Geological Survey of Canada

CURRENT RESEARCH
2003-C27

Structural evolution of the Woodburn Lake group in the area of the Meadowbank gold deposit, Nunavut

R.B. Hrabi, W.A. Barclay, D. Fleming, and R.B. Alexander

2003

Natural Resources Canada
Ressources naturelles Canada

CURRENT RESEARCH

©Her Majesty the Queen in Right of Canada 2003
ISSN 1701-4387
Catalogue No. M44-2003/C27E-IN
ISBN 0-662-34190-2

Authors' addresses

R.B. Hrabi (hrabi@geology.utoronto.ca)
University of Toronto
22 Russell Street
Toronto, Ontario M5S 3B1

W.A. Barclay (bbarc@attcanada.ca)
W.A. Barclay Exploration Services Ltd.
23 Grenadier Road
Toronto, Ontario M6R 1R1

D. Fleming (info@cumberlandresources.com)
R.B. Alexander (info@cumberlandresources.com)
Cumberland Resources Ltd.
One Bentall Centre, Suite 950
505 Burrard Street, Box 72
Vancouver, British Columbia V7X 1M4

Publication approved by Canada-Nunavut Geoscience Office

Structural evolution of the Woodburn Lake group in the area of the Meadowbank gold deposit, Nunavut

R.B. Hrabi, W.A. Barclay, D. Fleming, and R.B. Alexander

Hrabi, R.B., Barclay, W.A., Fleming, D., and Alexander, R.B., 2003: Structural evolution of the Woodburn Lake group in the area of the Meadowbank gold deposit, Nunavut; Geological Survey of Canada, Current Research 2003-C27, 10 p.

Abstract: The Meadowbank gold project consists of five deposits hosted in the Neoarchean Woodburn Lake group of the western Churchill Province, including the recently delineated Vault deposit, located 7 km north-northeast of the previously defined mineralized zones in the 'Third Portage Lake' area. The supracrustal rocks of the Meadowbank area have experienced a polyphase deformation history spanning the Neoarchean to Paleoproterozoic. This contribution discusses the stratigraphic and structural framework of the corridor of rocks between the Meadowbank gold deposits and the recently discovered Vault deposit to the north.

Résumé : Le projet de mine aurifère Meadowbank inclut cinq gisements logés dans le groupe néoarchéen de Woodburn Lake, dans la Province de Churchill occidentale. Parmi ces gisements, mentionnons le gisement Vault, qui a été récemment délimité et qui se trouve à 7 km au nord-nord-est des zones minéralisées préalablement définies dans la région du lac Third Portage. Les roches supracrustales de la région de Meadowbank ont subi une déformation polyphasée qui a duré du Néoarchéen au Paléoprotérozoïque. Le présent article porte sur le cadre stratigraphique et structural du corridor de roches qui est situé entre les gisements aurifères de Meadowbank et le gisement Vault, lequel a été découvert récemment au nord.

INTRODUCTION

The Meadowbank gold deposit, located 80 km north of Baker Lake, Nunavut, is hosted in supracrustal rocks of the Woodburn Lake group (WLg; Ashton, 1981; Fraser, 1988). Previous studies in the map area include regional mapping at 1:250 000 (Tella and Heywood, 1983; Fraser, 1988), 1:100 000 (Henderson and Henderson, 1994), and 1:50 000 scales (Ashto, 1988; Zaleski et al., 1997b). Detailed mapping in the Meadowbank area has been completed by Sherlock et al. (2001a) and Wilkinson et al. (in press). These maps are supplemented by reports by Ashton (1981), Henderson et al. (1991), Zaleski et al. (1997a), and Kjarsgaard et al. (1997). In addition, thematic studies in the area include geochronology (Roddick et al., 1992; Davis and Zaleski, 1998) and regional- and deposit-scale metallogenic studies (Armitage et al., 1996; Kerswill et al., 1998; Sherlock et al., 2001b).

The Woodburn Lake group is part of a series of Neoarchean supracrustal sequences in the Rae domain of the Churchill Province (Fig. 1). The group comprises 1) a variety

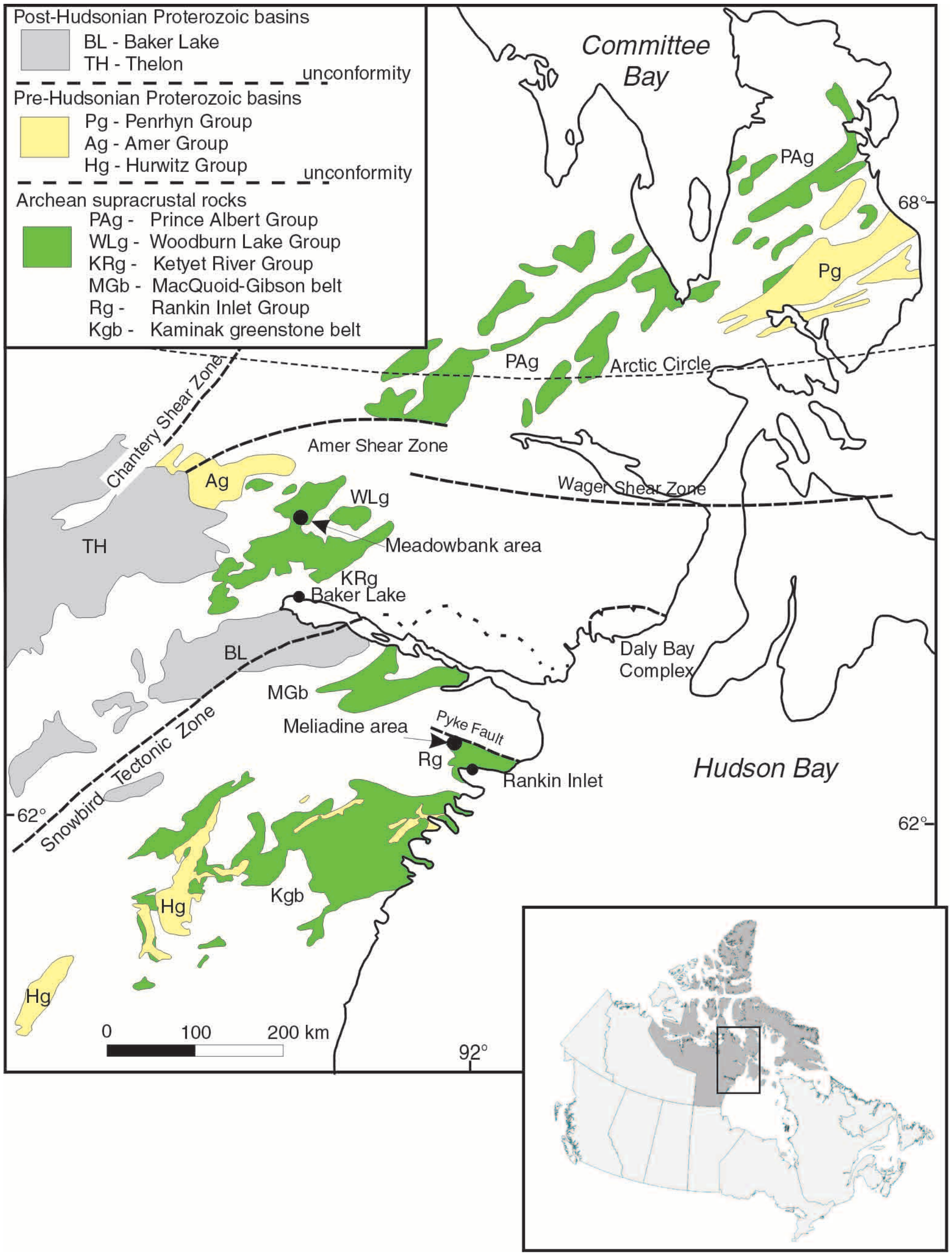

Figure 1. *Regional geology of the Rae and Hearne subprovinces of the western Churchill Province. The Meadowbank gold project is located in the Woodburn Lake group (WLg), one of a series of Archean supracrustal belts that extends from northern Saskatchewan to Baffin Island. Adapted from Zaleski et al. (1997a, Fig. 1).*

of ultramafic to felsic volcanic and volcaniclastic rocks, iron-formation, and related sedimentary rocks dated at ca. 2.71 Ga (Davis and Zaleski, 1998); 2) quartz arenite, conglomerate, and related sedimentary rocks; and 3) arkosic wacke and mudstone that are also interlayered with iron-formation (Ashton, 1988). The stratigraphy of the group, particularly the relationship of the quartz arenite to the volcanic rocks, remains unresolved (Ashton, 1988; Henderson et al., 1991; Kjarsgaard et al., 1997; Zaleski et al., 1997a).

Supracrustal rocks in the map area have experienced a polyphase deformation and metamorphic history. Most of the deformation episodes are interpreted to be Paleoproterozoic in age (Pehrsson et al., 2000; Wilkinson et al., in press), and peak greenschist- to amphibolite-facies metamorphic conditions were also reached during the Paleoproterozoic (Armitage et al., 1996; Wilkinson et al., in press).

The Meadowbank gold project is wholly owned by Cumberland Resources Ltd. and consists of the North Portage, Third Portage, Bay, and Goose Island deposits near ‘Third Portage Lake’, plus the recently delineated Vault deposit, located 7 km to the north-northeast (Fig. 2). The four deposits near ‘Third Portage Lake’ are mainly hosted in strongly altered and deformed sulphide-bearing iron-formation in a west-dipping, gently inclined fold (Sherlock et al., 2001a; Cumberland Resources Ltd., unpublished company document, 2002). In the Vault deposit, the gold mineralization is associated with sericite- and silica-altered intermediate to felsic volcanic rocks in a shallowly southeast-dipping high-strain zone (Cumberland Resources Ltd., unpublished company document, 2002).

The current project was designed to extend detailed mapping north from the ‘Third Portage Lake’ deposits (Sherlock et al., 2001a; Wilkinson et al., in press) to include the Vault

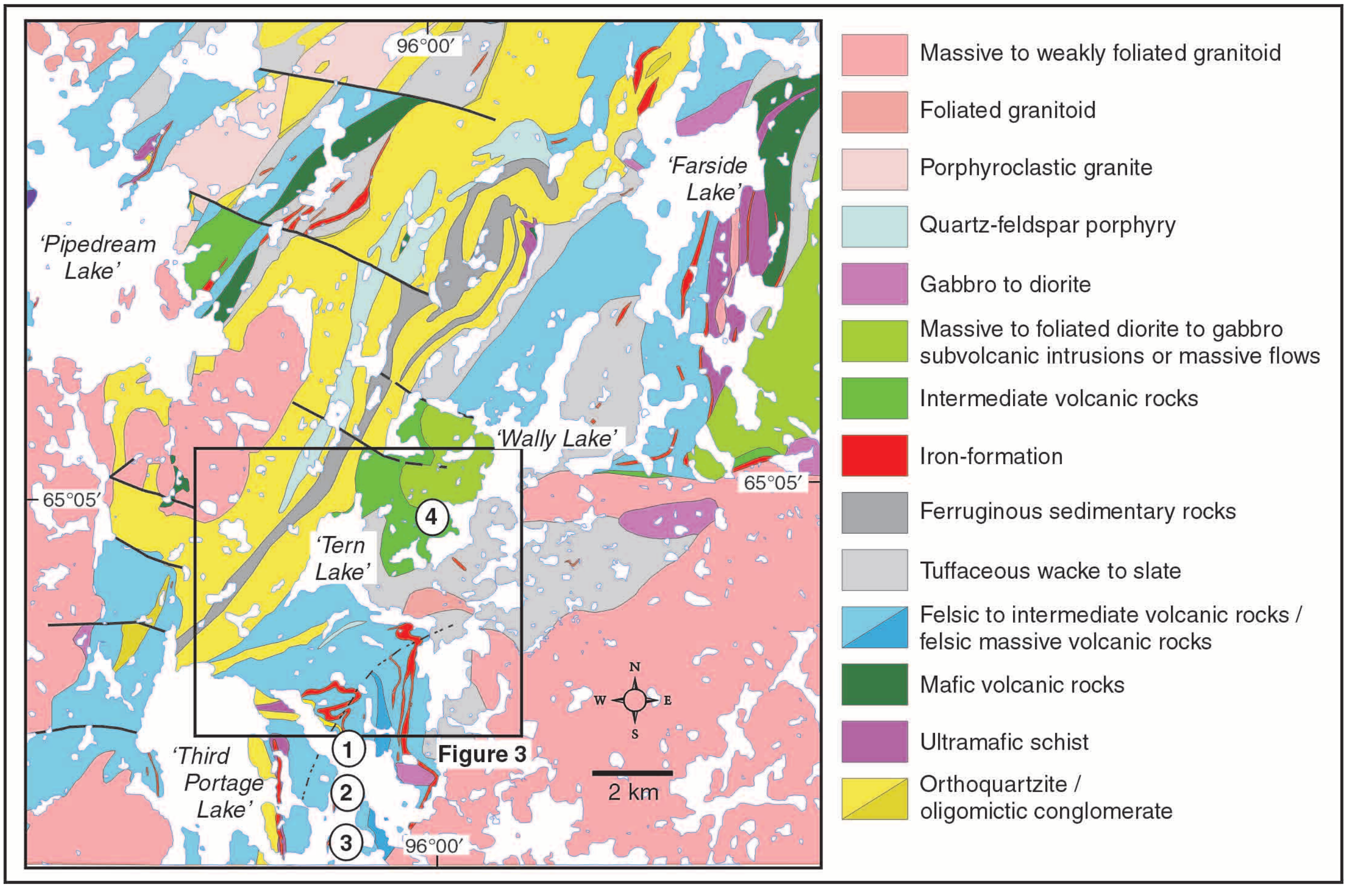

Figure 2. *Geology of the Woodburn Lake group and bounding granitoid rocks in the Meadowbank area. The map area for the current structural mapping is outlined by the box. The Meadowbank gold project includes the North Portage (1), Third Portage (2; Bay Island is just to the southwest), and Goose Island (3) zones close to ‘Third Portage Lake’, and the Vault deposit (4), located 7 km to the north-northeast. Geology and legend simplified from Zaleski et al. (1997b) and Sherlock et al. (2001a).*

(several of the geographic names in the study area are not included in the federal govenment’s list of formal geographic names; however, these informal names are considered important local landmarks and are therefore included offset by single quotation marks).

deposit area. It was initiated to better understand the distribution and geometry of the rock units, in order to explain the differences in host lithology and geometry between the two deposits.

ROCK TYPES

The map area is underlain almost exclusively by supracrustal rocks of the Woodburn Lake group (Fig. 3). All supracrustal rock units have been metamorphosed, but the prefix 'meta' has been omitted from the following descriptions.

Woodburn Lake group

Intermediate to felsic volcanic rocks

Intermediate to felsic volcanic rocks, dated at ca 2.71 Ga (Davis and Zaleski, 1998), are the oldest and most common rock type in the map area. These polyphase-deformed rocks are, in general, strongly foliated and often preserve evidence of isoclinal folds. This tight folding, combined with very sparse facing directions, precludes defining a stratigraphic succession.

In the north half of the area, the intermediate to felsic volcanic rocks consist of well preserved, foliated, interbedded ash tuff, lapilli ash tuff, and more rare volcanic breccia. Most of the intermediate to felsic volcanic rocks south of 'Tern Lake' have a similar composition, but the primary textures and structures are not well preserved. They are likely equivalent to the ash tuff and lapilli ash tuff described below.

The ash tuff and the matrix of the coarser grained facies consist of fine-grained plagioclase-quartz-chlorite±sericite± biotite. The variable content of both groundmass quartz and distinct quartz eyes indicates that the unit has a composition ranging from intermediate to felsic and is difficult to delineate in the field. Interbedded units of predominantly coarse ash tuff and predominantly fine ash tuff commonly have graded centimetre- to decimetre-scale beds. The lapilli ash tuff and volcanic breccia have a heterolithic clast composition consisting of yellow-buff weathering, resistant dacite fragments, intermediate volcanic fragments, and rare medium-grained mafic and vein-quartz fragments.

Plagioclase-quartz-sericite-chlorite schist forms an important subunit within the intermediate to felsic volcanic rocks and represents the main rock type west of the East BIF (banded iron-formation) and in the vicinity of the Vault deposit. It is a finely layered, strongly schistose rock with higher mica content and stronger carbonate and sericite alteration. Although it is highly schistose, examination of foliation surfaces reveals common ash-sized and occasional lapilli-sized fragments, suggesting it is a more highly altered and deformed equivalent of the ash tuff and lapilli ash tuff unit.

A distinctive unit of massive felsic volcanic rock, found in the south part of the map area, has a homogeneous composition of medium-grained quartz and plagioclase phenocrysts in a fine-grained quartz-plagioclase-biotite matrix. It has been interpreted as a massive felsic flow or subvolcanic intrusion (Sherlock et al., 2001a), and has an interpreted crystallization age of ca. 2.71 Ga (Davis and Sherlock, unpublished data, 2001).

Wacke to mudstone sedimentary rocks

Well bedded wacke to siltstone and mudstone are found interlayered with intermediate to felsic volcanic rocks at the south end of 'Tern Lake' and predominate along the east edge of the map area (Fig. 3). These units include interbedded coarse-grained sandstone layers and thin mudstone layers, interbedded fine-grained sandstone to siltstone, and interbedded siltstone to mudstone. The coarse-grained sandstone consists of rounded, clear, 1 mm quartz, feldspar, and lithic grains in a fine-grained quartz-feldspar-biotite-chlorite matrix. Examples of graded bedding and flame structures were found, but the strongly folded nature of the unit suggests these facing directions are only locally representative.

The interlayering of this unit with the intermediate to felsic volcanic rocks and the similarities in overall composition suggest that the wacke to mudstone was derived from the volcanic rocks. There is likely a continuum, from primary volcaniclastic rocks to variably reworked, epiclastic sedimentary rocks, that creates some uncertainty in determining the contact between the two units.

Iron-formation

In the Meadowbank area, three major units of banded iron-formation have been named the West BIF, Central BIF, and East BIF (Armitage et al., 1996). All of the mineralized zones in the 'Third Portage Lake' area are hosted in the Central BIF, but only the East BIF occurs in the map area (Fig. 3). The iron-formations consist of millimetre- to centimetre-scale laminations of magnetite, chert, and grunerite, in variable proportions, commonly interlayered with centimetre- to decimetre-scale layers of chlorite-rich rock.

Iron-formation is also present as thin layers interbedded with the intermediate volcanic rocks and wacke north and east of 'Tern Lake'. These consist of centimetre- to decimetre-scale layers of millimetre-scale magnetite, chert, and grunerite laminations. Units of iron-formation interlayered with volcanic and sedimentary rocks can be mapped and extrapolated using aeromagnetic anomalies (Fig. 3).

Ultramafic to mafic rocks

Strongly foliated, medium-grained quartz diorite to gabbro intrusions are interlayered with the intermediate to felsic volcanic rocks found to the east and south of (Fig. 3). These rocks consist of 1 to 2 mm plagioclase phenocrysts and strongly chlorite-altered hornblende in a foliated plagioclase-chlorite±epidote±actinolite matrix. They are locally oblique to layering in the volcanic rocks, but their strong foliation suggests that these rocks are older than the unfoliated gabbro to diorite unit.

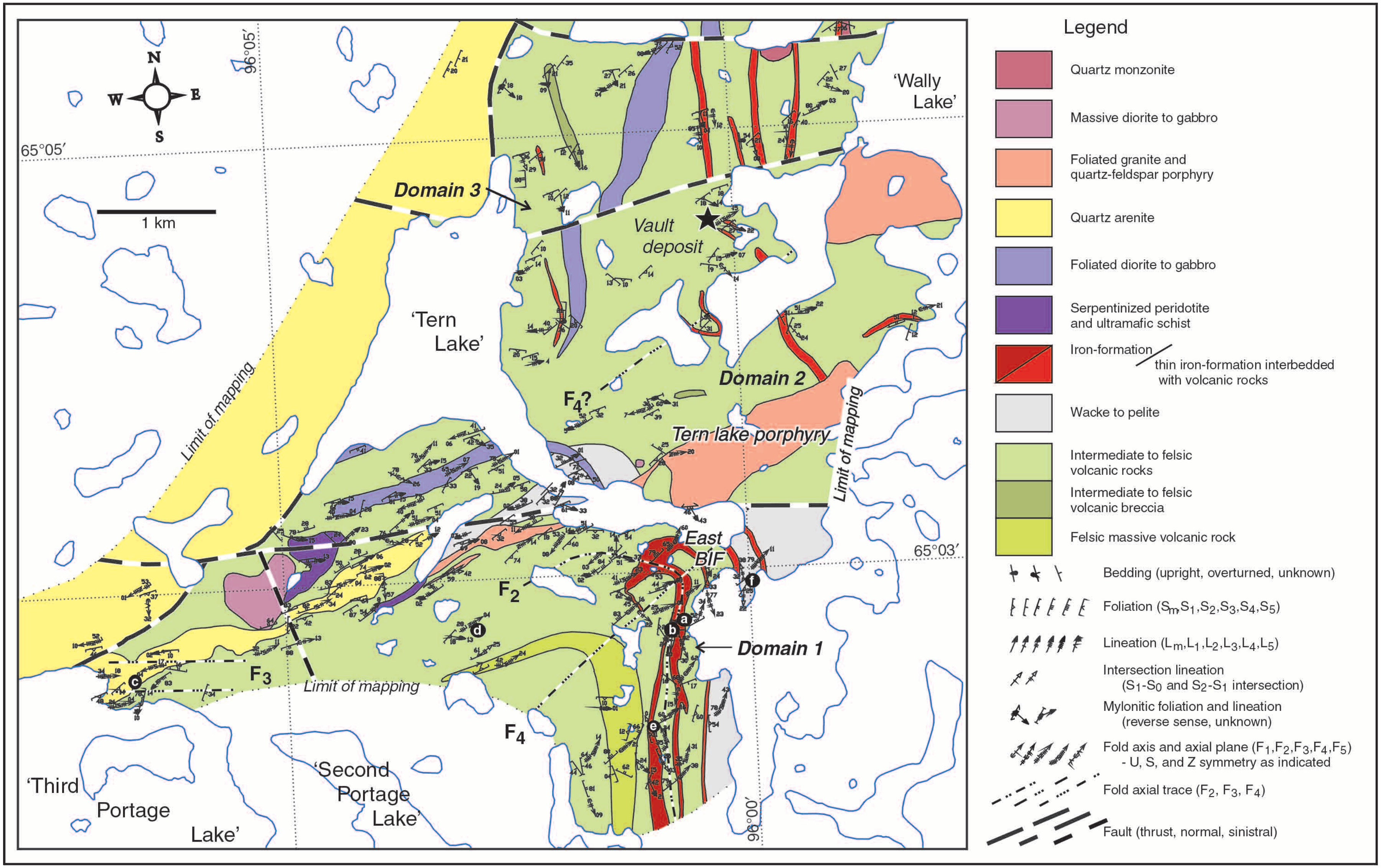

Figure 3. *Detailed geology of the project area. The deposits of the 'Third Portage Lake' area are just to the southwest. The Vault deposit is highlighted. Circled letters indicate the locations of the photographs in Figure 4.*

Ultramafic rocks, a characteristic part of the Woodburn Lake group (Ashton, 1988), are present within the map area as ultramafic schist and serpentinized peridotite. The ultramafic schist is found along the south margin of the thin quartz arenite unit and is composed of carbonate-chlorite-talc±tremolite schist with accessory magnetite and pyrite.

The serpentinized peridotite crops out as a relatively large intrusion between the quartz arenite units south of . It is light green weathering and dark green-black in colour, and has massive, homogeneous serpentine groundmass cut by numerous serpentine-carbonate-magnetite fractures and a very irregular schistosity.

Quartz arenite and associated sedimentary rocks

A distinctive unit of white-weathering, white quartz arenite crops out as prominent ridges on the west side of the map area. A wide, southeast-dipping unit forms the west margin of the map area west of 'Tern Lake', and a thinner, south-southeast-dipping unit is exposed between the north end of 'Third Portage Lake' and 'Tern Lake' (Fig. 3).

The quartz arenite is medium grained, strongly recrystallized, and layered on a decimetre to metre scale, with no facing directions observed. Bedding planes are defined by millimetre- to centimetre-scale layers of muscovite-rich quartz schist, and the quartz arenite is interlayered with decimetre- to metre-scale layers of quartz-muscovite schist. Within the quartz arenite are layers of granule conglomerate containing 2 to 4 mm, rounded quartz or chert grains and 1 mm magnetite and fuchsite grains. Outside the map area, the quartz arenite is also associated with oligomictic and polymictic conglomerate (Zaleski et al., 1997a; Wilkinson et al., in press).

The absolute age of the quartz arenite is unresolved. Uranium-lead dating of detrital zircons from the quartz arenite provides a maximum depositional age of ca. 2.81 Ga (Davis and Zaleski, 1998), but it could be significantly younger if it is unconformable on the 2.71 Ga volcanic rocks (Ashton, 1988; Zaleski et al., 2001; Wilkinson et al., in press). Within the map area, however, the contacts of the thick quartz arenite units are all structurally modified and, along the western margin, the volcanic rocks are interpreted to be thrust onto the quartz arenite.

Postvolcanic intrusive rocks

In the Meadowbank area, large, ca. 2.62 to 2.60 Ga granitic intrusive complexes (Ashton, 1988; Roddick et al., 1992; Davis and Zaleski, 1998) border the Woodburn Lake group on its east and west margins (Zaleski et al., 1997b). The 'Tern Lake' porphyry intrudes the volcanic rocks along the south end of 'Tern Lake' (Fig. 3) and has an interpreted crystallization age of 2.63 Ga (Davis and Zaleski, unpublished data, 2000). It is a foliated, mottled pink to flesh rock consisting of medium-grained phenocrysts of blue quartz and potassium and plagioclase feldspar in a fine-grained groundmass of quartz-feldspar-chlorite±biotite±magnetite. At its southwest end, it consists of an interfingering set of thin sills and/or dykes intruding the volcanic rocks parallel to the dominant fabric.

Less deformed, possibly Paleoproterozoic (Wilkinson et al., in press), leucocratic diorite to gabbro intrude the volcanic rocks as two stocks to the east and west of 'Tern Lake'. These have a homogeneous, ophitic, equigranular texture composed of fine- to medium-grained plagioclase and chlorite-altered amphibole. The intrusions are generally not foliated, but the larger intrusion west of 'Tern Lake' has a strong foliation at its contact with the quartz arenite unit.

At the north edge of the map area, a weakly foliated, medium grey, fine-grained quartz monzonite intrudes the volcanic rocks. It consists of quartz, plagioclase feldspar, potassium feldspar, and medium-grained biotite. The quartz monzonite and intermediate to felsic volcanic rocks nearby are cut by thin dykes of red, biotite±hornblende quartz syenite to syenite.

STRUCTURAL HISTORY

The Woodburn Lake group has experienced a polyphase deformation history spanning the Neoarchean to Paleoproterozoic. The overall geometry of the area is dominated by Type 2 'mushroom' interference patterns that resulted from the superposition of upright F_4 folds on inclined F_2 folds (Fig. 3). The map area can be divided into three domains using the major F_4 axial trace that refolds the East BIF as one boundary and the less obvious change in orientation of D_1 and D_2 fabrics south of the Vault deposit that may represent the adjacent fold trace (Fig. 3). The following description of the structural features in the map area agrees in most respects with those given by Pehrsson et al. (2000) and Wilkinson et al. (in press).

Deformation D_1

The earliest deformation recognized in the Meadowbank area comprises isoclinal to tight folds (F_1), axial-planar schistosity (S_1) that is commonly observed as a nearly bedding-parallel foliation, mineral lineation, and bedding-S_1 intersection lineation (L_1). Resolving the effects of D_1 and D_2 deformation is a common problem in the map area, and the main foliation in outcrop is often mapped as a generic S_m. These structures are either D_1 or transposed D_1-D_2 fabrics.

The degree to which different structures develop is partly dependent on rock type. The iron-formation is preferentially folded and has only moderate foliation development. Isoclinal, intrafolial folds are commonly observed in the iron-formation (Fig. 4a), but it is often ambiguous whether they are D_1 or D_2 structures. In the hinge areas of D_2 folds, however, the geometry of isoclinal to tight D_1 folds can be resolved from the D_2 overprint (Fig. 4b).

In quartz arenite, compositional layers are defined by muscovite-rich bands. The strong bedding-parallel schistosity in these bands, plus a parallel foliation defined by flattened quartz grains, suggests the layering is a composite S_0-S_1 fabric. In volcanic rocks in the Vault area, a well developed, shallowly southeast-dipping foliation, axial planar to minor D_1 folds, represents the earliest fabric recognized.

Deformation D_2

The D_2 structures comprise tight to close, generally upright to inclined folds (F_2), axial-planar foliation (S_2), strong clast- and mineral-elongation lineation, and S_2 intersection lineation (L_2). The D_2 fabrics are heterogeneously developed in both volcanic rocks and the iron-formation. The development of S_2 ranges from a rather weakly developed axial-planar foliation in the hinge zone of some F_2 folds to a strong transposition fabric of S_0, S_1, and S_2 on the limbs of F_2 folds (e.g., in the East BIF in domain 1). Where there is a strong transposition of fabrics in the iron-formation, a well developed intersection lineation creates a distinctive pencil structure that can then be traced around later (D_3 or D_4) folds (Fig. 4e).

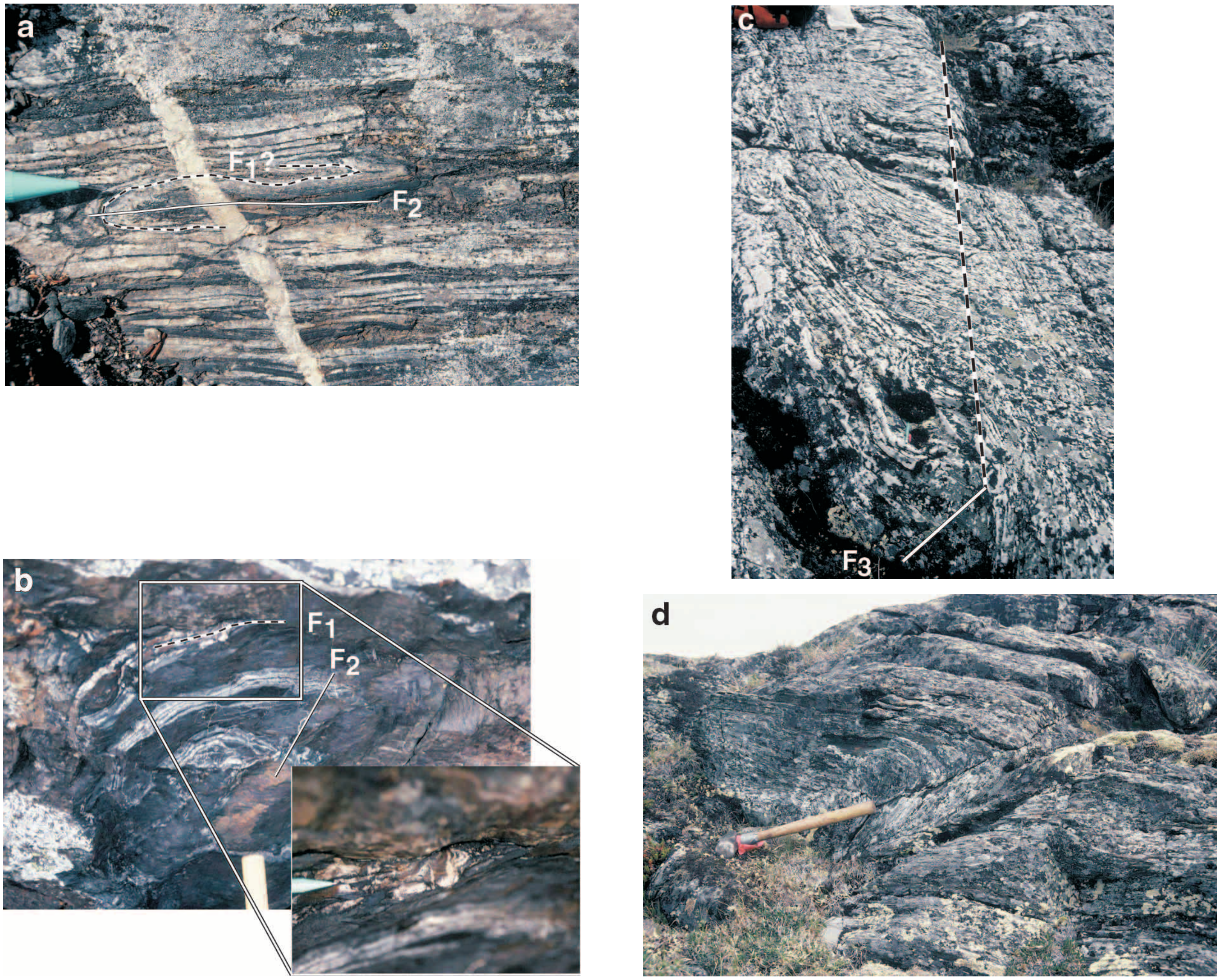

***Figure 4. a**) Plan view of folded iron-formation showing an isoclinal, intrafolial fold. The isoclinal fold, interpreted to be an F_2 fold, appears to be folding an earlier F_1 fold, although the F_1 hinge was not observed here and the transposed nature of the rock makes interpretation difficult. **b**) Looking south at a vertical face of folded iron-formation at the hinge of an F_2 fold. The recumbent, shallowly south-plunging isoclinal F_1 fold is refolded about an upright, shallowly south-plunging F_2 fold. **c**) Looking obliquely east-southeast at folded quartz arenite. The F_3 folds the S_0-S_1 fabric about shallowly to moderately north-northwest-inclined, shallowly east-northeast-plunging folds. This creates an open fold profile with a south-south-east-dipping enveloping surface, which can also be observed at the map scale. **d**) Looking east-southeast at a vertical face of tighter F_3 folds in the intermediate to felsic volcanic rocks. The folds are moderately north-northwest inclined and shallowly east-southeast plunging, as in Figure 4c.*

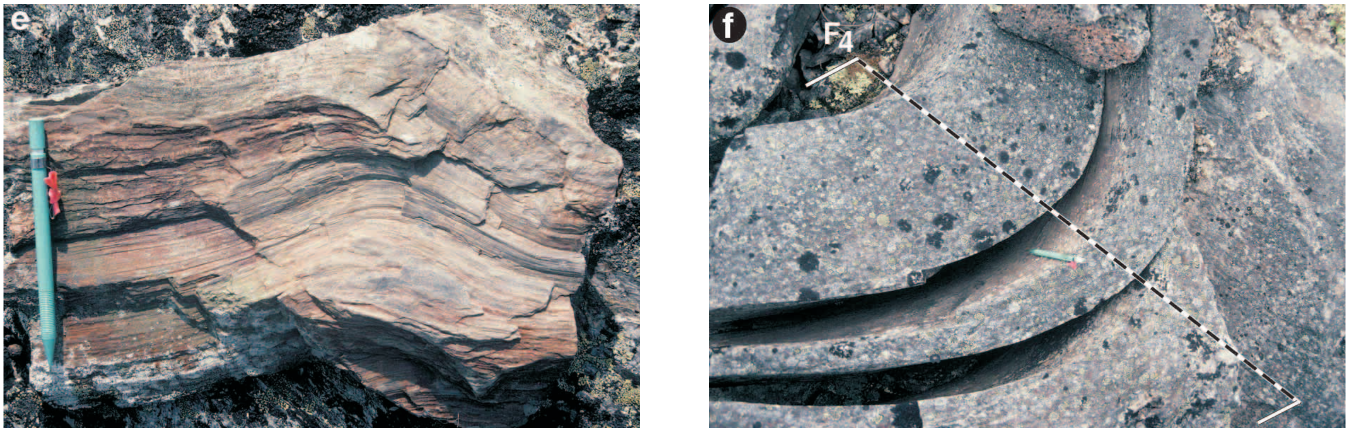

Figure 4. ***e****) Sample of iron-formation with strong S_2-S_1 intersection lineation folded about an open fold. The geometry of this fold is similar to in situ, upright, shallowly northeast-plunging F_4 folds in the outcrop.* ***f****) Oblique view to the southeast of wacke folded about an open, upright, northeast-plunging F_4 fold. The F_4 refolds a tight to isoclinal F_2 fold. Although it is hard to positively identify all the folded surfaces, an earlier fold is interpreted to predate the F_2 fold because two intersection lineations (interpreted to be S_2-S_1 and S_2-S_0 intersection lineations) with slightly different orientations are both folded about the later, upright F_4 fold.*

The high-strain zone that hosts the Vault deposit is also interpreted to be an expression of D_2 deformation. Within the zone, there is a very finely spaced, shallowly southeast-dipping cleavage that strongly transposes earlier fabrics. At the margins of the zone, however, rotation and flattening of earlier S_1 fabrics into the S_2 planes can be observed. Minor structures in the Vault zone, such as outcrop-scale low-angle faults that cut and thrust-repeat the transposed S_1-S_2 fabric, are also observed. The L_2 stretching directions are consistent with an oblique, northwest-vergent thrust-fault movement along the high-strain zone.

A fault along the contact between quartz arenite and volcanic rocks on the west margin of the map area was identified by Ashton (1988) and interpreted to be a southeast-dipping D_2 thrust fault by Pehrsson et al. (2000) and Wilkinson et al. (in press). This fault continues along this contact to the north margin of the map area (Fig. 3). Little expression of it was observed in the quartz arenite in the footwall, but the volcanic rocks in the hanging wall become progressively more strained toward the fault. Clasts in lapilli ash tuff are increasingly flattened and stretched closer to the fault, and the rock exhibiting the highest strain is a southeast-dipping, finely laminated mylonite. The combination of northwest-vergent minor folds and a near down-dip lineation supports a thrust movement along the structure.

Both margins of the thin quartz arenite unit south of 'Tern Lake' are highly strained with a very strong, penetrative, south-southeast-dipping schistosity. No kinematic indicators were observed, so it is not possible to resolve whether these zones are faults or are localizing strain due to rheological contrasts between rock types. The relationship of these zones to the thrust fault along the contacts of the quartz arenite is an important question that remains unresolved.

Deformation D_3

The effects of D_3 deformation are best expressed in domain 2 (Fig. 3). Here, shallowly to moderately dipping S_2 and composite S_2-S_1 fabrics are folded about shallowly east-northeast or west-southwest-plunging, shallowly to moderately northwest-dipping F_3 folds. These folds are open to close and sometimes chevron-shaped in profile (Fig. 4c, d). They range from centimetre to metre scale in outcrop, but have only subtle expression on the map (Fig. 3) because the fold limbs are either steeply or shallowly south-southeast dipping (Fig. 4c). Well developed crenulation lineation is subparallel to the F_3 fold axes and, in more micaceous or chloritic rocks, is accompanied by an S_3 crenulation cleavage that was observed to fan around some folds.

In domain 1, folds with similar profiles plunge to the north or northeast and are moderately inclined to the northwest, suggesting they are folded about the F_4 that refolds the East BIF. The F_3 folds reorient the strong S_2-S_1 intersecting lineation in the iron-formation but are themselves folded about open, upright, northeast-trending F_4 fold axes. Distinguishing between the F_3 and F_4 fold sets is sometimes difficult, particularly where the S_3 foliation has a steeper dip, but the asymmetry of the minor F_3 folds in domain 1 is inconsistent with the F_4 fold geometry.

Deformation D_4

The fourth major phase of ductile deformation has an important effect on the geometry of the rock units and the mineralized zones in the Meadowbank area (Zaleski et al., 1997b; Sherlock et al., 2001b). The superposition of northeast-trending, upright F_4 folds on inclined F_2 folds causes distinct Type 2 'mushroom' interference patterns, observed at the nose of the F_4 fold in the East BIF (Fig. 3) and in the Central

BIF to the south (Sherlock et al., 2001b; Wilkinson et al., in press). Moderately developed crenulation lineation (L_4) is subparallel to the F_4 fold axis. In the map area, most F_4 fold axes and L_4 lineations plunge to the northeast, whereas, in the Central BIF, the F_4 axes are doubly plunging where they refold opposite-dipping limbs of F_2 folds (Sherlock et al., 2001b; Wilkinson et al., in press).

Deformation D_5

Gentle warping of S_1 or S_2 fabrics is interpreted to represent the final phase of ductile deformation in the Meadowbank area, although no overprinting of D_4 features was observed. This fold event has only a very minor effect on the geometry of the rock units and the gold deposits in the Meadowbank area.

Brittle structures

Two sets of brittle or brittle-ductile faults cut the map area, but clear crosscutting relationships were not observed. A set of steeply south-dipping, east- to east-southeast-striking faults cuts all rock types in the area (Ashton, 1981; Zaleski et al., 1997b). These are particularly evident where they offset the quartz arenite–volcanic contact with apparent dextral horizontal separation (Fig. 3), and may be responsible for the termination of the thin quartz arenite unit south of 'Tern Lake'. Fault scarps on the south side of the 'Tern Lake' porphyry and elsewhere, extensional quartz veins along the fault traces, termination of magnetic anomalies, and small-scale features in the volcanic rocks all suggest that these are south-side-down normal faults. Similar normal faults are documented in the Whitehills Lake area (Zaleski et al., 1999) and cutting the ca. 1.81 to 1.78 Ga Baker Lake Group (Rainbird et al., 2001; Wilkinson et al., in press).

A set of northwest-striking sinistral faults (Wilkinson et al., in press) is also present. One is interpreted to offset the thin quartz arenite north of 'Second Portage Lake' and continues southeast, following a trace through 'Second Portage Lake' and a distinct topographic lineament beyond. This fault could account for the S-shaped offset of the quartz arenite and Central BIF mapped between the Third Portage and North Portage deposits (Sherlock et al., 2001a).

DISCUSSION

The structural and stratigraphic framework of the 'Third Portage Lake' area can be traced northward into the area of the Vault deposit. Both the overall geometry of the rock units in the map area and the geometry of the mineralized zones in the 'Third Portage Lake' area result from the superposition of D_2 and D_4 folds. Similarly, the change in orientation of the D_2 high-strain zones between 'Third Portage Lake' and the Vault deposit can be explained by reorientation of these D_2 structures by the superposition of later, upright F_4 folds. South-side-down movement on a normal fault separating the Vault and Third Portage areas, combined with the effects of fold superposition, may explain why the major iron-formations that characterize the Third Portage area do not reappear near the Vault deposit.

In the Meadowbank area, a wide variety of mineralization styles spans the deformation history, with the most important associated with D_1 and D_2 deformation. In the vicinity of both the Third Portage area deposits and the Vault deposit, zones of high D_2 strain both deform earlier mineralized structures and host new syn-D_2 mineralization (Armitage et al., 1996; Sherlock et al., 2001a; Cumberland Resources Ltd., unpublished company document, 2002). The D_2 high-strain zone at Vault overprints and locally transposes earlier bedding and D_1 structures. Mesoscopic structures indicate that it is a northwest-vergent D_2 thrust fault and may be related to the major D_2 thrust fault that emplaces older volcanic rocks onto younger quartz arenite at the western margin of the map area.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the logistical support supplied at the Meadowbank camp by Cumberland Resources Ltd and the assistance given by G. Davidson, R. March, and J. Kellner during the field season. Discussions about the geology of the Meadowbank area with R. Sherlock and S. Pehrsson were very beneficial. L. Wilkinson and S. Pehrsson kindly supplied a draft copy of their open file map. This paper benefited from a critical review by R. Sherlock and S. Pehrsson.

REFERENCES

Armitage, A.E., James, R.S., and Goff, S.P.
1996: Gold mineralization in Archean banded iron formation, Third Portage Lake area, Northwest Territories, Canada; Exploration and Mining Geology, v. 5, p. 1–15.

Ashton, K.E.
1981: Preliminary report on geological studies of the "Woodburn Lake Group" northwest of Tehek Lake, District of Keewatin; *in* Current Research, Part A; Geological Survey of Canada, Paper 81-1A, p. 269–273.
1988: Precambrian geology of the southeastern Amer Lake area (66 H/1), near Baker Lake, N.W.T.; Ph.D. thesis, Queen's University, Kingston, Ontario, 335 p.

Davis, W.J. and Zaleski, E.
1998: Geochronological investigations of the Woodburn Lake group, western Churchill Province, Northwest Territories: preliminary results; *in* Radiogenic Age and Isotopic Studies: Report 11; Geological Survey of Canada, Current Research 1998-F, p. 89–97.

Fraser, J.A.
1988: Geology of Woodburn Lake map area, District of Keewatin; Geological Survey of Canada, Paper 87-11, 12 p.

Henderson, J.R. and Henderson, M.N.
1994: Geology of the Whitehills-Tehek lakes area, District of Keewatin, Northwest Territories; Geological Survey of Canada, Open File 2923, scale 1:100 000.

Henderson, J.R., Henderson, M.N., Pryer, L.L., and Cresswell, R.G.
1991: Geology of the Whitehills-Tehek area, District of Keewatin: an Archean supracrustal belt with iron-formation–hosted gold mineralization in the central Churchill Province; *in* Current Research, Part C; Geological Survey of Canada, Paper 91-1C, p. 149–156.

Kerswill, J.A., Goff, S.P., Wilkinson, G.A., Kjarsgaard, B.A., Bretzlaff, R., and Samaras, C.
1998: An update on the metallogeny of the Woodburn Lake Group, western Churchill Province, Northwest Territories; *in* Current Research 1998-A; Geological Survey of Canada, p. 29–41.

Kjarsgaard, B.A., Kerswill, J.A., and Jenner, G.A.
1997: Lithostratigraphy and metallogenic implications of komatiite–banded iron-formation–felsic volcanic rocks of the Archean Woodburn Lake group, Pipedream lake, central Churchill Province, Northwest Territories; *in* Current Research 1997-C; Geological Survey of Canada, p. 101–110.

Pehrsson, S.J., Wilkinson, L., Zaleski, E., Kerswill, J., and Alexander, B.
2000: Structural geometry of the Meadowbank deposit area, Woodburn Lake group – implications for genesis of a major gold deposit in the western Churchill Province; Geological Association of Canada–Mineralogical Association of Canada, Joint Annual Meeting, Geocanada 2000: The Millenium Geoscience Summit, Program and Abstracts (CD-ROM), v. 25, Abstract 829, 4 p.

Rainbird, R.H., Hadlari, T., and Davis, W.
2001: Sequence stratigraphy and tectonic setting of the 1.78–1.74 Ga Wharton Group, Baker Lake and Thelon Basins, western Churchill Province, Nunavut; Geological Association of Canada–Mineralogical Association of Canada, Joint Annual Meeting, Program and Abstracts, v. 26, p. 123.

Roddick, J.C., Henderson, J.R., and Chapman, H.J.
1992: U-Pb ages from the Archean Whitehills-Tehek lakes supracrustal belt, Churchill Province, District of Keewatin, Northwest Territories; *in* Radiogenic Age and Isotopic Studies: Report 6; Geological Survey of Canada, Paper 92-2, p. 31–40.

Sherlock, R.L., Alexander, R.B., March, R., and Kellner, J.
2001a: Geology of the Meadowbank iron formation–hosted gold deposit; Geological Survey of Canada, Open File 3149, scale 1:7500.

Sherlock, R.L., Alexander, R.B., March, R., Kellner, J., and Barclay, W.A.
2001b: Geological setting of the Meadowbank iron-formation–hosted gold deposits, Nunavut; Geological Survey of Canada, Current Research 2001-C11, 16 p. (CD-ROM or online at http://www.nrcan.gc.ca/gsc/bookstore)

Tella, S. and Heywood, W.W.
1983: Geology of the Amer Lake (NTS 66 H) map area, District of Keewatin, Northwest Territories; Geological Survey of Canada, Open File 942, scale 1:250 000.

Wilkinson, L., Pehrsson, S., and Zaleski, E.
in press: Geology of the Meadowbank gold deposit area, Nunavut; Geological Survey of Canada, Open File 4269, scale 1:20 000.

Zaleski, E., Corrigan, D., Kjarsgaard, B.A., Jenner, G.A., Kerswill, J.A., and Henderson, J.R.
1997a: Preliminary results of mapping and structural interpretation from the Woodburn project, western Churchill Province, Northwest Territories; *in* Current Research 1997-C; Geological Survey of Canada, p. 91–100.

Zaleski, E., Corrigan, D., Kjarsgaard, B.A., Kerswill, J.A., Jenner, G.A., and Henderson, J.R.
1997b: Geology, Woodburn Lake group, Meadowbank River to Tehek Lake (66 H/1, 56 E/4), District of Keewatin (Nunavut), Northwest Territories; Geological Survey of Canada, Open File 3461, scale 1:50 000.

Zaleski, E., Davis, W.J., and Sandeman, H.A.
2001: Continental rifting, mantle magmas, and basement/cover relationships; International Archean Symposium, AGSO–Geoscience Australia, Volume 2001/37, p. 374–376.

Zaleski, E., Duke, N., L'Heureux, R., and Wilkinson, L.
1999: Geology, Woodburn Lake group, Amarulik Lake to Tehek Lake, Kivalliq Region, Nunavut; Geological Survey of Canada, Open File 3743, scale 1:50 000.

Geological Survey of Canada Project 000028