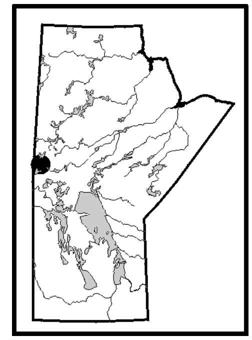
GS-5

GEOLOGY OF THE ALBERTS LAKE AREA (NTS 64K13SE AND 14SW), MANITOBA

by H.P. Gilbert



Gilbert, H.P. 2002: Geology of the Alberts Lake area (NTS 63K13SE and 14SW), Manitoba; *in* Report of Activities 2002, Manitoba Industry, Trade and Mines, Manitoba Geological Survey, p. 45–58.

SUMMARY

The Alberts Lake area contains parts of both the Lac Aimée and Sourdough Bay fault blocks, separated by the northeast-trending Sourdough Bay Fault. Mapping of the Lac Aimée Block in the area northwest of the fault defined a diverse assemblage of volcanic rocks akin to those in modern island arcs; these include mafic flows, volcanic fragmental rocks, felsic intrusive and minor extrusive rocks, and fine-grained turbidite deposits. In contrast, the terrane immediately southeast of the Sourdough Bay Fault, and constituting the central part of the Sourdough Bay Block, consists mainly of massive rhyolite and related breccia, with only minor basalt. This felsic volcanic terrane is separated from the north part of the Sourdough Bay Block by a granitoid terrane that extends between Alberts Lake and Naosap Lake (Preliminary Map 2002-1). The north part of the block is devoid of felsic volcanic rocks and consists largely of arc-type mafic volcanic flows, volcanic fragmental rocks and subordinate turbidite deposits. Lithostratigraphic differences between the central and north parts of the Sourdough Bay Block suggest these terranes may be separate tectonostratigraphic units. New geochemical data is expected to clarify the origin and affinities of the volcanic rocks within the Sourdough Bay Block.

INTRODUCTION

A five-week field program was focused on the central and north parts of Alberts Lake and the contiguous area between Alberts Lake and Lac Aimée (Fig. GS-5-1, GS-5-2; Table GS-5-1). Preliminary Map 2002-1 is a compilation of the results of field mapping in 1996, 1997 and 2002; geological data in the south-central part of the map are the result of mapping in the current (2002) study area. The objectives of the project are to

- upgrade existing geological maps in the north part of the Flin Flon Belt by Bateman and Harrison (1945) and Kalliokoski (1949), and provide continuity between two recently mapped areas at Lac Aimée and Naosap Lake (Gilbert, 1999, Open File Map OF99-1);
- study the structure, stratigraphy and volcanic geochemistry of the area, in order to assess the tectonostratigraphic and economic significance of volcanic rock assemblages; and
- investigate mineralized localities and assess their economic significance.

The current map area (shown in Fig. GS-5-2) is bisected by the Sourdough Bay Fault, a major northeast-trending, block-bounding feature that separates southeast-facing, mainly mafic volcanic rocks to the northwest (Lac Aimée Block) from a west- to northwest-facing, mainly felsic volcanic sequence to the southeast (Sourdough Bay Block). The Lac Aimée Block is deformed in a southwest-plunging synclinorial structure delineated by regional foliation trends and sporadic top indicators, such as graded bedding and pillow structure (Fig. GS-5-3). Southeast of the Sourdough Bay Fault, according to the limited structural data available, the felsic volcanic terrane in the Sourdough Bay Block forms a west- to northwest-facing homocline.

Felsic volcanic rocks in the Sourdough Bay Block are in gradational contact with an ovoid tonalitic intrusion to the northeast, suggesting the intrusion is synvolcanic and genetically related to the volcanic rocks. South of Alberts Lake, a massive gabbro intrusion with subordinate granitoid phases separates the volcanic terrane at Alberts Lake from the south part of the Sourdough Bay Block (Fig. GS-5-1).

REGIONAL SETTING

The Sourdough Bay fault block is one of the most extensive tectonic components in the Flin Flon Belt (Figs. GS-5-1) and extends laterally for approximately 28 km from the area north of Naosap Lake to Athapapuskow Lake in the south (Bailes and Syme, 1989). The north part of the Sourdough Bay Block, in the vicinity of Naosap Lake, contains arc-type mafic volcanic flows, volcanic fragmental rocks and subordinate turbidite deposits (Gilbert, 1997). The central part of the fault block at Alberts Lake, in contrast, consists mainly of felsic volcanic rocks, whereas south part (at northern Athapapuskow Lake) consists of a lithologically diverse assemblage of mafic to intermediate flows, felsic to mafic volcaniclastic rocks, and sedimentary deposits (Bailes and Syme, 1989). Felsic volcanic rocks are predominant in the south part of the Sourdough Bay Block (Baker Patton Complex; Bailes and Syme, 1989); the felsic complex contains one gold deposit and at least seven massive sulphide deposits (Gale and Dabek,

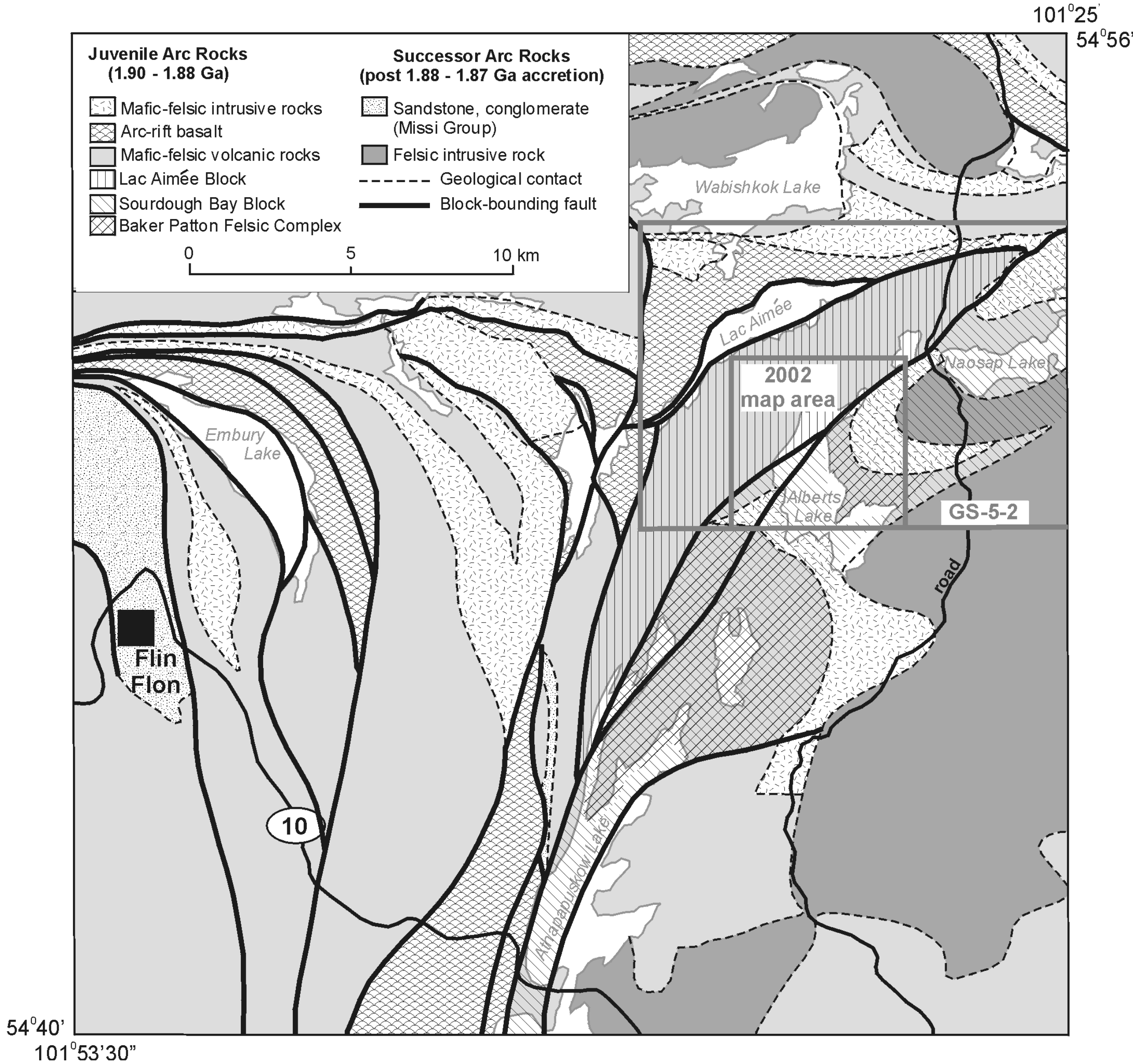


Figure GS-5-1: Simplified geology of the south-central part of the Flin Flon Belt.

2002) — a significant fact for any future economic assessment of the felsic volcanic terrane in the central part of the block at Alberts Lake. Structural data in both the south and central parts of the Sourdough Bay Block indicate that the sequence is a west- to northwest-facing homocline.

STRUCTURE

Five deformation periods (Table GS-5-2) have been recognized in the Lac Aimée–Naosap Lake area (Gilbert, 1997), all of which postdate the 1.88–1.87 Ma tectonic accretion of the Amisk collage (Lucas et al., 1996). The earliest deformation event produced north- to west-trending major F_1 folds and an associated regional foliation in the area northeast of Lac Aimée (Animus Lake Block in Fig. GS-5-2; Fig. GS-5-3). This early deformation event is also responsible for the regional foliation (S_1) in the study area at Alberts Lake, but no early (F_1) folds have been identified. The S_1 foliation is deformed by west- to southwest-plunging F_2 folds in the Lac Aimée Block (Lac Aimée synclinorium in Fig. GS-5-3). The F_2 synclinal fold that extends through Eagle Head Lake is especially well defined by the trends of both S_1 foliation and S_0 (volcanic flows and sedimentary layering). A predominantly south-southwest-plunging L_2 lineation occurs in both the Lac Aimée and Sourdough Bay blocks.

Major northwest-trending, open F_3 folds deform the axial traces of F_2 folds in the Lac Aimée synclinorium. This deformation event also produced an associated S_3 strain-slip cleavage that occurs sporadically within volcanic-derived

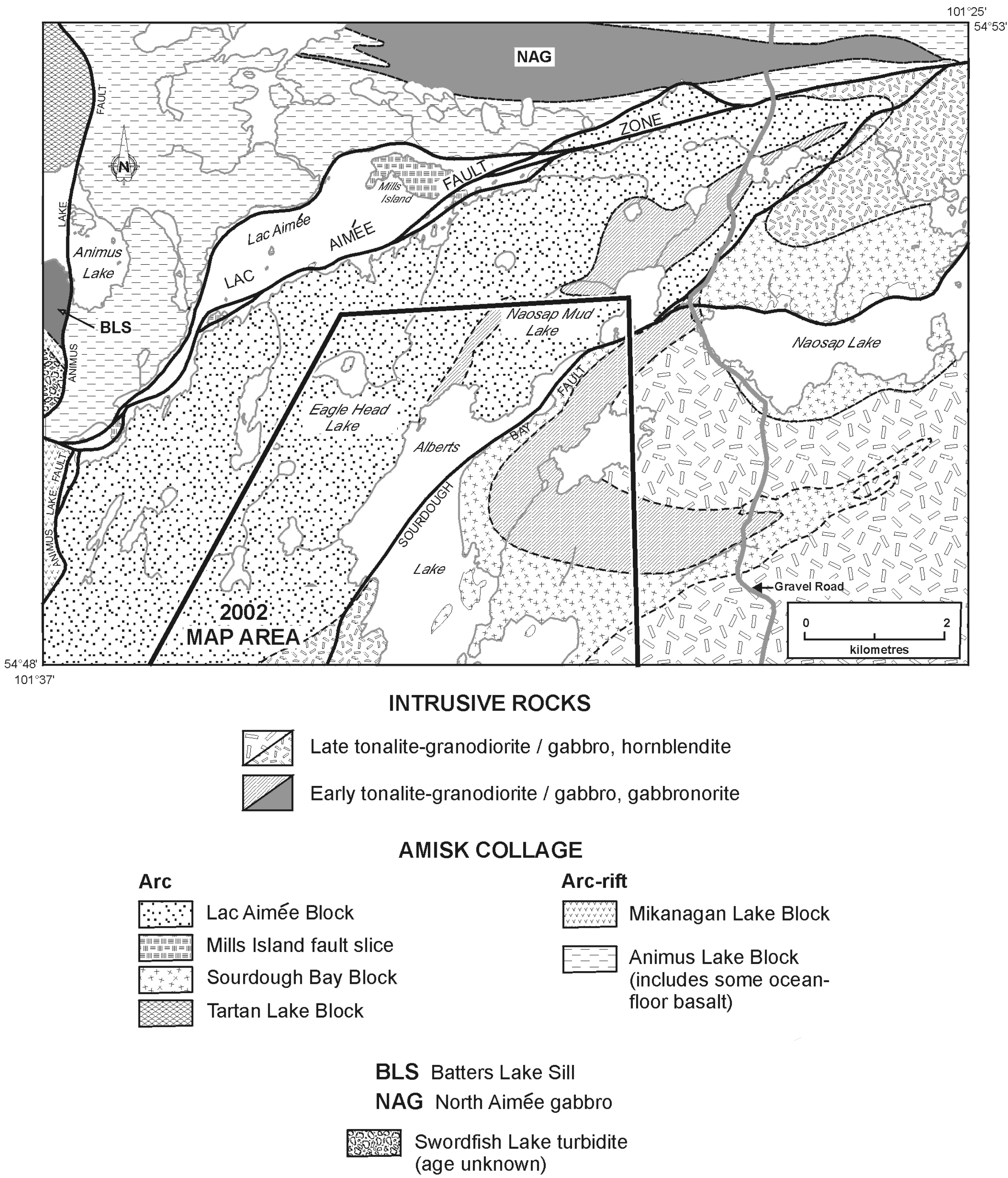


Figure GS-5-2: Main structural subdivisions, tectonic features and intrusive units in the Lac Aimée–Naosap Lake–AlbertsLake area.

schist and fine-grained sedimentary rocks (Gilbert, 1997).

The D_4 deformation is most prominently manifested as a northeast-trending open fold in the Animus Lake Block. This deformation event, which is attributed to sinistral movement along the Flin Flon–Kisseynew boundary during crustal-scale deformation of the Amisk collage (Ashton, 1993), is not recognized within the Lac Aimée and Sourdough Bay fault blocks.

The D_5 brittle deformation produced strike-slip shears and faults at high angles to the regional foliation that are commonly associated with pronounced topographic lineaments. Reactivation of early major faults (e.g., the northeast-trending Sourdough Bay Fault) probably also occurred during D_5. This early block-bounding structure juxtaposes the stratigraphically and structurally contrasting Lac Aimée and Sourdough Bay fault blocks (Fig. GS-5-2). Whereas the

Table GS-5-1: Table of formations in the Lac Aimée–Naosap Lake–Alberts Lake area.

		PRECAMBRIAN
Post 1.88 Ga intrusive rocks		
	12	*Diabase, (aphyric to plagioclase phyric)*
	11	*Tonalite, granodiorite; granite, aplite*
	10	Gabbro, minor hornblendite
Amisk Collage		
Intrusive rocks – synvolcanic or penecontemporaneous with 1.88 Ga volcanism (may include <1.88 Ga intrusive rocks)		
	9	Mafic intrusive rocks: gabbro, gabbronorite, hornblendite, leucogabbro, diabase
	8	Felsite, plagioclase-quartz porphyry
	7	Tonalite, leucotonalite, quartz diorite; granodiorite, granite; minor diorite
Volcanic and sedimentary rocks		
Lac Aimée and Sourdough Bay arc and arc-rift volcanic rocks; related turbidite-type sedimentary rocks		
	6	Feldspathic greywacke, siltstone, siliceous siltstone, argillite, oxide facies iron formation
	5	Rhyolite (plagioclase±quartz phyric); rhyolite breccia; minor felsic tuff
	4	Basalt, basaltic andesite (aphyric to plagioclase±pyroxene phyric); volcanic breccia, tuff and diabase; related schist and gneiss
		Fault contact
Animus Lake mafic volcanic rocks (inferred arc-rift and ocean-floor in origin); minor related sedimentary rocks		
	3	*Basalt (aphyric); minor plagioclase-phyric basalt, tuff, breccia and diabase; sulphide facies iron formation, feldspathic greywacke, siltstone*
		Fault contact
Tartan Lake arc-type basalt		
	2	*Basalt (aphyric to plagioclase phyric)*
		Fault contact
Mikanagan Lake arc-rift basalt		
	1	*Basalt (aphyric); minor spherulitic, plagioclase±pyroxene-phyric basalt and diabase*

Note. Unit 6 may include sedimentary rocks that postdate 1.88 Ga volcanism. The relative ages between units 10, 11 and 12 and between units 7, 8, and 9 are not determined.

fault is thought to have originated during tectonic accretion prior to D_1, tectonic transport and final emplacement of the Lac Aimée Block within the Amisk collage was probably only completed just prior to D_2 (Gilbert, 1997). Repeated movement along the Sourdough Bay Fault is inferred from the fabric of tectonic breccia in the northeast part of the map area, which contains diverse, tectonically laminated and randomly oriented blocks (Gilbert, 1996). The fault is related to other block-bounding structures elsewhere in the Flin Flon Belt that were initiated during tectonic accretion of the Amisk collage, and underwent subsequent reactivation (Syme, 1995).

STRATIGRAPHY

The geology of parts of both the Lac Aimée and Sourdough Bay fault blocks has been previously described (Gilbert, 1986, 1996, 1997). The geological units described in this report occur within the current (2002) map area centred on Alberts Lake (i.e., the southeast flank of the Lac Aimée Block and the central part of the Sourdough Bay fault block; Fig. GS-5-2). Numbers in parentheses correspond to unit numbers in Preliminary Map 2002-1.

Lac Aimée Block

Basalt, basaltic andesite, aphyric to plagioclase phyric, pillowed to massive; minor related volcanic breccia, diabase and gabbro (unit 4a)

Massive basalt flows and related fragmental rocks are the predominant lithological types in the Lac Aimée fault

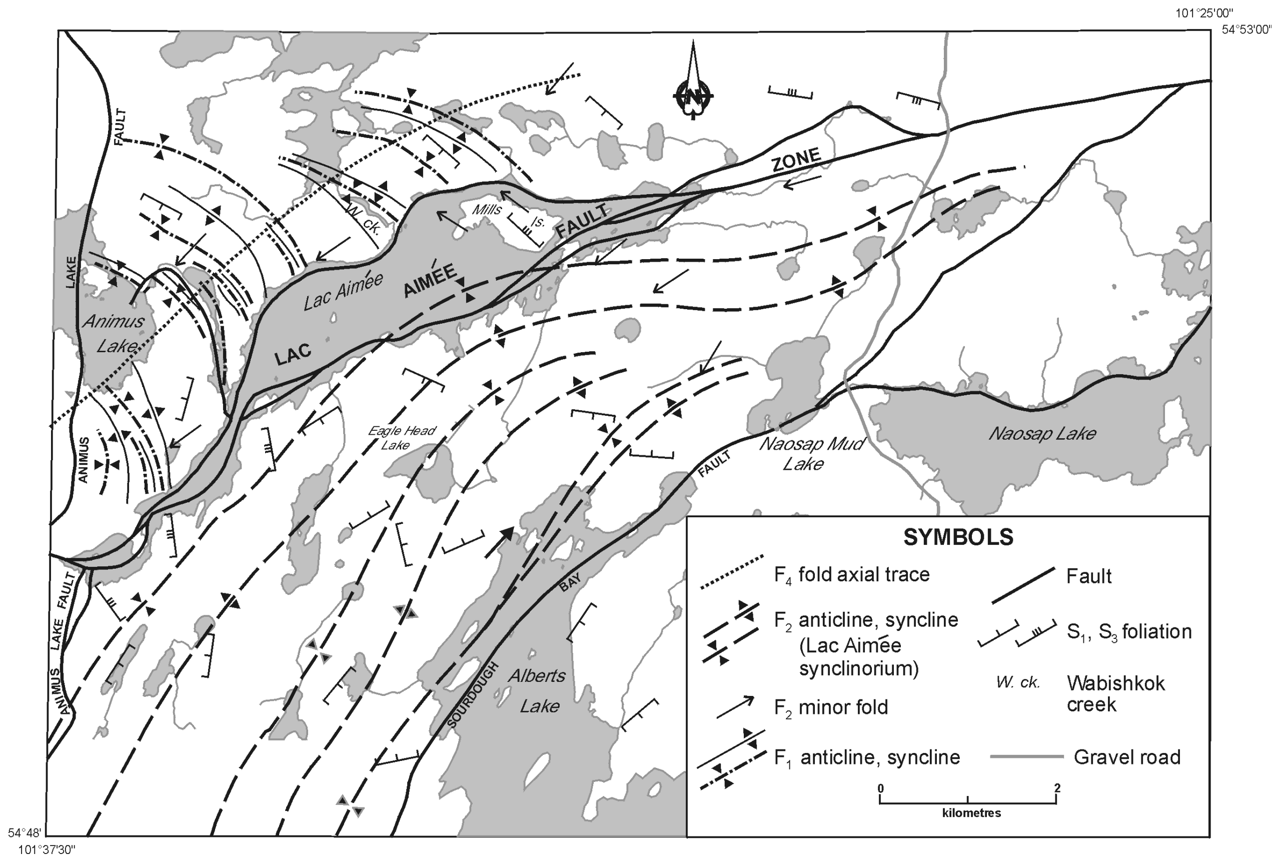


Figure GS-5-3: Major structural elements in the Lac Aimée–Naosap Lake–Alberts Lake area.

Table GS-5-2: Deformation history in the Lac Aimée–Naosap Lake–Alberts Lake area (post 1.88–1.87 Ga tectonic accretion of the Amisk collage).

D_1	Regional west- to southwest-trending S_1 foliation; inferred related major folds in Lac Aimée block. Juxtaposition of Lac Aimée and Sourdough Bay fault blocks along Sourdough Bay Fault preceded and/or accompanied D_1. Major tight to isoclinal F_1 folds with moderately to steeply dipping axial planes (overturned to northeast) occur in Animus Lake block (northwest of Lac Aimée Block).
D_2	Tight to isoclinal major folds (west- to southwest-plunging Lac Aimée synclinorium in Lac Aimée Block). Minor folds and lineations plunge west to southwest and northeast.
D_3	Major, northwest-trending open folds result in warping of axial traces of F_2; associated S_3 strain-slip cleavage.
D_4	Northeast-trending open fold in the Animus Lake Block, attributed to sinistral movement along the Flin Flon–Kisseynew boundary (not recognized in Lac Aimée and Sourdough Bay blocks).
D_5	Brittle faulting and shearing within fault blocks. Reactivation of early block-bounding structures (e.g., Sourdough Bay Fault).

block. These volcanic rocks, which are geochemically akin to modern arc and arc-rift rocks (Gilbert, 1997), include diverse pillowed and massive flows intercalated with amygdaloidal breccia (unit $4a_3$) that is locally predominant toward the southeast margin of the fault block. The mafic rocks are largely aphyric, but sparsely plagioclase-phyric flows occur sporadically. The mafic volcanic sequence attains a thickness of approximately 1 km at the north end of Alberts Lake.

Pillowed basalt (unit 4a) is well preserved in the core of the syncline at Eagle Head Lake, where the volcanic flow trends define the trace of the major fold (Preliminary Map 2002-1). The pillows at that locality are typically 0.4 to 2 m in size, locally undeformed and provide unequivocal tops (Fig. GS-5-4). The flows are mainly aphyric and weather grey-green to beige-grey; thermal contraction fractures at pillow margins are not uncommon, whereas polygonal cooling joints are comparatively rare. The majority of mafic flows in the Eagle Head Lake area are not conspicuously amygdaloidal, but some units contain quartz or altered plagioclase amygdules ranging in size from fine (0.3–0.8 mm) to medium grained (1–2 mm). Amygdaloidal units are locally intercalated with flow-breccia and nonvesicular flows at a scale of 2 to 10 m.

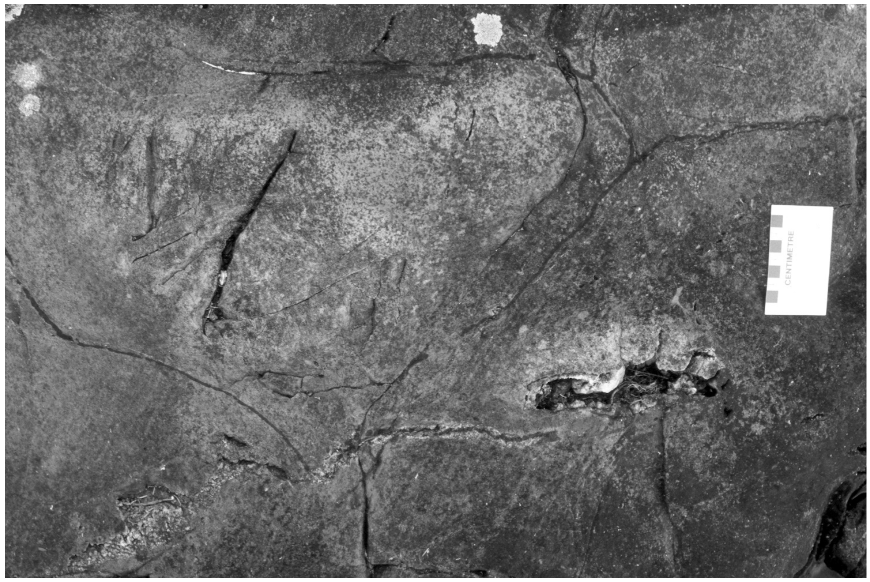


Figure GS-5-4: Stratigraphic tops at the shore of Eagle Head Lake are indicated by an undeformed pillow and an open vug with concave upper surface.

Plagioclase-phyric mafic units (phenocrysts 1–3 mm, 10–30% of the rock) up to 50 m thick are intercalated with aphyric basalt in the southwest part of the map area, close to the contact with gabbro (10). Most of these units are interpreted as diabase sills (9e), but pillowed plagioclase-phyric basalt and related breccia (4a) also occur at that locality. One unit is megaphyric, with localized concentrations of euhedral plagioclase phenocrysts (up to 2.5 x 4 cm, 10–35% of the rock).

In the north part of Alberts Lake, mafic volcanic rocks are characterized by an abundance of fragmental rocks relative to massive flows; both rock types are typically amygdaloidal. The majority of both the fragmental and massive rocks contain 10 to 50% ovoid quartz amygdules (typically 0.1–1 cm), but the amygdaloidal texture is locally coarser (0.5–3 cm) and large open vugs (3–8 cm wide) are not uncommon. Subordinate amygdule types are filled with plagioclase (±quartz) or hornblende (±chlorite). Disseminated pyrite constitutes 1 to 5% of the basaltic rocks and interpillow chert occurs in a few units. Pillow structure is commonly deformed or disrupted, both by volcanic and subsequent tectonic processes, and thus reliable stratigraphic top indicators are sparse in the north part of Alberts Lake. Pillowed flows are locally moderately epidotized and, less commonly, strongly silicified.

Basaltic breccia (unit $4a_3$) underlies an island approximately 180 m wide in the north part of Alberts Lake (Preliminary Map 2002-1). The fragmental rock, which is lithologically identical to flow-breccia units (1–12 m thick) that are intercalated with pillowed basalt flows, is essentially monolithic; clasts are basaltic and differ only in their amygdaloidal texture. Sporadic, rare siliceous fragments are interpreted as altered mafic volcanic types that could represent silicified parts of a source flow unit. The unsorted breccia is matrix- to clast-supported and densely amygdaloidal; angular to subrounded fragments are typically 3 to 10 cm long (up to 30 cm) and constitute 30 to 75% of the rock.

Intermediate to mafic heterolithic breccia, minor tuff (unit 4c)

A formation of reworked volcanic fragmental deposits up to 230 m thick extends laterally for approximately 2.5 km within the mafic volcanic sequence northwest of Alberts Lake. The unit thins to the southwest and wedges out in the area south of Eagle Head Lake. To the northeast, the formation is laterally gradational with mafic tuff and derived turbidite that extend around the north end of Alberts Lake to Naosap Mud Lake and beyond, to the fold closure of the Lac Aimée synclinorium in the northeast corner of the map area (Preliminary Map 2002-1).

Heterolithic volcanic breccia contains diverse fragments of basalt (amygdaloidal to nonamygdaloidal, variously epidotized) and plagioclase±quartz–phyric felsic types that locally contain lenticular chloritic aggregates. The unsorted clasts are subangular to angular, moderately to strongly attenuated, and range in size from lapilli to larger fragments (0.2–0.5 m) and sporadic blocks (up to 1 x 0.15 m). Fine- to coarse-grained tuffaceous interlayers (±lapilli) are 0.2 to 5 m thick and commonly diffusely laminated or well bedded at a scale of 1 to 20 cm. The tuff, which is lithologically identical to the matrix of heterolithic breccia, locally displays southeast-facing graded bedding (defined by feldspathic grains and locally lapilli); siliceous laminae (0.5–2 cm) occur in the upper parts of some units. In contrast, some mafic tuff layers are massive and homogeneous over intervals of 3 m or more.

The volcanic fragmental rocks (unit 4c) are interpreted as redeposited by subaqueous debris flows and turbidity currents. The lack of sorting in heterolithic breccia, the angular fragment shapes and the occurrence of sporadic large blocks are consistent with a mass-flow mode of emplacement. The stratigraphic association of sedimentary rocks with the breccia indicates a subaqueous depositional environment. Diffuse to well-defined bedding and grading in tuffaceous interlayers within the breccia are attributed to reworking by turbidity currents.

Felsic volcanic rocks (unit 5)

Felsic porphyritic rocks occur in several lensoid units within the predominantly mafic volcanic terrane in the southeast part of the Lac Aimée Block. These rocks are mainly massive and homogeneous, in contrast to the essentially fragmental felsic volcanic units in the Sourdough Bay Block (Preliminary Map 2002-1). The felsic units are lithologically akin to minor felsic porphyry dikes and sills (unit 8), but definitive evidence for their origin (intrusive vs. extrusive) is largely absent. For example, a 180 m wide unit in the southwest part of the map area consists of a coarsely porphyritic rock with large quartz and plagioclase phenocrysts (0.5–1 cm, each up to 15% of the rock) and up to 5% pyritohedra; the porphyritic texture is locally less coarse grained, but otherwise the unit is homogeneous and its origin (sill or flow) cannot be ascertained.

The felsic unit southeast of Eagle Head Lake (Preliminary Map 2002-1) is also mainly homogeneous, but is interpreted as extrusive because it contains an 8 m wide, monolithic fragmental zone with attenuated lapilli-size clasts and sporadic blocks up to 15 by 1 cm. This unit is sparsely plagioclase-quartz phyric (phenocrysts are 0.2–0.8 mm, 5–10% of the rock) and lithologically similar to some porphyritic dikes (unit 8a). The moderately to strongly foliated felsic rocks of unit 5 predate the regional (S_1) foliation and are interpreted as volcanic in origin; they probably include both intrusive and extrusive rock types.

A fragmental rhyolite flow (unit 5c, 5a) occurs at an island in the west-central part of Alberts Lake, close to the southeast margin of the Lac Aimée Block. The felsic flow is at least 12 m thick and overlies densely amygdaloidal, highly altered and mineralized pillowed basalt to the northwest (see ‘Economic Geology’ section). The fragmental unit (Fig. GS-5-5) is monolithic and consists largely of angular to tabular blocks (10–40 cm, up to 0.25 x 0.5 m) and sporadic rhyolite lobes up to 2 m long that together constitute 40 to 65% of the rock. The clasts are plagioclase phyric (0.5–3 mm, 5–25% of the rock) and a minority contain elongate chloritic amygdules (1–7 mm long, up to 20% of the rock). The breccia is lithologically gradational with a subordinate massive rhyolite zone (approximately 2 m wide) within the fragmental unit, which is assumed to represent the brecciated margin of a cooling lava flow.

Feldspathic greywacke, siltstone (unit 6a)

Fine-grained sedimentary rocks, interpreted as reworked tuffaceous deposits, occur along strike from heterolithic volcanic breccia (unit 4c) in the area north of Alberts Lake. This southeast-facing sedimentary formation is up to 425 m thick and extends for approximately 8 km along strike, from northwestern Alberts Lake to the northeast corner of the map area (Preliminary Map 2002-1).

Figure GS-5-5: Rhyolite breccia (unit 5c) in the west-central part of Alberts Lake. Angular to amoeboid fragments are interpreted as the result of brecciation at the margin of a cooling lava flow.

Feldspathic greywacke and siltstone occur both as massive deposits (up to 4 m thick) and as well-bedded units with layering on a 0.5 to 20 cm scale. Fine detrital feldspathic grains (0.3–1.0 mm) are preserved in the greywacke, which locally displays normal size grading over the basal 10 to 40 cm zone of a bed, transitional upward to siltstone. Scour by greywacke into underlying finer grained sedimentary rocks also locally indicates top directions (Fig. GS-5-6).

Hornblende-chlorite porphyroblastic aggregates (1–3 mm, 15% of the rock) occur in a few siltstone units. Pale green to cream-weathering, thinly laminated siliceous siltstone (4–12 cm thick) at the top of some units is interpreted as derived, in part, from chert. Rare siltstone rip-ups within greywacke beds and sporadic graded bedding in these units are attributed to deposition by turbidity currents.

Sourdough Bay Block

Mafic volcanic rocks (unit 4)

Basaltic flows and related fragmental rocks constitute less than 10% of the central part of the Sourdough Bay Block. Enclaves of the mafic rocks occur within the predominantly felsic volcanic terrane north of the southeast bay of Alberts Lake, and also at the northwest margin of the tonalite intrusion (unit 7a) east of the lake (Preliminary Map 2002-1). Contact relations between the felsic and mafic volcanic rocks were rarely observed; at one locality, rhyolite breccia (unit 5c) truncates the fabric of an older basaltic unit (Fig. GS-5-7). Elsewhere, volcanic enclaves are fault bounded; a 15 by 3.5 m tectonic lens of rhyolite breccia occurs within basalt (unit 4a) at one locality very close to the

Figure GS-5-6: Scour of siliceous siltstone by overlying feldspathic greywacke (unit 6a) in the turbidite formation north of Alberts Lake.

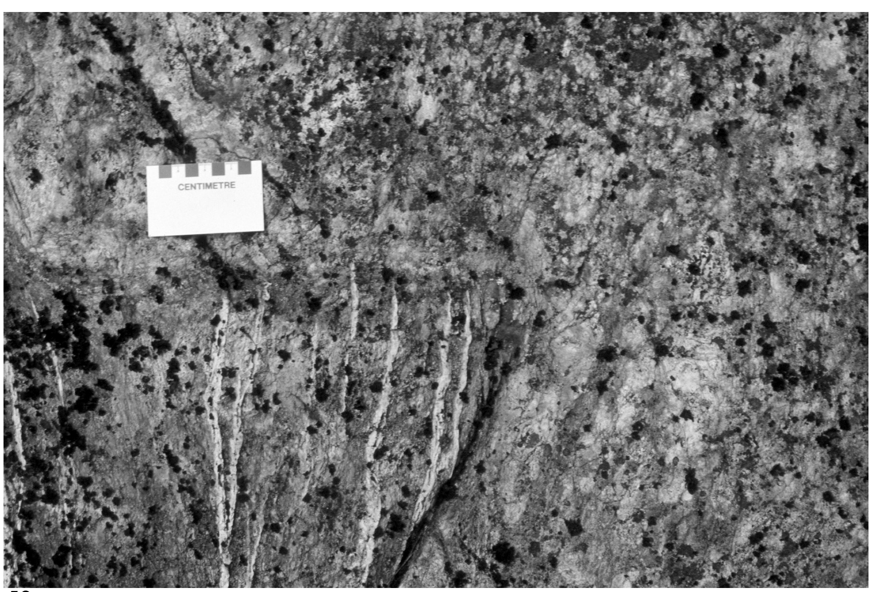


Figure GS-5-7: Contact between basalt (unit 4a) and rhyolite breccia (unit 5c), southeastern bay of Alberts Lake. The basaltic foliation and associated early quartz veins are truncated by the younger felsic rock.

eastern extremity of Alberts Lake. The Sourdough Bay basaltic flows are locally intercalated with both flow-breccia (units $4a_2$, $4a_3$) and coarse, heterolithic debris-flow deposits (unit 4c).

Pillowed to massive basaltic flows and related breccia (unit 4a) in the central part of the Sourdough Bay Block are lithologically similar to those in the Lac Aimée Block (*see* above). Moderately flattened pillows in the Sourdough Bay basalt (1–2 m long) indicate west-facing tops; megapillows (up to 5 x 1.7 m) occur at several localities in the southeast part of Alberts Lake. The mafic flows are aphyric to locally sparsely plagioclase phyric (<5% phenocrysts); amygdaloidal texture is common but amygdules (mainly quartz) are generally smaller and less abundant than in the Lac Aimée basalt. Some units display very coarse amygdaloidal texture; for example, conspicuous spheroidal epidote amygdules (0.5–3.5 cm) occur in one flow that is extensively epidotized. The coarsely amygdaloidal unit is associated with related breccia interlayers, gabbro and diabase within a 90 m wide enclave in the felsic volcanic terrane east of Alberts Lake.

Aphyric basalt flows at the northeast shore of Alberts Lake are intercalated with plagioclase-phyric diabase units (phenocrysts 0.5–2 mm, 10–25% of the rock) that constitute approximately 20% of the section. Whereas these flows are unaltered, amygdaloidal pillowed basalt further south, at an islet just east of the (projected) Sourdough Bay Fault, contains 15 to 35% ovoid epidosite pods (up to 60 cm long) that are derived from the altered cores of pillows (Fig. GS-5-8).

Mafic tuff (unit 4b) in association with chert (unit 6b) occurs at two localities within the felsic volcanic terrane at the southeast shore of Alberts Lake. At the east shore of Christie's island[1] (Preliminary Map 2002-1), a dark green weathering, locally iron-stained mafic tuff unit contains a 12 cm thick, disrupted layer of white chert. Only the west margin (0.5 m thick) of the tuff deposit is accessible at the shore, but the unit is estimated to be only a few metres thick on the basis of the known stratigraphy along strike. The contact between the tuff and rhyolite breccia to the west has been intruded by a concordant diabase unit (9–15 m thick). A second mafic tuff-chert occurrence within the felsic volcanic terrane is located approximately 1 km north of Christie's island. The 3 m thick unit consists of fine-grained chloritic tuff that contains subordinate chert interlayers; the chert is locally magnetiferous and partly folded and disrupted. The well-foliated tuff is characterized by ovoid secondary epidosite domains (2–10 cm, 10–30% of the rock). A 15 m wide aphyric basalt unit occurs along strike from the mafic tuff.

Heterolithic volcanic breccia (unit 4c) is intercalated with massive, quartz amygdaloidal basalt and flow-breccia at the southeast bay of Alberts Lake. The unit is unsorted, matrix- to clast-supported, and contains fragments of aphyric basalt (variously amygdaloidal) and subordinate rhyolite (variously plagioclase phyric); clasts are subangular to angular and typically range from lapilli to small blocks (1–10 cm). Sporadic blocks of coarsely amygdaloidal basalt up to 0.5 by 1 m are also incorporated in the fragmental deposit, which is interpreted as a debris flow. An adjacent outcrop, interpreted as a different debris flow, consists of a partly disrupted, diffusely laminated, mafic volcanic rock (either basalt or tuff). The deposit contains rafted mafic blocks (up to 0.5 x 1 m) and smaller rhyolite fragments within a mafic matrix (Fig. GS-5-9).

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[1] unofficial name

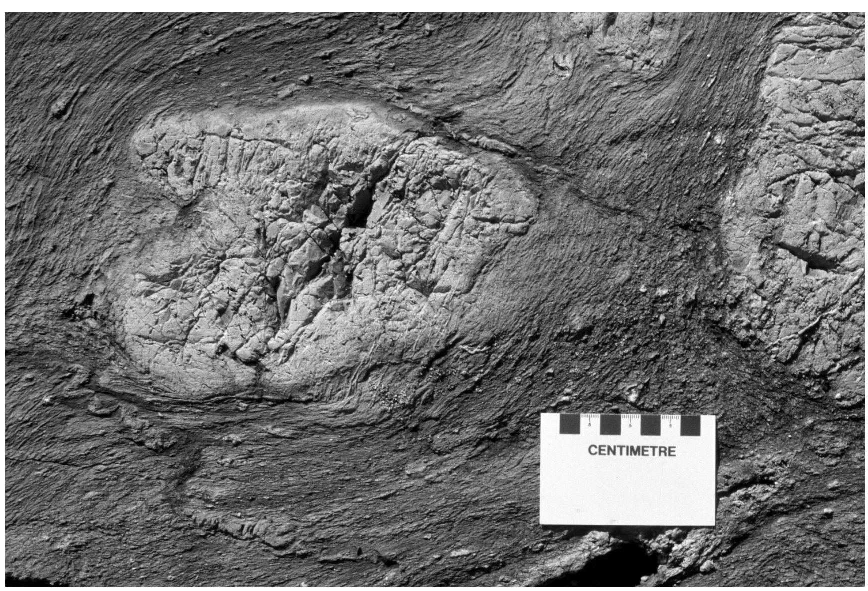

Figure GS-5-8: Epidosite alteration domains in aphyric pillowed basalt (unit 4a), islet in the centre of Alberts Lake.

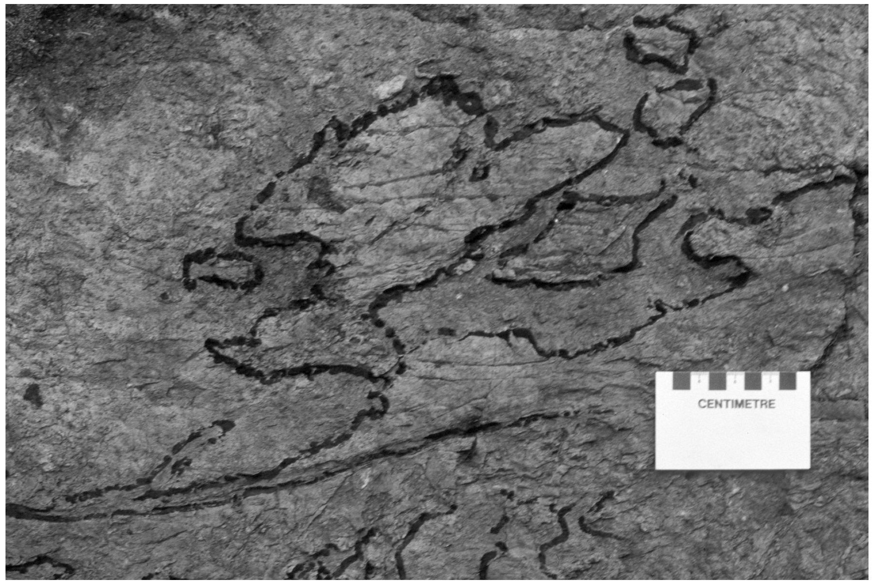

Figure GS-5-9: Mafic debris flow (unit 4c) with angular to irregularly shaped blocks in a mafic matrix, southeast bay of Alberts Lake.

Felsic volcanic rocks (unit 5)

The central part of the Sourdough Bay Block east of Alberts Lake consists mainly of massive rhyolite (unit 5a) and related rhyolite breccia (unit 5c). This felsic volcanic terrane is flanked to the south by major gabbro and granodiorite intrusions (Kalliokoski, 1949) and appears to be in gradational contact with a tonalitic intrusion that extends east from Alberts Lake to Naosap Lake (Fig. GS-5-2). Rhyolite breccia at the east shore of Alberts Lake is transitional with massive rhyolite, which in turn is gradational with the tonalite immediately to the northeast.

Rhyolite and rhyolite breccia in the southeast part of Alberts Lake are intimately intercalated at a scale of 2 to 10 m. The massive felsic flows (unit 5a), which are subordinate to rhyolite breccia, are sparsely feldspar phyric and locally contain minor amygdules (quartz, epidote or chlorite). Differentially weathered flow lamination at a scale of 1 to 10 mm occurs in several units, whereas narrow (2–5 cm) concordant zones with spherulitic fabric are rare. Secondary epidosite domains occur in some felsic flows as sporadic ovoid pods (1–10 cm) with fine, exsolved quartz blebs.

Rhyolite breccia (unit 5c) is interpreted as autoclastic and is characterized by a chaotic, unsorted assemblage of rhyolite fragments that constitute up to 70% of the rock (Fig. GS-5-10). The breccia consists of predominantly small (0.5–10 cm), angular to irregular fragments and sporadic blocks up to 70 cm across (Fig. GS-5-11). The rock also contains sporadic, flow-laminated rhyolite lobes (up to 2 x 3 m) and elongate tongues that are locally flow folded, possibly due to the extrusion of massive rhyolite into unconsolidated hyaloclastic deposits. The majority of the clasts are finely flow-laminated at a scale of 1 to 3 mm; the laminar fabric is commonly warped or contorted due to contemporaneous flow during incorporation of the fragments and emplacement of the breccia. Massive, nonlaminated, white

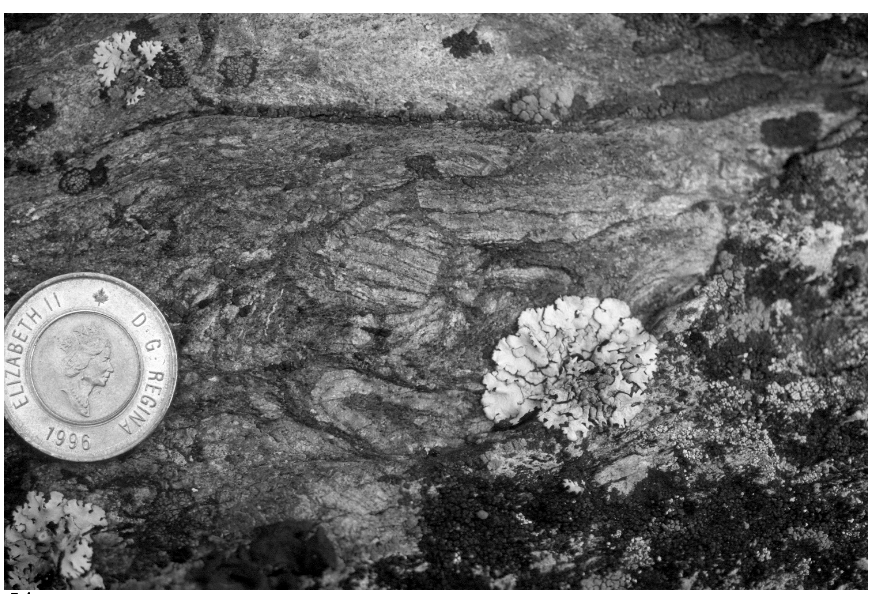

Figure GS-5-10: Rhyolite breccia (unit 5c) with flow-laminated, angular fragments, some of which are plastically deformed, southeast shore of Alberts Lake.

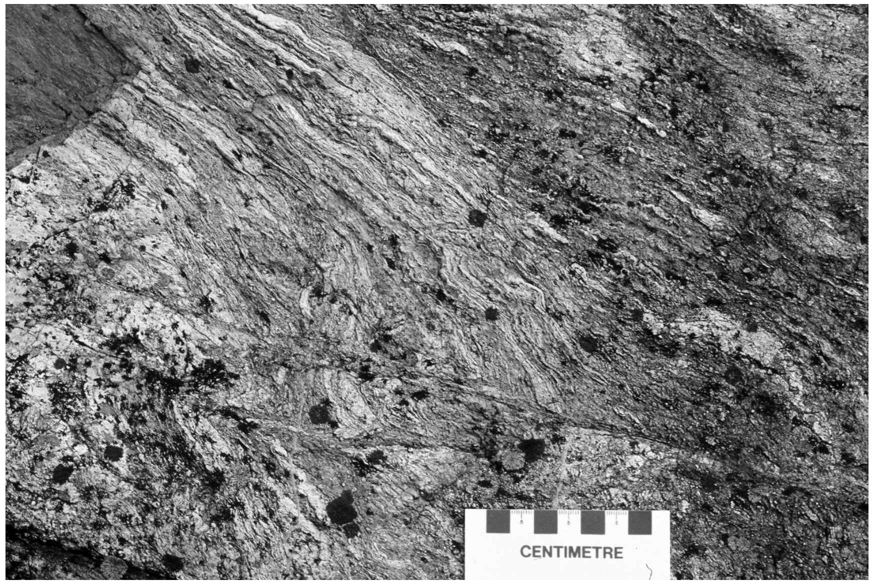

Figure GS-5-11: Flow-laminated rhyolite block in breccia (unit 5c), southeast shore of Alberts Lake.

rhyolite clasts account for less than 10% of the rock. The breccia is sparsely plagioclase (±quartz) phyric and locally contains pyritohedra and chloritized hornblende porphyroblasts. Finely pitted, weathered surfaces, attributed to secondary carbonatization, are common within the felsic volcanic unit.

Chert, cherty siltstone (unit 6b)

Laminated chert (unit 6b) is associated with sporadic mafic tuff units within the felsic volcanic terrane at southeastern Alberts Lake (see description of unit 4b). At one locality 1 km north of Christie's island, four thin (1–4 cm) chert beds within a mafic tuff unit are contorted and disrupted (Fig. GS-5-12), resulting in tabular rafts of sediment within the 3 m wide mafic tuff. The chert is characterized by fine (1–3 mm), white and dark grey laminae that are slightly magnetiferous. Along strike from the mafic tuff, a 15 m wide basaltic unit also contains sporadic white chert as tabular to irregularly shaped rafts (up to 0.8 m long and 4–25 cm thick) that are assumed to be derived from sedimentary layers. In addition, a 25 cm thick chert bed occurs at the contact between two flows (aphyric and plagioclase phyric, respectively) within the mafic volcanic unit. The chert is locally mineralized with up to 7% pyrite-chalcopyrite and associated malachite over a 10 cm wide zone. Similar mineralized chert also occurs at the contact between a basalt flow and a related mafic sill. The contacts between the mafic volcanic–chert formation and flanking felsic volcanic rocks at this locality have been intruded by several prominent felsic porphyry intrusions (unit 8b).

Figure GS-5-12: Laminated chert bed (unit 6b) within mafic tuff is folded and disrupted, 1 km north of Christie's island, Alberts Lake.

INTRUSIVE ROCKS

Intrusive rocks inferred as synvolcanic or penecontemporaneous with 1.88 Ga volcanism

Tonalite, leucotonalite, quartz diorite (unit 7a)

The granitoid terrane between Alberts and Naosap lakes (Fig. GS-5-2) consists of tonalite, granodiorite and related porphyritic phases. The granitoid rocks are not all coeval, but include both an early tonalitic phase, penecontemporaneous with volcanism at Alberts Lake, and later granitoid rocks that postdate the regional S_1 foliation at Naosap Lake (Kalliokoski, 1949; Gilbert, 1997). Kalliokoski (1949) mapped the central part of this terrane as "fine-grained granodiorite" and the peripheral zones as "quartz latite" (felsic porphyry). Only the northeast margin of this granitoid terrane (Gilbert, 1997) and the southwest part, east of Alberts Lake (Preliminary Map 2002-1), have been mapped by this author.

The southwest part of the granitoid terrane consists of fine- to medium-grained, massive tonalite to leucotonalite (unit 7a), characterized by hypidiomorphic (plagioclase) texture and 3 to 7% disseminated pyrite. The tonalite locally contains ragged chloritic aggregates (2–3 mm, 5–10% and locally 20% of the rock) and, toward the margin of the intrusion, the rock is finer grained and sparsely plagioclase±quartz phyric. The granitoid rocks are interpreted as penecontemporaneous with volcanism because they are lithologically gradational with massive, sparsely plagioclase-phyric rhyolite (unit 5a) that occurs immediately to the southwest. This rhyolite is locally characterized by irregular fracturing interpreted as a result of 'in situ' cooling and contains minor breccia zones; the predominantly massive felsic volcanic facies is transitional southward with the massive to fragmental rhyolite terrane (units 5a, 5c) at southeast Alberts Lake.

Plagioclase±quartz porphyry (unit 8b)

Felsic porphyry intrusions occur sporadically within both the Lac Aimée and Sourdough Bay fault blocks. These concordant to locally discordant intrusions range from 0.5 to 15 m in width, and include at least four distinct rock types, based on phenocryst size and content. Sparsely porphyritic intrusions with 3 to 15% plagioclase (±quartz) phenocrysts are lithologically akin and probably related to extrusive rhyolite units in both the Lac Aimée and Sourdough Bay blocks. Conspicuous quartz-plagioclase porphyry dikes that contain up to 20% quartz and 25% plagioclase phenocrysts (1–5 mm) are of uncertain origin; these rocks are possibly slightly younger than the sparsely porphyritic dikes and may represent one of the latest magmatic phases associated with the volcanism. Densely plagioclase-phyric felsic dikes in the northwest and west-central parts of Alberts Lake contain 30 to 60% plagioclase, but little or no quartz; these early intrusions predate the regional S_1 foliation and are truncated by later felsitic dikes. A fourth rock type that occurs only at the southeast shore of Alberts Lake is characterized by a fine- to medium-grained, subporphyritic (plagioclase) texture and contains evenly distributed, elongate basalt xenoliths (0.5–3 cm, 5–15% of the rock). All of the above porphyry phases are massive to moderately or strongly foliated and are considered to be penecontemporaneous with volcanism. In addition to the early porphyry types, postvolcanic felsic dikes locally truncate the regional (S_1) foliation; the younger dikes include both felsite and sparsely plagioclase±quartz–phyric porphyry.

Leucogabbro, anorthositic gabbro (unit 9d)

A roughly circular plug of quartz-bearing leucogabbro (unit 9d), approximately 700 m in diameter, occurs within the mafic volcanic section immediately north of Alberts Lake (Preliminary Map 2002-1). The intrusion, which contains 5 to 10% basalt xenoliths, consists of fine- to medium-grained leucogabbro that is massive to moderately foliated (S_1). The rock consists mainly of plagioclase and subordinate amphibole (up to 30%) and is characterized by hypidiomorphic plagioclase texture; intersertal quartz aggregates constitute up to 8% of the rock. The intrusion is interpreted as penecontemporaneous with volcanism, on the basis of the inferred pre-S_1 age and stratigraphic setting within the basaltic sequence; however, a younger age cannot be ruled out.

Diabase, porphyritic diabase (unit 9e)

Gabbro and diabase intrusions (unit 9e) that occur sporadically within the basaltic flows in the Lac Aimée Block include both aphyric and subordinate porphyritic types. Pyroxene-phyric diabase contains euhedral mafic phenocrysts (1–5 mm, 15–40% of the rock) altered to secondary amphibole. Plagioclase-phyric mafic units (phenocrysts 1–3 mm, 10–30% of the rock) up to 50 m thick are intercalated with aphyric basalt in the southwest part of the map area, close to the contact with gabbro (Fig. GS-5-2); the mafic units are interpreted as intrusive sills (unit 9e), but they may alternatively be extrusive and affiliated with unit 4.

Diabase dikes constitute 5 to 10% of the predominantly felsic volcanic terrane east of Alberts Lake, in the

Sourdough Bay Block. The massive to foliated dikes (unit 9e) are lithologically similar to diabase units within the Lac Aimée basalt. The mafic dikes east of Alberts Lake are typically 1 to 6 m wide and include both very fine grained types and less fine grained, distinctive 'sugary-textured' diabase. Fine thermal contraction fractures occur locally along dike margins. Ovoid hornblende amygdules or derived chloritic aggregates and epidote-filled amygdules along dike margins are characteristic of some intrusions. Elsewhere, the mafic dikes display laminated, pale to dark grey margins or zoning, characterized by aphyric margins and plagioclase-phyric cores. Minor diabase units (unit 9e) also occur within the tonalite (unit 7a) east of Alberts Lake.

Post–1.88 Ga intrusive rocks

Gabbro, amphibolite (10a)

Massive gabbro at the south margin of the map area contains two (or more) different phases that are distinguished on aeromagnetic maps (Heine, 1996). At the south shore of Alberts Lake, the intrusive rock is a homogeneous, mesocratic, subophitic gabbro. The contact with volcanic rocks northwest of the gabbro is marked by a topographic lineament that may locally be coincident with the Sourdough Bay Fault.

ECONOMIC GEOLOGY

Most occurrences of mineralization are either within strongly altered zones in basaltic flows or at contacts between mafic volcanic rocks and intrusive felsic porphyry or tonalite dikes. The west margin of the tonalite terrane east of Alberts Lake contains several iron-stained zones derived from pyritic mineralization along the shoreline, close to the inferred contact with basaltic flows (Preliminary Map 2002-1). The south end of the tonalite sill at the northwest shore of the lake is characterized by iron staining, pervasive carbonatization and quartz veining in a highly sheared zone at the contact with basalt. Sporadic occurrences of disseminated to stringer sulphide mineralization occur within aphyric and plagioclase-phyric basalt just north of the mafic volcanic–gabbro contact at southwestern Alberts Lake. One silicified flow contains ovoid pyrite-pyrrhotite aggregates (1 cm) with malachite rims. Extensive gossan development at the north end of an island in the west-central part of Alberts Lake is associated with sulphide mineralization in strongly silicified and epidotized basalt. Mineralization is sporadic over a 5 m wide zone within densely quartz-amygdaloidal basalt flows that contain subordinate volcanic breccia, felsic porphyry and quartz veins; disseminated pyrite-pyrrhotite and sulphide aggregates (up to 7%) occur in all rock types within the zone. Similar mineralization occurs in rhyolite breccia at the northeast corner of the island. Several occurrences of gold mineralization have been documented by Heine (1996) in quartz veins within the gabbro intrusion immediately south of the map area.

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REFERENCES

Ashton, K.E. 1993: Structure of the southern flank of the Kisseynew Gneiss Belt in Saskatchewan; *in* Trans-Hudson Orogen Transect, Report of Third Transect Meeting, Regina, Saskatchewan, April 1-2, 1993, LITHOPROBE Secretariat, Univerity of British Columba, LITHOPROBE Report No. 34, p. 84–87.

Bailes, A.H. and Syme, E.C. 1989: Geology of the Flin Flon–White Lake area; Manitoba Energy and Mines, Minerals Division, Geological Report GR 87-1, 313 p.

Bateman, J.D. and Harrison, J.M. 1945: Mikanagan Lake; Geological Survey of Canada, Map 832A, scale 1:63 360, with marginal notes.

Gale, G.H. and Dabek, L.B. 2002: Geology of the Baker Patton Complex, Flin Flon, Manitoba (parts of NTS areas 63K12, 13); Manitoba Industry, Trade and Mines, Manitoba Geological Survey, Geoscientific Map MAP2002-1.

Gilbert, H.P. 1986: Geological investigations in the Tartan Lake–Lac Aimée area; *in* Report of Activities 1986, Manitoba Energy and Mines, Minerals Division, p. 43–48.

Gilbert, H.P. 1996: Geology of the Lac Aimée–Naosap Lake area; *in* Report of Activities 1996, Manitoba Energy and Mines, Geological Services, p. 32–39.

Gilbert, H.P. 1997: Geology of the Lac Aimée–Naosap Lake area (NTS 63K/13SE and 63K/14SW); *in* Report of Activities, 1997, Manitoba Energy and Mines, Geological Services, p. 84–98.

Gilbert, H.P. 1999: Geochemistry of Paleoproterozoic volcanic rocks in the Lac Aimée–Naosap Lake area, Flin Flon Belt (parts of NTS 63K/13SE and 63K/14SW); Manitoba Energy and Mines, Geological Services, Open File Report OF99-1, 21 p.

Heine, T.H 1996: Geology of the Alberts Lake area; *in* Report of Activities, 1996, Manitoba Energy and Mines, Geological Services, p. 40–42.

Kalliokoski, J. 1949: Weldon Bay; Geological Survey of Canada, Map 1020A, scale 1:63 360, with marginal notes.

Lucas, S.B., Stern, R.A., Syme, E.C., Reilly, B.A. and Thomas, D.J. 1996: Intraoceanic tectonics and the development of continental crust: 1.92–1.84 Ga evolution of the Flin Flon Belt, Canada; Geological Society of America Bulletin, v. 108, p. 602–629.

Syme, E.C. 1995: 1.9 Ga arc and ocean floor assemblages and their bounding structures in the central Flin Flon Belt; Trans-Hudson Orogen Transect, Report of Fifth Transect Meeting, Regina, Saskatchewan, April 3-4, 1995, LITHOPROBE Secretariat, University of British Columbia, LITHOPROBE Report No. 48, p. 261–272.