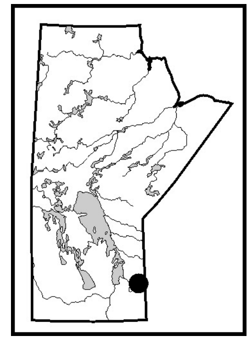
GS-17 Geological investigations in the Bird River area, southeastern Manitoba (parts of NTS 52L5N and 6)

by H.P. Gilbert



Gilbert, H.P. 2006: Geological investigations in the Bird River area, southeastern Manitoba (parts of NTS 52L5N and 6); *in* Report of Activities 2006, Manitoba Science, Technology, Energy and Mines, Manitoba Geological Survey, p. 184–205.

Summary

A regional mapping project in the Neoarchean Bird River Belt (BRB) of southeastern Manitoba was initiated by the Manitoba Geological Survey in 2005. Both reconnaissance mapping and localized, more detailed work in the east and west parts of the greenstone belt were carried out. Mapping was continued in the east and central parts of the belt in 2006, with a focus on stratigraphy and volcanic geochemistry.

The north margin of the belt consists of basalt (Lamprey Falls Formation) akin to modern back-arc basin basalt (BABB). The basalt is structurally overlain by a south-facing, arc-type volcanosedimentary sequence that postdates the BABB-type sequence. New U-Pb zircon dates show that turbidites (Booster Lake Formation) and fluvial-alluvial deposits (Flanders Lake Formation), which are largely confined to the east part of the greenstone belt, postdate the arc-type rocks by approximately 30 m.y. The fault-bounded Booster Lake Formation extends through the central part of the BRB, dividing it into north and south panels. The south panel consists mainly of felsic volcanic fragmental rocks and north-facing basaltic units of inferred arc-type composition.

A subsidiary supracrustal belt extends along the Winnipeg River south of the 'main' greenstone belt in the Bird River area. The mid-ocean-ridge basalt (MORB)–like basaltic rocks predominant in the Winnipeg River area are compositionally similar to the basalt formation at the north margin of the greenstone belt; these two components are correlated stratigraphically and named accordingly as the Lamprey Falls Formation.

Sporadic zones of mineralization occur within the arc-type volcanosedimentary sequence in the BRB, and prominent mineralization also occurs within the Lamprey Falls Formation. North of Bird River, the latter formation locally contains Cr–platinum group element (PGE) and minor base-metal sulphide mineralization in gabbroic sills assumed to be related to the mafic-ultramafic Bird River Sill. Lamprey Falls Formation basalt on the south shore of the Winnipeg River contains a conspicuous 65 m wide zone of pyrite-pyrrhotite-chalcopyrite mineralization associated with a volcanic exhalitive unit of chert and oxide-facies iron formation.

Introduction

Geological investigations were initiated in 2005 in the Neoarchean BRB of southeastern Manitoba (Figure GS-17-1). Mapping and thematic geological studies were undertaken jointly by the Manitoba Geological Survey (MGS) and the University of Waterloo, supported by funding from the Natural Sciences and Engineering Research Council of Canada (NSERC) and financial support provided by Gossan Resources Limited, North American Palladium Ltd., Mustang Minerals Corp. and Tantalum Mining Corporation of Canada Ltd. (Tanco). The purpose of this work is both to provide an up-to-date, detailed geological map and to carry out focused geoscientific research in an area where several exploration projects are currently underway. The project is part of an ongoing initiative by MGS to upgrade geological data in areas of Manitoba where the existing maps are outdated.

Mapping by the author is one of four research projects in the BRB. The other projects are as follows: regional mapping and tectonic studies by Duguet et al. (GS-16, this volume), detailed mapping and pegmatite studies by Kremer and Lin (GS-18, this volume) and a study of the Cr and PGE-hosting, mafic-ultramafic Bird River Sill by Mealin (GS-19, this volume). This report presents the results of 1:20 000 scale geological mapping of supracrustal rocks in the BRB, with a focus on stratigraphy and volcanic geochemistry. Uranium-lead radiometric dating is underway to supplement the existing geochronological database in the region; new dates reported here indicate the approximate maximum ages for the deposition of two epiclastic rock formations that postdate the volcanic rocks in the BRB.

Geological mapping in 2006 was conducted by the author in the east and central parts of the BRB throughout June and July. Mapping in the Booster–Bird lakes area extended westward the area investigated in 2005 (Gilbert, 2006). In mid-July, a short mapping program was carried out in a narrow supracrustal belt in the Winnipeg River area that, although separated from the main greenstone belt by a granitoid terrane in the Birse–Shatford lakes area, is considered to be part of the BRB (Figure GS-17-2).

Exploration history, previous work and current exploration

Exploration and geological investigations in the Bird River area span the past century, dating from the pioneering work of Tyrrell (1900). Economic interest in the

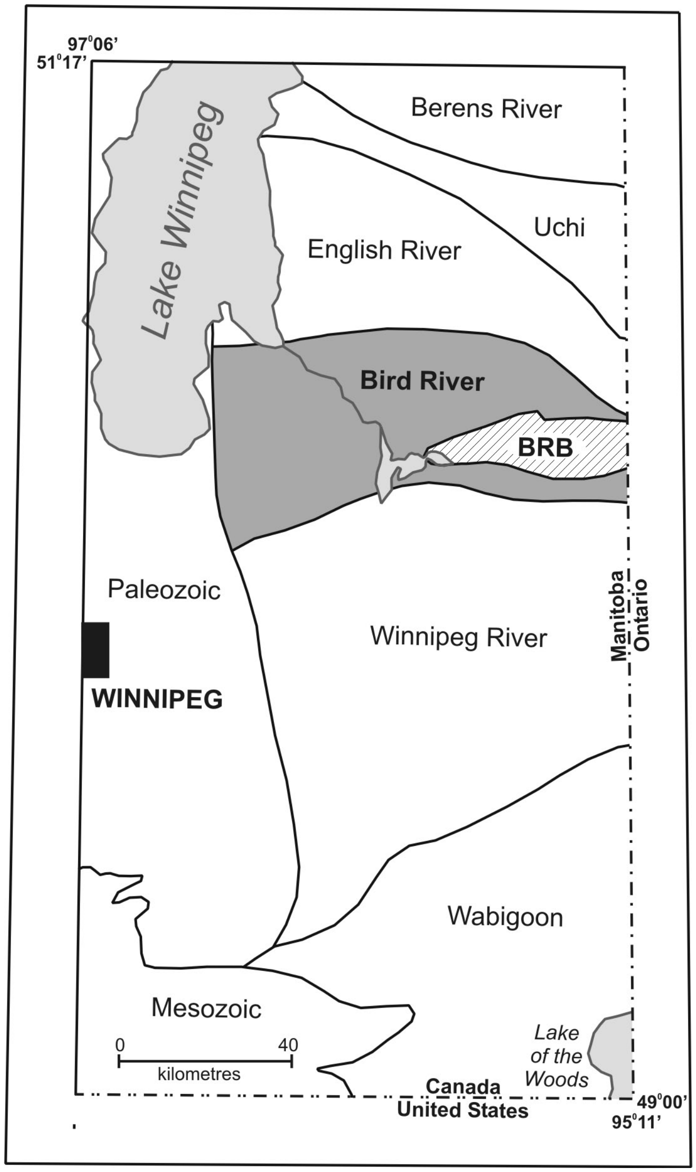


Figure GS-17-1: *Regional map showing the BRB and geological domains in southeastern Manitoba.*

region was initially focused on the potential of sporadically occurring, Mo-bearing pegmatites, as well as the discovery of Ni-Cu ore at Cat Lake in the area north of Bird Lake. Subsequent exploration was targeted on rare earth– and Sn-bearing pegmatites at Shatford and Bernic lakes, as well as chromitiferous layers in the mafic-ultramafic Bird River Sill. The Tanco mine at Bernic Lake produced Sn and Ta ore for a brief interval in 1929 and later, in the 1950s, was a source of Li; the mine became fully operational as a Ta producer in 1969. Minor amounts of Cs, Be and Rb were also formerly recovered from the ore at Bernic Lake. The Tanco mine, wholly owned by the Cabot Corporation, is currently an important source of Ta and Cs; the mine is the only Ta producer in North America and contains 60 to 80% of known world reserves of Cs.

In the central part of the BRB, Cu and Ni were produced for a decade until the mid-1970s from the Dumbarton (and subsequently the Maskwa) orebodies, located just a few kilometres north of Bernic Lake. Renewed production of Ni is planned following the delineation of significant reserves in the Maskwa orebody by Mustang Minerals Corp. (Mustang Minerals Corp., 2006). Current exploration in the BRB is focused on PGE, base metals and prospects for new sources of rare earth elements in pegmatites.

The first systematic geological mapping of the BRB was undertaken in the 1950s (Springer, 1948, 1949, 1950; Davies, 1952, 1955a, 1955b, 1956, 1957). Geological investigations were subsequently carried out by Trueman (1971), who produced a study of the Bird River Sill; the sill has also been the subject of geological investigations by Theyer (1981, 1983, 1991, 2002) and Scoates (1983, 1988; Scoates et al., 1987, 1989). The BRB was mapped by Trueman (1980) as a Ph.D. thesis. Cerny at al. (1981)

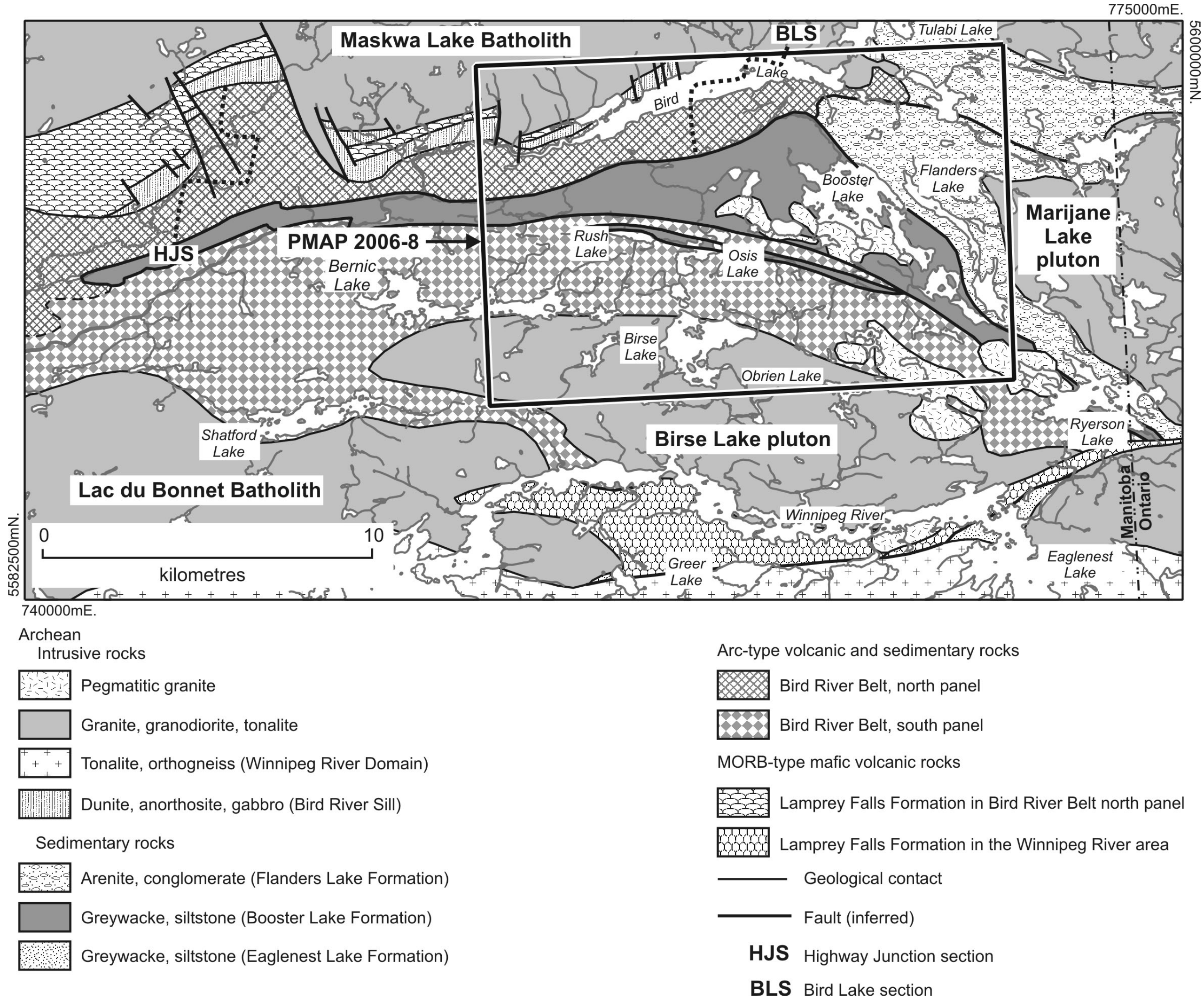


Figure GS-17-2: *Geological map of the BRB.*

provided a comprehensive study of the abundant pegmatite intrusions of the region, as well as a synthesis and interpretation of the regional geology. A 1:250 000 scale geological map (Manitoba Energy and Mines, 1987) represents the most recent compilation of the geology of the area.

Regional setting

The BRB, located between the English River Domain to the north and the Winnipeg River Domain to the south (Figure GS-17-1), has been interpreted as a collage of various tectonostratigraphic components that are deformed in a major synclinorial structure (Cerny et al., 1981). The oldest rocks are MORB-like ocean-floor or BABB-type sequences that constitute both the northernmost structural unit in the BRB and the narrow supracrustal belt approximately 20 km to the southeast, in the Winnipeg River area. Both the northern and southern MORB-like basaltic units were assigned to the 'Lamprey Falls Formation' by Cerny et al. (1981), and that term has been retained in the present mapping. (Figure GS-17-2; Table GS-17-1). The mafic-ultramafic Bird River Sill extends along the south side of the Lamprey Falls Formation in the area west of Bird Lake**.** In the Winnipeg River area, the south margin of the supracrustal sequence consists of volcanic-derived epiclastic rocks of the Eaglenest Lake Formation (Cerny et al., 1981), assumed to be in fault contact with Lamprey Falls Formation basalt.

The 'northern' Lamprey Falls Formation component at the north margin of the BRB is structurally overlain by an arc-type volcanosedimentary assemblage that constitutes the main part of the greenstone belt. The arc-type sequence was subdivided into the Bernic Lake and Peterson Creek formations by Cerny et al. (1981), but current mapping by the author has indicated a need for a re-evaluation of these stratigraphic subdivisions; hence, the previous terminology has not been adopted in this report. Available U-Pb zircon dates (Wang, 1993) are consistent with a slightly younger age for rhyolitic rocks in the arc-type assemblage (Peterson Creek Formation,

Table GS-17-1: Geological formations in the BRB.

Late intrusive rocks
Granite, pegmatite, granodiorite, tonalite, quartz diorite (Lac du Bonnet Batholith, **2660 ±3 Ma**)
Sedimentary rocks
FLANDERS LAKE FORMATION **(2697 ±18 Ma)**
Lithic arenite, polymictic conglomerate
================== *Fault (inferred)* ==================
BOOSTER LAKE FORMATION **(2712 ±17 Ma)**
Greywacke-siltstone turbidite, conglomerate
~~ *Unconformity* ~~~~~~~~~~~~~~~~~~
Intrusive rocks
MISCELLANEOUS INTRUSIONS
Gabbro, diorite, quartz-feldspar porphyry; granodiorite (Maskwa Lake Batholith II: **2725 ±6 Ma**) (Pointe du Bois Batholith: **2729 ±9 Ma**)
Metavolcanic and metasedimentary rocks — arc assemblage (2740 ±4 Ma)
Mafic to felsic volcanic and related intrusive rocks; greywacke-siltstone turbidite, chert, oxide-facies iron formation, polymictic conglomerate; derived gneiss and schist
Intrusive rocks
BIRD RIVER SILL (**2745 ±5 Ma**)
Dunite, peridotite, picrite, anorthosite and gabbro
================== *Fault (inferred)* ==================
Metavolcanic and metasedimentary rocks
LAMPREY FALLS FORMATION
Basalt (aphyric to plagioclase-phyric; locally pillowed, amygdaloidal or megacrystic), related volcanic breccia
================== *Fault (inferred)* ==================
EAGLENEST LAKE FORMATION
Greywacke-siltstone turbidite
Older intrusive rocks
Granodiorite (Maskwa Lake Batholith I: **2872 ±11 Ma**, **2844 ±12 Ma**)

2740 ±4 Ma) relative to the Bird River Sill, which is synvolcanic in age (2745 ±5 Ma).

Two sedimentary formations postdate the volcanic rocks by at least 7 m.y.: the greywacke-siltstone turbidite Booster Lake Formation (maximum depositional age 2712 ±17 Ma) and the fluvial-alluvial Flanders Lake Formation (2697 ±18 Ma). These data indicate a probable approximate 30 m.y. age difference between the volcanic and younger epiclastic rocks. Since the contact between these two formations has not been observed, their stratigraphic relationship and relative ages are not known. In the map of Cerny et al. (1981), these formations are in fault contact, but new data at Booster Lake indicate a possible conformable relationship. The Booster Lake turbidites extend throughout the length of the BRB, whereas the Flanders Lake sedimentary rocks are confined to the east part of the belt and extend beyond the provincial boundary to the area east of Reynar Lake in Ontario (Gilbert, 2005).

For the purpose of this report, the BRB has been divided into north and south panels, separated by the fault-bounded Booster Lake Formation that extends through the centre of the greenstone belt (Figure GS-17-2). The north panel consists of the 'northern' Lamprey Falls Formation component and the volcanosedimentary sequence immediately to the south that extends to the north margin of the Booster Lake Formation. The south panel consists of the predominantly volcanic sequence that extends southward from the Booster Lake Formation to the granitoid pluton at Birse Lake.

BRB south panel: Booster–Birse lakes section

The south panel of the BRB in the area east of Bernic Lake consists of a diverse assemblage of rhyolitic and basaltic rocks that are assumed to be in intrusive contact with the Birse Lake pluton to the south, and juxtaposed along a faulted contact against south-facing Booster Lake turbidites to the north (Figure GS-17-2). At both the north and south margins of this volcanic sequence, basaltic units up to 0.5 km thick display well-preserved north-facing pillows. The sequence between, and apparently conformable with, the flanking mafic units consists mainly of felsic volcanic rocks, with minor intercalated basalt, that lack stratigraphic facing indicators (Gilbert, 2006).

The felsic and intercalated mafic volcanic rock units in the Booster–Birse lakes section are characterized by a lensoid configuration of units that apparently reflects their original distribution rather than a tectonic interleaving. Contacts between the mafic and felsic volcanic rocks are rarely seen but, where they are exposed, the units appear to be in conformable contact, without conspicuous shearing (Figure GS-17-3). In contrast to the BRB north panel (*see* below), the south panel of the greenstone belt is characterized by tectonic attenuation, locally pervasive metasomatic alteration and abundant pegmatite intrusions that are hindrances to stratigraphic analysis. There is, however, sufficient evidence to show that conglomerate,

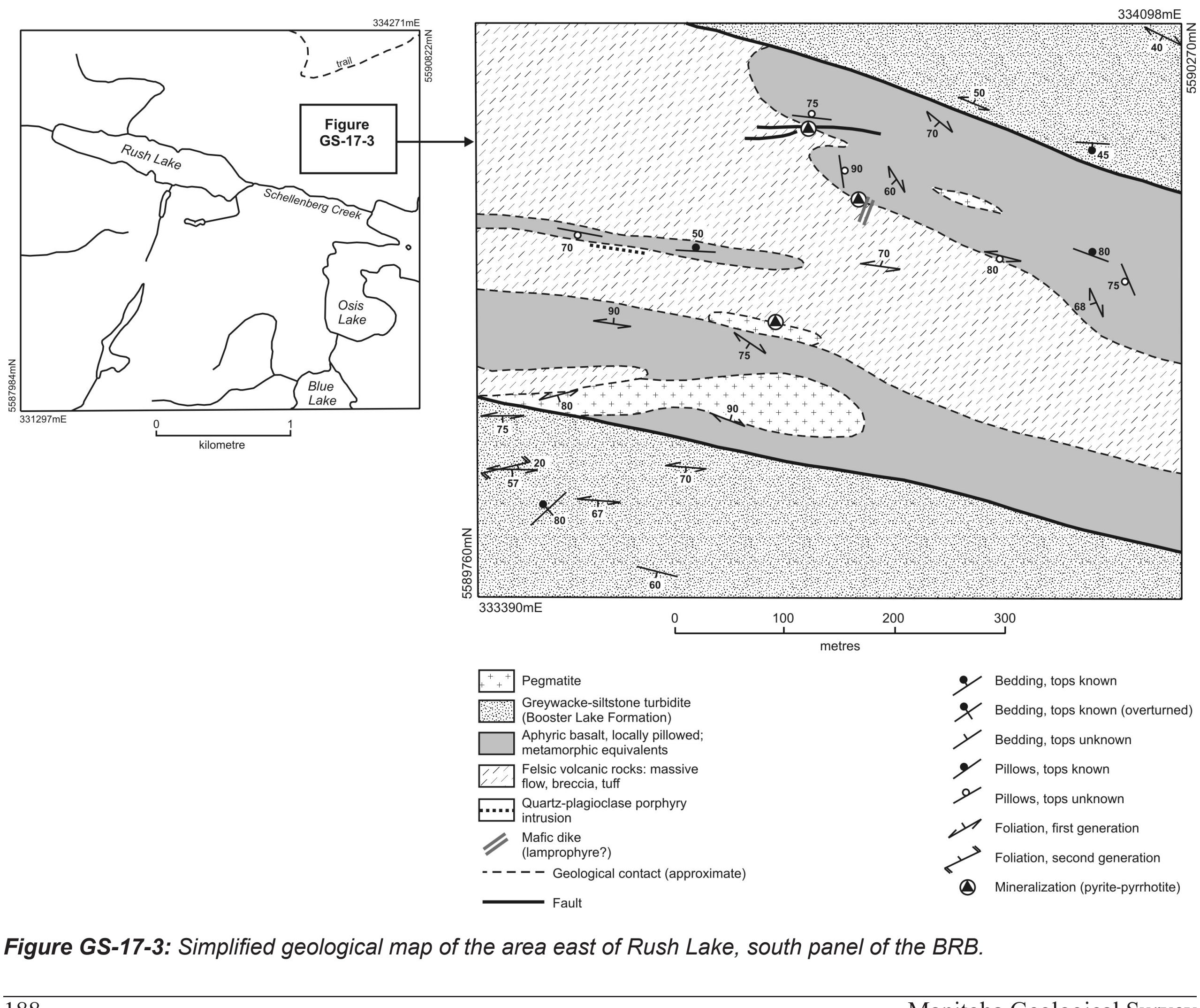


Figure GS-17-3: *Simplified geological map of the area east of Rush Lake, south panel of the BRB.*

if present at all, is not a significant part of the sequence, casting doubt on the reliability of previous mapping, which identified conglomerate as the principal component of the section (Cerny et al., 1981).

Felsic fragmental rocks and related massive flows

Felsic volcanic rocks constitute approximately half of the BRB south panel in the area east of Osis Lake and over 80% of the central part of this panel, between the flanking basaltic units at the north and south margins (Figures GS-17-2, -4). The majority of these felsic rocks are fragmental, but massive extrusive and intrusive rhyolitic units occur sporadically within the sequence. Most felsic fragmental rocks in the south part of the sequence are heterolithic and consist of detritus of probable pyroclastic origin that is locally reworked, whereas most felsic breccia units in the north part of the sequence are monolithic, closely associated with extrusive rocks and assumed to be autoclastic in origin. The northernmost 150 m of the felsic volcanic section in the area east of Osis Lake consists of a sequence of massive rhyolite, breccia and felsic tuff that possibly represents an upward-fining sequence to the north.

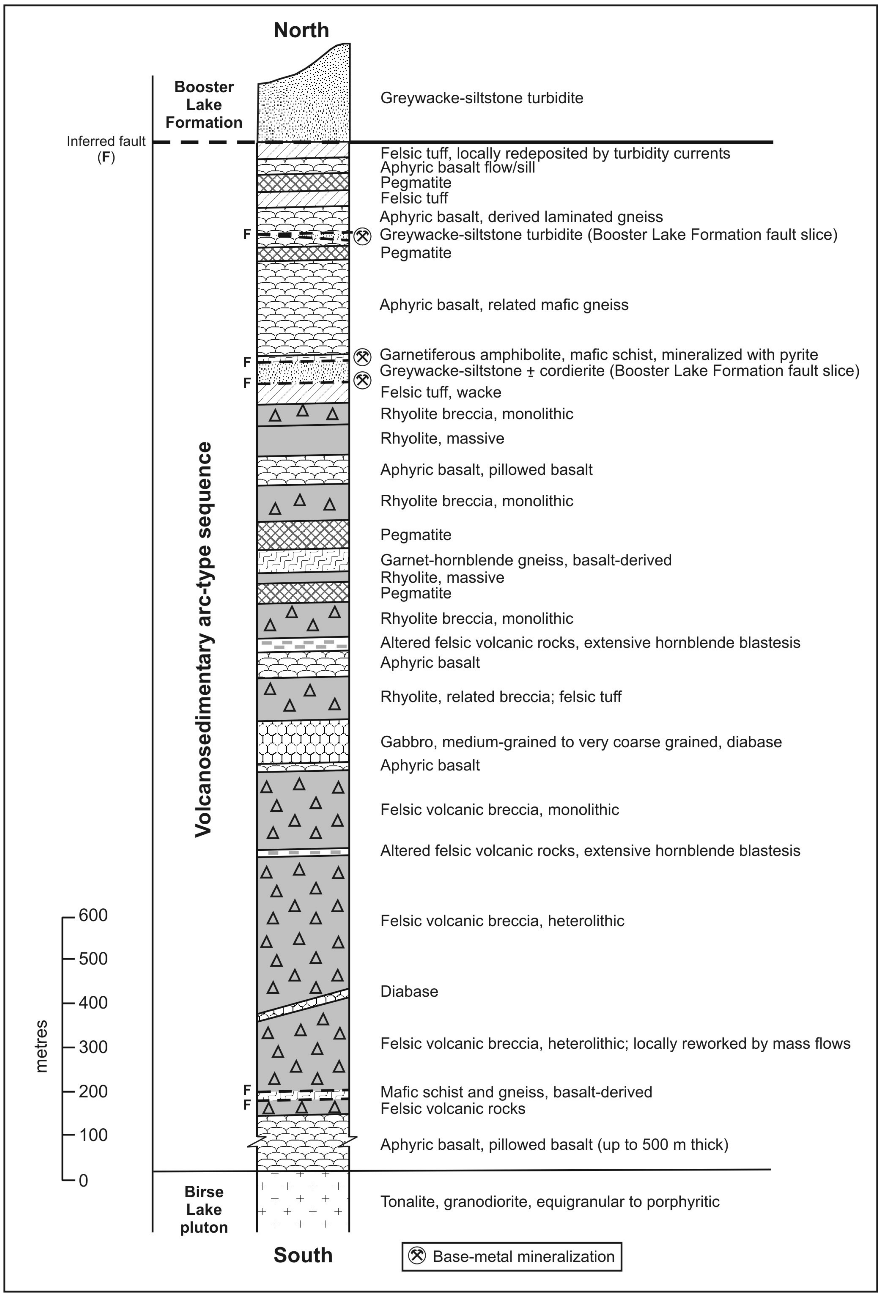


Figure GS-17-4: *North-south stratigraphic section of the south panel of the BRB from the Booster Lake Formation to Birse Lake (Booster-Birse lakes section).*

Heterolithic felsic volcanic breccia

Heterolithic felsic volcanic breccia contains angular, plagioclase±quartz-phyric rhyolite fragments, as well as minor intermediate to mafic types. The tuffaceous, felsic to intermediate matrix contains evenly distributed plagioclase grains and is locally characterized by pervasive metasomatism (Figure GS-17-5a). Domains of mafic alteration are locally tectonically disrupted and appear similar to primary fragments. The heterolithic breccia is generally devoid of original layering but, at one locality in the lower part of the section, felsic and sporadic mafic fragments are sorted and graded in 10 to 25 cm thick lensoid units (Figure GS-17-5b). The clasts are angular to subangular and the unit is interpreted as a reworked pyroclastic deposit, possibly emplaced by mass flow.

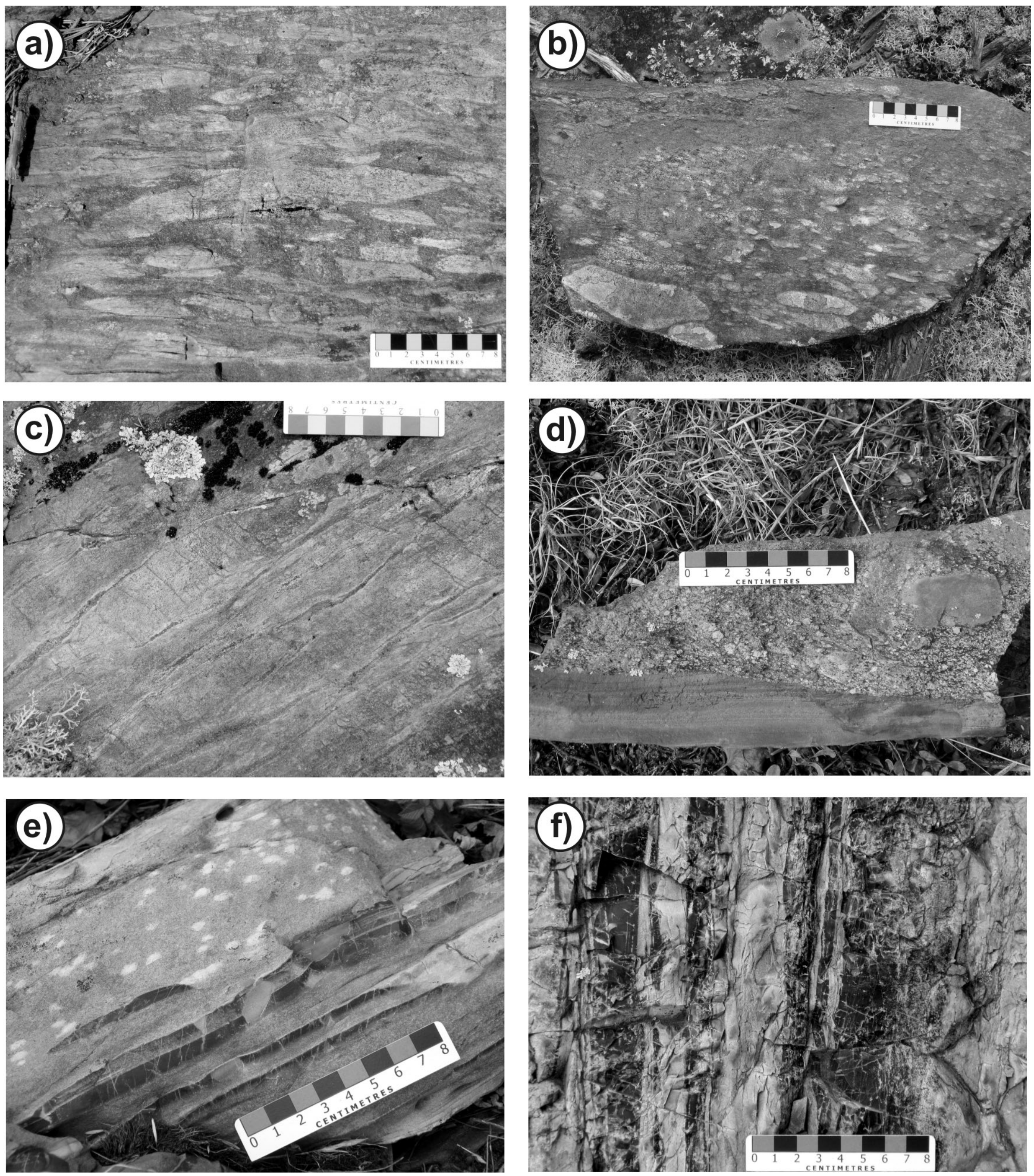


Figure GS-17-5: ***a)*** *Heterolithic felsic breccia with altered mafic matrix (BRB south panel);* ***b)*** *reworked felsic volcanic breccia displaying normal size-grading (BRB south panel);* ***c)*** *thermal contraction fractures in massive rhyolite flow (BRB south panel);* ***d)*** *laminated tuff scoured by sediment gravity flow that deposited the overlying lapilli tuff bed (Highway Junction section, unit 1W);* ***e)*** *scoured chert laminae with rip-ups in greywacke turbidite (Highway Junction section, unit 3W);* ***f)*** *bedded chert within 23 m thick member (Highway Junction section, unit 5W).*

Monolithic felsic volcanic breccia

Monolithic felsic volcanic breccia occurs both as minor fragmental zones within massive rhyolite flows and as more conspicuous breccia deposits that contain subordinate massive components. One breccia unit, located close to the southeast corner of the map area (Gilbert, 2006), is up to 200 m thick and consists of a monolithic assemblage of pebble- to cobble-sized, angular rhyolitic fragments in a felsic matrix. Spherulitic texture is locally characteristic of both the fragments and matrix, which is thus assumed to have been originally magmatic (as opposed to tuffaceous) in origin.

Felsic tuff

Felsic tuff is common in the upper part of the Booster–Birse lakes section. One 65 m thick tuff unit at the top (north margin) of the sequence extends laterally for over 4 km in the area between Osis Lake and the south part of Booster Lake (Gilbert, 2006). The rock contains detrital felsic grains and localized, fine diffuse laminae but is otherwise devoid of bedding. Farther east, the same unit is characterized by more conspicuous bedding (at a scale of 0.5–4 cm), minor siltstone laminae and detrital grains of quartz and plagioclase up to 5 mm, suggesting the tuffaceous rocks were locally redeposited by turbidity currents, together with finer grained detritus.

Massive rhyolite

Massive rhyolite flows constitute a minor part of the Booster–Birse lakes section. The flows are typically 10 to 20 m wide and locally characterized by a plagioclase-(quartz)-phyric texture that confirms their magmatic origin; in some units, thin anastomosing micaceous stringers are interpreted as derived from thermal contraction fractures, subparallel to the surface of the volcanic flow (Figure GS-17-5c). Some flows contain zones of in situ brecciation that are gradational with autoclastic breccia domains.

Alteration in felsic volcanic rocks

Primary features in felsic volcanic rocks within the BRB south panel are locally obscured by metasomatic alteration and subsequent metamorphic recrystallization. Such alteration occurs both as sporadic minor domains and in a conformable metasomatic zone in the central part of the felsic fragmental sequence that is characterized by pervasive hornblende blastesis (Figure GS-17-4). Immediately east of Osis Lake, this metasomatic zone is associated with a ground magnetic anomaly and contains several mineralized pyritic units over a 10 m wide interval. The mineralization occurs north of a coarsely porphyroblastic, 18 m thick unit of chlorite-sericite-cordierite(?)-bearing gneiss. A conspicuous aeromagnetic anomaly that coincides with the mineralized zone extends along strike for more than 10 km from Osis Lake to the area south of Summerhill Lake (Gilbert, 2006; Geological Survey of Canada, 1966).

Basalt, aphyric, mostly pillowed; related amphibolite and mafic gneiss

Basaltic units, ranging from 10 to 500 m in thickness, are intercalated with felsic volcanic units in the BRB south panel. The thickest and best preserved of these mafic units occur at or close to both the north and south margins of the Booster–Birse lakes section. Basaltic rock units in the stratigraphic interval between the northern and southern units are compositionally similar to, but typically more altered and deformed than, the flanking mafic volcanic units. Reliable pillow-top indicators are largely confined to the latter units, which are north facing in both cases.

The basalt is aphyric with moderate-sized pillows, typically 0.5 to 1 m long, and sporadic larger pillows up to 2.5 m by 0.7 m. Dark grey or yellow-grey weathering selvages reflect secondary chloritic and epidotic minerals, respectively. Tectonic attenuation varies from moderate to severe, but locally the mafic flows are almost undeformed, due to the fact that tectonic strain was confined to narrow (0.5–1 m) incompetent zones in which the basalt was altered to mafic schist and gneiss. Polygonal cooling fractures occur in one flow in the south part of the Booster–Birse lakes section. The pillowed basalt flows are assumed to be compositionally akin to juvenile-arc-type basalt. Alteration of the basalt to more siliceous and/or feldspathic compositions, which is interpreted to be due to synvolcanic hydrothermal fluids, occurs both at a small, within-pillow scale and also in larger, conformable zones that are locally associated with pyritic mineralization.

A conspicuous alteration zone occurs at the south margin of the thick (450 m) pillowed basalt unit that extends along the north flank of the BRB south panel Gilbert, 2006). This zone was examined at three localities over a strike length of 8 km. At the easternmost locality, intense silicification occurs over a 3 m wide zone that is part of a wider (~30 m) section where the basalt is highly attenuated and variously altered to quartz-plagioclase-hornblende-garnet gneiss, characterized by localized pervasive quartz veins and patchy gossan staining. Approximately 5 km west-northwest, stratigraphically equivalent basalt at the margin of the same volcanic unit is pervasively altered and characterized by chloritic schist, garnet-bearing gneiss and massive, very coarse grained garnetite over a 20 m wide zone. These garnetiferous gneisses locally contain pyrite-pyrrhotite mineralization, extensive gossan staining and a spatially associated magnetic anomaly. Similar pyrite-pyrrhotite mineralization is present at the same stratigraphic horizon near the east end of Rush Lake, approximately 8 km west-northwest of the first-described occurrence. At the

Rush Lake locality, the mineralization occurs at the contact between basalt and rhyolite, and is associated variously with a) a shear zone oblique to the volcanic rock contact, and b) a mafic (lamprophyre?) dike that intersects the contact.

BRB north panel

The BRB north panel is that part of the greenstone belt between the Maskwa Lake Batholith to the north and the Booster Lake Formation to the south (Figure GS-17-2). Compared to the BRB south panel, the north panel is both lithologically more diverse and, in general, better preserved, thus facilitating detailed stratigraphic analysis. Reconnaissance mapping and detailed north-south transects through the BRB north panel have led to a provisional interpretation that the section is a south-facing monocline.

The MORB-like Lamprey Falls Formation is the northernmost component of the BRB and is structurally overlain by volcanic and sedimentary rocks to the south that are geochemically akin to modern arc-type volcanic rocks (Gilbert, 2005). A major structural break is inferred between these two components on the basis of their contrasting geochemical affinity and, locally, a conspicuous topographic lineament at the contact that may correspond to a major fault or shear zone. The mafic to ultramafic Bird River Sill is coincident with a part of this structural discontinuity and is locally seen to intrude the Lamprey Falls Formation (Mealin, GS-19, this volume). South of the Bird River Sill, a stratigraphic disconformity within the arc-type sequence is indicated by a 75 m wide, polymictic conglomerate unit.

Lamprey Falls Formation

The Lamprey Falls Formation at the north margin of the BRB, which is geochemically akin to modern BABB (Gilbert, 2005), consists mainly of massive to pillowed, aphyric flows that are invariably south facing. Basaltic flow-breccia, mafic tuff and synvolcanic gabbro are subordinate components, and a unit of plagioclase-megacrystic basalt occurs close to the top of the formation (Trueman, 1980). South of the Lamprey Falls basalt, structurally overlying arc-type rocks have been interpreted as relatively younger (Cerny at al., 1981; Gilbert, 2005; Duguet et al., 2005). This interpretation is supported by the occurrence, within the Lamprey Falls Formation, of a younger porphyritic andesite dike with an arc-type rare earth element (REE) profile that is virtually identical to that of a porphyritic basalt flow within the arc-type sequence (Figure GS-17-6a). Mid-ocean-ridge basalt (MORB)–like

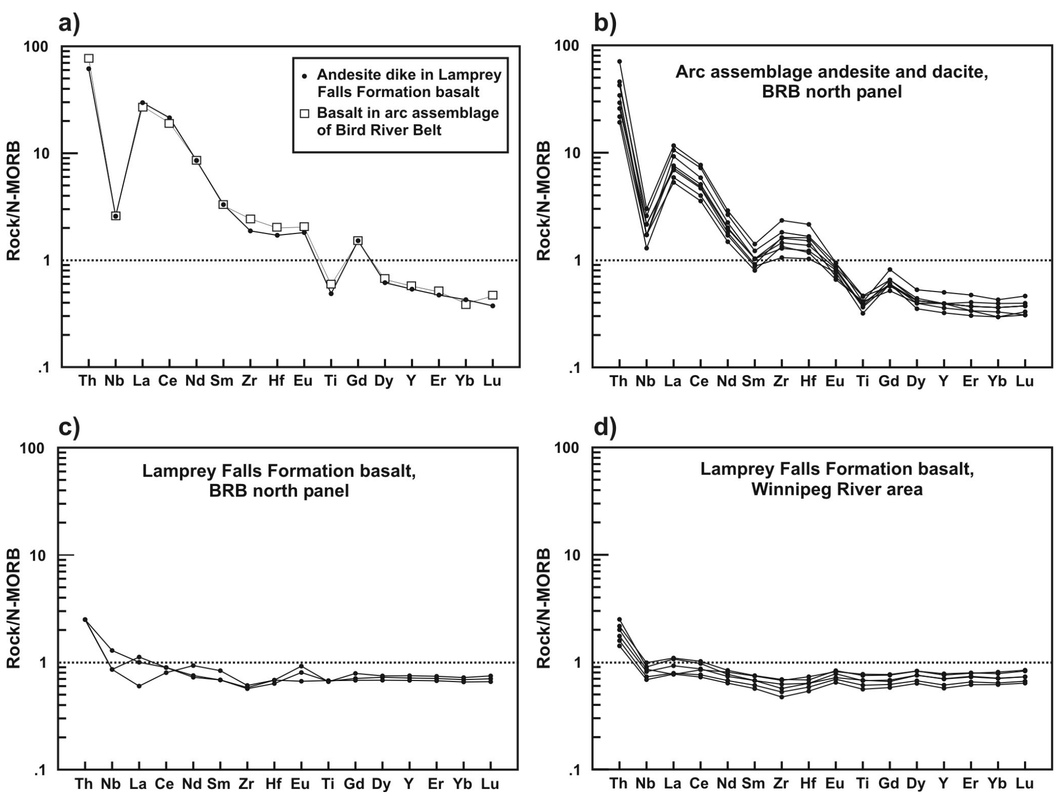


***Figure GS-17-6:** Extended element plots of **a)** plagioclase-phyric basalt flow of juvenile-arc affinity within the volcanosedimentary section, north panel of the BRB and a porphyritic andesite dike of juvenile-arc affinity, emplaced within Lamprey Falls Formation basalt, 20 km west of the flow; **b)** arc assemblage basalt in the BRB north panel; **c)** mid-ocean-ridge basalt (MORB)–like Lamprey Falls Formation basalt in the BRB north panel; **d)** MORB-like Lamprey Falls Formation basalt at the Winnipeg River. Normalizing values are after Sun and McDonough (1989).*

Lamprey Falls Formation basalt in the BRB north panel and geochemically analogous Lamprey Falls basalt at the Winnipeg River exhibit flat, slightly depleted REE patterns (relative to N-MORB) with moderately elevated Th content, in contrast to the profiles of BRB arc assemblage volcanic rocks (Figure GS-17-6b, -6c, -6d).

Arc-type volcanosedimentary sequence

Two transects were made through the volcanosedimentary sequence in the BRB north panel (Figure GS-17-2): a western transect ('Highway Junction section') in the vicinity of the junction between Provincial Roads 314 and 315, and an eastern transect in the Bird Lake area. Stratigraphic units in the western transect (Figure GS-17-7) are numbered 1W to 15W, to distinguish them from units 1E to 8E in the eastern transect (*see* 'Bird Lake section' below). No correlation is implied between units with the same number in these two stratigraphic sections. Brief summaries of the two stratigraphic sections are provided in this report; more detailed lithological descriptions of individual rock units are provided in Data Repository Item DRI2006002[1].

[1] MGS Data Repository Item DRI2006002, containing the data or other information sources used to compile this report is available online to download free of charge at www2.gov.mb.ca/itm-cat/freedownloads.htm or on request from minesinfo@gov.mb.ca, or Mineral Resources Library, Manitoba Science, Technology, Energy and Mines, 360–1395 Ellice Avenue, Winnipeg, MB R3G 3P2, Canada.

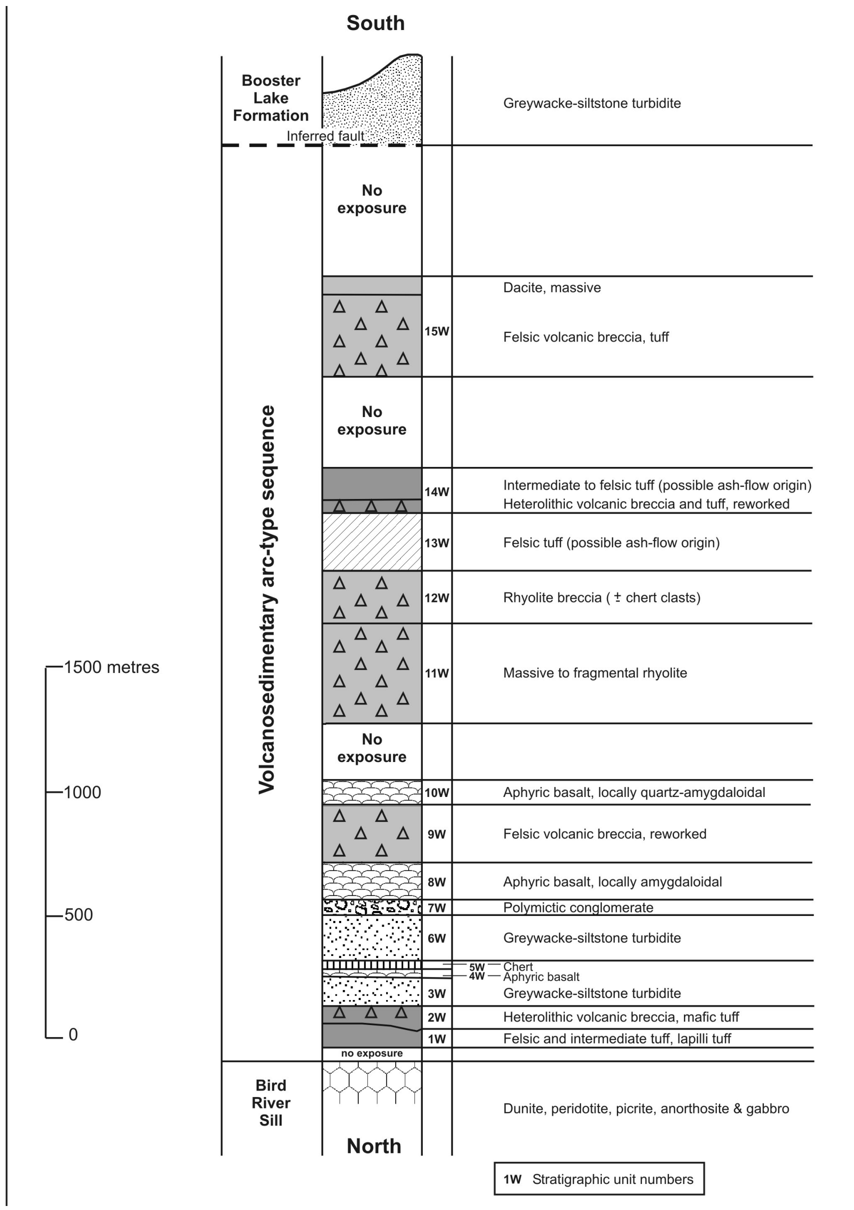


Figure GS-17-7: *South-north stratigraphic section of the north panel of the BRB, in the vicinity of the junction between Provincial Roads 314 and 315 ('Highway Junction section').*

Highway Junction section

The 3.75 km Highway Junction section contains fifteen separate map units in a predominantly south-facing sequence. The northernmost 0.65 km part of this section comprises seven units that consist exclusively of sedimentary and reworked volcaniclastic rocks, except for a minor unit of aphyric pillowed basalt. Southward stratigraphic facing in this northern part of the section is indicated by exceptionally well preserved turbidite features within the epiclastic rock units, as well as by scouring in reworked volcaniclastic rocks at the base of the sequence (Figure GS-17-5d). Localized folding, however, is indicated approximately 0.5 km above the base by a north-facing scoured contact within south-facing turbidite beds. Duguet et al. (GS-16, this volume) also reported top reversals in this part of the sequence. The remaining part of the Highway Junction section consists of felsic and subordinate mafic flows and volcanic fragmental rocks that were locally redeposited by subaqueous mass flows.

Stratigraphic transect

The northernmost seven units (1W to 7W) of the Highway Junction section (Figure GS-17-7) consist of a diverse assemblage of felsic to mafic tuff, related epiclastic deposits and minor basalt. Rip-ups, load structures, scour and disrupted bedding in the clastic rocks suggest a high-energy depositional environment characterized by turbidity currents and possible gravity-induced mass flows (Figure GS-17-5e). A 15 to 30 m thick, aphyric basalt unit (4W) is an apparently conformable member within this volcaniclastic-epiclastic sequence. A conspicuous, 23 m thick chert member (unit 5W; Figure GS-17-5f) overlying the basalt is locally disrupted and folded due to soft-sediment deformation.

Polymictic conglomerate (unit 7W) derived mainly from basalt (Figure GS-17-8a) constitutes the uppermost sedimentary unit within the northern, epiclastic-volcaniclastic part of the Highway Junction section. The unsorted conglomerate is approximately 75 m thick and contains cobbles and sporadic boulders up to 65 cm by 12 cm, including clasts of banded chert (Figure GS-17-8b) that match closely the well-bedded chert of unit 5W, approximately 175 m stratigraphically below the conglomerate deposit (Figure GS-17-5f).

The central part of the Highway Junction section consists of aphyric basalt and massive to fragmental rhyolite (units 8W to 12W; Figure GS-17-8c), as well as felsic lithic-crystal tuff of possible ash-flow origin (unit 13W). No stratigraphic facing indicators were observed in the sequence from unit 8W to 13W, but a reworked volcaniclastic deposit to the south (unit 14W) displays scour, rip-ups (Figure GS-17-8d), graded bedding and flame structures that indicate the unit is south facing. The uppermost unit in the sequence (15W) consists of felsic volcanic fragmental rocks, related dacite and intrusive porphyry.

Bird Lake section

Stratigraphic details of the northern, 0.5 km to 1 km wide part of the Bird Lake section (Figure GS-17-9) are incomplete because much of the section there is covered by the lake, but some comparisons can be made between this part of the Bird Lake section and the Highway Junction section (Figure GS-17-7) on the basis of facies types. Higher metamorphic grade and stronger deformation in the Bird Lake section have apparently resulted in the loss of some primary features, thus hindering direct comparison between individual, lithologically defined units within the two sections.

The north part of the Bird Lake section is a predominantly epiclastic sequence that is assumed to correspond to the lower (northern) part of the Highway Junction section (Figure GS-17-7, units 1W–7W). Stratigraphic-top indicators are virtually absent in the Bird Lake area, but the section is assumed to face south on the basis of its similarity with the sequence in the south-facing Highway Junction section to the west. A single case of south-facing crossbeds in the west part of Bird Lake is consistent with this interpretation. The south parts of both sections consist largely of massive to fragmental felsic volcanic rocks and related intrusive units. The Bird Lake sequence appears to be relatively less diverse overall; for example, there are no counterparts of several units that were documented in the Highway Junction section (e.g., 1W, 2W, 5W, 7W and 14W). On the other hand, in the latter section, there are no analogues to the oxide-facies iron formation and remarkable porphyroblastic metasedimentary rocks that occur in the central and west parts of Bird Lake.

Stratigraphic transect

Fine-grained metasedimentary rocks interpreted as turbidite deposits (Figure GS-17-9, unit 1E) extend for over 3.5 km along the south shore of eastern Bird Lake; the estimated maximum width of the unit is 0.65 km. A massive to fragmental, felsic volcanic unit over 200 m thick (unit 2E) occurs within the north (inferred lower) part of unit 1E. The felsic rocks underlie islands in the east-central part of Bird Lake (Dean Islands; Gilbert, 2006), so contact relationships between units 1E and 2E are not seen.

Aphyric, pillowed basalt (unit 3E), assumed to overlie the thick turbidite sequence (unit 1E), has been mapped at two localities in the eastern Bird Lake area. The mafic flow unit is at least 110 m thick where it intersects Booster Creek, immediately north of Provincial Road 315; a pillowed basalt flow interpreted as stratigraphically equivalent occurs 3 km farther west, on a small island close to the south shore of Bird Lake. This flow is

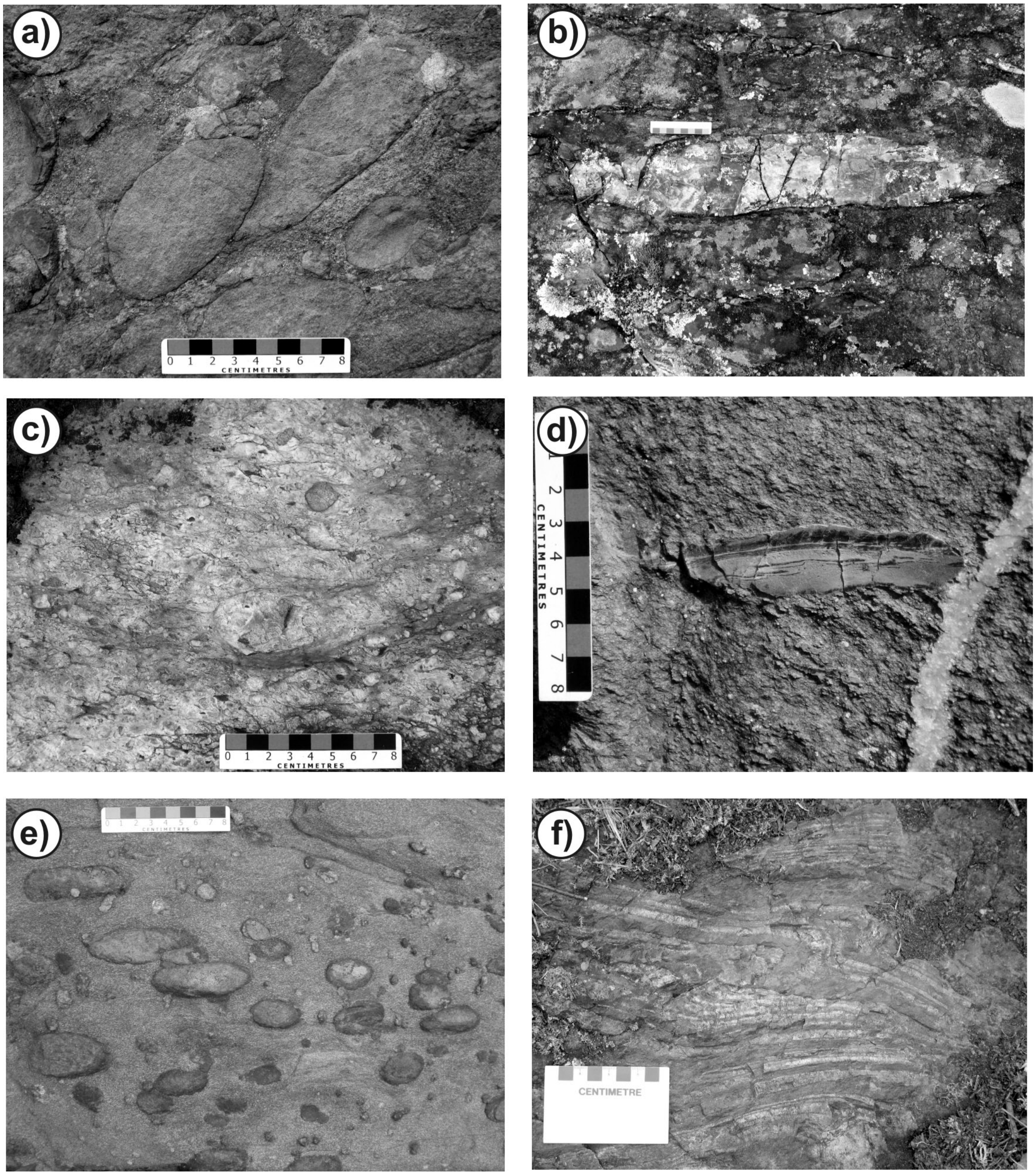


Figure GS-17-8: ***a)*** *Polymictic conglomerate (Highway Junction section, unit 7W);* ***b)*** *Layered chert boulder in polymictic conglomerate (Highway Junction section, unit 7W);* ***c)*** *Massive rhyolite with breccia domains (Highway Junction section, unit 11W);* ***d)*** *Chert rip-up in lapilli tuff, interpreted as a reworked volcaniclastic deposit (Highway Junction section, unit 14W);* ***e)*** *Garnet and oval cordierite porphyroblasts in metasiltstone (Bird Lake section, unit 4E);* ***f)*** *Bedded chert and magnetiferous siltstone (Bird Lake section, unit 6E).*

apparently conformable with a 6 m thick mineralized oxide-facies iron formation to the south, which is associated with porphyroblastic metasiltstone (Figure GS-17-8e), gneiss and amphibolite (unit 4E).

South of the iron formation (unit 4E), a 1.25 km thick sequence of massive and related fragmental rhyolite (unit 5E) extends throughout the area south of Bird Lake between Provincial Road 315 and the Booster Lake Formation (Gilbert, 2006). At least two massive rhyolite phases can be distinguished: sparsely plagioclase phyric and coarsely quartz-plagioclase phyric. Garnetiferous gneiss derived from altered felsic volcanic rock occurs sporadically within unit 5E. The south margin of the unit is strongly mylonitized close to the contact with the Booster Lake Formation.

Oxide-facies iron formation (unit 6E) occurs within

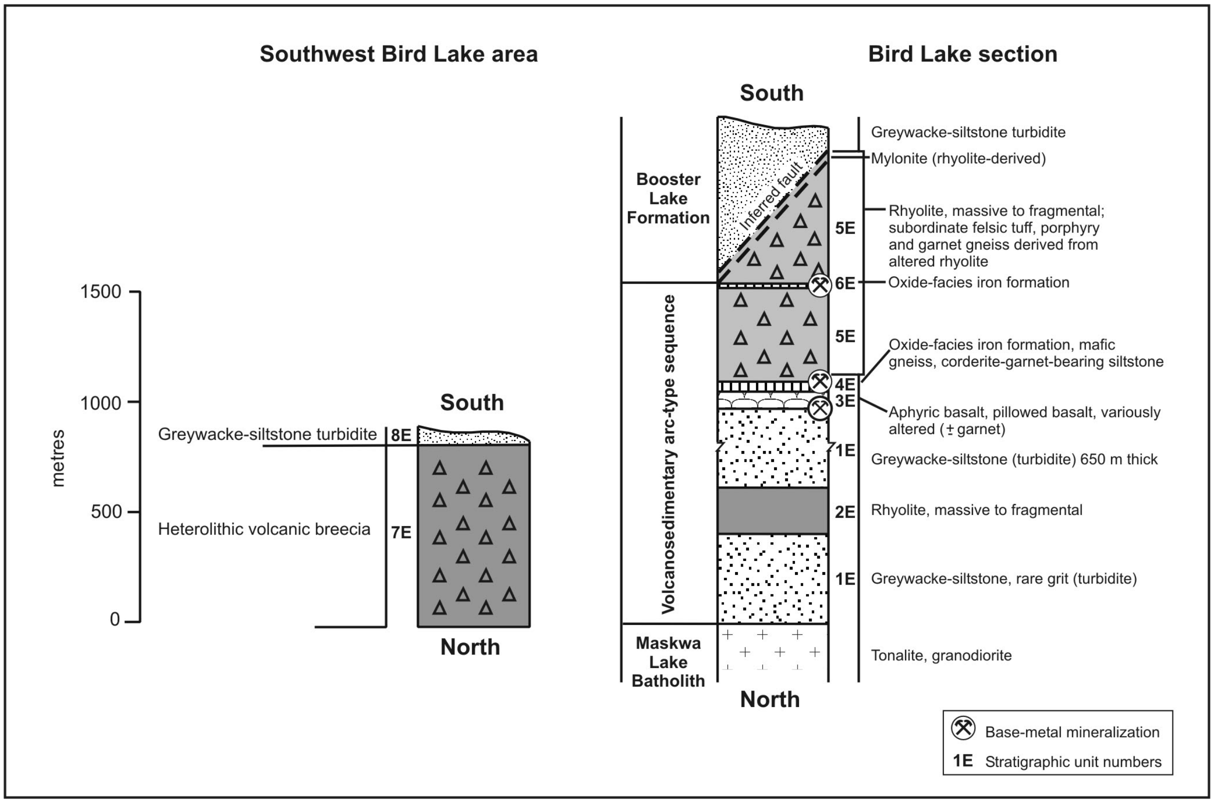


Figure GS-17-9: *South-north stratigraphic section of the north panel of the BRB, from the Booster Lake Formation to Bird Lake ('Bird Lake section').*

the felsic volcanic sequence (unit 5E) at a locality east of Booster Creek (Gilbert, 2006). Unit 6E consists of thinly interlayered magnetiferous siltstone and chert in units up to 8 m thick (Figure GS-17-8f). Patchy pyrite mineralization is characteristic of these strata, which are associated with a prominent positive aeromagnetic anomaly (Geological Survey of Canada, 1966).

Southwest Bird Lake area

Heterolithic breccia (unit 7E) and turbidite deposits (unit 8E) in the southwest part of Bird Lake are of uncertain age and stratigraphic position relative to units 1E to 6E in the Bird Lake section (Figure GS-17-9). Heterolithic volcanic breccia at least 850 m thick (unit 7E) extends for 2.8 km along the south shore of western Bird Lake. The breccia contains a variety of fragment types assumed to be derived from the arc-type volcanic sequence, including mafic to felsic volcanic clasts, subordinate fine-grained tonalite and possible sedimentary detritus. The deposit is unsorted, with angular to subrounded fragments ranging up to boulder size (e.g., 1 m by 2 m; Figure GS-17-10a). Elsewhere, the breccia contains rows of small blocks, possibly aligned during mobilization and emplacement of the unit by subaqueous mass flow (Figure GS-17-10b). At several localities, the fragmental deposit contains sporadic clasts with a penetrative foliation that appears to predate emplacement of the mass flow (Figure GS-17-10c). In the southwest part of Bird Lake, the volcanic breccia (unit 7E) is porphyroblastic with small micaceous aggregates (2–4 mm), as well as larger cordierite porphyroblasts. The cordierite occurs both as rare dark blue, pseudohexagonal crystals (Figure GS-17-10d) and as elongate anhedral porphyroblasts up to 25 cm by 4 cm in size.

A well-layered turbidite deposit (unit 8E), >20 m thick, is assumed to overlie the heterolithic breccia (unit 7E) at the west end of Bird Lake. Unit 8E consists of partly carbonatized, intermediate to felsic wacke and siltstone, interlayered at a scale of 3 to 35 cm and characterized by abundant, stratabound ovoid cordierite porphyroblasts up to 1 cm long.

Both the structural setting and the age of units 7E and 8E are unknown because their contacts are not exposed. Unit 7E appears to occupy an equivalent stratigraphic position to that of the fine-grained sedimentary rocks of unit 1E in the east part of Bird Lake: both units occupy the northernmost part of the supracrustal sequence in the Bird Lake area (Gilbert, 2006). Heterolithic breccia of unit 7E locally contains foliated fragments that appear to have been metamorphosed prior to their incorporation in the mass flow deposit. If this deposit does contain previously metamorphosed detritus derived from the arc-type volcanosedimentary assemblage (units 1E to 6E), a significant difference in age is indicated between the two rock sequences. Similarly, the cordierite-bearing,

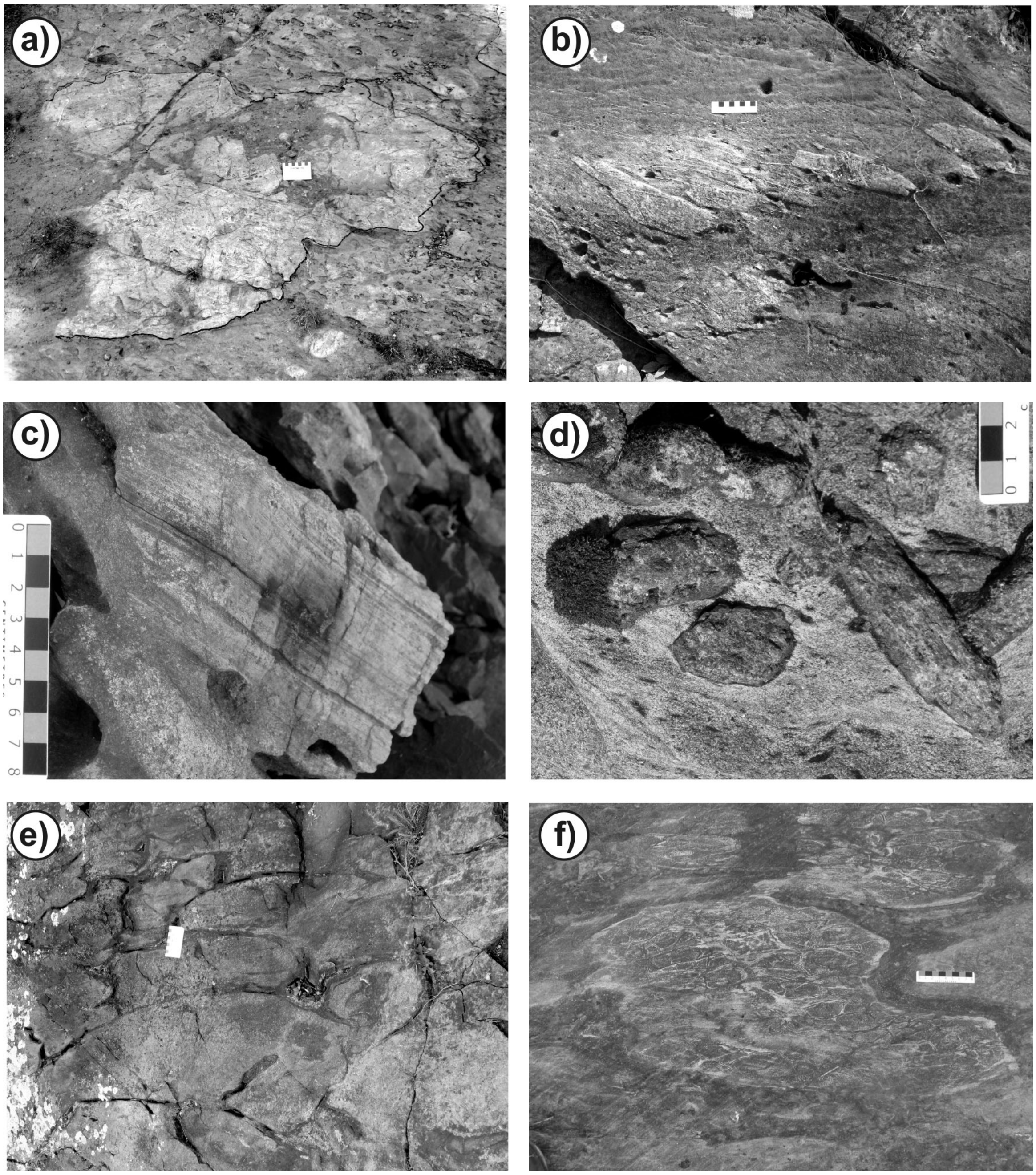


Figure GS-17-10: ***a)*** *Rhyolite boulder in heterolithic breccia interpreted as a mass flow deposit (southwest Bird Lake area, unit 7E);* ***b)*** *Aligned clasts in heterolithic breccia (southwest Bird Lake area, unit 7E);* ***c)*** *Epiclastic fragment with foliation predating incorporation in mass flow deposit (southwest Bird Lake area, unit 7E);* ***d)*** *Cordierite porphyroblasts in matrix of mass flow deposit (southwest Bird Lake area, unit 7E);* ***e)*** *Aphyric pillowed basalt (Lamprey Falls Formation, south shore of the Winnipeg River);* ***f)*** *Polygonal, metasomatic alteration pattern within pillowed basalt (Lamprey Falls Formation, south shore of the Winnipeg River).*

turbiditic sedimentary rocks of unit 8E may also postdate the arc volcanic rocks; the porphyroblastic unit is more comparable to rocks in the relatively younger Booster Lake Formation than the turbidites (unit 1E) in the east part of Bird Lake that are assumed to be part of the arc assemblage and represent an alternative analogous unit. On the other hand, there are no lithologically similar counterparts of the volcanic fragmental unit (unit 7E) in either of the two ‘younger’ BRB formations (Booster Lake and Flanders Lake formations), which are known to postdate the volcanic rocks (*see* discussion in ‘Booster Lake Formation’ below). In conclusion, units 7E and 8E are provisionally assigned to the arc-type volcanosedimentary sequence, pending further investigations of the local and regional stratigraphy.

Booster Lake Formation

New data on the turbidite sequence at Booster Lake were added this year to the mapping in 2005, which documented a series of northwest- to west-trending D_1 folds in the fine-grained epiclastic sequence (Gilbert, 2005). An additional northwest-trending, synclinal fold axis was delineated along the northeast margin of the formation, which thus has a 'back-to-back' contact relationship with northeast-facing conglomerate of the Flanders Lake Formation immediately to the northeast (Gilbert, 2006). This relationship suggests that the formational contact is unconformable and/or faulted. The turbidites are mainly intermediate in composition, but felsic wacke interbeds occur locally, especially toward the east margins of the formation at Booster and Summerhill lakes. The metamorphic grade appears to increase slightly in the southeast part of the turbidite basin.

Volcanic-derived conglomerate is interlayered with fine-grained turbidite beds along the northeast shore of the island immediately southeast of Penzick Island, in the northeast part of Booster Lake (Gilbert, 2006). The conglomerate interbeds contain fragments of aphyric basalt, rhyolite, felsic porphyry and possible quartz, which together constitute up to 60% of the rock. The clasts (pebbles, cobbles and sporadic boulders) are strongly attenuated, with elongation ratios of approximately 1:7. Conglomerate units are up to 2 m thick and intimately intercalated with greywacke, pebbly wacke and cordierite-bearing siltstone units. These strata, which are close to the hinge zone of a major synclinal fold at the northeast margin of the Booster Lake Formation, may represent the youngest rocks in the turbidite sequence. The closest rock outcrop in the stratigraphic sequence to the northeast is polymictic conglomerate of the Flanders Lake Formation. Conglomerate interbeds are found nowhere else within the turbidite section at Booster Lake, although conglomerate has been reported elsewhere in the formation, possibly confined to the west part of the turbidite basin, where it is locally associated with sulphide-facies iron formation (Cerny et al., 1981).

The stratigraphic significance of the conglomerate interbeds is uncertain. They are provisionally interpreted as part of a transitional facies between the turbidite sediments (Booster Lake Formation) and fluvial-alluvial sequence to the northeast (Flanders Lake Formation), because they appear to be unique in the east part of the turbidite basin and occur at a stratigraphic interval where relatively finer grained sediments (rather than conglomerate) might be anticipated in a waning turbidite sequence. Nevertheless, both the structural data (indicating a back-to-back relationship) and new geochronological data (*see* below) are more consistent with an unconformity between these two sedimentary formations. Further work is required to determine the significance of the interlayered greywacke-conglomerate section at this locality.

Geochronology

New U-Pb isotope data on zircons from metasedimentary rocks in the eastern BRB confirm previous interpretations that a significant age difference exists between the arc-type assemblage in the Bird Lake area (previously described as the Peterson Creek and Bernic Lake formations; Cerny et al., 1981) and younger sedimentary rocks of the Booster Lake and Flanders Lake formations (Gilbert, 2005; Duguet et al., 2005). The youngest analyzed detrital zircon in a sample of Booster Lake Formation turbidite yielded a subconcordant age of 2712 ±17 Ma, which currently serves as the best estimate for the maximum age of deposition (Figure GS-17-11). Comparing this with the 2740 ±4 Ma age for a felsic volcanic unit in the arc-type assemblage (Peterson Creek Formation; Wang, 1993) suggests an approximate 30 m.y. age difference between the Booster Lake Formation and older arc-type rocks in the BRB.

Uranium-lead isotope analysis of zircons from the Flanders Lake Formation supports this observation, but the data do not establish the relative ages of the Booster Lake and Flanders Lake formations. The U-Pb concordia plot of Flanders Lake Formation zircon data includes several relatively young but discordant zircons (Figure GS-17-11b); the youngest concordant zircon age obtained for the Flanders Lake Formation is 2697 ±18 Ma, tentatively suggesting a slightly younger maximum age for deposition of the Flanders Lake Formation relative to the age of Booster Lake turbidite sedimentation.

Two principal sources of detrital zircons are indicated by the data for both Booster Lake and Flanders Lake epiclastic rocks (Figure GS-17-12). Spikes at ca. 2710 to 2730 Ma are assumed to represent a volcanosedimentary source corresponding to arc volcanism in the BRB, whereas ca. 3025 Ma spikes are attributed to older granitoid plutonism. The relative importance of these two sources is different for the two sedimentary formations: that is, the Booster Lake Formation contains relatively more detritus from the 'older' granitoid terrane, whereas, in the Flanders Lake Formation, detritus derived from ca. 2740 Ma volcanism is predominant. The ancient (ca. 3430 Ma) zircon shown in the Booster Lake Formation (Figure GS-17-12a) is noteworthy, and may be interpreted as evidence for a detrital source component in the Winnipeg River Domain (M.T. Corkery, pers. comm. 2006).

Structural inliers in the BRB south panel

At least two fault slices of the Booster Lake Formation occur within the volcanic sequence that forms the south panel of the BRB (Gilbert, 2006). The more conspicuous of these units extends laterally for over 8 km from the area north of O'Brien Lake to the area west of Rush Lake; the fault slice is at least 130 m wide in the west but thins to between 28 and 65 m in the centre, east of Osis Lake. Turbidites in this fault-bounded

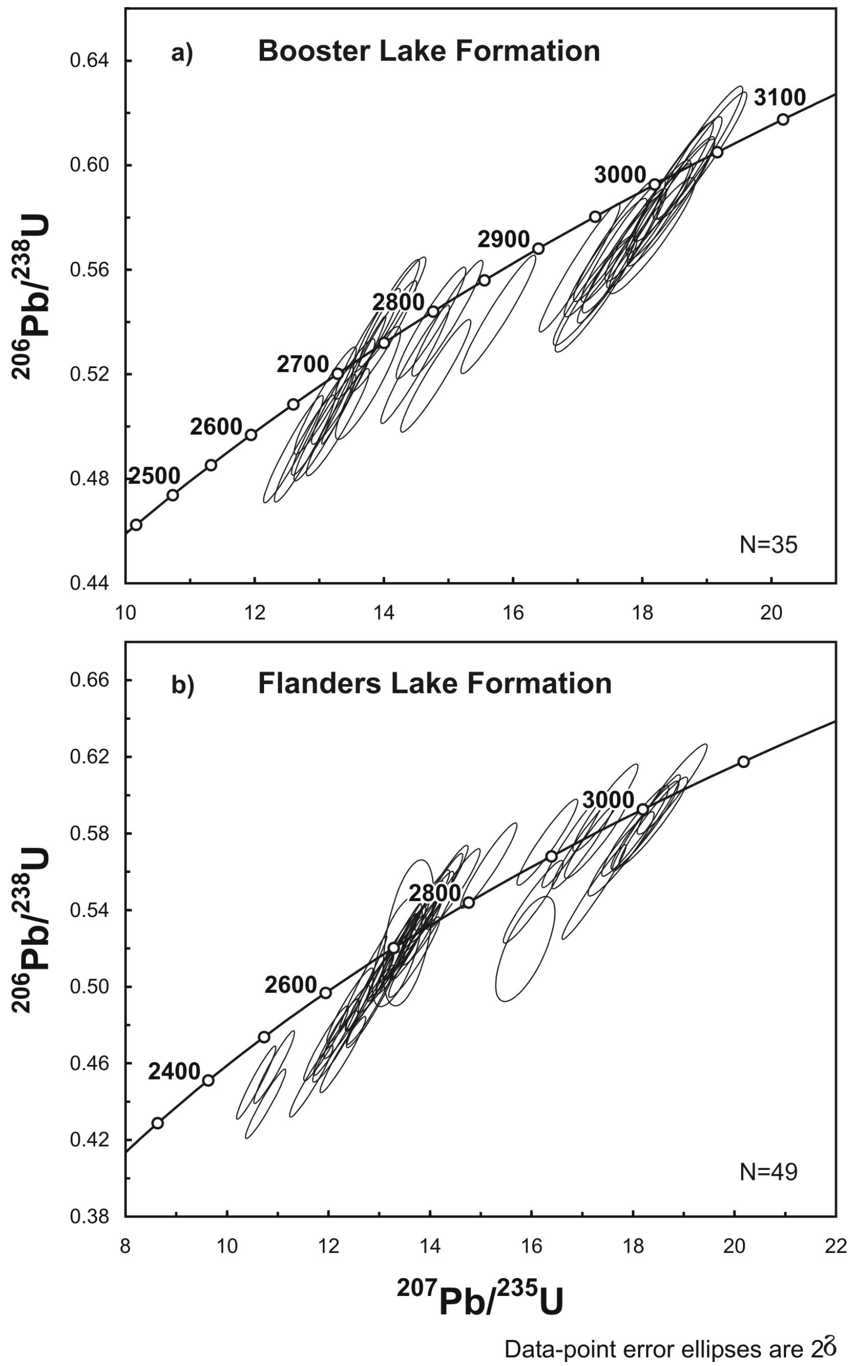


Figure GS-17-11: *Concordia plot of U-Pb zircon ages from metasedimentary rocks of the Booster Lake and Flanders Lake formations, obtained by laser-ablation multicollector inductively coupled plasma mass spectrometry (LA-MC-ICP-MS).*

unit consist of cyclic greywacke-siltstone beds that display graded bedding and local flame structures, scour and parallel lamination. Stratabound, elongate cordierite porphyroblasts (1–2 cm long) occur sporadically, especially at the north margin of the fault slice. Bedding trends in the unit vary from west-northwest (concordant) to northeast, highly discordant with the inferred bounding faults (Figure GS-17-3); thus, emplacement of the structural inlier postdated at least one early deformation event. A smaller turbidite fault slice occurs parallel to and approximately 275 m north of the first unit, in the area east of Osis Lake. The second unit is at least 40 m wide, but its lateral extent has not been determined.

Winnipeg River area

A belt of volcanosedimentary rocks, which extends along the Winnipeg River from northern Eaglenest Lake

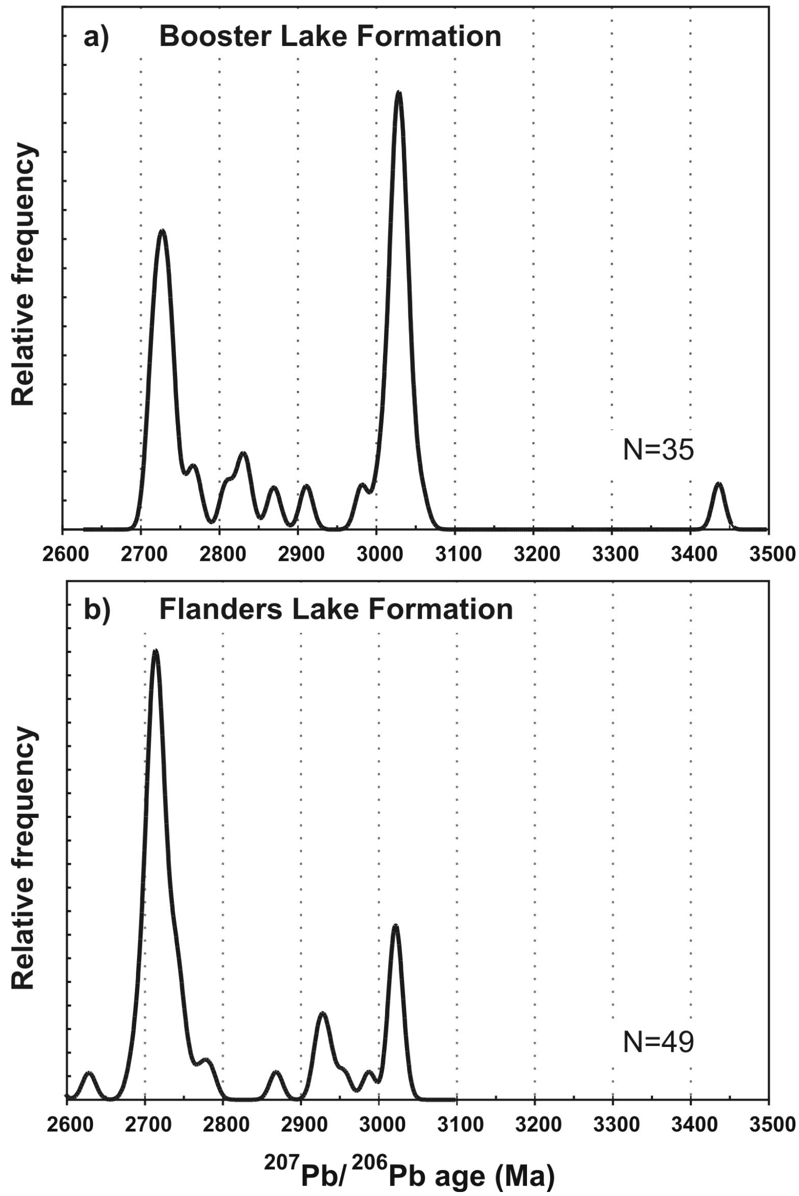


Figure GS-17-12: *Relative frequency distribution diagrams for U-Pb zircon ages from metasedimentary rocks of the Booster Lake and Flanders Lake formations obtained by laser-ablation multi-collector inductively coupled plasma mass spectrometry (LA-MC-ICP-MS). 'Relative frequency distribution' shows the frequency of each class as a part or a fraction of the total frequency for the entire distribution.*

to Lamprey Rapids (formerly know as Lamprey Falls), is separated from the 'main' BRB by a younger granitoid intrusion south of Birse Lake (Figures GS-17-2, -13). The belt at the Winnipeg River is juxtaposed along an inferred fault against rocks of the 'main' BRB in the area southeast of Ryerson Lake, close to the Manitoba–Ontario provincial boundary. The Winnipeg River Belt is bounded to the south by granitoid rocks of the Winnipeg River Domain.

The supracrustal belt at Winnipeg River consists mainly of aphyric pillowed basalt and related gabbro of the Lamprey Falls Formation and a subsidiary unit of greywacke and siltstone (Eaglenest Lake Formation) that is interpreted to be in fault contact with the Lamprey Falls Formation (Cerny et al., 1981). The mafic volcanic sequence is predominantly north facing, but local top reversals in the west part of the belt indicate the presence of a major fold structure. The fine-grained greywacke and siltstone of the Eaglenest Lake Formation in the east part of the belt young to the south and, for this reason, are interpreted to be in fault contact with the Lamprey Falls basalt immediately to the north. In the west part of the belt, a poorly exposed felsic breccia unit on the south shore of the Winnipeg River is interpreted as fault bounded and is provisionally assigned to the arc volcanic assemblage (Table GS-17-1); however, there are insufficient data to clearly establish the stratigraphic significance of this unit.

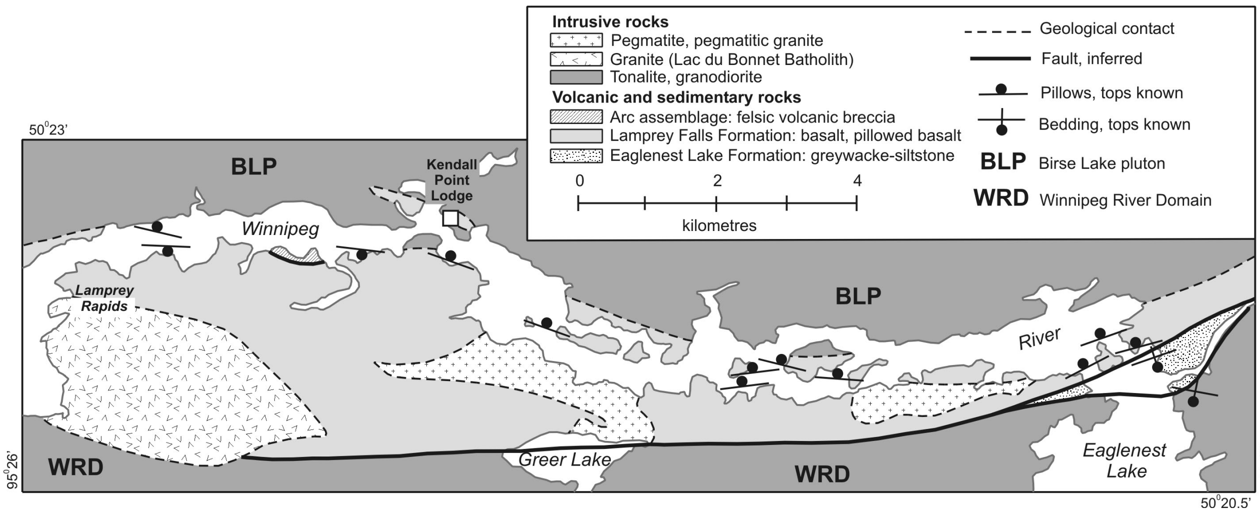


Figure GS-17-13: *Geological map of the Winnipeg River area.*

Lamprey Falls Formation

Basalt, aphyric, mostly pillowed; related amphibolite and mafic gneiss

The Lamprey Falls Formation in the Winnipeg River area is similar to the MORB-type, pillowed flow sequence, assumed to be stratigraphically equivalent, at the north margin of the BRB (Figure GS-17-2). In the Winnipeg River area, this formation is approximately 2.5 km wide and extends south to Greer Lake (Figure GS-17-13). The basalt is aphyric and commonly quartz amygdaloidal, locally with amygdule-rich domains confined to the upper margins of pillows. Pillows, typically 0.5 to 1 m in size (up to 1 m by 5 m) are commonly undeformed and provide excellent top indicators (Figure GS-17-10e). Polygonal cooling fractures were observed in one flow in the west part of the belt. The fine-grained basaltic rocks are locally altered and recrystallized, resulting in coarser grained, polygonal hornblende-plagioclase domains within individual pillows (Figure GS-17-10f). Conspicuous garnet porphyroblasts (0.5–1.5 cm) occur sporadically and, in marginal parts of the formation close to granitoid rock contacts, the basalt is recrystallized to very coarse grained garnet-hornblende-plagioclase gneiss with garnetite layers up to 0.5 m thick.

Chert, oxide-facies iron formation

Several exhalitive chert-magnetite formations occur within the Lamprey Falls basalt sequence along the south shore of the Winnipeg River. The most conspicuous of these is a 25 m wide unit that consists mainly of white-grey chert, finely laminated at 1–5 mm scale, with subordinate oxide-facies iron formation characterized by 0.5 to 3 cm thick layers of chert, chloritic amphibolite (±magnetite) and ankerite. This volcanic exhalitive unit displays widespread rusty-weathered surfaces that represent oxidized domains of secondary pyrite mineralization. An alteration zone, more than 40 m wide with pervasive pyrite-pyrrhotite-chalcopyrite mineralization, occurs immediately south of the chert and oxide-facies iron formation (*see* 'Economic considerations' section). The mineralized chert and iron formation unit was observed to extend laterally for over 0.5 km. Sporadic, minor (0.3–1.7 m thick) units of similar chert, associated with both magnetite laminae and sulphide mineralization, occur elsewhere within mafic volcanic flows in the central and western parts of the Lamprey Falls Formation. Some of these units are tectonically attenuated and discontinuous due to strike-parallel shearing. Elsewhere, a tectonically undeformed unit consists of discontinuous layers and highly irregular, lobate bodies that suggest synsedimentary incorporation of the chert into a contiguous basalt flow prior to cooling.

Arc volcanic assemblage

Felsic fragmental rocks

Felsic volcanic breccia, located approximately 2 km west of Kendall Point Lodge (Figure GS-17-13) trends east-west for over 600 m along the south shore of Winnipeg River and may extend farther west to Shatford Lake (Figure GS-17-2; Cerny et al., 1981). The fragmental unit is monolithic and contains pale grey felsic pebbles, cobbles and sporadic larger clasts (up to 35 cm by 18 cm) in a cream-weathering siliceous matrix. The breccia is moderately to strongly attenuated (fragment elongation ratios vary up to 15:1) and locally tectonically brecciated. Dark grey, elongate mafic rafts are interpreted as disrupted, early concordant diabase veins.

Eaglenest Lake Formation

Fine-grained greywacke and siltstone, interpreted as turbidite deposits (Eaglenest Lake Formation), occur at the south margin of the Lamprey Falls Formation in the north part of Eaglenest Lake (Figure GS-17-13). Whereas the north margin of the turbidite sequence is interpreted as fault bounded, the south margin is intruded by granitoid rocks of the Winnipeg River Domain to the south (Beakhouse, 1977). The turbidites are approximately 600 m thick and interpreted to be south facing, based on sporadic occurrences of graded beds, rare flame structures and rip-ups. The epiclastic sequence is characterized by finely laminated, pale grey feldspathic greywacke, dark green-grey siltstone and localized, conformable, altered and recrystallized zones of medium-grained hornblende and plagioclase. Garnet porphyroblasts and minor pyritic domains occur sporadically, and iron formation occurs close to the north margin of the section (Cerny et al., 1981).

The stratigraphic position of the Eaglenest Lake Formation is unknown. The apparent back-to-back relationship with north-facing Lamprey Falls basalt to the north supports the interpretation of a major fault between the two formations. The Eaglenest Lake turbidites are lithologically similar to epiclastic rocks assumed to be the basal stratigraphic unit of the arc assemblage at Bird Lake (Figure GS-17-9, unit 1E). If the Eaglenest Lake turbidites are, in fact, part of the arc assemblage, a younger age of deposition relative to the Lamprey Falls Formation is implied.

Economic considerations

Mineral showings were encountered in all parts of the BRB mapped in 2006, except for the turbidite sequence at Booster Lake. These mineral occurrences can be divided into the following three types: a) those associated with oxide-facies iron formation; b) those located at the lower and upper contacts of a 450 m thick basalt unit in the BRB south panel; and c) conformable mineral showings within basalt, rhyolite, felsic porphyry or fine-grained metasedimentary rocks. The most conspicuous mineralized zone of type (a) is located on the south shore of the Winnipeg River, where a 25 m wide unit of chert and oxide-facies iron formation with pyritic domains occurs within basalt of the Lamprey Falls Formation. A 40 m wide alteration zone south of the chert is characterized by pervasive pyrite-pyrrhotite-chalcopyrite mineralization; the hostrock in this mineralized zone appears to be basalt and/or siltstone. Massive sulphides occur in 1 to 2 cm wide veins and coarse disseminated aggregates (Table GS-17-2, mineralized samples (MS 1 and 2). The total 65 m width of surface mineralization is a minimum figure, because of a lack of outcrop to the south. Minor chert units elsewhere within the same volcanic flow section also contain pyritic mineralization (Table GS-17-2, MS 3).

Two mineralized zones, also coincident with oxide-facies iron formation, occur in the north panel of the BRB. At the first locality, close to the south shore of central Bird Lake, a 6 m wide section of thinly bedded chert and massive magnetite contains several rusty zones with base-metal mineralization (Table GS-17-2, MS 4). The iron formation (Figure GS-17-9, unit 4E) occurs in an inferred south-facing sequence between altered, carbonatized pillowed basalt to the north and garnet-cordierite-bearing metasiltstone to the south (Figure GS-17-8e). A narrow (1 m), mineralized magnetiferous zone also occurs at this locality, immediately south of the basalt unit (Table GS-17-2, MS 5). Mineralized rocks at the lakeshore approximately 1 km farther west (Table GS-17-2, MS 6) are interpreted as part of the same stratigraphic unit. The second mineralized iron formation (Figure GS-17-9, unit 6E) is located south of Bird Lake within or at the south (upper) margin of the felsic volcanic unit south of Provincial Road 315 (Gilbert, 2006). Several concordant zones of base-metal sulphide mineralization (Table GS-17-2, MS 7, 8 and 9) occur in the magnetiferous siltstone-chert member (Figure GS-17-8f), which is partly deformed and disrupted, resulting in localized fault breccia.

Contact-related mineralization (type (b) above) occurs sporadically at the south margin of the 450 m thick basaltic unit that extends along the north flank of the BRB south panel (Gilbert, 2006). At least three mineralized localities (Table GS-17-2, MS 10 and 11) occur over a strike length of 8 km along this contact (*see* 'Basalt, aphyric, mostly pillowed; related amphibolite and mafic gneiss' section). Localized pyritic mineralization also occurs at the north margin of this thick basalt unit (Table GS-17-2, MS 12).

Mineralization type (c) consists of conformable zones that occur within specific lithological units. Within the BRB south panel, both rhyolite and pillowed basalt flows locally contain minor (<1 m) zones of this type (Table GS-17-2, MS 13), and a 10 m wide mineralized zone (Table GS-17-2, MS 14) occurs in the central part of the south panel, associated with metasomatic alteration and a conspicuous aeromagnetic anomaly (*see* 'Alteration in felsic volcanic rocks' section). In the Winnipeg River area (Figure GS-17-13), a similar but minor zone of mineralization in fine-grained metasedimentary rocks of the Eaglenest Lake Formation was sampled for geochemical analysis (Table GS-17-2, MS 15). Farther west, at a locality on the north shore of the Winnipeg River, a 70 m thick felsic porphyry sill within basalt of the Lamprey Falls Formation contains a network of massive pyrite-pyrrhotite veins in the central part of the intrusion, associated with silicification and brittle deformation (Table GS-17-2, MS 16). The Lamprey Falls Formation in the west part of the BRB north panel contains a 16 m wide, Cu-Zn-Ni-Au-bearing unit (Gilbert, 2005). The section at this locality contains abundant gabbro sills that host Cr and PGE mineralization in conformable zones, which were prospected by Falconbridge Limited through the 1980s (Poplar Bay property; Assessment File 94609, Manitoba Science, Technology, Energy and Mines, Winnipeg). Significant Cr_2O_3 (up to 13% over 3 m), as well as

Table GS-17-2: Selected analytical data for mineralized rocks in the BRB.

Field sample no.	Mineralized sample no.	UTM Zone 14U, NAD 83		Au	Ag	Cu	Cd	Mo	Pb	Ni	Zn	As	Co	Cr	Sb	W
		Easting	Northing	(ppb)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
32-06-0563-1	MS 1	337321	5580158	6	< 0.3	123	< 0.3	< 1	< 3	71	69	4.1	47	243	0.2	< 1
32-06-0563-10	MS 2	337321	5580158	< 2	< 0.3	123	< 0.3	< 1	< 3	146	58	1.5	39	259	0.4	< 1
32-06-0553-2	MS 3	339234	5580454	< 2	< 0.3	377	< 0.3	< 1	< 3	18	83	4.2	15	11	0.2	< 1
32-06-0633-18	MS 4	334375	5593693	< 2	< 0.3	94	< 0.3	< 1	6	38	74	< 0.5	11	59	0.5	< 1
32-06-0632-1	MS 5	334598	5593762	10	0.5	96	< 0.3	< 1	4	12	189	2.3	5	42	0.3	3
32-06-0654-5	MS 6	333169	5593512	64	20	6490	7.1	27	7	41	949	< 0.5	108	36	0.3	38
32-06-0229-1	MS 7	338124	5593313	< 2	< 0.3	46	< 0.3	< 1	20	10	75	11.3	3	20	2.3	< 1
32-06-0229-2	MS 8	338124	5593313	13	0.3	55	< 0.3	< 1	9	49	82	8.7	15	39	1.6	< 1
32-06-0256-2	MS 9	336351	5593106	3	< 0.3	19	< 0.3	< 1	< 3	14	78	1.8	7	45	0.3	< 1
32-06-0505-2	MS 10	336273	5588890	9	< 0.3	14	< 0.3	< 1	15	10	73	162	3	28	< 0.1	< 1
32-06-0412-2	MS 11	333604	5590071	18	1	36	0.3	6	13	70	77	19800	50	23	10.8	< 1
32-06-0491-1	MS 12	335961	5589181	< 2	0.5	114	< 0.3	9	14	16	118	7.8	21	12	0.6	73
32-06-0418-5	MS 13	333578	5589927	< 2	0.4	34	< 0.3	< 1	< 3	5	59	178	7	7	0.2	310
32-06-0388-9	MS 14	334898	5588724	< 2	2.7	34	< 0.3	< 1	48	2	139	4.9	< 1	< 2	< 0.1	< 1
32-06-0539-7	MS 15	343325	5580182	< 2	< 0.3	313	< 0.3	< 1	< 3	68	135	2	51	73	< 0.1	< 1
32-06-0576-2	MS 16	332770	5583002	< 2	0.4	40	< 0.3	< 1	10	34	23	15.7	58	29	0.3	< 1

Pt (up to 500 ppb) and Pd (1175 ppb), are reported in drill logs at this locality; surficial grab samples yielded up to 5000 ppb combined Pt+Pd.

The most prospective rock types for base-metal mineralization in the map area are MORB-type basalt of possible BABB affiliation (e.g., Lamprey Falls Formation at the Winnipeg River; Table GS-17-2, MS 1, MS 2 and MS 3). In the case of the Lamprey Falls Formation at the BRB north margin, there is also potential for magmatic mineralization associated with gabbroic intrusions along strike from, and probably related to, the Bird River Sill, analogous to the above-described mineral deposit at the Poplar Bay property. Oxide-facies iron formation within volcanic rocks of inferred juvenile-arc affiliation is also prospective for both base-metal and Au mineralization (Table GS-17-2, MS 6).

Acknowledgments

J. Scanlon is thanked both for her capable field assistance and for a considerable amount of data entry on the computer. The field mapping benefited from collaboration and discussion with co-workers M. Duguet and P. Kremer. Subsequently, R-L. Simard and A. Bailes assisted by editing the first draft of this report. B. Lenton drafted the figures. Uranium-lead zircon dates were provided by C. Böhm. Sincere thanks are extended to all the above, as well as to R. Cooke of Gossan Resources Limited, who generously provided a helicopter for one day in order to investigate part of the map area that would otherwise have been inaccessible.

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