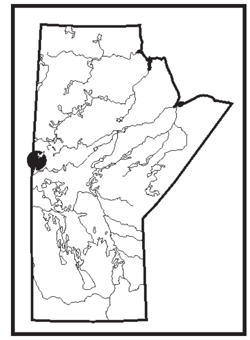
GS-1 Geological investigations in the northern Flin Flon Belt, Manitoba (parts of NTS 63K13NE and 63K14NW)

by H.P. Gilbert



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Summary

A short field program in 2004 was carried out in order to complete detailed map coverage of the northern Flin Flon Belt between the Manitoba-Saskatchewan provincial boundary in the west and the plutonic rock terrane of the Naosap Lake area in the east. This work has not only completed the mapping but, in the process, has identified several significant geological features and a number of areas prospective for volcanogenic massive sulphide (VMS) and gold mineralization. The main findings of current mapping are as follows:

- Three geochemically and tectonically distinct volcanic rock suites ('transitional', mid-ocean ridge basalt (MORB)–like and juvenile arc) are present in the northern Flin Flon Belt. Transitional volcanic rocks of the Dismal Lake suite, which are compositionally intermediate between rare earth element (REE)–depleted arc basalt and MORB, extend in an arcuate pattern around the north margins of the Pistol Lake and Kotyk Lake granodioritic plutons. The transitional rocks are assumed to extend north to the contact between mafic volcanic rocks of the Flin Flon Belt and paragneiss of the Kisseynew Sedimentary Gneiss Belt. The VMS 'Ham Lake deposit' is located within this terrane, which may represent an arc-rift–type tectonic environment. Similar, geochemically transitional basaltic rocks occupy a terrane that extends from the central part of Bluenose Lake southeast toward Wabishkok Lake. In contrast, the northern and southern parts of Bluenose Lake consist of compositionally distinct MORB-like basalt occupying the limbs of a major antiformal fold that closes west of Bluenose Lake. Sporadic occurrences of MORB-type volcanic rocks at the north and south margins of the Dismal Lake Block may represent allochthonous fault slices and/or remnants of a formerly more extensive volcanic terrane that has been largely removed due to tectonism or assimilation by contiguous granitoid rocks.
- Juvenile-arc volcanic rocks underlie Wabishkok Lake and extend east to the Blueberry Lake–northern Naosap Lake area. Whereas these rocks consist mainly of massive basaltic andesite flows and related intrusions, the arc-volcanic suite in the Wabishkok Lake–Blueberry Lake area also includes subordinate rhyolite and heterolithic volcanic breccia. The Wabishkok Lake arc-volcanic suite is in fault contact with the Dismal Lake transitional arc-MORB suite, and is intruded by younger gabbroic and granitoid rocks of the Pistol Lake and Kotyk Lake plutons.
- The north part of the block-bounding Animus Lake Fault is interpreted to bifurcate and extend west through the central and south parts of Bluenose Lake. The more southerly branch of this major fault extends through the narrows between the south and southwest lobes of Bluenose Lake, where it is marked by a conspicuous fault breccia unit at least 17 m wide. A tectonic slice of arc tholeiitic basalt and volcanic breccia occurs within the fault in the south part of Bluenose Lake; pyrite-pyrrhotite mineralization occurs locally within the arc-type rocks and contiguous basalt to the north. The Animus Lake Fault can be traced south into a major structural break that extends across the Flin Flon Belt for a distance of over 45 km.
- The south part of Lac Aimée Block contains diverse arc tholeiitic basalt, ferrobasalt, heterolithic breccia, felsic fragmental rocks, mafic tuff and a large plagioclase-quartz porphyry sill that is apparently Z-folded on the northwest limb of a major syncline. Turbidite deposits and unsorted volcanic fragmental rocks of probable mass-flow origin, as well as bedded volcaniclastic deposits, extend along the southeast flank of the fault block.
- Felsic rocks within the juvenile-arc basaltic section east of Blueberry Lake include an inferred, massive to fragmental rhyolite formation, and a massive porphyry sill of possible volcanic affiliation. The felsic rocks are located close to the margin of the arc-volcanic rock suite, where it is in contact with transitional arc-MORB basaltic flows to the north.

Introduction

Geological mapping at a scale of 1:20 000 was carried out by the author in the northern part of the Flin Flon Belt during the years 1986–1990 and 1996–2003 (Gilbert, 1986, 1987, 1988, 1989, 1990, 1996, 1997, 1998, 1999, 2001a, 2002, 2003a). The 2004 field program completed detailed map coverage in the northern Flin Flon Belt, between the Manitoba-Saskatchewan provincial boundary in the west (latitude 101º53'W) and the plutonic rock terrane in the Naosap Lake area in the east (Figures GS-1-1, -2). Throughout this project, geological mapping has been carried out

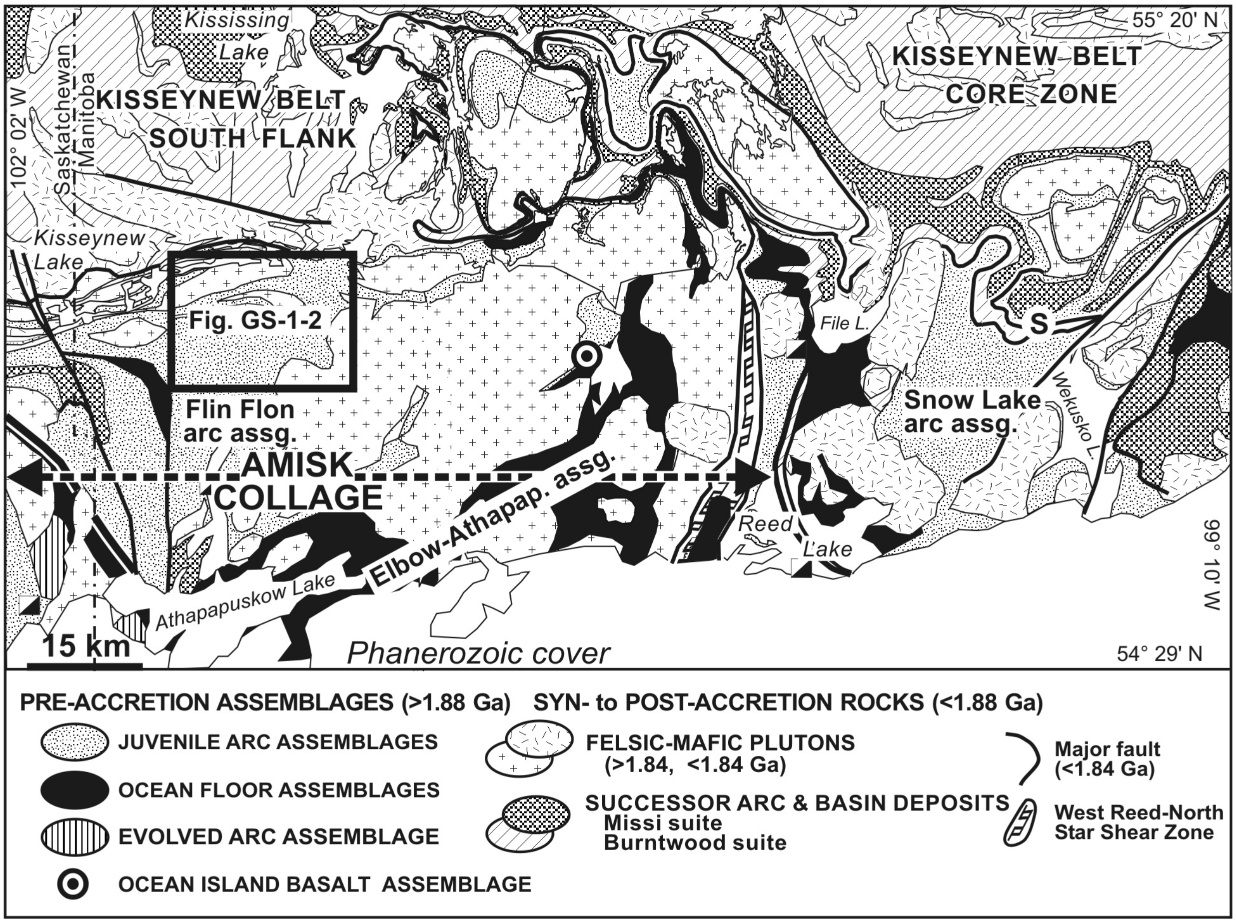

Figure GS-1-1: *Simplified geology of the Flin Flon greenstone belt, showing the major tectonostratigraphic assemblages and location of the project area.*

with concurrent geochemical investigations, in order to determine the nature and distribution of the various tectono-stratigraphic components in the northern Flin Flon Belt, and to evaluate their economic potential.

In 2004, a five-week field program focused on four localities in the Bluenose Lake–Wabishkok Lake–Naosap Lake–Lac Aimée area (Figures GS-1-1, -2):

1) In the Bluenose Lake area, detailed mapping delineated distinctive MORB, transitional (arc-MORB) and juvenile-arc volcanic rock suites that converge westward in a structurally complex part of the northern Flin Flon Belt (Gilbert, 2003a, 2003b).
2) In the south part of the Lac Aimée Block, new stratigraphic and structural data were obtained in the area immediately east of Animus Lake Fault.
3) In the Dismal Lake–Blueberry Lake area, where mineral exploration is currently underway, mapping and geochemical sampling were undertaken to define the boundaries between volcanic rocks of arc, MORB and geochemically transitional arc-MORB types. Features of economic significance in this area include
    - a VMS mineral deposit (Ham Lake) and a stratigraphically conformable zone of mineralization at Dismal Lake (Gilbert 2003a);
    - several clusters of EM conductors (Gilbert, 2003b; Assessment File 93337, Manitoba Industry, Economic Development and Mines,Winnipeg); and
    - several massive and fragmental felsic volcanic formations, exhalative deposits (chert), and alteration zones with garnet-anthophyllite-chlorite gneiss.
4) East of Blueberry Lake (Figure GS-1-2), mafic and felsic volcanic rocks close to the margin of the supracrustal rock terrane were examined to investigate their stratigraphic relationships and assess their potential for base-metal mineralization.

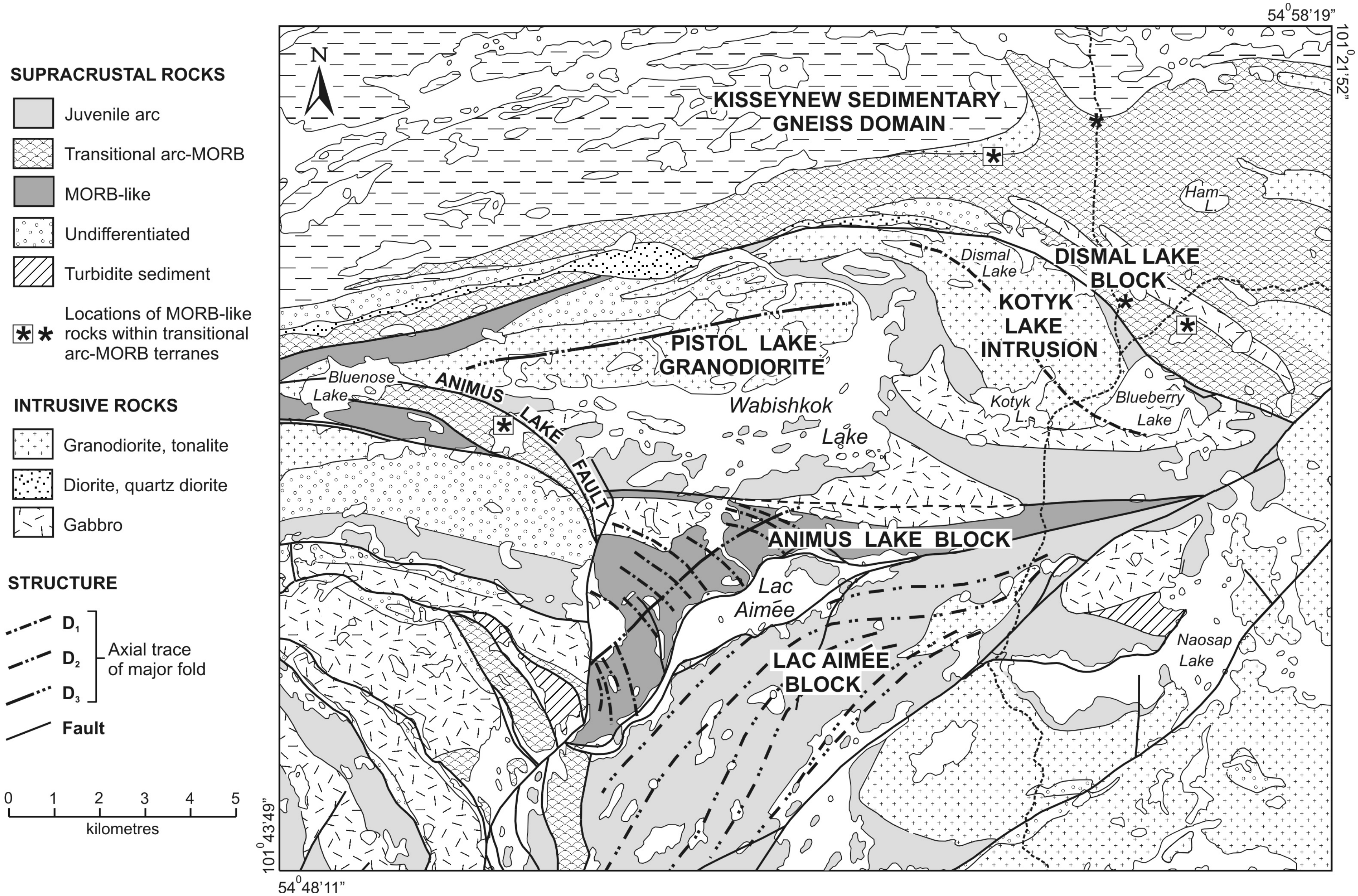

Figure GS-1-2: *Geology of the Wabishkok Lake area, north part of the Flin Flon Belt.*

Tectonostratigraphic setting

The north part of the Flin Flon Belt is a tectonic collage in which MORB-like rocks and transitional-arc to MORB-type components are tectonically intercalated with arc-volcanic rocks; these components are separated by major faults related to 1.88–1.87 Ga intraoceanic tectonic accretion (Lucas et al., 1996; Gilbert, 1998, 1999). The northernmost volcanic rocks, which are inferred to be in fault contact with paragneiss of the Kisseynew Sedimentary Gneiss Belt to the north, are geochemically transitional (arc- to MORB-like) in composition. This panel of rocks was provisionally interpreted to be juvenile arc in origin (Gilbert, 2003a) because of the presence of a base-metal sulphide deposit and a conspicuous zone of hydrothermal alteration in the vicinity of Ham Lake (A.F. 90398, 90483); the interpretation was based on the fact that almost all massive sulphide mineral deposits in the Flin Flon Belt are located in arc-type or arc-rift–type volcanic terranes (Syme and Bailes, 1993; Syme et al., 1996, 1999; Bailes and Galley, 1999). Recent geochemical data (2003) show that the northernmost panel of volcanic rocks (Figure GS-1-2) is geochemically intermediate between REE-depleted arc and normal mid-ocean ridge basalt (N-MORB).

Structural geology

The diverse tectonostratigraphic components of the Flin Flon Belt were juxtaposed along major regional faults during a 1.88–1.87 Ga intraoceanic tectonic accretion event (Lucas et al., 1996; Syme, 1995). The structural history of the northern Flin Flon Belt, which includes at least four phases of deformation postdating the intraoceanic tectonic accretion, has been previously described (Gilbert, 1996, 1997, 2001a, 2002, 2003a). The following discussion is confined to features of the Animus Lake Fault that are apparent from recent field and geochemical data.

The Animus Lake Fault (Figure GS-1-2) is interpreted as a major crustal fracture that was initiated during 1.88–1.87 Ga tectonic accretion. The fault, which can be traced southward across the Flin Flon Belt for a distance of over 45 km (NATMAP Shield Margin Project Working Group, 1998), may originally have been a low-angle thrust plane. The Animus Lake Fault separates two contrasting structural domains in the north part of the Flin Flon Belt: west of the fault, structural features trend northwest to west, whereas east of the fault, the structural trends are mainly northeast to east. The north part of the Animus Lake Fault bifurcates and extends west through the central and south parts of Bluenose Lake. The more southerly branch of the fault extends through the narrows between the south and southwest lobes of Bluenose Lake, where it is marked by a conspicuous fault breccia unit at least 17 m wide. In the Bluenose Lake–Animus Lake area, the Animus Lake Fault juxtaposes arc, MORB-like and transitional arc-MORB volcanic rock types; a tectonic slice of arc tholeiitic basalt occurs within the fault at the narrows in the south part of Bluenose Lake.

Stratigraphy

Comprehensive lithostratigraphic descriptions of the various components in the northern Flin Flon Belt have been previously published (Gilbert, 1996, 1997, 1999, 2001a, 2002, 2003a). This report provides additional information on arc-type rocks at Lac Aimée, Wabishkok Lake and Bluenose Lake (Figure GS-1-2), which are part of the Flin Flon arc assemblage (Lucas et al., 1996; Bailes and Syme, 1989).

Arc volcanic rocks (Lac Aimée Block)

The Lac Aimée arc volcanic suite (Figure GS-1-2) consists mainly of massive basalt to basaltic andesite flows intercalated with subordinate mafic tuff, massive to fragmental rhyolite and heterolithic volcanic breccia (Gilbert, 1999, 2002). The following additional lithostratigraphic data are the result of the current (2004) mapping in the southwest part of the Lac Aimeé Block.

Ferrobasalt

A 40 m thick ferrobasalt unit occurs 1.5 km south of the south end of Lac Aimée, in the axial zone of a northeast-trending anticlinal fold (Figure GS-1-3). This fine-grained, green-brown–weathering rock is typically massive and aphyric. Subordinate zones within the ferrobasalt unit include a slightly coarser grained phase and a plagioclase-phyric phase with up to 20% feldspar phenocrysts (0.5–1.5 mm); these are interpreted as related intrusive units. Conspicuous, finely disseminated magnetite grains constitute approximately 5% of these rocks, and polygonal cooling fractures are locally characteristic. The ferrobasalt is assumed to be conformable with contiguous, pale to medium green weathering, pillowed tholeiitic basalt, but contacts are not exposed. The geochemical classification of the ferrobasalt unit is only provisional, because analytical data are not yet available.

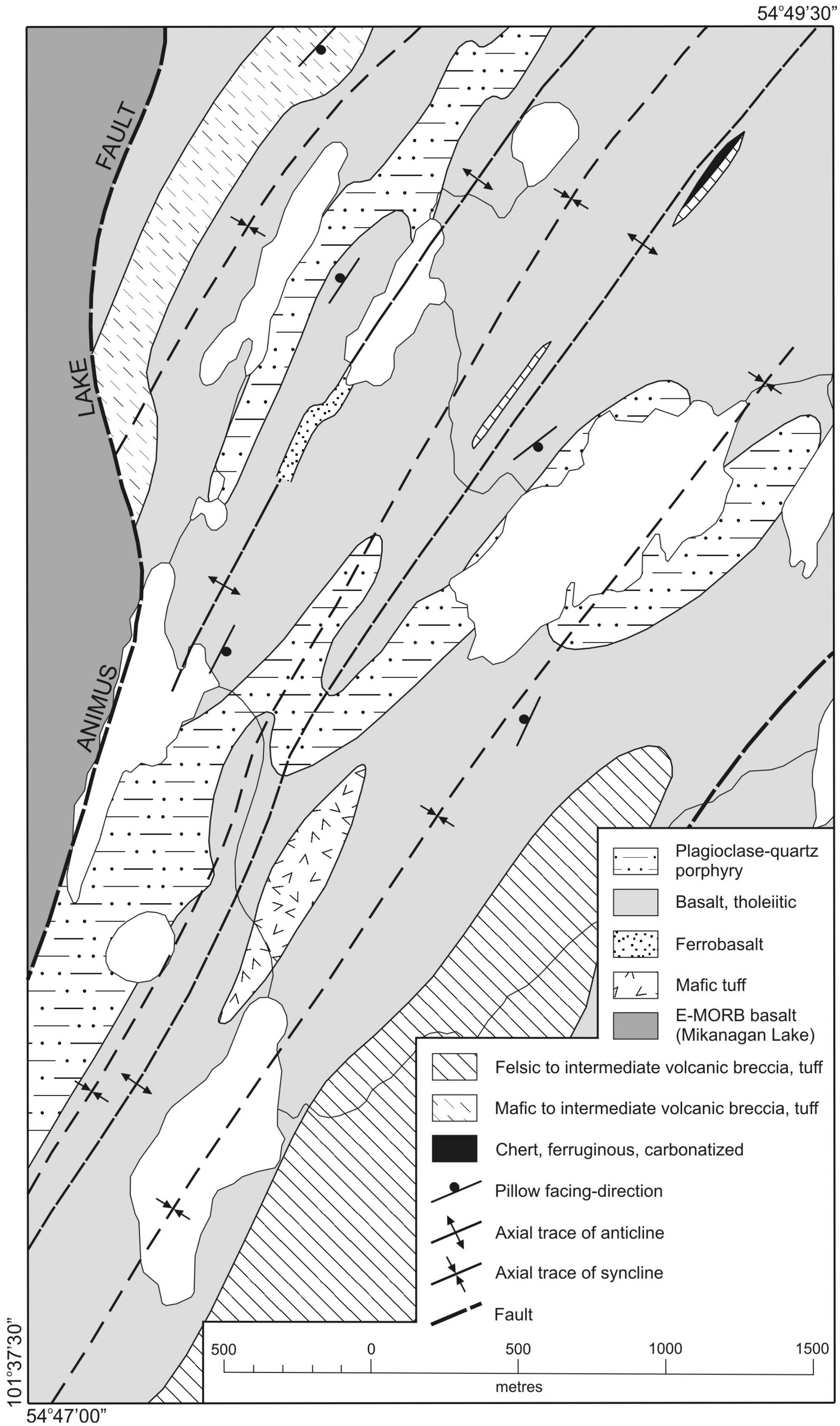

Figure GS-1-3: *Geology of the southwest part of the Lac Aimée Block.*

The ferrobasalt unit, which was traced for 0.3 km along strike, is located within an elongate, transitional arc-MORB formation of possible arc-rift origin that extends northeast through the Lac Aimée juvenile-arc terrane for approximately 8 km (*see* Gilbert, 1999, Figure 2). The presence of ferrobasalt within the transitional basalt formation is consistent with an extension-related, rifted environment of extrusion (Gilbert, 1999). Rifted-arc environments in the Flin Flon Belt are known to be important for the localization of VMS mineralization (Syme et al., 1999).

Felsic to intermediate volcanic breccia, tuff and chert

A heterolithic volcanic breccia and tuff unit, at least 12 m (but less than 50 m) thick, occupies the axial zone of a northeast-trending anticlinal fold, 0.5 km east of the parallel fold structure in which the ferrobasalt unit is located (Figure GS-1-3). Within this fragmental unit, a finely laminated tuff bed (Figure GS-1-4) is truncated by heterolithic breccia that contains a chaotic, unsorted assemblage of white and green-grey lapilli and blocks (felsic to intermediate or altered mafic volcanic rocks), in addition to sporadic blocks of the laminated tuff (Figure GS-1-5). The diverse clasts are angular to subangular and constitute approximately 40% of the deposit, which is characterized by a fine-grained tuffaceous matrix. The breccia-tuff unit occurs within a sequence of basalt and pillowed basalt, and is interpreted as a reworked volcanic fragmental deposit. Finely laminated subaqueous tuff of possible turbidite origin has been partly incorporated into the coarser fragmental unit, in which the composition and contact relationships are consistent with reworking, transportation and emplacement of the volcanic detritus by mass flow.

Approximately 1 km to the northeast and along strike from this deposit, a felsic to intermediate tuff and ferruginous chert unit (also at least 12 m thick) occurs within the same basaltic sequence (Figure GS-1-3). The pervasively

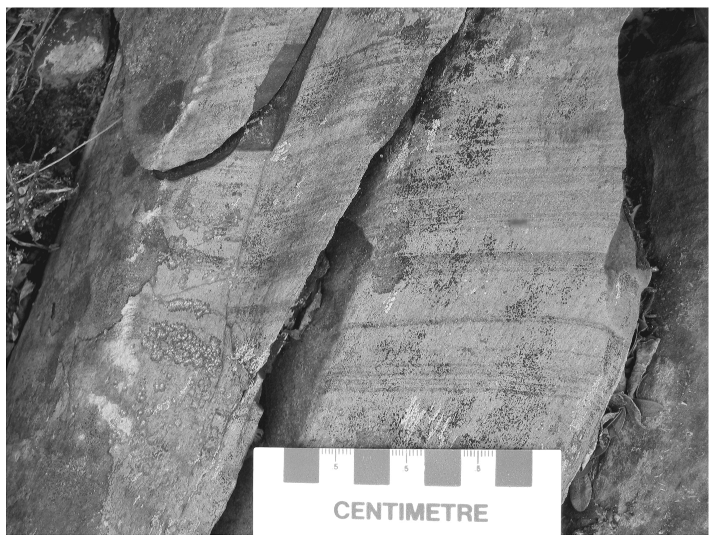

Figure GS-1-4: *Laminated intermediate tuff within the axial zone of an anticline, Lac Aimée Block.*

Figure GS-1-5: *Heterolithic volcanic breccia within the axial zone of an anticline, Lac Aimée Block.*

carbonatized tuff-chert unit, which is locally highly sheared, contains subordinate plagioclase porphyry of inferred intrusive origin. Sericite and porphyroblastic ankerite (up to 75%) occur throughout the zone; chert beds contain up to 7% disseminated pyrite. The presence of chemical sedimentary rocks within the predominantly basaltic stratigraphic sequence suggests there was a pause in extrusive magmatism during which volcanic exhalative activity and chert deposition occurred, penecontemporaneous with emplacement of reworked volcanic detritus in an adjacent basin (the breccia-tuff deposit, along strike to the southwest). The felsic to intermediate fragmental deposits at this stratigraphic interval are assumed to be derived from a magmatic source that was coeval with but separate from that of the basaltic flows.

A second volcanic fragmental deposit, 1.5 km south of the breccia-tuff unit described above, contains plagioclase-phyric felsic clasts and rare, dark grey mafic fragments. This second breccia unit, which is at least 200 m thick, is crudely sorted and intercalated with intermediate crystal tuff and lapilli tuff units. The matrix-supported fragmental deposit contains mainly lapilli-size to small cobble-size angular clasts, but sporadic large blocks (up to 0.9 m by 0.4 m) occur locally, consistent with a mass-flow mode of emplacement (Figure GS-1-6).

Plagioclase-quartz porphyry

A large (0.4 km by 2.5 km) plagioclase-quartz porphyry sill was discovered this year in the southwest part of the Lac Aimée Block. The rock contains 10–20% plagioclase (0.5–2 mm) and 2–5% quartz (0.2–0.8 mm) phenocrysts, is massive to cataclastically foliated and locally displays rare polygonal cooling fractures. Felsic porphyry and porphyritic rhyolite are subordinate but economically significant components of the Lac Aimée Block, in view of the association between base-metal ore deposits and felsic volcanic rocks in the Flin Flon arc assemblage (Syme and Bailes, 1993; Syme et al., 1996). Plagioclase-quartz porphyry constitutes up to 25% of the arc-volcanic terrane south of the west part of Lac Aimée. The felsic porphyry is interpreted as the intrusive counterpart of compositionally similar volcanic flows in the Lac Aimée arc-volcanic suite, some of which are flow laminated or contain fragmental zones associated with their extrusive origin (Gilbert, 1999).

Arc-volcanic rocks (Wabishkok Lake Block)

The Wabishkok Lake arc-volcanic suite consists mainly of massive to pillowed, aphyric basaltic andesite and related gabbro; subordinate felsic volcanic units and heterolithic breccia are largely confined to the Kotyk Lake–Blueberry Lake area in the east part of the Wabishkok Lake Block (Gilbert, 2001b). The Wabishkok Lake suite has been described previously (Gilbert, 2001a, 2003a); the current (2004) field investigation focused on rhyolitic rock units in the area east of Blueberry Lake.

Quartz-plagioclase–phyric rhyolite, felsic porphyry

Two felsic rock units occur within the arc-volcanic sequence east of Blueberry Lake (Figure GS-1-7). These rocks, previously mapped as late felsic porphyry (Kalliokoski, 1949), are re-interpreted to be part of

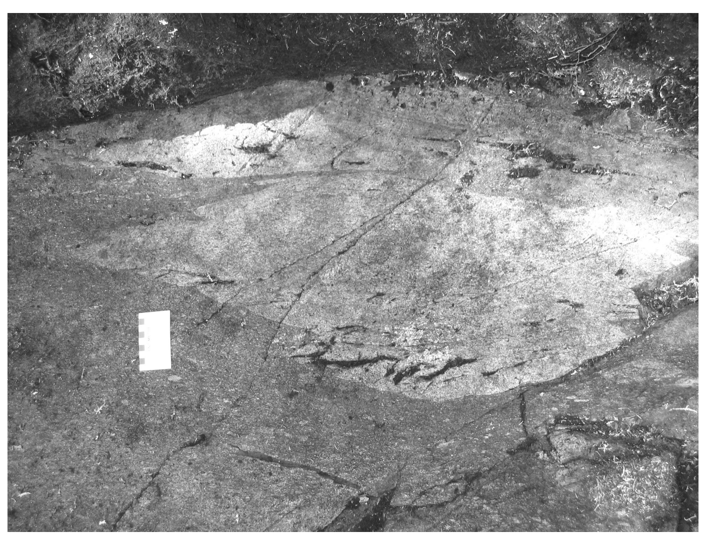

Figure GS-1-6: *Boulder-size felsic clasts in volcanic breccia of inferred debris-flow origin, south part of Lac Aimée Block.*

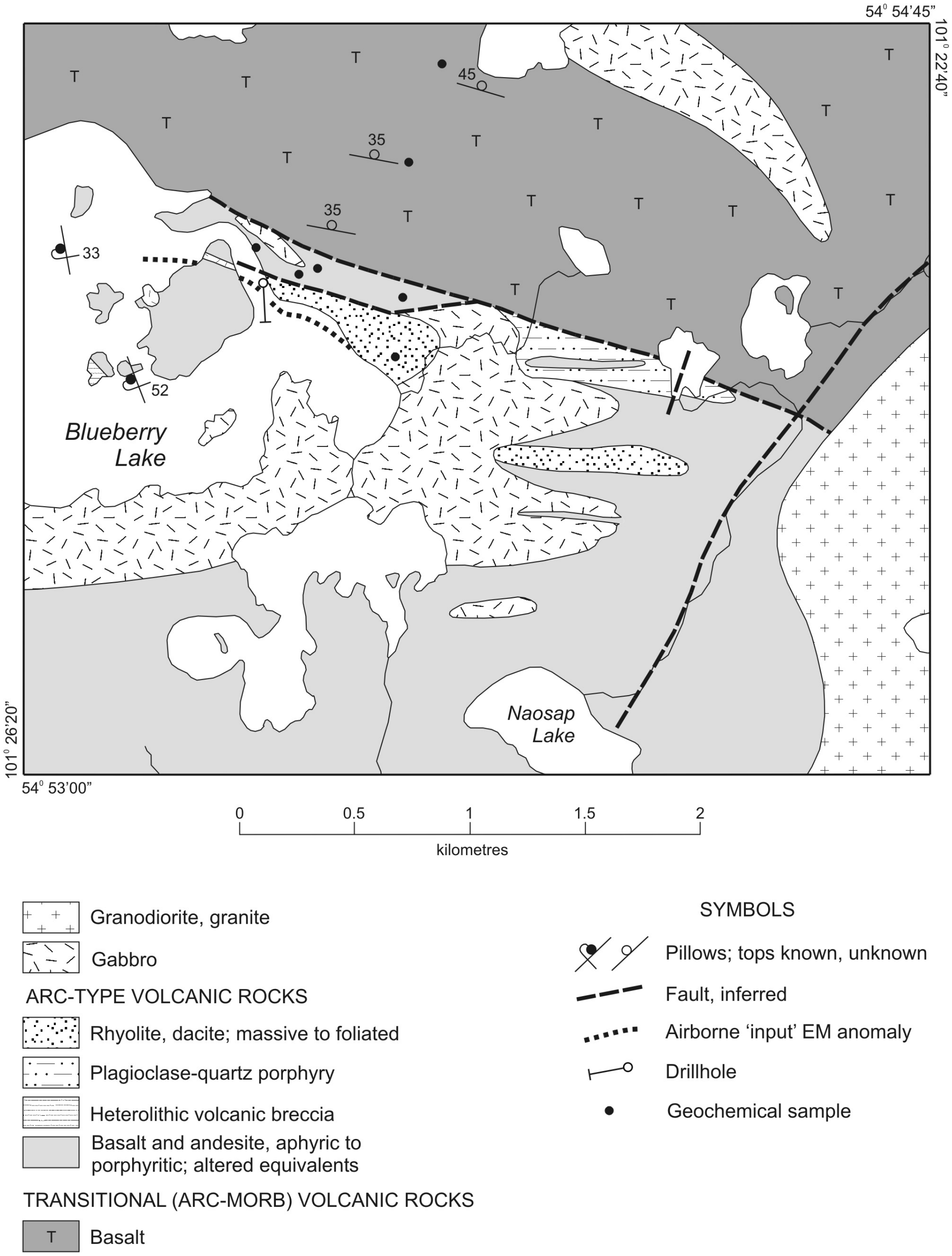

Figure GS-1-7: *Geology of part of the arc-type volcanic sequence east of Blueberry Lake.*

the Wabishkok Lake arc-volcanic suite, based on features attributed to primary (volcanic) processes. This revised interpretation is significant for mineral exploration, because the majority of VMS ore deposits in the Flin Flon Belt are stratigraphically associated with felsic volcanic rocks within the Flin Flon arc assemblage (Syme and Bailes, 1993).

A lensoid rhyolite unit, between 120 and 180 m thick, occurs 1 km east of the southeast corner of Blueberry Lake. This felsic unit is porphyritic, with quartz and plagioclase phenocrysts (up to 2 mm) constituting 15% and 8% of the rock, respectively. Fragmental zones are widespread within the otherwise massive rhyolite; the lack of conspicuous shearing or cataclasis within these zones suggests they are autoclastic rather than tectonic in origin (Figure GS-1-8). Subangular to ellipsoidal fragments, typically 1–5 cm long, occur in a felsic aphanitic matrix that is variously epidotized

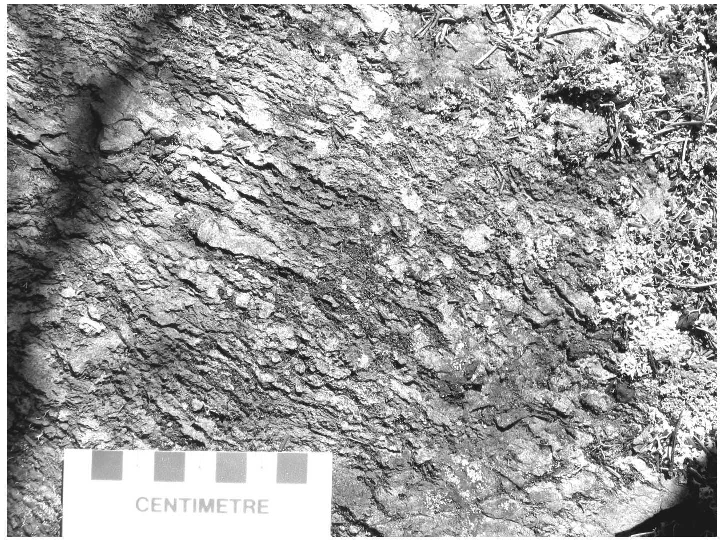

Figure GS-1-8: *Fragmental rhyolite within the arc-type volcanic sequence east of Blueberry Lake.*

or chloritized. Irregular to anastomosing fractures within massive parts of the flow are attributed to 'in situ' brecciation during cooling. Elsewhere, rare dark convoluted laminae are interpreted as primary flow laminae.

A second porphyritic felsic rock unit, at least 130 m thick, occurs within the basaltic section north of the rhyolite lens. This unit is massive and devoid of fragmental zones, although brecciation of inferred 'in situ' cooling origin is common. The south margin of this felsic lens intrudes contiguous basaltic flows, and the porphyry unit is thus interpreted as intrusive.

Arc-volcanic rocks (Bluenose Lake enclave)

A tectonic enclave of juvenile-arc basalt occurs within MORB-type basalt in the south part of Bluenose Lake (Figure GS-1-9; *see* 'Geochemistry' section, below). The 75–150 m wide structural lens also contains heterolithic volcanic breccia and fault breccia. The lateral extent of the tectonic enclave is unknown, but it probably exceeds several kilometres in strike length (*see* 'Bluenose Lake area' in 'Economic considerations' section).

Basalt, heterolithic volcanic breccia and fault breccia

Juvenile-arc basalt at the shore of southern Bluenose Lake is a very fine grained homogeneous unit, locally with slightly coarser grained domains attributed to metamorphic recrystallization. The unit is at least 5 m thick and extends through the narrows in the south part of Bluenose Lake, where the mafic volcanic rock is locally altered and mineralized with pyrite over a 2.5 m wide zone on the south shore (Figure GS-1-9).

Intermediate to felsic breccia within the tectonic lens at southern Bluenose Lake contains pale grey, aphanitic felsic lapilli and small cobbles within a fine-grained, felsic to intermediate tuff matrix. The clasts are strongly lineated, with a shallow plunge to the west. The breccia deposit is at least 10 m thick, but its lateral extent is unknown.

A conspicuous fault-breccia zone occurs close to the north margin of the Bluenose Lake tectonic enclave (Figure GS-1-10). Angular fragments, ranging from granules to tabular blocks up to 25 cm long, constitute approximately 50% of the rock. The clasts consist of very fine grained to aphanitic felsite, characterized by fine, dark grey laminae or diffuse schlieren that were locally folded prior to incorporation of the fragments in the breccia. The very fine grained amphibolitic matrix is green-grey to rusty brown or maroon weathering, due to secondary carbonate and hematite that are pervasive through approximately half of the 17 m wide outcrop.

Geochemistry of tectonostratigraphic components in the northern Flin Flon Belt

The geochemistry of the northern part of the Flin Flon Belt has been discussed previously (Gilbert, 1998, 1999, 2003a, 2003c). In this report, the tectonostratigraphic map of the northern Flin Flon Belt is updated (Figure GS-1-2), the geochemically distinct components are described and their potential for economic mineralization is discussed, in light of recent (2003) geochemical data.

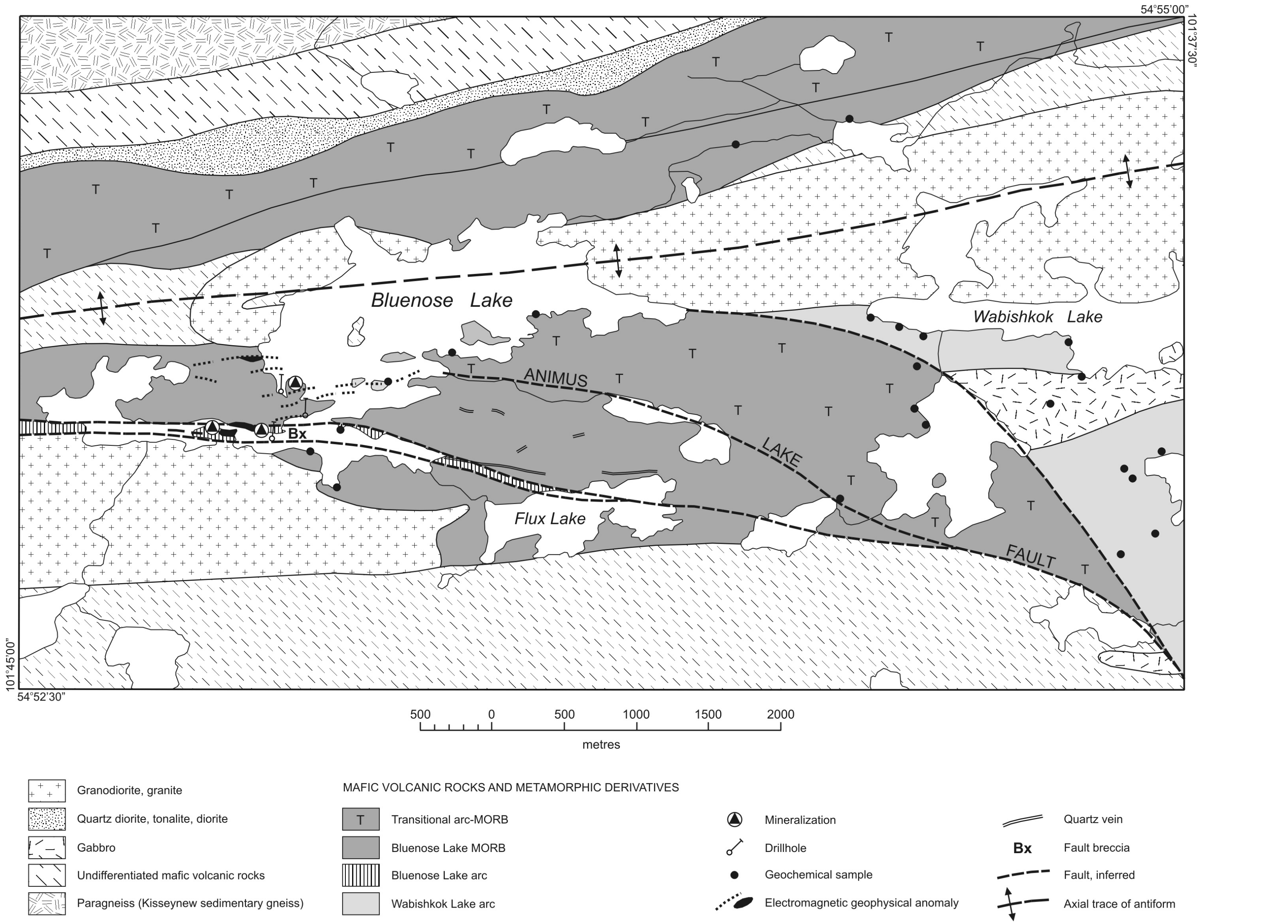

Figure GS-1-9: *Geology of the Bluenose Lake area. Locations of diamond-drill holes, electromagnetic conductors and quartz veins are from Hudson Bay Exploration and Development Company Limited (unpublished data, 1978, 1979, 1985).*

Figure GS-1-10: *Fault breccia at the narrows in southern Bluenose Lake. Randomly oriented, angular tectonic clasts within the pervasively carbonatized, hematitic amphibolite matrix contain fine laminae that were deformed prior to formation of the breccia.*

Transitional, depleted-arc to MORB-like basaltic rocks

The northernmost volcanic rocks in the Flin Flon Belt consist almost entirely of basalt, related gabbro and derived metamorphic rocks. In the absence of definitive geochemical data, these rocks were provisionally classified as having juvenile-arc tectonic affiliation (Gilbert 2003a), based on the local occurrence of hydrothermally altered rocks and VMS-type mineralization within the northern volcanic terrane; such features are most commonly observed within arc-type rocks elsewhere in the Flin Flon Belt. Recent data indicate the northernmost volcanic rocks are intermediate between REE-depleted arc and MORB in composition; such rocks are classified in this report as 'transitional arc-MORB'. The available data indicate that an extensive terrane of such 'transitional' volcanic rocks (Dismal Lake suite) exists along the north flank of the Flin Flon Belt between Bluenose and Ham lakes (Figure GS-1-2); the tectonic affinity of the parts of this terrane shown as undifferentiated in the figure will be confirmed when analytical data for current (2004) samples have been obtained. Dismal Lake transitional basalt is characterized by flat to moderately positive sloping profiles in extended element plots, with REE contents ranging from equivalent to N-MORB to relatively strongly depleted (Figure GS-1-11b). Contents of TiO_2, Zr, Ni and Cr in Dismal Lake transitional basalt are intermediate between Wabishkok Lake arc and MORB-type volcanic rocks within the northern Flin Flon Belt (Table GS-1-1); average TiO_2 contents of transitional, arc and MORB-type basalts in the northern Flin Flon Belt are 0.74, 0.46 and 0.90%, respectively.

A lensoid structural slice of transitional basalt extends from the central part of Bluenose Lake southeast toward Wabishkok Lake. Compared to the average Dismal Lake transitional basalt, Bluenose Lake transitional basalt is more REE depleted (Figure GS-1-11a, b), especially in high-field-strength elements, and has lower SiO_2 (Table GS-1-1); however, these two basalt types are otherwise compositionally very similar. The conspicuous negative Nb anomaly and Th/Nb ratios above primitive values that are characteristic of these transitional basalt suites are also typical of subduction-related arc magmas; these features are consistent with modification of an original MORB-like source magma that may previously have been depleted in light rare earth elements, relative to primitive mantle. Mixing of such a depleted MORB-like source with arc-type magma could result in the observed pattern of incompatible elements. The distinctive REE profile of the transitional, arc-MORB basaltic rock suites is possibly due to magma mixing during the emplacement of a depleted, MORB-like source magma into an extensional back-arc basin at an early stage of arc rifting, whereby subduction-related magma (associated with rifting) was mixed with the primitive source and resulted in compositionally transitional mafic volcanic rock types.

MORB-like basaltic rocks

Mid-ocean ridge basalt (MORB)–like basaltic rocks occur at several localities within the transitional volcanic terrane that extends along the north flank of the Flin Flon Belt. A unit of MORB-type basalt (Bluenose Lake MORB) occurs close to the axial zone of the major fold at Bluenose Lake (Figure GS-1-9); the rock unit, which is approximately 0.75 km thick, traces the west-plunging fold closure of the Wabishkok Lake antiform (Gilbert, 2001a, b) from the north to south shores of Bluenose Lake. The MORB-like rocks display almost flat REE profiles. Relative to N-MORB, Bluenose Lake MORB is characterized by slightly elevated Th, but otherwise REE contents are mostly slightly depleted (Figure GS-1-11c**;** Table GS-1-1).

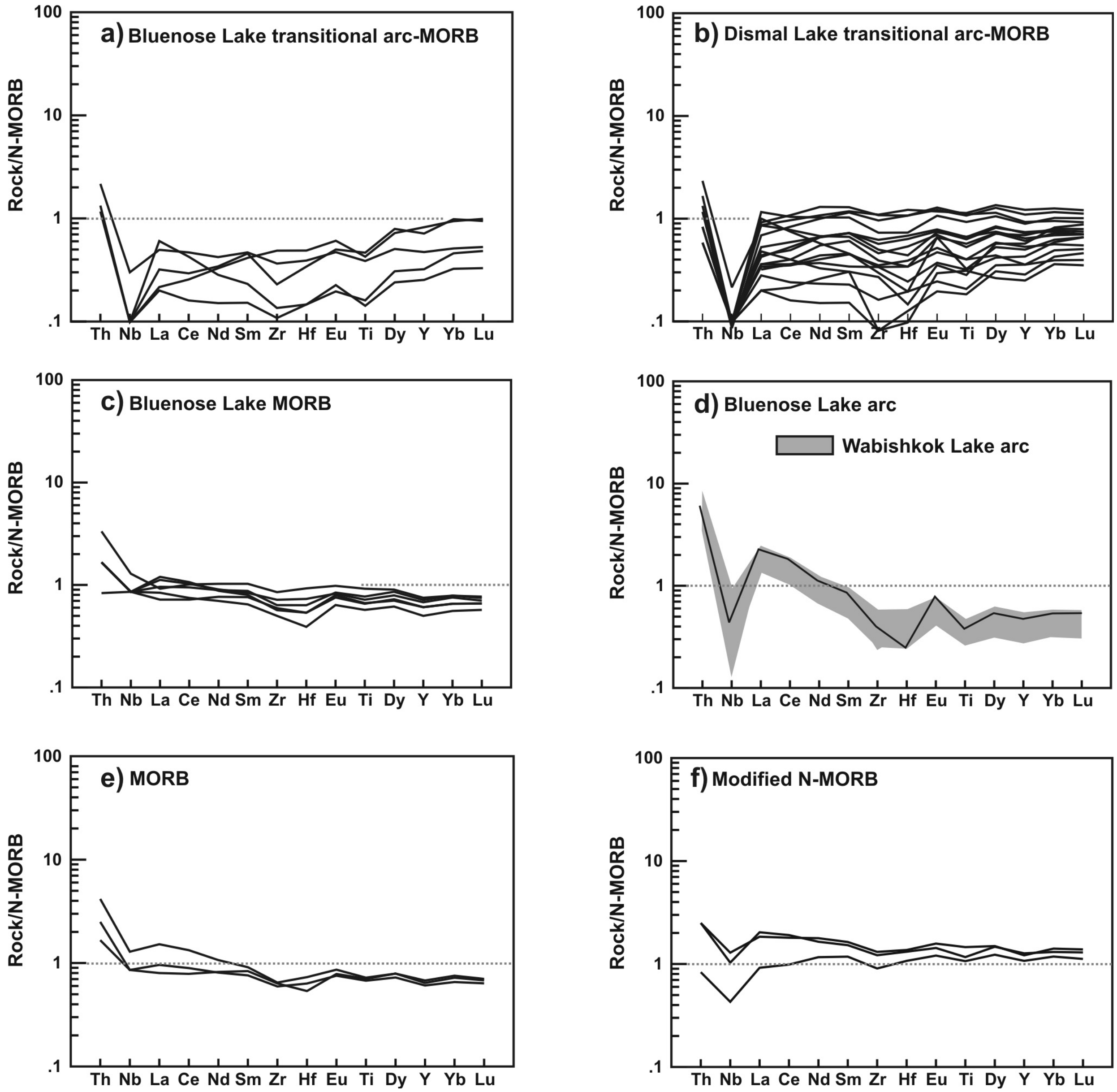

Figure GS-1-11: *N-MORB–normalized extended element plots of arc, MORB-like and transitional volcanic rocks in the Bluenose Lake–Wabishkok Lake–Dismal Lake area; normalizing values from Sun and McDonough (1989).*

Table GS-1-1: Averages of selected geochemical parameters for mafic volcanic rocks in the Bluenose Lake–Wabishkok Lake–Dismal Lake area; chondrite-normalized La/Yb ratios based on normalizing values in Sun and McDonough (1989).

Volcanic rock suite	SiO_2	Fe_2O_3	MgO	TiO_2	Cr	Ni	Zr	Nb	Th	La/Yb_{ch}	Th/Nb
Bluenose Lake transitional arc-MORB	47.8	12.9	7.5	0.4	103	64	20	0.1	0.1	0.9	0.4
Dismal Lake transitional arc-MORB	50.7	12.0	7.0	0.7	138	68	37	0.1	0.1	0.9	0.5
Bluenose Lake MORB	48.9	12.7	7.9	0.9	210	106	48	2.2	0.2	1.6	0.1
MORB	49.6	13.1	8.3	0.9	179	80	46	2.3	0.3	1.7	0.1
Modified N-MORB	52.3	14.9	5.1	1.6	23	22	85	2.1	0.2	1.4	0.1
Bluenose Lake arc	50.7	9.9	7.6	0.5	378	76	29	1.0	0.7	4.8	0.7
Wabishkok Lake arc	55.1	12.0	4.7	0.5	66	19	29	1.1	0.6	5.0	0.7

Two other geochemically distinctive types of MORB-like basalt occur sporadically within or at the margins of the transitional basalt terrane in the northern Flin Flon Belt. Mid-ocean ridge basalt (MORB)–type basalt (Figure GS-1-11e) occurs at or very close to the contact between arc-type and transitional basaltic rocks east of Dismal Lake and also at a locality in the area to the north, at or very close to the north margin of the transitional volcanic terrane (asterisk symbol in Figure GS-1-2). 'Modified N-MORB' (boxed asterisk symbol in Figure GS-1-2) occurs 1) at a locality within the Bluenose Lake transitional basalt terrane; 2) in the area north of Dismal Lake, at or close to the basalt-paragneiss contact; and 3) within the transitional basalt terrane east of Dismal Lake. 'Modified N-MORB' displays a REE profile very similar to that of N-MORB, but is distinguished by a moderate negative Nb anomaly in extended element plots (Figure GS-1-11f).

The occurrence of geochemically distinctive, MORB-like volcanic rocks within and at the margins of the extensive transitional basalt terrane on the north flank of the Flin Flon Belt can be attributed to one of the following models:

- Tectonic dismemberment and reassembly of 1) preexisting MORB-type ocean-floor rocks and 2) contiguous back-arc basin ('transitional') basalt during 1.88–1.87 Ga tectonic accretion of the oceanic-arc complex. In this case, contacts between the MORB-type and transitional rocks would be represented by early faults or thrusts.
- Intercalation of MORB and transitional basalt types in a conformable stratigraphic sequence, possibly due to the periodic incorporation of N-MORB from a magmatic source that was separate from that which provided transitional, depleted-arc to MORB-like basalt. In this case, conformable contacts between the MORB and transitional rock types would be anticipated. The available field data do not support the existence of (early) fault contacts between these two geochemically distinct basalt types, suggesting stratigraphic conformity, but further detailed mapping is necessary to clarify the contact relationships.

The provisional interpretation is that the transitional and MORB-like basalts are conformably intercalated, and the present sporadic distribution of MORB-type rocks within the terrane of transitional basalt is due to later deformation, primarily folding. This model is analogous to that suggested for the apparently conformable intercalation of N-MORB and E-MORB rocks in the Animus Lake Block, immediately south of Wabishkok Lake (Gilbert, 1999).

Arc-volcanic rocks (Bluenose Lake)

Juvenile-arc basalt at the narrows in southern Bluenose Lake is interpreted as part of an allochthonous fault slice within a splay of the Animus Lake Fault. Unlike Bluenose Lake MORB and transitional basalt types, in which primary features such as pillows and amygdaloidal texture are locally well preserved, the arc basalt unit that was sampled at Bluenose Lake is devoid of original volcanic features. The REE profile of the unit, characterized by high La/Yb ratios, is analogous to that of the Wabishkok Lake arc-volcanic suite (Figure GS-1-11d), but relatively lower SiO_2 and Fe_2O_3, and higher MgO, Ni and Cr in the Bluenose Lake unit (Table GS-1-1) indicate the magmatic source was less evolved than that of Wabishkok Lake basaltic andesite. The arc basalt, contiguous volcanic fragmental rocks and associated fault breccia at southern Bluenose Lake are apparently confined to a relatively narrow (75–150 m) tectonic enclave associated with a pronounced topographic lineament.

Economic considerations

Bluenose Lake area

Arc-volcanic rocks, structurally emplaced within MORB-type basalt in the vicinity of the narrows in southern Bluenose Lake, represent a significant base-metal exploration target. Several mineralized localities occur within this lensoid tectonic enclave; the most conspicuous occurrence is a 15 m wide altered and mineralized zone with disseminated to massive pyrite (±pyrrhotite±magnetite) that was intersected by a diamond-drill hole in the central part of the enclave (Hudson Bay Exploration and Development Company Limited [HBED], unpublished data, 1961). Several additional mineralized zones occur immediately north of the narrows, over a stratigraphic width of approximately 350 m; one zone contains massive pyrite-pyrrhotite over a 30 cm wide section. The geochemical affinity of the basaltic host rocks in this section north of the narrows is undetermined because analytical data have not yet been obtained. Several electromagnetic (EM) conductors and a conspicuous magnetic anomaly are associated with the mineralized zones, both within and north of the narrows (HBED, unpublished data, 1978).

Two kilometres west of the narrows at southern Bluenose Lake and directly along strike from the tectonic enclave, an EM conductor extends due east from the southeast corner of Oblong Lake (Assessment File 94414, Manitoba Industry, Economic Development and Mines, Winnipeg). A ground geophysical survey reported a strong magnetic correlation with the EM anomaly and defined the strike length as 0.8 km; follow-up diamond-drilling intersected 'solid' pyrite and pyrrhotite mineralization within the anomalous zone (diamond-drill hole logs were not submitted with the assessment data).

A massive, Au-bearing quartz vein, up to 18 m thick, extends laterally for at least 0.75 km, from the southeast corner of Bluenose Lake east to the north shore of Flux Lake (Figure GS-1-9; HBED, unpublished data, 1922). The mineralized vein is subparallel to, and probably intersects, the east-southeast-trending faulted margin of the arc-volcanic enclave at southern Bluenose Lake; the quartz vein is assumed to postdate emplacement of the tectonic enclave, but its age of intrusion is unknown. The volcanic terrane between Bluenose and Flux lakes, which contains several branches of the Animus Lake Fault, is considered to be a significant Au exploration target, in view of the presence of several large, mineralized quartz veins in the area, and the widely documented association between major faulting and Au mineralization (Barley et al., 1989; Hodgson and Hamilton, 1989; Kerrich and Wyman, 1990; Fedorowich et al., 1991).

Lac Aimée Block

The Lac Aimée Block is characterized by several features considered positive for potential base-metal sulphide mineralization:

- Diverse lithological assemblage of arc-type geochemical affinity
- Localized arc-MORB–type 'transitional' basalt in the axial zone of a major anticlinal fold that may signify a partially rifted environment (Gilbert, 1999)
- Felsic volcanic rocks, including flow-banded and massive to fragmental rhyolite flows and porphyry intrusions

An additional feature discovered in the southwest part of the fault block during current (2004) mapping is a narrow but diverse lithostratigraphic zone that represents a significant stratigraphic break in the Lac Aimée basaltic sequence (Figure GS-1-3; *see* preceding description of 'Felsic to intermediate volcanic breccia, tuff and chert'). This zone contains fragmental rocks interpreted as subaqueous mass flows and, 1 km along strike, volcanic exhalative chert deposits. Similar stratigraphic breaks elsewhere in the Flin Flon arc assemblage (Lucas et al., 1996) are spatially associated with several base-metal orebodies (e.g., Cuprus and White Lake deposits; Bailes and Syme, 1989).

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