GS2021-4

Results of bedrock geological mapping in the Stuart Bay–Chickadee Lake area (east of Wekusko Lake), north-central Manitoba (parts of NTS 63J12, 13)

by K.D. Reid

In Brief:

- A complex volcanic stratigraphy is recorded within the Herb Lake fold with facing directions that suggest it represents a major syncline
- Close association of mafic crystal-rich turbidite and conglomerate of the McCafferty Liftover fault block suggest these were deposited in a deep-water environment by concurrent turbidity currents and debris flows, possibly adjacent to a fault scarp or elevated volcanic edifice
- The Crowduck Bay fault is a deep-seated ductile structure with strong penetrative fabrics that overprint earlier structures in the hangingwall and footwall

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Summary

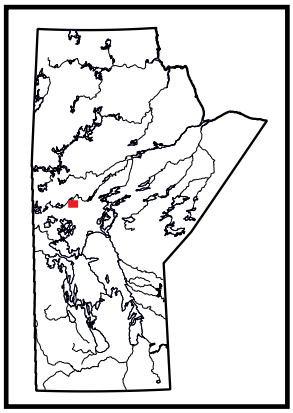
Bedrock geological mapping during the 2021 summer field season continued with 1:20 000 scale mapping east of Wekusko Lake, including the area around Stuart Bay, Chickadee Lake and the historical community of Herb Lake near the historic Rex-Laguna gold mine. The area encompasses a structurally complex confluence of at least three lithostratigraphically distinct tectonic blocks, recording the geological evolution of rocks in the eastern Paleoproterozoic Reindeer zone over a period lasting approximately 70 m.y. (ca. 1.91–1.83 Ga). In addition, these rocks have been of significant economic interest for over a century, following the discovery of gold here in 1914.

Introduction

In 1914, M.J. Hackett and R. Woosey discovered gold along the eastern shores of Wekusko Lake, near the community of Herb Lake. Subsequently, gold was intermittently produced from the Rex-Laguna deposit from 1918–1940. The Geological Survey of Canada conducted field mapping of the Herb Lake area 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.

The current geological mapping focuses on rocks east of Wekusko Lake; in particular, the area north and east of Stuart and Puella bays encompassing the Western Missi, Herb Lake, McCafferty Liftover and the Eastern Missi fault blocks (Figure GS2021-4-1; Ansdell et al., 1999; Connors et al., 1999). Primary objectives of the 2021 summer fieldwork include

- developing a 1:20 000 scale map detailing the stratigraphic framework of the 1.88–1.83 Ga arc volcanic and sedimentary rocks east and north of Stuart and Puella bays;
- 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 east of Wekusko Lake.



Regional setting and stratigraphic framework

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) in north-central Manitoba. 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

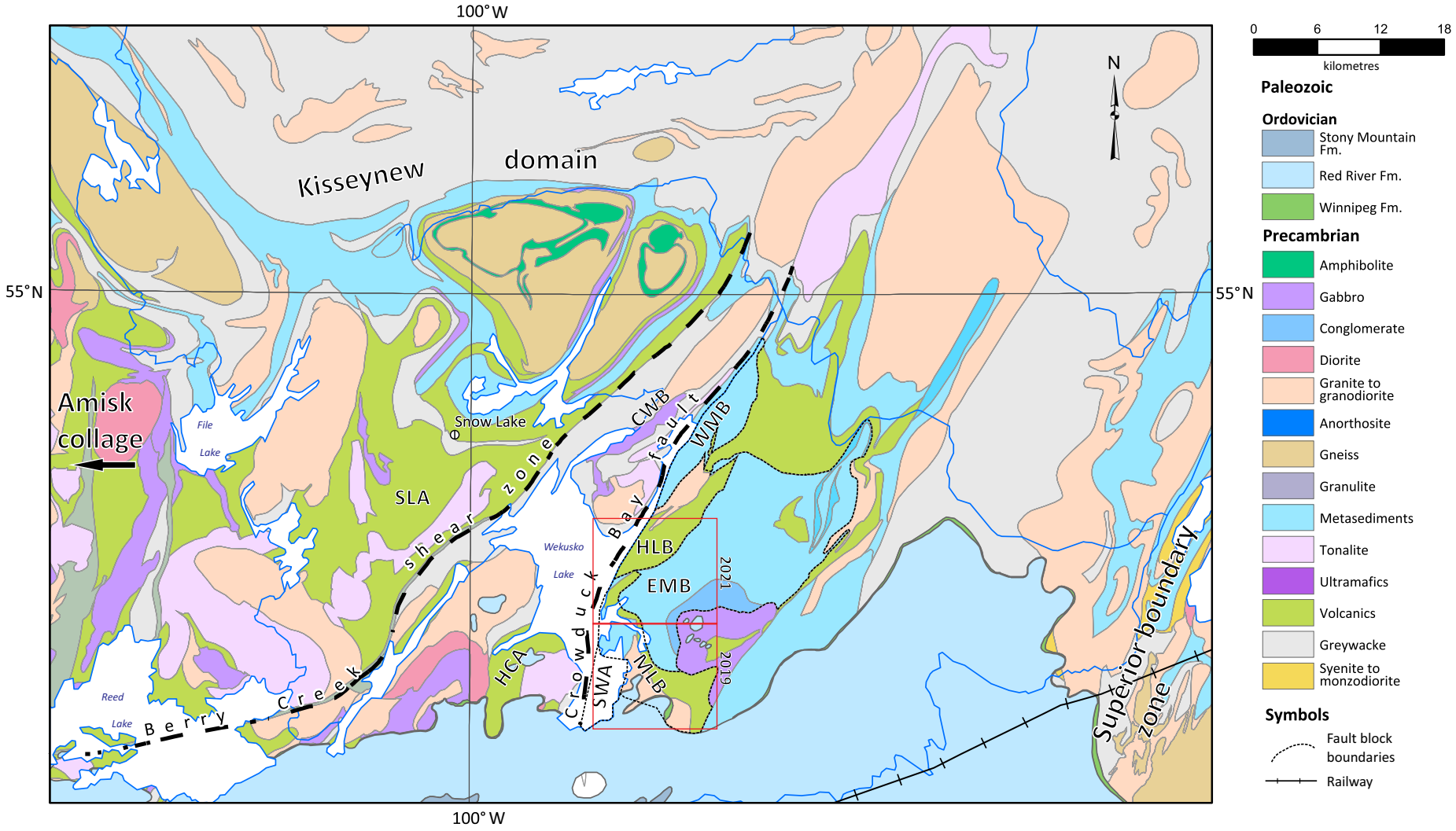


Figure GS2021-4-1: *Regional geological map showing the eastern segment of the Flin Flon domain including the areas mapped in 2019 and 2021 (see red rectangles; map is modified from an unpublished 1:250 000 scale provincial compilation), north-central Manitoba. Note the Kisseynew domain to the north, the Superior boundary zone to the east and Paleozoic cover rocks to the south. The 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 Central Wekusko fault block (CWB) are shown relative to the Berry Creek shear zone and Crowduck Bay fault.*

Lake arc assemblage), indicating that these segments of the FFD may have formed in distinct tectonic settings.

Figure GS2021-4-1 shows the location of the 2021 mapping area relative to Wekusko Lake. The Snow Lake subdomain (rocks between File and Reed lakes and the Superior boundary zone) consists of fault-bounded blocks, the most well known of these being the Snow Lake arc assemblage (SLA) to the northwest of Wekusko Lake. The Berry Creek shear zone and Crowduck Bay fault constrain a 15–20 km wide package of greywacke and mudstone, which extends southwest from the Kisseynew domain into the central portion of Wekusko Lake referred to by Ansdell et al. (1999) as the Central Wekusko fault block (CWB; Figure GS2021-4-1). Southwest of Wekusko Lake within the CWB is the Hayward Creek arc assemblage (HCA). Though no age determinations are presently available for these rocks, it is thought to be a juvenile arc (e.g., ca. 1.89 Ga) in thrust contact with Burntwood group sediments. Fault-bounded lithotectonic blocks east of the Crowduck Bay fault include ocean-floor basalts of the South Wekusko assemblage (SWA), evolved arc volcanic rocks of the McCafferty Liftover fault block (MLB) and Herb Lake fault block (HLB), and fluvial-alluvial sedimentary rocks of the Western Missi fault block (WMB) and Eastern Missi fault block (EMB; e.g., Ansdell et al., 1999; Gilbert and Bailes, 2005; Figure GS2021-4-1). A detailed review of the stratigraphic and structural context of the project area is given by Reid (2019a).

Results of 2021 fieldwork

Bedrock mapping in the Stuart Bay–Chickadee Lake area documented a number of structural and stratigraphic features, which have been used to develop a preliminary map (PMAP2021-1; Reid, 2021) and simplified page figure (Figure GS2021-4-2). A brief description of each map unit (oldest to youngest) and related features is provided below.

Pillowed basalt of probable ocean-floor affinity (unit F1)

South of the HLB (~2 km north of McCafferty Lift Over [ML]; Figure GS2021-4-2), pillowed basalts of probable ocean-floor affinity (unit F1) are in structural contact and appear to have been folded by the same regional structure as the HLB. This is evidenced by a change in facing direction of the pillowed basalts moving from northwest to southeast. Northwest of the apparent fold axial trace (Herb Lake syncline; Figure GS2021-4-2) the facing direction is overturned and younging to the northwest, whereas southeast of the axial trace it is upright and younging to the southeast toward the McCafferty fault. The basalt is weakly feldspar-pyroxene porphyritic and is characterized by blue-green weathering, thin (1–2 cm) chilled margins with minor epidote-altered interpillow hyaloclastite and lack of amygdules (Figure GS2021-4-3a). These rocks are considered ocean-floor basalt (unit F1) given their similarities to the blue-green–weathered pillow basalts along the southern and southeastern shores of Wekusko Lake, which have an ocean-floor affinity (N-MORB; Gilbert and Bailes, 2005).

McCafferty Liftover fault block (units S1–4)

Ansdell et al. (1999) referred to intermediate to felsic volcanic and volcaniclastic rocks in the Puella and Stuart bays area as the MLB, whereas Gilbert and Bailes (2005) called these rocks the Puella Bay suite and NATMAP Shield Margin Project Working Group (1998) classified them as the Schist-Wekusko assemblage. In this report, they are referred to as rocks of the MLB. The McCafferty fault separates feldspar-phyric andesite conglomerate (unit S1), feldspar-crystal–rich turbidite (unit S3) and volcaniclastic dacite (units S4a, b) from pillowed basalts (unit F1) and volcanic rocks of the HLB.

Unit S1 is clast-supported, heterolithic, volcanic cobble and boulder conglomerate comprising mainly subrounded plagioclase-phyric andesite clasts but also local dacite clasts (Figure GS2021-4-2; see unit S2 in Gilbert and Bailes, 2005). Weakly plagioclase-phyric massive andesite (unit S2) was observed in an outcrop (UTM Zone 14N, NAD83, 448600E, 6062983N) south of Puella Bay, outside the mapping area, and is inferred to occur underwater in the southwestern corner of the map; it contains rare amygdules but lacks features characteristic of cohesive flows and thus is possibly intrusive. A large flat-lying outcrop 100 m northwest of McCafferty Liftover (ML; Figure GS2021-4-2) preserves a complete 1.5 m thick feldspar-crystal–rich turbidite sequence; the feldspar-crystal–rich wacke and mudstone (unit S3) are thin to thick bedded with normally graded beds that consistently young to the east-southeast (Figure GS2021-4-3b). Farther along strike to the northeast, feldspar-crystal–rich layers are interbedded with subangular to subrounded, matrix- to clast-supported, andesite cobble conglomerate. These features are consistent with deposition as concurrent debris flows into a relatively deep-water setting with a steep adjacent slope.

The transition from unit S1 to S4a is marked by a change in matrix composition from feldspar-phyric andesite to dacite and the appearance of scoriaceous clasts. Clasts are typically 2–15 cm, subangular to subrounded and matrix supported (Figure GS2021-4-3c) in a light grey feldspar-phyric matrix. Unit S4b is a dark to medium grey, massive, weakly feldspar-phyric dacite that occurs along the south shore of Puella Bay (Figure GS2021-4-2; Reid, 2021). Feldspar in this unit commonly weathers an orangey colour and can been seen in sheared and brecciated dacite near the contact with the Puella Bay–Stuart Lake fault (Figure GS2021-4-3d). Two planar structural fabrics are common in rocks of the MLB, an early spaced cleavage that occurs in dacite (unit S4b) that strikes 310–330° and dips steeply to the northeast. The spaced cleavage is overprinted by a strong penetrative foliation that strikes 10–20° and dips steeply to the southeast toward Wekusko Lake and the Crowduck Bay fault (Figure GS2021-4-2).

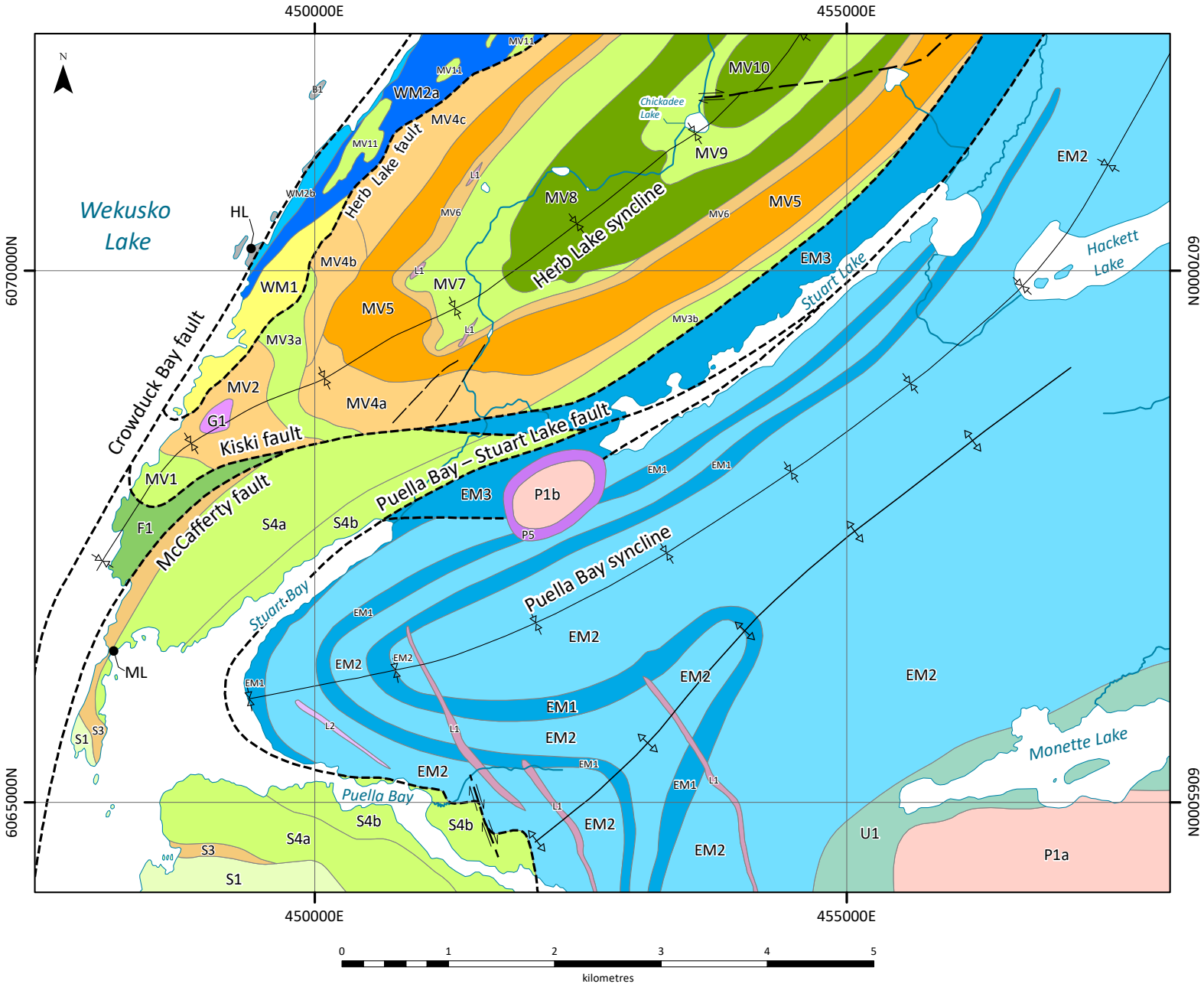


Figure GS2021-4-2: *Simplified geological map of the project area including historical points of reference (Herb Lake community [HL], McCafferty Lift Over [ML]), Chickadee Lake, Stuart Lake and Stuart Bay, eastern Wekusko Lake. For more detail including unit legend, see PMAP2021-1 (Reid, 2021). All co-ordinates are in UTM Zone 14N, NAD83.*

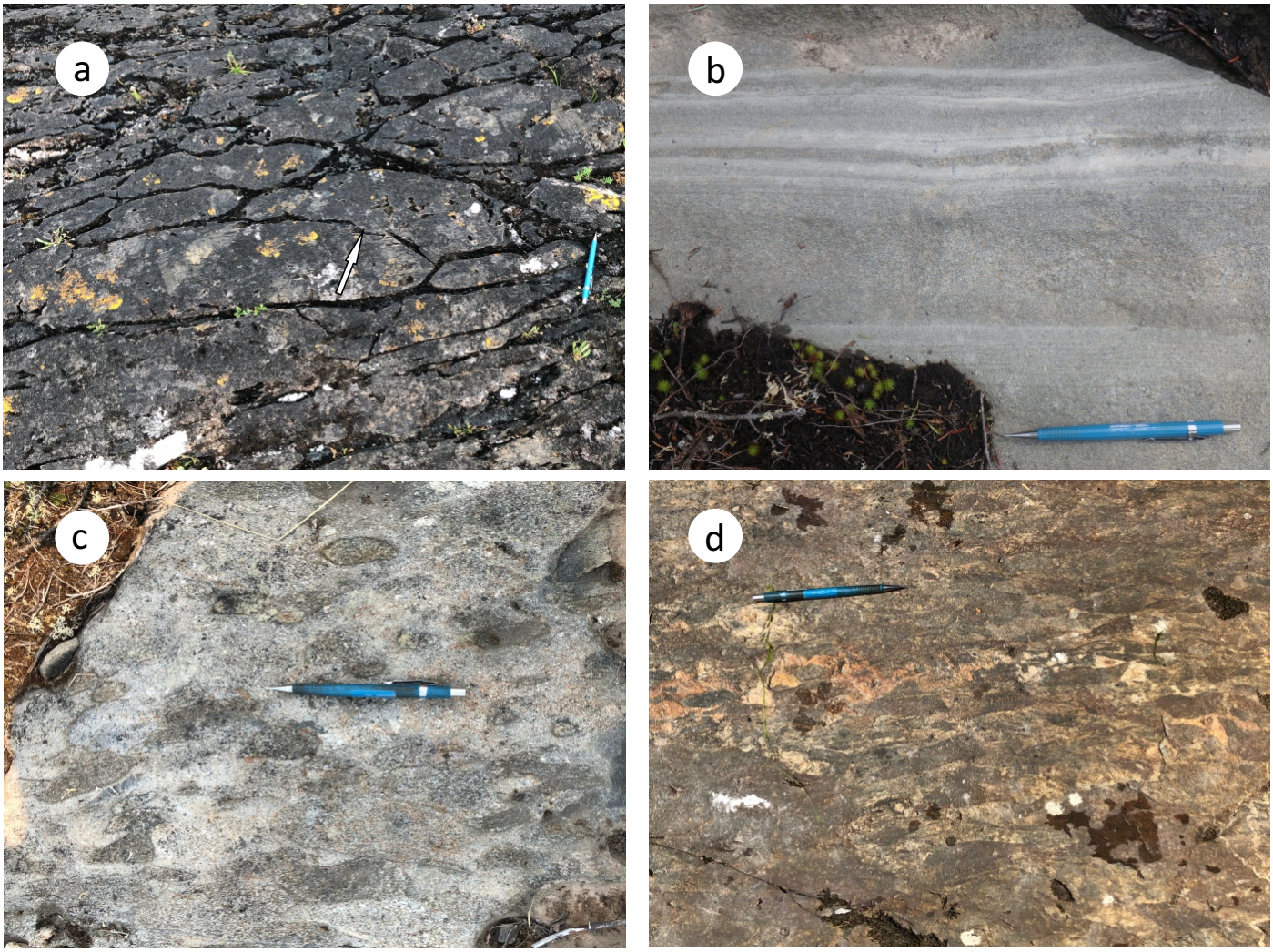


Figure GS2021-4-3: *Outcrop photographs of the South Wekusko assemblage and McCafferty Liftover fault block arc volcanic rocks:* ***a)*** *weakly feldspar-phyric pillowed basalt with classic pillow drape (arrow; unit F1; UTM Zone 14N, NAD83, 448186E, 6067872N);* ***b)*** *thin-bedded feldspar-crystal–rich wacke and mudstone (unit S3; 448684E, 6067417N);* ***c)*** *heterolithic feldspar-phyric andesite conglomerate (unit S4a; 450145E, 6068279N);* ***d)*** *brecciated orangey pink dacite (unit S4b; 451051E, 6067981N).*

Central Wekusko fault block (unit B1)

Highly strained, dark grey, thin- to thick-bedded greywacke and mudstone is observable near the Herb Lake community and along the shoreline to the northeast (Figure GS2021-4-2). These rocks display minor isoclinal folds, which are commonly rootless with their limbs sheared away. These rocks contain a strong penetrative foliation that strikes 10–20°, dips steeply to the southeast and parallels the trend of the Crowduck Bay fault (Figure GS2021-4-2).

Herb Lake fault block (units MV1–11)

Stockwell (1937) first recognized that rocks of the HLB are a complex package of volcanic strata that are tightly to isoclinally folded, and suggested the HLB represents a syncline. Recent mapping subdivides the HLB into 11 units (MV1–11) and determined that facing directions support the interpretation that it is a major syncline (Figure GS2021-4-2).

Directly north of the pillow basalts (unit F1; Figure GS2021-4-2), the rocks transition to weakly feldspar-phyric dacite (unit MV1). These rocks display two well-developed cleavages at a shallow angle to each other imparting a diamond-shaped stepped appearance to the outcrop. These fabrics are common throughout the HLB with an early spaced cleavage striking 45–60° and a later overprinting penetrative foliation that strikes 10–30°; both fabrics dip steeply to the southeast. Northeast of the MV1 dacite, the composition and mineralogy of the rocks change to become more mafic and feldspar-rich (up to 70%) with a medium grey fine-grained matrix (unit MV2). Feldspar grades from coarse to medium grained moving to the northeast; no bedding relationships were observed but occasional lithic lapilli fragments support this unit being volcaniclastic in origin (Figure GS2021-4-4a).

Moderately strained, monolithic, clast-supported, rhyolite lapillistone and minor felsic tuff (unit MV3a) occur directly northeast of unit MV2 (Figure GS2021-4-2). Thick beds of nor-

Figure GS2021-4-4: *Rocks of the Herb Lake volcanic block:* ***a)*** *feldspar-crystal–rich lapilli tuff with lithic clasts outlined by dashed lines (unit MV2; UTM Zone 14N, NAD83, 448899E, 6068340N);* ***b)*** *feldspar-phyric andesite tuff breccia to agglomerate (unit MV4b; 450312E, 6069960N), 15 cm long knife for scale;* ***c)*** *parallel-bedded feldspar volcanic sandstone with symmetric ripples draped by greywacke (unit MV6; 451520E, 6070975N);* ***d)*** *juvenile cuspate grey rhyolite fragments (arrow) in a light pink aphyric siliceous matrix (unit MV9; 453193E, 6071228N).*

mally graded felsic tuff on the northwest side of the Herb Lake syncline young to the east-southeast. Furthermore, northeast along the eastern limb of the Herb Lake syncline, a monolithic pebbly rhyolite conglomerate (unit MV3b) is considered to be the equivalent of unit MV3a (Figure GS2021-4-2); here, graded beds and minor scours indicate that this unit youngs to the northwest.

Unit MV4 is a variable intermediate volcaniclastic unit that has facies from pyroxene-plagioclase–phyric andesite conglomerate (unit MV4a) to feldspar-phyric andesite agglomerate (unit MV4b; Figure GS2021-4-4b) to heterolithic conglomerate (unit MV4c). The most distinctive of these units is the feldspar-phyric tuff breccia/agglomerate, containing irregular, subrounded, matrix- to framework-supported clasts up to 100 cm in diameter with mafic hornblende-rich rims. The change to unit MV5 is marked by a shift in extrusive character to cohesive andesite sheet flows, which are massive, containing medium-grained tabular plagioclase phenocrysts as well as amygdules and breccia near flow tops.

Thin to thick planar-bedded, volcanic, feldspar sandstone is the main constituent of unit MV6 and represents a marker unit within the volcanic pile. Along the northwest limb, it is approximately 100–150 m thick (Figure GS2021-4-2) and contains minor pebbly conglomerate and felsic ash tuff interbedded with the sandstone. An outcrop on the northwest limb preserves multiple cycles of normal gradation, minor scours and one bed with very fine sandstone draped over symmetric ripples, consistent with a younging direction to the southeast (Figure GS2021-4-4c). On the southeast limb of the fold, unit MV6 narrows slightly to 75–100 m thick and occurs as fine- to coarse-grained feldspar sandstone that lacks pebbly conglomerate and ash tuff.

Unit MV7 is mainly observed as massive feldspar-phyric dacite but minor millimetre- to centimetre-scale beds of ash tuff suggest that it is likely a series of metre-thick flows with

interflow volcaniclastic rocks. This unit is approximately 400 m thick on the northwest limb of the Herb Lake syncline but is absent on the southeast limb (Figure GS2021-4-2), where unit MV6 is in direct contact with basalt of unit MV8.

Unit MV8 transitions from fine to medium grained and pyroxene porphyritic near its lower contact with unit MV7, to fine grained with sub-metre amygdule-rich domains; this is interpreted to represent a number of basalt flows several metres thick, characterized by the amygdules near the top of each flow. The top of this unit is marked by centimetre-scale bedded mafic wacke and subrounded framework-supported mafic conglomerate suggesting postdepositional epiclastic reworking.

Unit MV9 is a distinct light pinkish-grey, weakly feldspar-quartz–phyric rhyolite, which was previously termed Chickadee rhyolite (e.g., Ansdell et al., 1999). Close inspection of this unit reveals that it contains grey aphyric juvenile (cuspate) clasts in a wavy foliated pinkish and grey matrix (Figure GS2021-4-4d), interpreted as eutaxitic texture typically observed in welded pyroclastic flows (e.g., McPhie et al., 1993).

Mafic rocks of unit MV10 occur directly to the northeast of the Chickadee rhyolite. The base of this unit is a massive, dark greenish-black, fine- to medium-grained rock with approximately 60% hornblende and 40% plagioclase; whereas stratigraphically up section (to the northeast) the unit transitions to sub-metre–bedded mafic lapilli tuff with a few scattered amygdules and minor epidote alteration around lapilli clasts.

Small outcrop windows of hypabyssal quartz-feldspar–phyric rhyolite (unit MV11) are noted intruding pebble conglomerate and felsic tuff of unit MV3a as well as argillaceous sandstone of unit EM3, but only in unit WM2a of the WMB do they form mappable units (Figure GS2021-4-2).

Western Missi fault block (units WM1–2)

The WMB is a narrow wedge-shaped package of felsic volcanic, volcaniclastic and sedimentary rocks that extends approximately 2.5 km southwest of the historical Herb Lake community (HL; Figure GS2021-4-2). Connors et al. (1999) interpreted it to be structurally juxtaposed to the HLB by the Herb Lake fault (Figure GS2021-4-2). The WMB preserves the stratigraphic contact between felsic volcanic rocks (unit WM1) and heterolithic pebbly conglomerate (unit WM2a); this contact can be observed approximately 700 m south of the old Herb Lake community along the shoreline.

The stratigraphic base of the WMB contains felsic volcanic rocks, which include massive, lobate, flow-banded and volcaniclastic varieties of rhyolite and dacite. Most are porphyritic with up to 15% 1–3 mm subhedral feldspar and up to 5% 1–2 mm subhedral quartz and local spherulites (Figure GS2021-4-5a). In one location, dacite tuff breccia and lapilli tuff grade over several metres into subrounded, clast-supported, rhyolite cobble conglomerate and then into heterolithic sandy pebbly conglomerate (unit WM2a) that contains tabular crossbeds (Figure GS2021-4-5b). North of the Herb Lake community (Figure GS2021-4-2) along the lakeside, pebbly conglomerate grades into trough-crossbedded feldspathic arenite with pebbles restricted to minor centimetre-scale beds (unit WM2b).

Eastern Missi fault block (units EM1–3)

Tightly folded, laterally continuous beds of conglomerate and sandstone form a syncline–anticline pair east of Puella and Stuart bays (Figure GS2021-4-2). Subrounded to rounded, clast-supported, polymictic cobble and boulder conglomerate forms the base of the succession (unit EM1; Figure GS2021-4-5c). Conglomerate layers are separated by intervals of trough-crossbedded feldspathic arenite (unit EM2; Figure GS2021-4-5d); the arenite preserves a distinct spaced cleavage that strikes 330 to 340° and dips moderately to the northeast. Farther to the east, a weak foliation can be seen striking 50° and dips steeply to the southeast. A change in sediment character was noted in both the conglomerate and the sandstone moving upsection. The conglomerate transitions from clast to matrix supported along with a reduction in clast variety, whereas the sandstone changes from coarse to fine grained in the upper sequence with minor light grey greywacke intraclasts.

Unit EM3 is distinct from other EM units in that in has a decreased quartz-grain content corresponding with an increase in argillaceous matrix and the presence of scattered subrounded mafic cobbles. Local trough-crossbeds indicate that this unit youngs to the northwest; this has previously been interpreted to represent an anticline centred on Stuart Lake (e.g., Connors et al., 1999). However, the change in sediment character could suggest it is in fault contact with units EM1 and 2 (see Puella Bay–Stuart Lake fault; Figure GS2021-4-2) and more closely associated with the Herb Lake volcanic rocks.

Volcanic rocks of uncertain age (unit U1)

Unit U1 is the geophysical extrapolation of a matrix- to clast-supported, intermediate to felsic volcanic conglomerate (Figure GS2021-4-2) that occurs directly to the south in the 2019 mapping area (see Reid, 2019b). These rocks are separated from the EMB by a distinct topographic low that extends into the Monette Lake area to the northeast; at this time the stratigraphic context of these rocks is unknown.

Intrusive rocks (units G1, P1, P5, L1–2)

Unit G1 is a medium- to coarse-grained gabbro (Figure GS2021-4-6a) with 60% plagioclase and 40% hornblende (pseudomorphs after pyroxene), which occurs within unit MV2 of the HLB (Figure GS2021-4-2). No intrusive relationships were observed so its time of emplacement is uncertain.

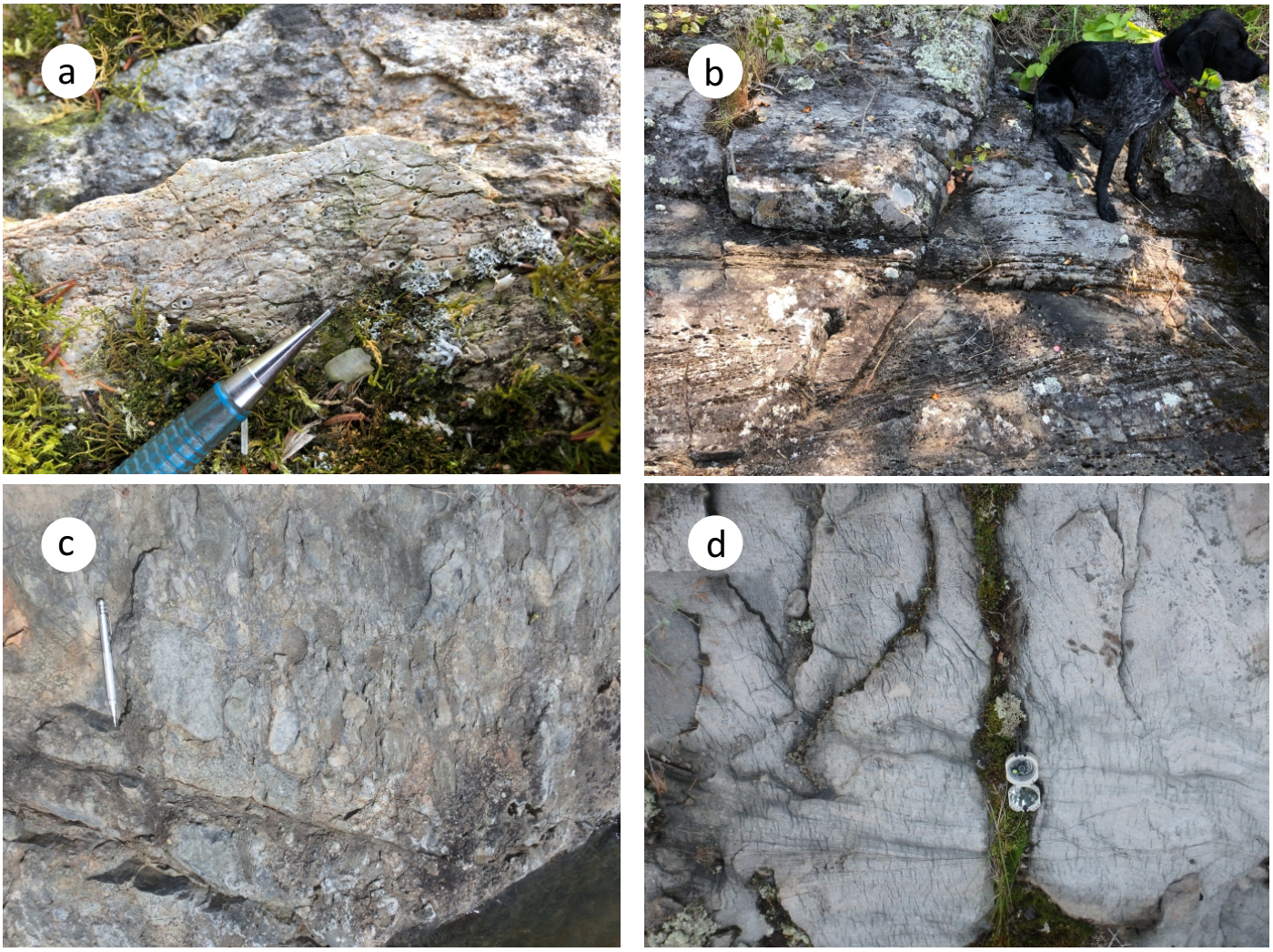


Figure GS2021-4-5: *Volcanic, volcaniclastic and sedimentary rocks of the Western Missi and Eastern Missi fault blocks:* ***a)*** *spherulitic rhyolite (unit WM1; UTM Zone 14N, NAD83, 448843E, 6068881N);* ***b)*** *planar-bedded pebbly conglomerate with tabular crossbeds (unit WM2a; 449346E, 6069829N), German short-haired pointer for scale;* ***c)*** *polymictic clast-supported heterolithic conglomerate (unit EM1; 449862E, 6065392N);* ***d)*** *trough-crossbedded sandstone with spaced cleavage (S_3; unit EM2; 450955E, 6065762N).*

Unit P1a in the southeastern corner of the map area is the geophysical extrapolation of the weakly deformed, medium-grained, Monette Lake granite observed to the south in the 2019 mapping area (see Reid, 2019b). A semicircular intrusion near the southwestern end of Stuart Lake consists of two parts: an inner granodiorite (unit P1b) and an outer quartz-bearing diorite (unit P5; Figure GS2021-4-2). Unit P1b is a pinkish-grey, medium-grained, equigranular granodiorite with 40% quartz, 35% K-feldspar, 15% plagioclase and 10% hornblende. Unit P5 has a distinct glomeroporphyritic texture, with feldspar (40%) and quartz (2–3%) forming sub-centimetre knots and the remainder being hornblende, which is pseudomorphous after pyroxene (Figure GS2021-4-6b).

A number of narrow (<75 m) gabbroic dikes cut both the EMB and the HLB (unit L1; Figure GS2021-4-2); these range from fine to medium grained with 70% hornblende and 30% plagioclase, which is typically aligned with a weak foliation (Figure GS2021-4-6c). A distinct quartz-feldspar–phyric granodiorite (unit L2) intrudes sandstone (unit EM2) of the EMB; it contains 4–15 mm subhedral quartz and feldspar in a finer-grained feldspar matrix (Figure GS2021-4-6d).

Discussion

The pillowed basalts of probable ocean-floor affinity directly north of McCafferty Lift Over (Figure GS2021-4-2; Reid, 2021) are assumed to be the oldest stratigraphic unit in the map area on the basis of their similarity to the SWA and other 1.90 Ga ocean-floor/back-arc–type rocks (e.g., Stern et al., 1995; Gilbert and Bailes, 2005). A change in pillow-facing direction corresponds to a southwestern extension of the axial trace from the Herb Lake syncline. This suggests that these units were in contact prior to the formation of the Herb Lake syncline, possibly as a result of early thrust faulting.

Rocks of the MLB form a homoclinal east-younging package bounded by the McCafferty fault to the northwest and the Puella Bay–Stuart Lake fault to the east (Figure GS2021-4-2).

Figure GS2021-4-6: *Intrusive rocks:* ***a)*** *medium- to coarse-grained gabbro (unit G1; UTM Zone 14N, NAD83, 449131E, 6068637N);* ***b)*** *glomeroporphyritic quartz diorite (unit P5; 451944E, 6067545N);* ***c)*** *medium-grained gabbro dike (unit L1) cutting Eastern Missi fault block sandstone (unit EM2; 454434E, 6065141N);* ***d)*** *quartz-feldspar–phyric granodiorite (unit L2; 449897E, 6065795N).*

The intimate association of feldspar-phyric andesite cobble/boulder conglomerate (unit S1) and feldspar-crystal–rich turbidite (unit S3) in the lower portion of the MLB record an interval of deep subaqueous deposition by concurrent turbidity currents and debris flows, likely adjacent to a fault scarp or elevated volcanic edifice. Units S4a and b mark a shift in volcanism from mafic to felsic, possibly linked to an evolving and fractionated magma chamber.

The HLB represents of a thick succession of felsic to mafic volcanic and volcaniclastic rocks. The lower portion of this volcanic pile (units MV1–4) records a period of felsic to intermediate volcaniclastic deposition followed by cohesive amgydule-bearing andesite flows (unit MV5). The feldspathic volcanic sandstone of unit MV6 is a marker bed, which can be traced from the northwest limb to the southeast limb of the Herb Lake syncline (Figure GS2021-4-2), and is interpreted to represent a hiatus in volcanic activity during which epiclastic reworking occurred prior to deposition of the overlying dacite and minor ash tuff (unit MV7). Symmetric ripples draped with finer clastic material suggest that unit MV6 may have formed in a shallow marine environment influenced by tidal variation. The upper portion of the volcanic pile is dominated by basalt (units MV8 and 10) separated by matrix-supported rhyolite lapilli tuff (unit MV9). The presence of cuspate juvenile clasts in a wispy matrix suggests that unit MV9 is at least in part pyroclastic in nature.

The WMB preserves the stratigraphic relationship between volcanism and epiclastic sedimentation. The apparent absence of a weathering profile might indicate that this transition occurred relatively quickly, reflecting a rapid shift from felsic volcanism to subaerial clastic deposition. The EMB represents a thick succession of siliciclastic material deposited in part by fluvial processes. A decrease in both clast and grain size from the base to the upper portions of this block might represent the progressive fill of a subbasin.

A summary of structural observations is as follows. Depositional features (S_0) are characterized by both volcanic and sedimentary textures. No arc accretionary structures were

observed during mapping but for discussion here, S_1 has been reserved for these structures as it has for the broader Flin Flon domain (e.g., Ryan and Williams, 1999). Spaced cleavage in the HLB and weak penetrative foliation in the EMB both strike 45–60° and are considered the earliest deformation fabrics (S_2). A distinct 330–340° striking spaced cleavage (S_3), which is common in the EMB and MLB but rarely observed in the HLB, overprints the earlier formed S_2 cleavage and foliation. Within 1–2 km of the Crowduck Bay fault, a strong penetrative foliation (S_4) strikes 10–30° and overprints all other fabrics in the hanging wall and footwall.

Further investigation of the stratigraphic and tectonic setting will be constrained through geochemical and petrographic analyses of samples collected. An in-depth study and compilation of all structural data for the region will help to further the knowledge of the structural evolution of the region. The result of this work will be the focus of later geoscientific reports and maps.

Economic considerations

The Snow Lake subdomain is recognized as a world-class volcanogenic massive sulphide district, having produced both copper and zinc consistently for decades (e.g., Galley et al., 2007). Many believe this has overshadowed the region's history as a significant lode gold producer (e.g., Rex-Laguna and New Britannia gold mines). Gold mineralization discovery and production in the mapping area has a long and intermittent history from 1914 to present. For a complete history and exhaustive list of gold occurrences in the map area, the reader is referred to Richardson and Ostry (1996).

New geological mapping described here and detailed in Reid (2021) for rocks east of Wekusko Lake emphasizes the complex stratigraphic and structural evolution of several fault-bounded lithostratigraphic blocks in the hanging wall to the Crowduck Bay fault. Traditionally, exploration for gold in this area has focused on the intersection of structures with competent rheology, such as quartz-feldspar porphyry adjacent to the Crowduck Bay fault (e.g., Rex-Laguna deposit). However, provided the tightness of folding affecting Herb Lake volcanic rocks, further focus should be given to areas of potential flexural slip and fold hinge dilation along the Herb Lake syncline. In particular, the area between Puella Bay, Stuart Bay and Stuart Lake is characterized by the confluence of the Puella Bay–Stuart Lake fault with adjoining structures; this area should be further examined for both dilation jogs and/or intersecting structures that may have acted as conduits for gold mineralizing fluids.

Further work will focus on building a comprehensive geological map and refined geological model for this region, which will aid explorers in developing new gold exploration targets and ideas.

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References

Ansdell, K.M., Connors, K.A., Stern, R.A. and Lucas, S.B. 1999: Coeval sedimentation, magmatism, and fold-thrust domain development in the Trans-Hudson orogen: geochronological evidence from the Wekusko Lake area, Manitoba, Canada; Canadian Journal of Earth Sciences, v. 36, p. 293–312.

Armstrong, J.E. 1941: Wekusko, Manitoba; Geological Survey of Canada, Map 665A, scale 1:63 360.

Connors, K.A., Ansdell, K.M. and Lucas, S.B. 1999: Coeval sedimentation, magmatism, and fold-thrust development in the Trans-Hudson orogen: propagation of deformation into an active continental arc setting, Wekusko Lake area, Manitoba; Canadian Journal of Earth Sciences, v. 36, p. 275–291.

Frarey, M.J. 1950: Crowduck Bay, Manitoba; Geological Survey of Canada, Map 987a, scale 1:63 360.

Galley, A.G., Syme, E.C. and Bailes, A.H. 2007: Metallogeny of the Paleoproterozoic Flin Flon belt, Manitoba and Saskatchewan; *in* Mineral Deposits of Canada: a Synthesis of Major Deposit Types, District Metallogeny, the Evolution of Geological Provinces, and Exploration Methods, W.D. Goodfellow (ed.), Geological Association of Canada, Mineral Deposits Division, Special Publication 5, p. 509–531.

Gilbert, H.P. and Bailes, A.H. 2005: Geology of the southern Wekusko Lake area, Manitoba (NTS 63J12NW); Manitoba Industry, Economic Development and Mines, Manitoba Geological Survey, Geoscientific Map MAP2005-2, scale 1:20 000, URL <https://www.manitoba.ca/iem/info/libmin/MAP2005-2.pdf> [October 2021].

Gordon, T.M. and Lemkow, D. 1987: Geochemistry of Missi group volcanic rocks, Wekusko Lake, Manitoba; Geological Survey of Canada, Open File 1442, 38 p.

Lewry, J.F. and Collerson, K.D. 1990: Trans-Hudson orogen: extent, subdivisions, and problems; *in* The Proterozoic Trans-Hudson Orogen of North America, J.F. Lewry and M.R. Stauffer (ed.), Geological Association of Canada, Special Publication 37, p. 1–14.

McPhie, J., Doyle, M. and Allen, R. 1993: Volcanic textures: a guide to the interpretation of textures in volcanic rocks; University of Tasmania, Centre for Ore Deposit and Exploration Studies, Hobart, Tasmania, 197 p.

NATMAP Shield Margin Project Working Group 1998: Geology, NATMAP Shield Margin Project area, Flin Flon belt, Manitoba/Saskatchewan; Geological Survey of Canada, Map 1968A, scale 1:100 000.

Reid, K.D. 2019a: Bedrock geological mapping of the Puella Bay area (Wekusko Lake), north-central Manitoba (part of NTS 63J12); *in* Report of Activities 2019, Manitoba Agriculture and Resource Development, Manitoba Geological Survey, p. 42–51, URL <https://www.manitoba.ca/iem/geo/field/roa19pdfs/GS2019-4.pdf> [October 2021].

Reid, K.D. 2019b: Preliminary geology of the Puella Bay area, Wekusko Lake, north-central Manitoba (NTS 63J12); Manitoba Agriculture and Resource Development, Manitoba Geological Survey, Preliminary Map PMAP2019-4, scale 1:15 000, URL <https://www.manitoba.ca/iem/info/libmin/PMAP2019-4.pdf> [October 2021].

Reid, K.D. 2021: Bedrock geology of the Stuart Bay–Chickadee Lake area (east of Wekusko Lake), north-central Manitoba (parts of NTS 63J12, 13); Manitoba Agriculture and Resource Development, Manitoba Geological Survey, Preliminary Map PMAP2021-1, scale 1:15 000, URL <https://www.manitoba.ca/iem/info/libmin/PMAP2021-1.pdf> [November 2021].

Richardson, D.J. and Ostry, G. (revised by Weber, W. and Fogwill, D.) 1996: Gold deposits of Manitoba; Manitoba Energy and Mines, Economic Geology Report ER86-1 (2nd edition), 114 p., URL <https://www.manitoba.ca/iem/info/libmin/ER86-1.zip> [October 2021].

Ryan, J.J. and Williams, P.F. 1999: Structural evolution of the eastern Amisk collage, Trans-Hudson orogen, Manitoba; Canadian Journal of Earth Sciences, v. 36, p. 251–273.

Stern, R.A., Syme, E.C., Bailes, A.H. and Lucas, S.B. 1995: Paleoproterozoic (1.90–1.86 Ga) arc volcanism in the Flin Flon belt, Trans-Hudson orogen, Canada; Contributions to Mineralogy and Petrology, v. 119, p. 117–141.

Stockwell, C.H. 1937: Gold deposits of Herb Lake area, northern Manitoba; Geological Survey of Canada, Memoir 208, 46 p.