures and access. In addition, the availability of high-resolution aeromagnetic data complements the mapping where exposure is lacking. The project area is geologically complex with preserved successor-arc volcanic and sedimentary rocks that provide a window into the evolution of the eastern Flin Flon domain. The rocks southeast and east of Wekusko Lake have been of considerable economic interest for over a century and are host to the Laguna deposit, the site of Manitoba's first gold mine.

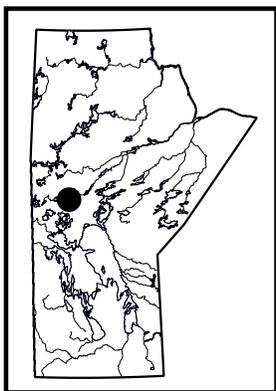
Introduction

The Flin Flon domain (FFD) is part of a series of Paleoproterozoic domains that form the internal Reindeer zone of the Trans-Hudson orogen (Lewry and Collerson, 1990). It has a distinct volcano-sedimentary stratigraphy that evolved from 1.91–1.83 Ga. The FFD is approximately 250 km from west to east, with an exposed north-south extent of approximately 40–50 km. The FFD is bounded to the east by the Superior province and the Superior boundary zone, is bounded to the north by turbidite greywacke and mudstone of the Kisseynew domain, and dips shallowly to the south under younger Phanerozoic platform carbonate rocks. Previous work by Stern et al. (1995) identified significant stratigraphic and geochemical differences between arc volcanic rocks west of Reed Lake (Amisk collage) versus those in the Snow Lake area (i.e., Snow Lake assemblage), indicating that these segments of the FFD may have formed in distinct tectonic settings.

Following discovery and intermittent production of gold (1918–1940) from the Laguna deposit in the northern half of the project area, the Geological Survey of Canada conducted field mapping of the Herb Lake fault block at a scale of 1:12 000 (1 in. to 1000 ft.; Stockwell, 1937), but the stratigraphic context was not well understood at the time. In the 1940s, the Geological Survey of Canada surveyed the region at a scale of 1:63 360 (1 in. to 1 mile; e.g., Armstrong, 1941; Frarey, 1950); the resulting maps provide much of the basis for later compilations in the area, such as those by the NATMAP Shield Margin Project Working Group (1998). Geochemical studies of the Herb Lake volcanic rocks by Gordon and Lemkow (1987) were guided by the mapping of Stockwell (1937). Ansdell et al. (1999) and Connors et al. (1999) conducted detailed structural, geochemical and geochronological studies of sedimentary and volcanic rocks; however, no comprehensive geological maps were published.

In the summer of 2019, a multiyear project was initiated to examine the bedrock geology southeast of Wekusko Lake. Bedrock geological mapping this summer was conducted at a 1:20 000 scale over an area of 8.5 x 11 km and will be combined with the mapping of another 8.5 x 11 km block to the north in 2020 to form a 17 km (north-south) by 11 km (east-west) map area. The lack of comprehensive mapping and the recent forestry activity (2008–2016), which resulted in significant new rock exposures and access, led to the selection of this area for bedrock geology mapping.

The current geological mapping focuses on rocks southeast of Wekusko Lake; in particular, two previously identified fault bound blocks, the McCafferty Lifter fault block and



the Eastern Missi fault block (Ansdell et al., 1999; Connors et al., 1999). Primary objectives of the 2019 summer field-work include

- updating and detailing the stratigraphic framework of the 1.88–1.83 Ga arc volcanic and sedimentary rocks east and southeast of Puella Bay,
- examining complex structural relationships between southwest-directed fold-and-thrust faulting (D_2) and northwest-directed transpression (D_3),
- incorporating high-resolution geophysical data with bedrock data to better constrain geological contacts and structures in poorly exposed areas, and
- using the lithostratigraphic and structural framework to evaluate the mineral potential of rocks southeast of Wekusko Lake.

Regional setting

Wekusko Lake is located in the eastern end of the FFD. Most of the lake is underlain by greywacke and mudstone turbidites of the Burntwood group from the Kisseynew domain to the northeast (Figure GS2019-4-1). Greywacke and mudstone extend to the southernmost part of the lake, separating arc volcanic rocks to the west from those

to the east, and continue southwest under Phanerozoic platform carbonates for at least 30 km (Reid, 2017). Snow Lake and Hayward Creek arc assemblages lie on the west side of Wekusko Lake; these are separated north from south, respectively, by the Berry Creek shear zone. On the east side of Wekusko Lake, the Crowduck Bay fault juxtaposes Burntwood group rocks against ocean-floor basalts, evolved arc volcanic rocks, and Missi group fluvial-alluvial sedimentary rocks (Figure GS2019-4-1).

Stratigraphic framework

The project and surrounding areas contain multiple tectonostratigraphic packages including 1) basalt of ocean-floor/back-arc affinity referred to as the South Wekusko assemblage (SWA), 2) intermediate to felsic arc rocks of the McCafferty Liftover fault block (MLB), 3) mafic to felsic arc volcanic rocks of the Herb Lake fault block (HLB), 4) fluvial-alluvial sediments of the Western and Eastern Missi fault blocks (WMB and EMB), and 5) greywacke and mudstone of the Burntwood group (BG; Figure GS2019-4-1), all of which were intruded by a variety of mafic and felsic plutonic rocks. Much of the following information is summarized from Ansdell et al. (1999) and Gilbert and Bailes

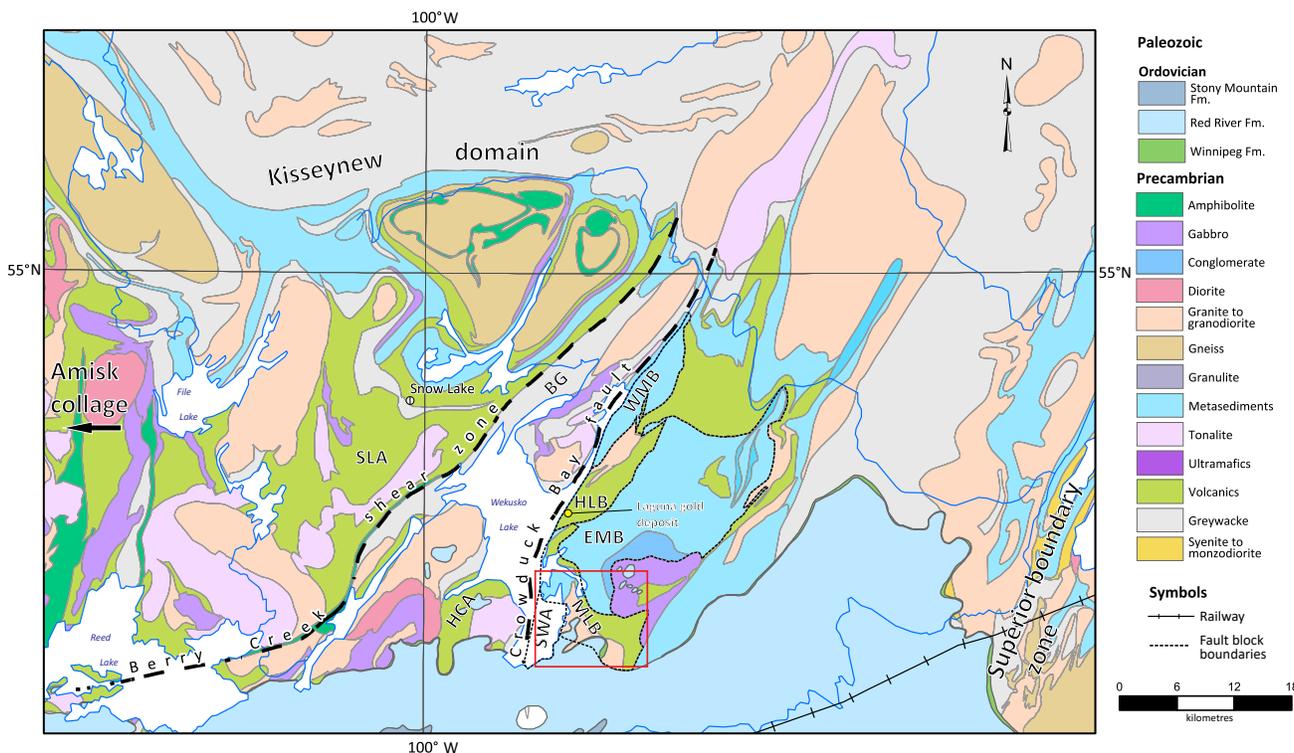


Figure GS2019-4-1: Map of the eastern segment of the Flin Flon domain including the location of the 2019 project area (see red rectangle; map is modified from unpublished 1:250 000 scale provincial compilation). Note the Kisseynew domain to the north, the Superior boundary zone to the east and Paleozoic cover rocks to the south. Snow Lake arc assemblage (SLA), Hayward Creek arc assemblage (HCA), South Wekusko assemblage (SWA), McCafferty Liftover fault block (MLB), Eastern Missi fault block (EMB), Herb Lake fault block (HLB), Western Missi fault block (WMB) and Burntwood group (BG) are shown relative to the Berry Creek shear zone and Crowduck Bay fault.

(2005); the reader is encouraged to see these papers for more details.

The southeastern shoreline of Wekusko Lake, near the community of Herb Lake Landing, contains massive to pillowed, plagioclase- and pyroxene-phyric basaltic flows of the SWA. The pillowed flows often contain minor inter-pillow hyaloclastite material, with localized epidote alteration. These rocks are similar to ocean-floor and/or back-arc sequences elsewhere in the Flin Flon domain (Gilbert and Bailes, 2005), with little or no felsic volcanic and volcanoclastic rocks, and geochemically resemble normal mid-ocean-ridge basalt of the 1.90 Ga Elbow-Athapapuskow assemblage (Stern et al., 1995). The SWA is interpreted as the oldest rock assemblage in the map area. The contact between the SWA and rocks of the structurally overlying MLB is not exposed, however, it is interpreted as tectonic (Gilbert and Bailes, 2005).

The MLB, also referred to as the Puella Bay suite by Gilbert and Bailes (2005), is a homoclinal sequence of east- to northeast-younging, intermediate to felsic volcanic rocks (e.g., Ansdell et al., 1999). The lowest stratigraphic unit in the MLB is an ~5 m wide basal mafic mudstone that grades over 15 m into a sequence of east-facing, bedded mafic to intermediate siltstone, greywacke and pebble conglomerate (Gilbert and Bailes, 2005). This rapidly grades to the east into monotonous, heterolithic, andesite cobble and boulder conglomerate, the most commonly observed rock type on many of the islands and points within and west of Broad Bay (Figure GS2019-4-2; Reid, 2019). Minor aphyric to plagioclase-phyric andesite occurs intercalated with the above heterolithic andesite conglomerate. Local amygdules and polygonal jointing suggest these may be flows or high-level intrusions. Felsic volcanic rocks, primarily massive dacite and intermediate to felsic volcanoclastic rocks, form the upper sequence of the MLB. Ansdell et al. (1999) were able to produce a relatively precise age of 1876 ± 2 Ma from the dacite thus constraining the minimum age of the MLB.

The HLB is an isoclinally folded package of mafic to felsic volcanic rocks in fault contact with the WMB to the north, MLB to the southwest and the EMB to the southeast (GS2019-4-1). Rocks at the centre of this fold are mainly basaltic, but become more felsic at the peripheries. The lack of pillowed flows and presence of welded felsic units suggest that volcanism was subaerial (Shanks and Bailes, 1977; Gordon and Gall, 1982). Dating by Gordon et al. (1990) produced a relatively precise age of 1832 ± 2 Ma for a sample of rhyolite from the fold centre. Ansdell et al. (1999) produced a similar age of 1836 ± 1.3 Ma, providing further evidence that these are some of the youngest volcanic rocks in the Trans-Hudson orogen. The young

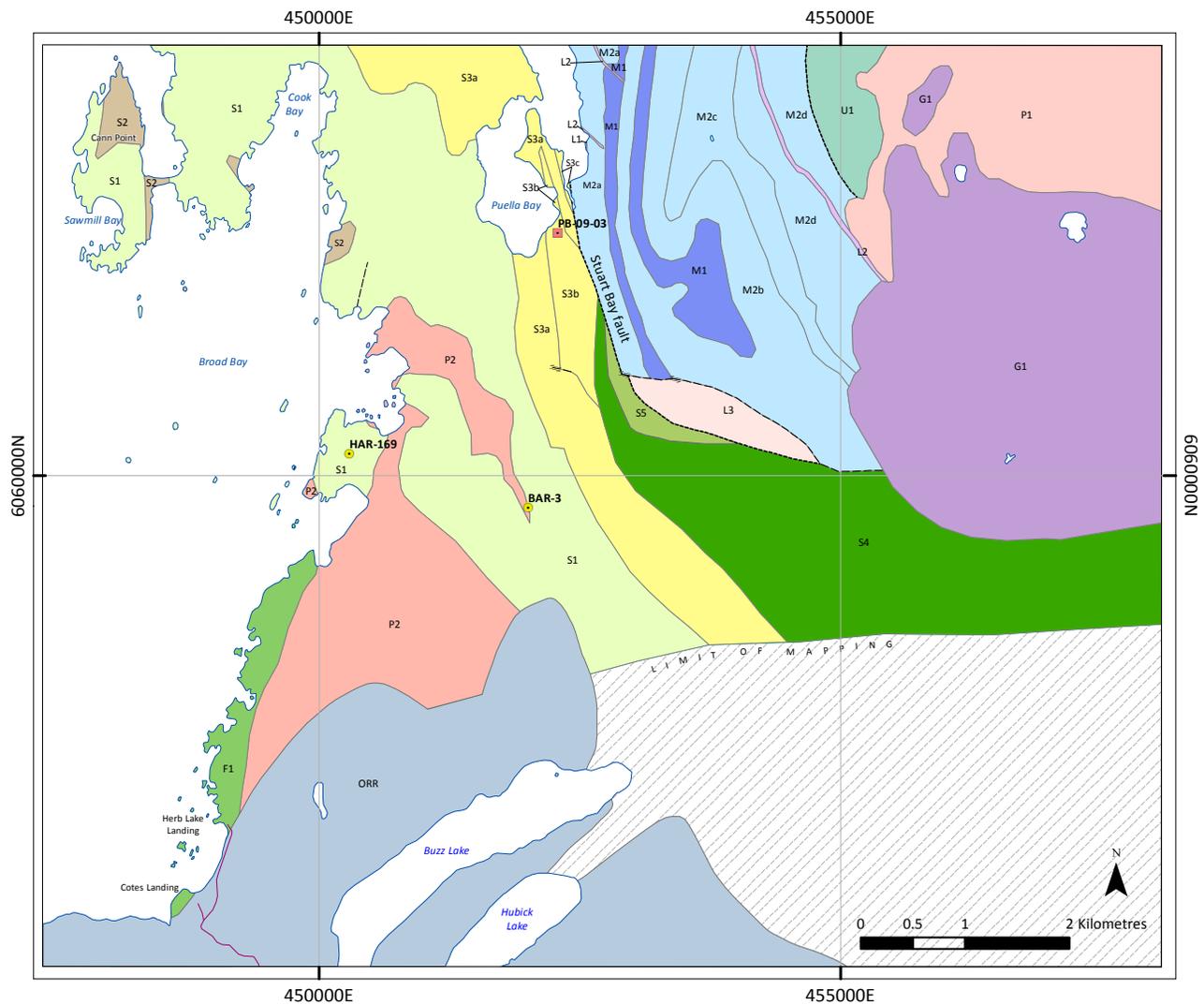
age of volcanism is unique in that it is synchronous with fold-and-thrust fault development as well as Missi group sedimentation (Ansdell et al., 1999).

Frarey (1950) first recognized and mapped fluvial-alluvial feldspathic arenite and polymictic pebble to boulder conglomerate east of Wekusko Lake. Ansdell et al. (1999) termed these sedimentary rocks the WMB and EMB based on their position north and south of the HLB, respectively. Fluvial-alluvial conglomerate and sandstone unconformably overlie spherulitic rhyolite at the south end of the WMB. Rhyolite yielded complex zircon age results that indicate that it could be as old as 1856 Ma or as young as 1830 Ma (Ansdell et al., 1999). Detrital zircons from the WMB range in age from 2004 to 1834 Ma (Ansdell et al., 1999). The EMB is stratigraphically broken into three conglomerate/sandstone successions—lower, middle and upper. The youngest detrital zircon in the lower sequence yielded an age of 1841 ± 21 Ma, and the lower sequence is cut by a 1826 ± 4 Ma feldspar porphyry dike. In comparison, the youngest detrital zircon in the upper sequence is 1832 ± 9 Ma (Ansdell et al., 1999). The lower sequence of the EMB yielded a range of detrital zircon ages from 1911 to 1841 Ma (Ansdell et al., 1999), which indicates that these sediments were collecting detritus from an already-formed accretionary collage, and that Missi group sedimentation was not synchronous throughout the Flin Flon domain.

Burntwood group rocks occur mainly west of the Crowduck Bay fault (west of the current project area), and subsequently underlie much of Wekusko Lake. Burntwood group greywacke and mudstone commonly show preserved bedforms and sedimentary structures indicating deposition by turbidity currents in a submarine fan (Bailes, 1980). Detrital zircons from Burntwood group rocks on the west side of Wekusko Lake suggest a depositional age of 1.855–1.84 Ga (David et al., 1996).

Structural context

The structural-tectonic history of the eastern FFD can be separated into four distinct periods (e.g., Connors et al., 1999; Ryan and Williams, 1999): 1) intra-oceanic accretion of arc and ocean floor assemblages (D_1 ; 1.88–1.87 Ga); 2) early successor-arc plutonism and basin deposition (1.87–1.84 Ga); 3) late successor-arc plutonism, basin deposition and southwest-directed thrusting (D_2 ; 1.84–1.83 Ga); and 4) northwest-directed transpressional shortening associated with the Trans-Hudson orogen (D_3 ; 1.83–1.81 Ga). No evidence of accretionary structures (D_1) was noted in the eastern Wekusko Lake area (e.g., Connors et al., 1999); however, Gilbert and Bailes (2005) suggested that the Broad Bay pluton is a late successor-arc



Phanerozoic rocks
ORR Ordovician, Red River Formation

Late intrusive rocks
L3 Granodiorite, porphyritic
L2 Gabbro, dike
L1 Dacite, quartz-feldspar porphyritic

Broad Bay intrusive rocks
P2 Granite, granodiorite

Monette Lake intrusive rocks
P1 Granite
G1 Gabbro

Eastern Missi fault block - fluvial-alluvial sedimentary rocks (1845 – 1835 Ma, Ansdell et al., 1999)

M2d Feldspathic arenite, crossbedded with minor conglomerate layers
M2c Feldspathic arenite, trough crossbedded
M2b Feldspathic arenite, magnetite bearing (<10%), trough crossbedded
M2a Feldspathic arenite, magnetite rich (>10%), trough crossbedded
M1 Conglomerate, polymictic

McCafferty Liftover fault block - volcanic, volcanoclastic and sedimentary rocks (1876 ±2 Ma, Ansdell et al., 1999)

S5 Heterolithic mafic volcanic conglomerate, matrix supported, felsic to intermediate plagioclase-phyric matrix
 Basalt, plagioclase-phyric pillowed flows
S4 with abundant quartz-filled amygdules, minor tuff breccia and interflow tuff layers
S3c Dacite, pebble conglomerate, feldspathic wacke and tuff
S3b Dacite, heterolithic volcanic conglomerate, locally scoria rich
S3a Dacite and/or rhyodacite, massive, feldspar porphyritic
S2 Andesite, pillowed flows to massive, locally amygdaloidal, possibly intrusive
S1 Andesite, heterolithic plagioclase-phyric (and minor dacite) cobble and boulder conglomerate, clast supported
South Wekusko assemblage - mafic volcanic rocks of probable ocean-floor/back-arc affinity
F1 Basalt, plagioclase- and pyroxene-phyric flows and pillows
Volcanic rocks of uncertain age
U1 Dacite, conglomerate (with minor andesite)

Fault
 - - - Fault, contact: approximate
 - - - Fault, major: approximate
 ⇐ - Fault, sinistral: approximate

Mineral occurrence in drillhole

● Gold
 ■ Lead, zinc
 — Road

Figure GS2019-4-2: Simplified geological map of the Puella Bay area, southeastern Wekusko Lake, based on 2019 mapping. For more detail see PMAP2019-4 (Reid, 2019).

intrusion that stitches an earlier D_1 fault. Fold-and-thrust deformation (D_2) is interpreted to have resulted in many of the map-scale isoclinal folds and faults observed within and bounding stratigraphic packages (e.g., Stuart Bay fault, Kiski fault, Herb Lake anticline); and in most instances predates peak metamorphism. Deformation associated with transpressional northwest-directed shortening (D_3) cross-cuts earlier D_2 structures and fabrics. The largest and most prominent D_3 structure in the area is the Crowduck Bay fault.

Results of 2019 fieldwork in the Puella Bay area

Bedrock mapping at a 1:20 000 scale in 2019 focused on characterizing rocks inland, south and east of Puella Bay. These areas have received very little attention during previous reconnaissance and shoreline mapping (e.g., Gilbert and Bailes, 2005) due to the lack of exposure and/or access. The 2019 mapping confirmed that MLB and EMB rocks are in structural contact to the south-southeast of Puella Bay for approximately 2 km. From there, the contact swings to the east-southeast and is intruded by a porphyritic pluton. A brief description of mapped rock units, displayed in Figure GS2019-4-2 (and in Reid, 2019), is given below.

South Wekusko assemblage (unit F1)

A few outcrops along the winter road north of Herb Lake Landing contain variably strained pillowed and massive plagioclase- and pyroxene-phyric basalt (unit F1). These rocks weather a distinct grey-green, are fine to medium grained and have rare carbonate-filled amygdules. Localized shearing, carbonate alteration, and poor exposure did not allow the resolution of contacts between massive and pillowed flows. Gilbert and Bailes (2005) suggested that massive varieties could be synvolcanic intrusions.

McCafferty Liftover fault block (units S1–S5)

Gilbert and Bailes (2005) mapped much of the shoreline in the areas of Cann Point and Broad Bay, and therefore these outcrops were not remapped in 2019. They described the rocks as a thick package of clast-supported, heterolithic volcanic cobble and boulder conglomerate that is dominated by subrounded plagioclase-phyric andesite but includes local dacite clasts (see unit S2 in Gilbert and Bailes, 2005; unit S1 in Figure GS2019-4-2). Volumetrically, it is the largest unit in the MLB. Minor amygdaloidal, aphyric to plagioclase-phyric massive andesite flows (unit S2; Figure GS2019-4-2) occur within the above mentioned conglomerate. Outcrops of andesite flows (unit S2) were

extrapolated inland using aeromagnetic data. Traversing from Broad Bay to the southern tip of Puella Bay (west to east) revealed a gradation from clast-supported heterolithic andesite conglomerate to matrix-supported (dacitic) feldspar-phyric andesite conglomerate (Figure GS2019-4-3a), followed by massive varieties of dacite (unit S3a; Figure GS2019-4-2). Within the massive dacite (unit S3a) is a package of heterolithic volcanic conglomerate containing both dacite and mafic scoria clasts, which gives the outcrop a pitted surface (unit S3b). Farther to the east, a small outcrop contains normally graded beds of pebble conglomerate, feldspathic wacke and reworked tuff indicating that, at least locally, the package is younging to the east (unit S3c; Figure GS2019-4-3b). This is consistent with the interpretation of the MLB being a homoclinal, east-younging sequence.

To the south and east of Puella Bay there is a change from felsic volcanic rocks (no contacts were observed) to amygdule-rich pillowed basalt and local pillow breccia (unit S4; Figure GS2019-4-3c). Pillowed flows are porphyritic with 2 to 3 mm-sized plagioclase and pyroxene phenocrysts in an aphanitic groundmass; pillow selvages are a dark green relative to the grey-green of the groundmass. Interflow tuff beds, pillow drapes and breccia suggest this package is northeast-younging, similar to rocks farther west in the MLB.

Heterolithic mafic volcanic conglomerate (unit S5) occurs directly to the north of the previously mentioned unit S4. This conglomerate differs from that of unit S1 in that the cobbles are mainly of medium- to coarse-grained, plagioclase-pyroxene-phyric gabbro with minor plagioclase-phyric andesite and fine-grained diorite. Additionally, clasts are subrounded to well rounded and suspended in a fine-grained, intermediate to felsic, plagioclase-rich matrix (matrix supported).

Volcanic rocks of uncertain age (unit U1)

Two outcrops east of the EMB contain matrix- to clast-supported, intermediate to felsic volcanic conglomerate (unit U1; Figure GS2019-4-2). The clasts are subrounded to subangular, 1 to 8 cm, mainly light grey feldspar-phyric dacite and minor pyroxene-phyric andesite. The matrix to the clasts is a dark grey-brown, fine-grained tuff. These rocks are separated from the EMB by a distinct topographic low that extends to Monette Lake to the north; it is possible that this represents a significant fault. At this time, the stratigraphic context of these rocks is unknown, but future investigations in the Monette Lake area may provide more detail.



Figure GS2019-4-3: Outcrop photographs of the McCafferty Liftover fault block arc volcanic rocks: **a)** recessively weathered, sub-rounded andesite clast (arrow) in an intermediate (dacite) matrix (unit S1; NAD83, UTM Zone 14N, 450513E, 6071429N); **b)** normally graded rhyolite pebble conglomerate and feldspathic wacke (arrow show younging direction; unit S3c; UTM 452299E, 6063126N); **c)** amygdaloidal pyroxene- and plagioclase-phyric pillow fragments (arrow; unit S4; UTM 453770E, 6059601N); **d)** isoclinally folded (F_2), plagioclase-crystal-rich mafic tuff cut by S_3 foliation (unit S4; UTM 453781E, 6059863N).

Eastern Missi fault block (units M1 and M2)

Directly north of the current project area, polymictic conglomerate (unit M1) forms the base of the EMB (Ansdell et al., 1999). East of Puella Bay, small exposures of polymictic pebble to boulder conglomerate (unit M1; Figure GS2019-4-2) occupy both topographic and aeromagnetic lows, and have an estimated 40–60 m thickness. The conglomerate is matrix supported and poorly sorted, with well-rounded clasts including light grey plagioclase-phyric dacite, aphyric rhyolite, aphyric basalt, grey vein quartz and minor laminated iron formation (Figure GS2019-4-4a). Southeast of Puella Bay, a weak clast flattening defines an S_3 foliation that is oblique to or perpendicular to bedding (S_0). This relationship is interpreted to represent an axial planar fabric within a macroscopic map-scale S-fold.

Trough crossbedded, medium- to coarse-grained feldspathic arenite (unit M2) is the most common lithology in the EMB (Figure GS2019-4-4b, c). Unit M2a, directly east

of Puella Bay, is characterized by heavy mineral laminations in trough crossbeds that contain up to 25% magnetite (Figures GS2019-4-2, -4d). Moving upsection to the east there is a consistent decrease in magnetite content (unit M2b, c), a subtle increase in muscovite and biotite, and better developed (or preserved) planar bedding (Figure GS2019-4-4c). At the top of the succession the arenite contains minor (<5%) pebbles and cobbles (unit M2d). Feldspathic arenite is consistently east- to northeast-younging, possibly indicating that, like the MLB, it is a homoclinal sequence.

Magnetite-rich, trough crossbedded sandstone (unit M2a) along the western shore of Puella Bay locally contains orange, quartz- and feldspar-phyric, 0.2 to 1.2 m elongate, subangular to subrounded stratobound features with silicified margins. One possibility is that these are concretions or mark areas of fluid flow in the sandstone. Trough crossbedding stratigraphically below these

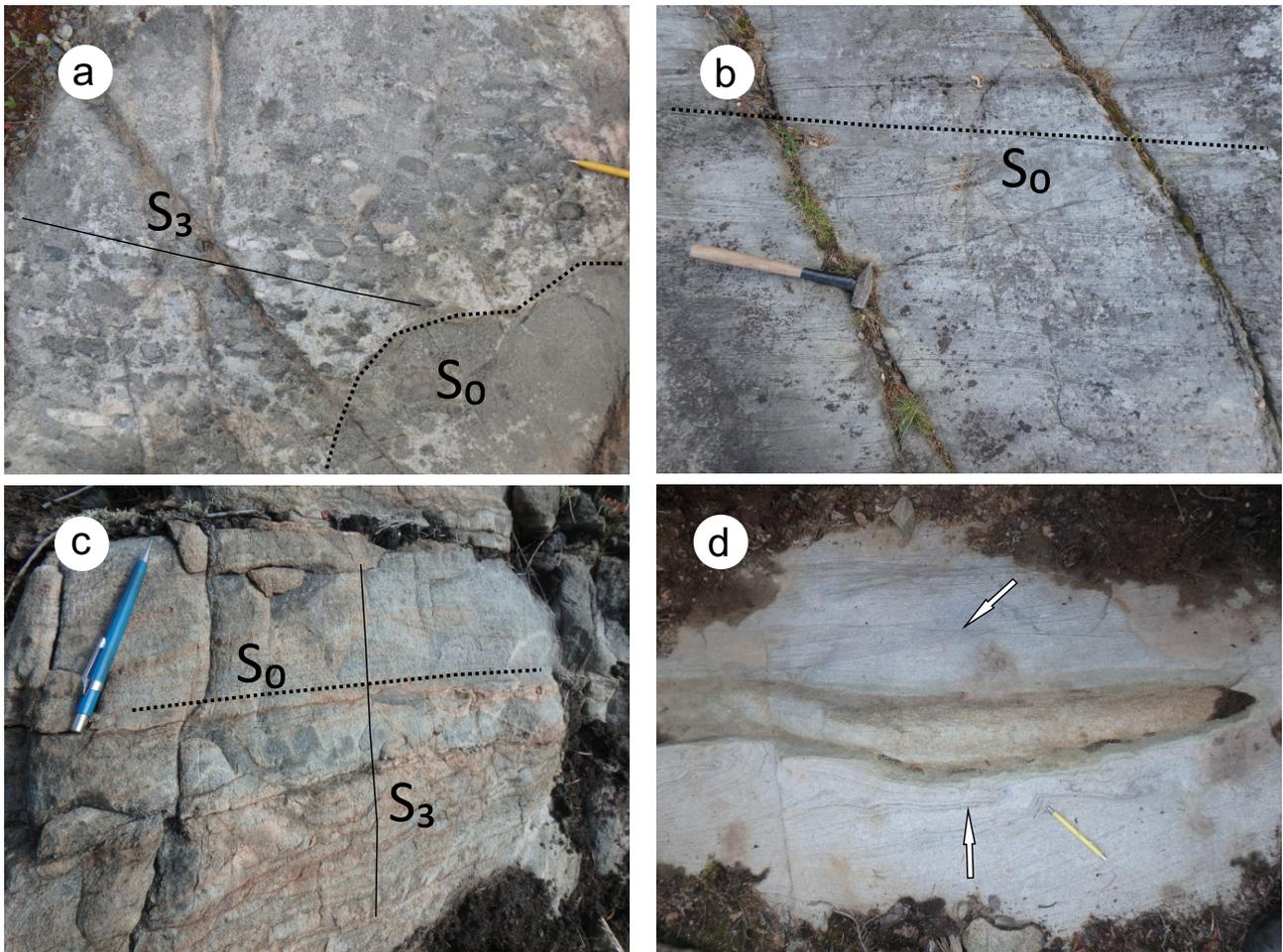


Figure GS2019-4-4: Outcrop photographs of the Eastern Missi fault block metasedimentary rocks: **a)** weak clast flattening defines S_3 foliation relative to bedding contact (S_0) between clast-supported polymictic conglomerate and feldspathic arenite (unit M1; NAD83, UTM Zone 14N, 453428E, 6061649N); **b)** trough crossbedded, magnetite-rich, feldspathic arenite with approximate strike of the bedding surface (S_0 ; unit M2a; UTM 452534E, 6063202N); **c)** planar bedding (S_0) is defined by biotite seams/hematite whereas the orientation of biotite perpendicular to bedding defines the S_3 foliation (unit M2c; UTM 453554E, 6062724N); **d)** trough crossbedded feldspathic arenite with a possible concretion or volcanic dropstone—note contorted bedding stratigraphically below (lower arrow) but not above the structure (upper arrow; unit M2a; UTM 452727E, 6062969N).

features can be disrupted, whereas overlying structures remain undisturbed (Figure GS2019-4-4d). This indicates possible soft sediment deformation. An alternative explanation could be that these are pumiceous volcanic bombs that flattened upon impact and resulted in the observed soft sediment deformation.

Intrusive rocks (units P and G)

The stratigraphy of the EMB and MLB is truncated by a semicircular, 3.5 km diameter gabbroic intrusion east of Puella Bay (unit G1; Figure GS2019-4-2). The gabbro is relatively massive, moderately deformed (moderate mineral lineation), seriate, medium grained and contains approximately 65% plagioclase and 35% pyroxene. A pinkish-orange, medium-grained, massive to weakly deformed granite (unit P1), which contains biotite and

possible muscovite, intrudes the gabbro (unit G1) along its north and northwestern flanks where subangular gabbroic xenoliths were observed in a fine-grained granitic matrix (Figure GS2019-4-5a). It is uncertain whether the gabbro (unit G1) and the granite (unit P1) are genetically related. East of Broad Bay and northeast of the community of Herb Lake Landing, several large outcrop ridges contain granite (unit P2) with a similar composition but slightly higher biotite content (up to 10%).

A 6 m wide body of quartz-feldspar–phyric dacite (unit L1) occurs at the southeast end of Puella Bay. The dacite dips and strikes parallel to crossbedded sandstone (EMB). Though the contacts of this felsic body are not well exposed, it is considered a dike or sill with internal layering related to multiple phases of injection (Figure GS2019-4-5b). Narrow, southwest-dipping gabbro dikes (unit L2),



Figure GS2019-4-5: Outcrop photographs of intrusive rocks in the Puella Bay area: **a)** granitic (unit P2) intrusive breccia with subangular gabbro (unit G1) fragments (arrow) east of Puella Bay (NAD83, UTM Zone 14N, 455243E, 6062910N); **b)** feldspar-phyric dacite dike with flow layering (arrow) in feldspathic arenite (unit L3; UTM 452534E, 6063202N); **c)** gabbro dike cutting feldspathic arenite (unit L2; UTM 452951E, 6063741N); **d)** feldspar-phyric (arrow) granodiorite (unit L1; UTM 453305E, 6060394N).

ranging from 5 to 25 m in width, cut perpendicular through crossbedded sandstone of the EMB (Figure GS2019-4-5c). Aeromagnetic data indicate that these dikes (unit L2) can trend over several kilometres and postdate early folding (D_2) of the EMB (Figure GS2019-4-2), but have a weak to moderate foliation related to (D_3) deformation. It should be noted that these dikes were not observed in rocks of the MLB.

Weakly deformed porphyritic granodiorite (unit L3; Figure GS2019-4-5d) stitches the Stuart Bay fault south-east of Puella Bay. Deformation resulted in weak alignment of the biotite. The granodiorite contains coarse- to very coarse, subhedral and elongate iridescent crystals that resemble feldspar, in a medium-grained quartz, plagioclase, K-feldspar and biotite groundmass; further petrography should help resolve the mineralogy.

Structural considerations

Nearly all rocks in the project area are deformed. Deformation is routinely manifested as clast flattening/

lineation, penetrative foliation and/or mineral lineation at the outcrop scale. Figure GS2019-4-3d shows a rare mesoscopic isoclinal fold (F_2) in feldspar crystal tuff (unit S1). This is the earliest recognized deformation in the MLB and is crosscut by a strong penetrative foliation (S_3). In the nose of the macroscopic S-fold east of Puella Bay, biotite is aligned perpendicular to bedding in feldspathic arenite, which is attributed to transpressional D_3 deformation (Figure GS2019-4-4c); the same relationship is shown in the area by weakly flattened clasts (Figure GS2019-4-4a). Clast- and mineral-lineations (L_3) commonly plunge steeply to the east-southeast, and align on D_3 planar fabrics and faults. The Stuart Bay fault (see Figure GS2019-4-2) is interpreted by Connors et al. (1999) to represent an early D_2 thrust fault that was steepened during D_3 transpression. Fieldwork conducted this summer does not refute this argument; however, a general observation is that feldspathic arenite in the immediate hanging wall shows little to no ductile deformation whereas volcanic rocks of the MLB in the direct footwall show mylonitic fabrics.

Discussion

Field investigations in the Puella Bay area have constrained the southern extension of the Stuart Bay fault and subsequently the contact between the MLB and EMB (Figure GS2019-4-2). Where the Stuart Bay fault trends from south-southeast to east-southeast the fault is intruded by porphyritic granodiorite (unit L3). The nature of this late intrusion is uncertain, but its emplacement appears to postdate D_2 folding and faulting but predate D_3 deformation, and possibly is related to dilation during reactivation of the Stuart Bay fault. Whole rock lithochemistry and petrography will be used to further investigate the granodiorite.

Unit S1 grades from clast-supported plagioclase-phyric andesite cobble and boulder conglomerate into plagioclase-phyric andesite (and local dacite) conglomerate supported by a dacite matrix near the contact with the overlying dacite units (unit S3a–c). Gilbert and Bailes (2005) noticed a similar gradation to the north of the project area, but also observed pebble conglomerate and arenite. These units may be present near the top of unit S1 (Figure GS2019-4-2), but heavy forest cover between Broad Bay and Puella Bay conceals them. Normally graded beds of pebble conglomerate, feldspathic wacke and reworked tuff (unit S3c) at the south end of Puella Bay suggest it is an upright, homoclinal sequence younging to the northeast.

A sequence of amygdaloidal pillowed basalt (unit S4) and mafic boulder conglomerate (unit S5), not previously described, occurs southeast of Puella Bay; the east- to northeast-younging directions indicated by these rocks suggest they may lie stratigraphically over dacite (unit S3) of the MLB. Although the geochemical affinity of these rocks is unknown, the occurrence of pillowed flows indicates at least local subaqueous deposition.

Clast-supported, intermediate to felsic, volcanic conglomerate (unit U1) east of the EMB was previously mapped as conglomerate of the Missi group (e.g., Frarey, 1950), which extends to the southern shores of Monette Lake. Aeromagnetic data does support a northerly extension of these rocks to the Monette Lake area. Based on this summer's observations, these rocks are now interpreted to be part of a new, previously not described, volcanic package that is in fault contact with the EMB.

Within the project area, fluvial-alluvial Missi group rocks (units M1, M2a-d) east of the Stuart Bay fault are an east-younging, homoclinal sequence. The succession records a transition from magnetite-rich trough crossbedded feldspathic arenite and polymictic conglomerate to medium- to fine-grained feldspathic arenite with more tabular bedforms, less magnetite, and increased bio-

tite and muscovite. An interpretation is that these Missi group rocks represent a shift from deposition in a high-energy fluvial environment, such as a braided river, to a lower-energy flow regime that produced tabular, normally graded beds with minor lamination and crossbedding.

Late gabbro dikes (unit L2) that cut the folded stratigraphy and upper beds of the EMB indicate that they were emplaced after the ca. 1826 Ma minimum age for sedimentation, but before the final stages of D_3 deformation. It is uncertain how these gabbro dikes relate to the late diabase dikes described by Gilbert and Bailes (2005); however, their timing of emplacement may be similar given that they cut phases of the ca. 1834 Ma Wekusko Lake pluton (Gordon et al., 1990) on the west side of Wekusko Lake.

Economic considerations

Four trenches related to a historic Zn-Pb-Cu showing were investigated directly south of Puella Bay; the rocks are strongly muscovite-chlorite-altered schists with up to 10% sulphide, and appear to be of possible felsic volcanoclastic origin. Drilling of the occurrence in 2009 (drillhole PB-09-03; Figure GS2019-4-2; Assessment File Number 74765, Manitoba Agriculture and Resource Development, Winnipeg) intersected multiple base-metal intervals including 207.21–207.42 m (0.46% Pb, 1.66% Zn), 238.16–238.51 m (0.5% Pb, 0.05% Cu, 2.49% Zn) and 245.77–246.24 m (0.47% Pb, 0.81% Cu, 2.19% Zn). The alteration and metal association of the mineralized intersects are suggestive of a volcanogenic massive-sulphide deposit within rocks of the MLB, and that the MLB has potential to host base-metal deposits.

The potential for gold mineralization in the hanging wall to the Crowduck Bay fault is exemplified by the Laguna gold deposit in the northern half of the project area (Figure GS2019-4-1), which produced 1833.9 kg of gold from 109 488 tonnes (16.75 Au g/t) between 1918 and 1940 (Richardson and Ostry, 1996). Notable gold was intersected in core from drillholes BAR-3 (Figure GS2019-4-2; Assessment File Number 94374) and HAR-169 (Figure GS2019-4-2; Assessment File Number 93516). In the fall of 1987, Granges Exploration Ltd. followed up on historical gold-bearing quartz veins near the 'Zona' shaft; all six drillholes intersected gold but the best intersections were from BAR-3 at 41.7–42.7 m (8.9 Au g/t), 46.7–47.7 m (15.9 Au g/t), 54.8–55.3 m (19.6 Au g/t) and 69.2–69.7 m (32.5 Au g/t). Hudson Bay Mining and Smelting Co., Limited drilled two very low frequency targets in the spring of 1985. Drillhole HAR-169 intersected 11.6 Au g/t at 45.3–45.8 m (148.8–150.3 ft., 0.37 oz/ton), 58.8 Au g/t at 54.6–55.0 m (179.2–180.5 ft., 1.88 oz/ton) and 5.6 Au g/t

at 56.7–57.0 m (186.0–187.0 ft., 0.18 oz/ton). Both gold occurrences are associated with quartz-carbonate veins along the sheared contact between metavolcanic and metaplutonic rocks. This highlights the importance of and close relationship between structural reworking and rheological contrast in the emplacement of gold.

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