Natural Resources Canada / Ressources naturelles Canada

GEOLOGICAL SURVEY OF CANADA — COMMISSION GÉOLOGIQUE DU CANADA

NATMAP
CARTNAT
Canada's National Geoscience Mapping Program
Le Programme national de cartographie géoscientifique du Canada

DESCRIPTIVE NOTES

MEADOWBANK RIVER AREA

INTRODUCTION

The Woodburn Lake group comprises a deformed sequence of Archean supracrustal rocks in the Rae province (Western Churchill Province, Fig. 1) north of the regional geophysical anomaly that defines the Snowbird tectonic zone (Hoffman, 1988). The Woodburn Lake group includes lithological associations that have figured prominently in discussions of Archean crustal evolution, i.e., komatiite-quartzite assemblages and greenstone-type volcanic and sedimentary sequences (Taylor, 1985; Ashton, 1988; Annesley, 1989). High grade equivalents of the Woodburn supracrustal rocks are thought to be present in granulite paragneisses 70 km to the northeast (Fraser, 1988). Archean assemblages similar to those of the Woodburn Lake group define a northeasterly trending discontinuous zone that extends for at least 1000 km through the Prince Albert group in the Committee Fold Belt (Frisch, 1982; Schau, 1982) to the Mary River group on northern Baffin Island (Bethune and Scammell, 1997). Throughout this region, interpretation of the Archean assemblages is complicated by Paleoproterozoic tectonometamorphic overprinting of variable intensity and by the presence of Paleoproterozoic supracrustal successions that, in some cases, are difficult to distinguish from Archean successions.

The Woodburn Project is a part of the Western Churchill NATMAP, a collaborative mapping initiative by the Geological Survey of Canada in Nunavut. The Project was initiated in 1996 in the area of Pipedream lake (locally called Tasirjuaraarjuk) and north of Third Portage lake (NTS 66H/1 and 56E/4, Fig. 1) with 1:50000-scale mapping (Zaleski et al., 1997a, b), mineral deposit studies (Kjarsgaard et al., 1997, Kerswill et al., 1998), and geochronological studies (Davis and Zaleski, 1998). The Meadowbank gold deposits are hosted by iron-formation in the central southern Pipedream-Third Portage lakes area (Fig. 1). During the 1998 field season, mapping was extended both to the north (NTS 66H/2, H/7, H/8, 56E/5, Zaleski et al., 1999a) and to the south (66A/16, 56D/13, Zaleski et al., 1999b, c). This preliminary map shows the results of field work in the northern area along the Meadowbank River. The area southeast of Ukalik Lake, mapped in 1996, is shown with revisions based on additional traverses. The main focus of the mapping has been the Woodburn Lake group and its relationships to plutonic rocks, including identification of intrusive relationships, possible candidates for basement to the supracrustal sequence, and structural relationships. Mapping in supracrustal rocks utilized air photos enlarged to 1:20000-scale and, where warranted, lithological units and contacts were followed outcrop by outcrop. Plutonic rocks away from supracrustal contacts were mapped in much less detail and, in some cases, large areas of dominantly plutonic rocks were 'spot checked' on helicopter-supported traverses.

REGIONAL GEOLOGY

The informal name 'Woodburn Lake group' was originally applied to a sequence of metavolcanic and metasedimentary rocks, including iron-formation and quartzite, in the southern Amer Lake map area (NTS 66H) (Ashton, 1981). Similar supracrustal rocks extend continuously to south of Schultz Lake, and intermittantly as inclusions or septa in the dominantly plutonic terrane between Schultz Lake and the Paleoproterozoic Amer group (Tella, 1994). To the east, supracrustal rocks of the Woodburn Lake group form long, northeasterly trending septa extending into the Tehek Lake plutonic complex (Schau, 1983) and toward the granulite terrane northeast of Woodburn Lake (Fraser, 1988).

Definition of the stratigraphic sequence and correlation of lithological units of the Woodburn Lake group have been persistent challenges. Quartzites form distinctive units regionally, and much effort has been directed at determining their stratigraphic position(s) and structural repetitions. Ashton (1988), Fraser (1988) and Annesley (1989) placed quartzites at the top of the sequence, overlying volcanic and volcaniclastic rocks and interbedded iron-formation. Ashton proposed an unconformity at the base of the quartzite east of Pipedream lake marked by intermittant occurrences of oligomictic basal conglomerate. The unconformable relationship was based on the interpretation of stratigraphic truncations in the underlying volcanic and sedimentary rocks, the diverse depositional settings implied by the lithological units below and above the unconformity, and high abundances of Cr and Ni in the quartzite suggesting a detrital component derived from mafic or ultramafic rocks. North of Whitehills Lake, Taylor (1985) interpreted a stratigraphic succession with greywacke at the base followed by volcanic rocks (including mafic and komatiitic rocks) and iron-formation, to quartzite overlain by mafic volcanic rocks at the top of the sequence (Fig. 1). In contrast in the Pipedream and Third Portage lakes area, Kjarsgaard et al. (1997) proposed a sequence with quartzite at the base, overlain by komatiite, intermediate to felsic volcanic and sedimentary rocks.

In the area north of Third Portage lake, Zaleski et al. (1997a, b) considered it likely that quartzites lie at the stratigraphic base of the sequence, and proposed that the presence of oligomictic conglomerate between quartzite and the volcano-sedimentary sequence was consistent with an unconformity above the quartzite. The relative age relationships were supported by the presence of quartz-rich clasts, interpreted as quartzite, in debris-flow deposits in felsic volcanic rocks, as well as by younging indicators. U-Pb zircon dating of felsic lapilli tuff in the overlying sequence identified the youngest rocks known thus far in the Woodburn Lake group (2710 + 3.5/-2.1 Ma, Davis and Zaleski, 1998). The detrital zircon population in the quartzite is dominated by 2.96 Ga grains, and the youngest zircon poorly constrains the maximum age of deposition to be at least 2.81 Ga (Davis and Zaleski, 1998). To the north near the Meadowbank River, and to the south between Whitehills and Amarulik Lakes (Fig. 1), imprecise ages of 2.8 Ga have been reported for felsic volcanic rocks (Tella et al., 1985; Roddick et al., 1992). These ages are in the process of being revised (W.J. Davis, pers. comm.).

SUPRACRUSTAL ROCK UNITS AND RELATIONSHIPS

The Meadowbank River area (Fig. 1) lies north of the Pipedream lake (traditionally called 'Tasirjuaraarjuk') and Third Portage lake area mapped in 1996 (Zaleski et al., 1997a, b), and overlaps with previous mapping by Heywood (1977), Tella and Heywood (1983), Ashton (1988), Fraser (1988), and Tella (1994). The supracrustal rocks in the area northwest of Tasirjuaraarjuk and Quggiilik on the Meadowbank River can be subdivided into two major lithological sequences, separated by orthoquartzite; 1) interlayered komatiites and felsic volcanic rocks unconformably overlain by orthoquartzite, and 2) a volcanic sequence with iron-formation and minor greywacke that structurally overlies orthoquartzite. The character of the contact between quartzite and the upper volcanic and sedimentary sequence is unknown. Because of greater structural complexities southeast of Quggiilik in the area of Ukalik Lake, stratigraphic relations are less evident at this point.

Komatiites and Felsic Volcanic Rocks overlain by Orthoquartzite

North and west of Nukiplilik along the Meadowbank River, komatiites (**Km**) and quartz-eye felsic rocks (**Flq**) are intercalated in layers from 1 to 100's of metres in width. Minor thin layers of iron-formation (**If**) are present locally. The layering defines an east-west structural grain. Penetrative fabrics are mostly confined to high strain domains, and weak or absent elsewhere. Primary volcanic structures and textures preserved in komatiites include spinifex textures, polyhedral jointing, breccia zones, possible pillows, and massive to layered flows. The felsic rocks contain quartz eyes that vary from 0.5-1 cm ellipsoidal lenses of dark monocrystalline quartz to 0.5-5 mm euhedral quartz crystals. Plagioclase phenocrysts are common. The matrix is massive, white to grey, silicic, and very fine grained to aphanitic. The felsic rocks are commonly homogeneous on outcrop scale. However, two kilometres northwest of Nukiplilik Qikiqtaa, a large outcrop area of multiphase monolithic felsic breccias is partly encircled by a layer of komatiite that dips steeply outward (65° 19'N, 96° 20'W). The breccias are characterized by subtle internal contacts between different phases with a high proportion of angular lithic felsic fragments, including fragments of previously brecciated material. The contact between felsic breccias and komatiite is sharp. The felsic rocks were interpreted as autobreccias formed in a felsic dome or volcanic centre that either intruded into komatiites, or was onlapped by komatiite flows. In view of the low strain state in much of the area, the interlayering of komatiites and felsic volcanic rocks is interpreted as volcanic stratigraphy.

West of the Meadowbank River, quartz-eye felsic rocks and komatiites are overlain by white, locally pyritic and rusty, quartzite (**Qz**). Observations suggest that the contact is an unconformity that is deformed by upright, upward-facing folds. Bedding in the quartzite is well defined by prominent parting along bedding planes typically at 1 cm-1 m intervals, and schistosity is locally present at a low angle to bedding. The southern contact of the northernmost lens of quartzite is marked by conglomerate (**Qcg**) which grades from polymictic to oligomictic toward the quartzite (65° 18'N, 96° 5.5'W, 5 km west of Nukiplilik Qikiqtaa). The polymictic conglomerate contains fine grained clasts of intermediate to mafic composition, as well as quartz-rich clasts, whereas the oligomictic conglomerate contains only quartz-rich clasts. Quartz-rich clasts preserve rounded or subrounded shapes, while intermediate to mafic clasts and the matrix are flattened and schistose. A few metres north of the conglomerate, cross-bedding in the quartzite shows upright younging toward the north away from the contact. Near the northern contact of the quartzite lens, schistosity (bedding not recognized) in quartzite dips moderately toward the south, subparallel to flow layering in komatiite immediately to the north. Spinifex sheaves in the komatiite show southward younging toward the quartzite contact.

The same unconformable contact is repeated to the south across a kilometre or more of mostly felsic volcanic rocks (65° 17.3'N 96° 25'W). This interpretation is supported by a change to southward-dipping bedding and schistosity in quartzite, by local outcrops of conglomerate near the contact, and by southward-younging cross-bedding in quartzite (Tella and Heywood, 1983). To the east, polymictic conglomerate on the southeastern shore of Nukiplilik Qikiqtaa contains intermediate to mafic volcanic(?) and quartz-rich clasts and may be part of the basal conglomerate marking the unconformity. However, in this location, the conglomerate is in transitional contact with debris-flow deposits (**Fld**) that show an overall northward decrease in fragment sizes and proportion of epiclastic components and grade into crystal and lapilli tuffs. The transitional character of the contact suggests that the unconformity may not represent a long period of time. Quartzite also crops out on the north side of Nukiplilik Qikiqtaa, but primary features are obscure.

West of the Meadowbank River, mafic layers and quartz-eye felsic rocks are present in the quartzite in two areas. The more northerly occurrence comprises mafic schist (**Mv**) possibly related to the komatiites (65° 17'N 96° 23'W). The relationships suggest either exposure of underlying volcanic rocks by a fault or interbedding of quartzites and volcanic rocks. In the occurrence southwest of Qamanauganaakuluk, the mafic rocks (**Dtm**) are coarsely ophitic and massive, resembling a gabbroic sill or dyke intruded into the quartzite (65° 3.5'N, 96° 30'W). Six kilometres west of the river (65° 18'N, 96° 30'W), a massive to locally foliated metadiorite body is intruded by granite. In two exposures (one shown at map scale), the diorite is in sharp contact with quartz-eye felsic rocks that are indistinguishable from the volcanic rocks to the east. In one case, the quartz-eye felsic rock is apparently intrusive into diorite. The relationships suggest that the gabbros and diorites are subvolcanic or massive phases of the volcanic sequence.

West and southeast of Ukalik Lake (65° 15'N, 96° 03'W and 65° 14'N, 95° 57.7'W, respectively), polymictic conglomerates are associated with orthoquartzites in two locations. Southeast of the lake, the extensive areas of conglomerate are mostly oligomictic, dominated by quartz clasts, but clasts of massive granitoid and muscovite schist are present in some beds. West of the lake, the presence of rounded cobbles of quartz-eye felsic volcanic rocks as an important component of the clast population suggests that the conglomerate may be correlative with the basal conglomerate that overlies the unconformity northwest of the Meadowbank River. However, the stratigraphic and structural relationships in the Pipedream-Third Portage lakes area require more work. In contrast to the quartzites near the Meadowbank River, those near Ukalik Lake are interbedded with slates (**Sl**) and associated with greywackes (**Wk**), raising the possibility that they are not the same unit. Structural complications are also evident at Ukalik Lake. Conglomerate occupies the inner hinge region of a fold, whereas quartz-eye felsic rocks, komatiites and ultramafic schists are on the other side of the quartzite outside of the fold. Preliminary results of U-Pb zircon dating, suggest that felsic volcanic rocks both east and west of the quartzite may be the same age, including rocks associated with komatiites on Pipedream lake (Tasirjuaraarjuk) south of the map area (W.J. Davis, pers. comm., 1999). In the south, the ages, in combination with topping indicators that consistently show easterly younging (Zaleski et al., 1997b), imply early structural imbrication of the sequence. The relationship of the Ukalik Lake area to the stratigraphic succession on the Meadowbank River remains ambiguous until discrimination between structural repetitions and stratigraphic recurrences of similar-looking lithological units is further resolved.

Volcanic Rocks with Iron-Formation and minor Greywacke

South of Nukiplilik and northwest of Quggiilik along the Meadowbank River, a more varied volcanic and sedimentary sequence is present comprising ultramafic, mafic, intermediate and felsic volcanic rocks, iron-formation and cherty tuffs interbedded with iron-formation, and minor greywacke. The relationship of these rocks to quartzite and the underlying komatiite-felsic volcanic sequence is uncertain, but along the Meadowbank River east of Qamanauganaakuluk, bedding in quartzite dips toward the southeast, apparently underneath felsic to intermediate rocks (**Fiv**) interbedded with iron-formation. The presence of quartz-rich (quartzite?) clasts in a debris-flow deposit in the volcanic rocks also suggests that the volcanic and sedimentary sequence overlies quartzite.

Nutipliliup Qikiqtaa and the area to the east is dominated by mafic to intermediate volcanic rocks (**Miv**) intercalated with thin (cm) to thick (100's of metres) units of layered felsic tuffs, cherts and iron-formation (**Fch**, **If**). The mafic to intermediate rocks are typically massive flows, commonly porphyritic with coarse (5-8 mm) plagioclase and amphibole phenocrysts (or amphibole pseudomorphs?) in a dark fine grained matrix. Felsic tuffs or chert are typically thinly bedded, and interbedded with banded chert-magnetite iron-formation. To the northeast, the sequence is interrupted by plutonic rocks and by faults, and discontinuities across the Meadowbank River suggest that the river may in part follow fault zones.

Fabric development and metamorphic grade increase toward the northeast, and metamorphic recrystallization makes the identification of protoliths more difficult. Intermediate to felsic plagioclase-porphyritic volcanic rocks (**Fiv**) are abundant; however, near the northern margin of the supracrustal rocks, recrystallized felsic to intermediate volcanic rocks may be confused with deformed medium grained granites. Ultramafic rocks (**Um**) are present in the northeastern corner of the map area in a single zone, 30-250 metres in width, traced for about 7 km (65° 23'N, 95° 56'W). Primary features are obscure or obliterated. The ultramafic rocks are associated with banded magnetite-chert iron-formation (**If**), biotitic greywacke (**Wk**) and plagioclase-crystal tuffs (**Fiv**), as well as with amphibole granofels (**Ah**), metasedimentary rocks with mixed chemical and clastic components. The associations are quite different from those of the interbedded komatiites and quartz-eye felsic volcanic rocks, and consistent with the presence of two very different, komatiitic suites.

In the southwestern part of the map area, felsic to intermediate volcanic rocks, and mafic to intermediate schists interpreted as greywackes (**Wkm**), are considered equivalent to the volcanic and sedimentary sequence to the east. However, some units typical of the eastern sequence, such as iron-formation and interbedded cherts, tuffs and iron-formation, have not been observed. As along the Meadowbank River southeast of Nutipliliup Qikiqtaa, the metavolcanic rocks are underlain by quartzite.

PLUTONIC ROCKS

The supracrustal sequence is interrupted by abundant plutonic rocks, predominately granite to granodiorite (**Gt**), quartz-feldspar porphyry (**Pp**) and diorite (**Dt**). The plutonic rocks vary from massive to foliated to mylonitic, and the presence or absence of tectonic fabrics is apparently related to the ambient strain state of area. However, even massive granites tend to show tectonic foliation near contacts with supracrustal rocks. The granites are commonly porphyritic, containing quartz eyes or Kfeldspar megacrysts or augen, in a medium to coarse grained, biotite-magnetite-bearing, granitic matrix. In some areas, the granites have a deep pink to brick-red weathered appearance, apparently due to hematization and alteration. Throughout the map area, isolated occurrences of feldspar porphyry with a fine to medium grained, dark, biotite-rich matrix were grouped with plutonic rocks. Quartz-eye granites are common north and west of the lower komatiite-felsic volcanic sequence and, in some cases, finer grained quartz-feldspar porphyritic granite forms the outcrops near contacts with supracrustal rocks. The fine grained porphyritic granite was distinguished from volcanic porphyry on the basis of field identification of Kfeldspar in the phenocryst population. Three kilometres west of the Meadowbank River, a quartz-eye granite truncates the unconformable contact between volcanic rocks and quartzite. The granite is mainly massive with weak to moderate tectonic foliation locally developed near contacts, consistent with an intrusive relationship. In the northeastern map area, equigranular granites to granodiorites are common, locally containing diffuse biotitic schlieren that may be the remnants of supracrustal inclusions. One such biotitic zone (**Gtb**), about 300 metres in width, extends northeastward from Nukiplilik. Between Nukiplilik and Quggiilik, the map pattern of alternating granite-granodiorite and supracrustal rocks suggests that granitoid sheets were interleaved with the supracrustal sequence prior to folding (see below).

Dioritic to gabbroic rocks were observed in several areas north of the Meadowbank River. Foliation trends in the diorite-gabbro and in the surrounding granites outline curvilinear patterns which tend to be broadly conformable to their contacts. The patterns suggest a sheeted plutonic complex with domes or interference folds exposing plutonic rocks from different structural levels. South of the Meadowbank River, dioritic to gabbroic rocks define smaller elongate bodies and, in one case, include a distinctive orbicular diorite (**Dto**). Northwest of Nukiplilik Qikiqtaa, several fine grained, diabase(?) dykes, about 3-5 metres in width, cut across the komatiites and felsic rocks at a low angle to the dominant structural trend. Six kilometres west of Nukiplilik Qikiqtaa, a lamprophyre dyke (**Lm**) intrudes komatiites subparallel to layering and schistosity.

STRUCTURE AND METAMORPHISM

The map area can be divided into 3 structural domains based on strain state and the intensity of fabric development, style of folding and relationships of folds and fabrics, and metamorphic grade. The largest domain lies north and south of the Meadowbank River west of longitude 96° 05'W, encompassing an area of low strain enclaves, open to tight macroscopic folds, and local zones of strong penetrative fabrics. Chlorite-talc-carbonate assemblages in ultramafic schists are consistent with greenschist-facies metamorphic grade. To the east, a second domain north of the Meadowbank River is characterized by pervasive subhorizontal L > S fabrics, apparently coaxial with a macroscopic antiform. In domain 2, ultramafic rocks are characterized by amphibole-garnet-magnetite parageneses, and iron-formation commonly contains garnet and amphibole indicating amphibolite-facies metamorphic grade. The third domain lies south of the Meadowbank River, east and west of Ukalik Lake, in an area that was mapped mainly in 1996 (Zaleski et al., 1997a, b). In domain 3, the dominant northeasterly trending schistosity (previously described as S1, ibid.) has an axial planar relationship to macroscopic and mesoscopic folds (previously described as F1, ibid.) of lithological units. Greenschist-facies assemblages, including chlorite-muscovite-chloritoid-kyanite, are observed in slates and phyllites in domain 3 (ibid.).

In domain 1, the unconformable contact between the interbedded komatiite-felsic volcanic sequence and quartzite is repeated by upright, upward-facing, east-west-trending folds, consisting of a syncline-anticline pair. The syncline apparently plunges to the west; however, the simplest way to account for the occurrence of quartzite on northern Nukiplilik Qikiqtaa to the east is by a 'porpoising' or doubly-plunging fold axis. Schistosity in the quartzite and volcanic rocks changes dip direction across the fold traces and, while this observation needs to be better constrained, it does suggest that the folds deform an earlier fabric. To the south of the anticlinal trace, bedding and schistosity in the quartzite consistently dip moderately to shallowly toward the south. The southward plunging bedding-schistosity intersection lineations are nearly orthogonal to the orientation inferred for the fold axes, consistent with the suggestion that these structural elements are not cogenetic.

West of the Meadowbank River, the granite body that intrudes the unconformable contact divides the quartzite into two main outcrop areas. Bedding and the dominant schistosity in the supracrustal rocks show systematic changes in attitude around the granite body, consistent with the presence of a northerly trending macroscopic anticlinal fold trace in the granite. The map pattern defined by granite-quartzite contact and by the diorite body intruded by granite north of the quartzite suggest that the granite is itself folded. Structural analysis of the folded fabrics shows that the attitude of the fold axis varies from 190/30 to 145/15 from south to north along the curved axial surface trace. Locally developed crenulation lineations and crenulation cleavage in the supracrustal rocks, and schistosity in the granite near the hinge region, may be related to the fold. The nearly isoclinal appearance of the fold in map view is partly due to the moderate plunge. Preliminary interpretation suggests that the curvature of the axial trace is not related to the easterly trending folds of the unconformable contact. Since bedding in the quartzite west of the granite consistently strikes northwest to west-northwest and dips moderately toward the south and southwest, the quartzite lies entirely south of the east-west-trending anticlinal fold trace, suggesting that the granite intrudes across both the unconformity and the fold.

The quartzite in the southwestern corner of the map is separated from the quartzite to the northeast by the upper volcanic and sedimentary sequence and granitoid rocks. Schistosity and bedding throughout the sequence dip consistently toward the south and west, showing that the quartzite is not repeated by a fold. Granite in the area 5 km west-southwest of Qamanauganaakuluk shows strong gneissic to mylonitic fabrics, and the contact with quartzite to the north is a high strain zone of interleaved granite and quartzite (65° 14.7'N, 96° 32.7'W).

In the interlayered komatiites and felsic volcanic rocks north and west of Nukiplilik Qikiqtaa, penetrative fabrics (schistosity and crenulation cleavage) increase south toward the river and, to some degree, toward contacts with quartzite. In areas of high strain, felsic rocks are transitional to quartz-eye muscovite schists, and komatiites are pervaded by carbonate and grade to ultramafic schists characterized by talc, tremolite, serpentine, magnetite and Fe-carbonate (**Kms**). Felsic and ultramafic interlayering in schistose rocks is strongly transposed and attenuated and, in many cases, the two are not recognizable as separate components. Strongly layered rocks such as iron-formation show recumbent isoclinal folds of layering and schistosity. Kink folds, penetrative crenulation cleavages and pencil cleavages are present, suggesting intersection of multiple foliations. Crenulation cleavages and axial planes of folds have strikes of 225-280° and shallow to moderate northerly dips. Similar fabric elements are found in all 3 structural domains and were previously described as S2 and F2 (Zaleski et al., 1997a, b; now subject to revision, see below), although no associated macroscopic structures were identified.

The high strain along the shore of the Meadowbank River is apparently not associated with any major displacement of lithological units and the strongly developed schistosities, folds and crenulation cleavages seem to be primarily due to flattening. The intense fabric development does not obviously continue inland in the supracrustal rocks, nor in the granite, to the west. However, the crudely east-west trending lamprophyre and diabase dykes may have intruded along faults or pre-existing zones of weakness related to the high strain zone. The macroscopic east-west-trending folds of the unconformable contact between the komatiite-felsic sequence and quartzite tighten toward the projected high strain zone. Crenulation cleavages and the axial planes of folds associated with the high strain zone dip shallowly to moderately toward the north. In contrast, a steep or southerly dip is inferred for the axial plane of the east-west trending anticline of the unconformable contact, suggesting that these folds are not cogenetic with the high strain zone but, rather, that the tightening is due to superimposed strain. The trace of the fold of granite and diorite to the west changes to northwesterly. The change in orientation and the presence of local schistose zones suggests that flattening affected the area and that it post-dated the intrusion of granite and the northerly trending, granite-cored anticline.

In domain 1, in the volcanic sequence and iron-formation east of Qamanauganaakuluk and south of the Meadowbank River, northeasterly trending, macroscopic folds are defined by the map pattern of interlayered lithological units. The rocks are commonly massive, and the dips of bedding and contacts are poorly known.

Domain 2 to the northeast is characterized by subhorizontal to shallowly southwest-plunging, L > S fabrics that are nearly ubiquitous in both granites and supracrustal rocks. The lineations are coaxial or nearly coaxial with a macroscopic fold that deforms the granite to granodiorite sheets and supracrustal rocks, as well as schistosity. Stereographic projection shows that poles to schistosity and bedding define a girdle about an axis of 240/06 that is nearly coaxial with the peak distribution of lineations (231/08), which suggests that the dominant lineation is associated with the fold (Zaleski et al., 1999a).

In domain 3, the dominant east-northeasterly trending schistosity dips moderately to the southeast and is axial planar to mesoscopic and macroscopic folds of bedding, contacts and lithological units. The previous description of schistosity and folds as S1 and F1 respectively (Zaleski et al., 1997a, b) may need revision as petrographic observations suggest that the dominant schistosity is in part a transposed crenulation cleavage of a pre-existing fabric. In the area east and west of Ukalik Lake, the komatiite and ultramafic schist associated with quartz-eye felsic volcanic rocks, the quartzite, and the polymictic conglomerate resemble the lithological units northwest of the Meadowbank River. However, an understanding of the complex stratigraphic and structural relationships in this area will require more work.

Northeasterly to east-northeasterly trending, macroscopic folds that deform earlier schistosity are present in all 3 structural domains. The differences in fold style and fabric relations between the domains may be partly related to differences in metamorphic grade, greenschist-facies in domains 1 and 3, and amphibolite-facies in domain 2. In domain 2, granitoid sheets and supracrustal rocks are folded about a shallowly southwestward-plunging axis that is coaxial with L > S fabrics. In domain 3, granites may be involved in the folding, for example 6 km south of Ukalik Lake, and a ca. 2620 Ma quartz-feldspar porphyry dyke contains a schistosity (65° 11.4'N, 95° 59'W; Davis and Zaleski, 1998) that is subparallel to the axial planar fabrics in the supracrustal rocks. The attitude of the schistosity indicates that the axial planes of the folds dip moderately toward the south-southwest. The attitudes of linear fabric elements (stretching and mineral lineations, mesoscopic fold axes) is variable (Zaleski et al., 1997a), perhaps influenced by the orientations of pre-existing fabrics.

Domain 1 generally shows relatively low strain, and the geometry of the northeasterly trending folds and their relationship to granites are poorly constrained. The folding deformed locally developed earlier fabrics, and was not associated with development of new fabrics. The east-west-trending syncline-anticline pair is truncated by granite which is involved in a younger, northerly trending fold (west of Nukiplilik Qikiqtaa). The granite has not been dated, but it resembles 2.61-2.62 Ga porphyritic granites (Ashton, 1988; Davis and Zaleski, 1998), suggesting the east-west folding may be Archean. The relationships of the east-west-trending and northerly-trending folds to the northeasterly-trending folds is unclear. However, northeasterly-trending folds deform granites in domains 2 and 3 and, in domain 3, it appears that the postulated early fold of quartzite, conglomerate, komatiite and felsic rocks could be the refolded equivalent of the east-west-trending folds in domain 1.

ECONOMIC GEOLOGY

Eight mineral occurrences were identified in the map area during a compilation of information in assessment reports (Table 1). All comprise metal-rich veins, in some cases of multiple generations (e.g., Calvin and Hippo), and are apparently structurally controlled. In addition, several areas of rusty gossan or stockwork to semi-massive sulphide showings were observed during mapping. In particular, iron-formation and greywacke near the ultramafic schist in the northeastern corner of the map are host to extensive gossan zones. In several areas north and east of Qamanauganaakuluk, quartzites and conglomerates contain pyritic gossans. About three kilometres southeast of Qamanauganaakuluk, granite is moderately to intensely epidotized, saussuritized and locally carbonatized to the extent that, in some cases, plagioclase is completely replaced by green calc-silicate minerals and the rock has a pink-green mottled appearance. The alteration is associated with molybdenite mineralization on seams and fractures.

ACKNOWLEDGEMENTS

The Woodburn Project was initiated by Jack and Mariette Henderson. Collaborators in the broader mapping and research program include Bill Davis, Continental Geoscience Division, Bruce Kjarsgaard, Mineral Resources Division, and George Jenner, Memorial University. Field notes and station locations from the reconnaissance mapping program of Heywood, Tella and Annesley supplied by Subhas Tella were very helpful in directing the present mapping. Gerry Harron and McChip Resources Ltd. made available the results of a high resolution aeromagnetic survey and detailed mapping on claims held by McChip Resources Ltd.. The field program was operated out of the Meadowbank camp of Cumberland Resources Ltd., and Brian Alexander, Roger March, and Ewald Gossner of Cumberland Resources Ltd. are gratefully acknowledged for their co-operation and logistical help during the field season. The map and notes were greatly improved by the thorough reviewing of John Henderson.

REFERENCES

Annesley, I.R.
1989: Petrochemistry of the Woodburn Lake Group komatiite suite, Amer Lake, N.W.T., Canada; unpublished Ph.D. Thesis, University of Ottawa, Ottawa, 406 p.

Ashton, K.E.
1981: Preliminary report on geological studies of the "Woodburn Lake Group" northwest of Tehek Lake, District of Keewatin; in Current Research, Geological Survey of Canada, Paper 81-1A, p. 269-274.
1988: Precambrian geology of the southeastern Amer Lake area (66H/1), near Baker Lake, N.W.T.; unpublished Ph.D. Thesis, Queen's University, Kingston, 335 p.

Bethune, K.M., and Scammell, R.J.
1997: Legend and descriptive notes, Koch Island area, District of Franklin, Northwest Territories, (part of NTS 37C); Geological Survey of Canada, Open File 3391, Sheet 4 of 4.

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

Donaldson, J.A.
1966: Geology, Schultz Lake, District of Keewatin; Geological Survey of Canada, Preliminary Map 7-1966, scale 1:253 440.

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

Frisch, T.
1982: Precambrian geology of the Prince Albert hills, western Melville Peninsula, Northwest Territories; Geological Survey of Canada, Bulletin 346, 70 p.

Heywood, W.W.
1977: Geology of the Amer Lake map-area, District of Keewatin; in Report of Activities, Part A, Geological Survey of Canada, Paper 77-1A, p. 409-410.

Hoffman, P.F.
1988: United plates of America, the birth of a craton: early Proterozoic assembly and growth of Laurentia; Annual Reviews of Earth and Planetary Sciences, v. 16, p. 543-603.

Kerswill, J.A. Goff, S.P., Wilkinson, L., Jenner, G.A., Kjarsgaard, B.A., Bretzlaff, R., and Samaris, C.
1998: An update on the metallogeny of the Woodburn Lake group, western Churchill Province, Northwest Territories; in Current Research 1998-C, 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.

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.

Sanborn-Barrie, M.
1994: Structural investigation of high-grade rocks of the Kramanituar complex, Baker Lake area, Northwest Territories; in Current Research 1994-C, Geological Survey of Canada, p. 121-133.

Schau, M.
1982: Geology of the Prince Albert group in parts of Walker Lake and Laughland Lake map areas, District of Keewatin; Geological Survey of Canada, Bulletin 337, 62 p.
1983: Baker Lake map sheet (56D); Geological Survey of Canada, Open File 883.

Taylor, F.C.
1985: Precambrian geology of the Half Way Hills area, District of Keewatin; Geological Survey of Canada, Memoir 415, 19 p.

Tella, S.
1994: Geology, Amer Lake (66H), Deep Rose Lake (66G), and parts of Pelly Lake (66F), District of Keewatin, Northwest Territories; Geological Survey of Canada, Open File 2969, scale 1:250 000

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

Tella, S., Heywood, W.W., and Loveridge, W.D.
1985: A U-Pb age on zircon from a dacite porphyry, Amer Lake map area, District of Keewatin, NWT; in Current Research, Part B, Geological Survey of Canada, Paper 85-1B, 371-374.

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 (66H/1, 56E/4), District of Keewatin (Nunavut), Northwest Territories; Geological Survey of Canada, Open File 3461, scale 1:50 000.

Zaleski, E., L'Heureux, R., Duke, N., Wilkinson, L., and Davis, W.J.
1999a: Komatiites and felsic volcanic rocks overlain by quartzite, Woodburn Lake group, Meadowbank River area, Western Churchill Province, Northwest Territories (Nunavut); in Current Research 1999, Geological Survey of Canada, p. 9-18.

Zaleski, E., Duke, N., L'Heureux, R., Davis, W.J., and Wilkinson, L.
1999b: Clastic and chemical sedimentary sequences, Woodburn Lake group, Amarulik Lake to Tehek Lake, Western Churchill Province, Northwest Territories (Nunavut); in Current Research 1999, Geological Survey of Canada, p. 19-28.

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

Table 1

MINERAL OCCURRENCES

No.	Name	Type	Symbol	Commodities	Minerals	References
1		Gold	○	Au	Py	DIAND Assessment Report 082906
2		Gold	○	Au		DIAND Assessment Report 082136
3		Gold	○	Au-Ag		DIAND Assessment Report 082136
4	Hippo1	Gold	○	Au-As	Py-Apy	DIAND Assessment Report 082136
5	Hippo2	Gold	○	Au-Ag-As	Apy-Py	DIAND Assessment Report 082136
6	Calvin	Base Metal	□	Ag-Cu-Pb-(Au)	Cpy-Gal-Py	DIAND Assessment Report 082136, 082999
7	Calvin East	Polymetallic	◇	Au-Ag-Cu-Pb	Py-Cpy-Gal	DIAND Assessment Report 082688, 082136, 082999
8		Gold	○	Ag-(Au)		DIAND Assessment Report 082136

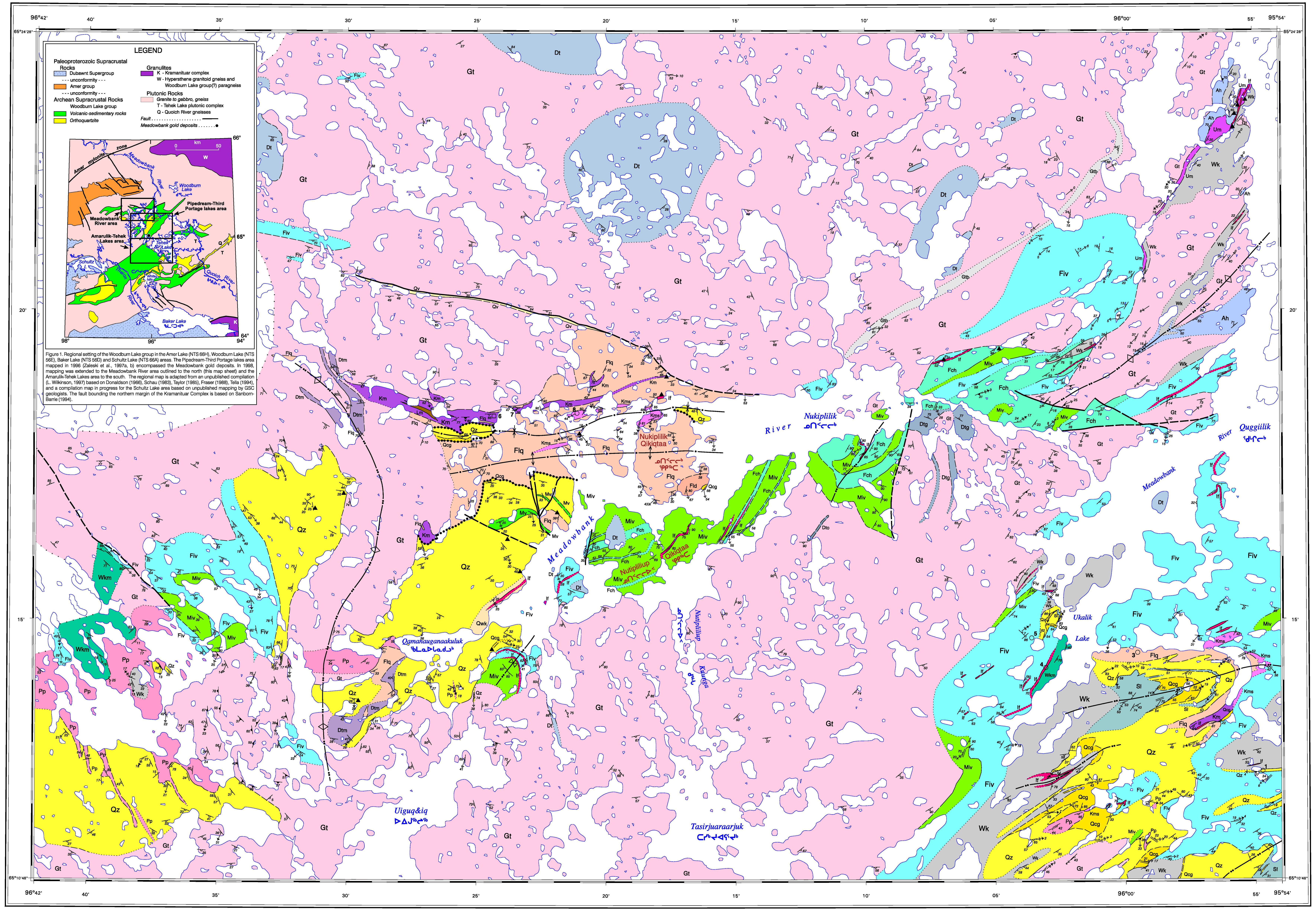


Figure 1. Regional setting of the Woodburn Lake group in the Amer Lake (NTS 66H), Woodburn Lake (NTS 56E), Baker Lake (NTS 56D) and Schultz Lake (NTS 66A) areas. The Pipedream-Third Portage lakes area mapped in 1996 (Zaleski et al., 1997a, b) encompassed the Meadowbank gold deposits. In 1998, mapping was extended to the Meadowbank River area outlined to the north (this map sheet) and the Amarulik-Tehek Lakes area to the south. The regional map is adapted from an unpublished compilation (L. Wilkinson, 1997) based on Donaldson (1966), Schau (1983), Taylor (1985), Fraser (1988), Tella (1994), and a compilation map in progress for the Schultz Lake area based on unpublished mapping by GSC geologists. The fault bounding the northern margin of the Kramanituar Complex is based on Sanborn-Barrie (1994).

LEGEND

PALEOPROTEROZOIC

- **Lm** — *Lamprophyre dykes, massive, fine grained with biotite phenocrysts*

ARCHEAN OR PALEOPROTEROZOIC

- **Qv** — *Quartz veins and pervasively silicified fractured rocks, could include some true quartzite or chert*
- **Gt** — *Granite to granodiorite, medium to coarse grained, commonly porphyritic with Kfeldspar phenocrysts or augen (1-5 cm in length) and/or blue, grey or white quartz eyes (3-10 mm diameter), biotite-and magnetite- bearing, includes red weathering alkalic varieties, and epidotized and sausserized altered granite locally with molybdenite and/or specular hematite mineralization on fractures, massive to foliated to locally mylonitic*
- **Gtb** — *Biotitic quartzo-feldspathic paragneiss enclaves in granite*
- **Pp** — *Quartz-feldspar porphyry, fine grained, massive to foliated*
- **Dt** — *Diorite to gabbro, medium to coarse grained, ophitic to subophitic, massive to foliated*
- **Dtg** — *Hybrid mixed diorite and granite, heterogeneous with diffuse enclaves of felsic and amphibole-rich composition, includes local intrusion breccias comprising mafic to intermediate clasts in granitic matrix*
- **Dto** — *Orbicular diorite, orbicules (up to 5 cm) comprising coarse grained white plagioclase in dark fine to medium grained matrix*

ARCHEAN

WOODBURN LAKE GROUP

(Stratigraphic sequence above quartzite uncertain, all supracrustal rocks are metamorphosed at low to medium grade)

- **Wkm** — *Mafic to intermediate wacke to slate, commonly with quartz, plagioclase and lithic grains in medium to dark green to black matrix, tuffaceous mafic rocks, streaky layering*
- **Wk** — *Greywacke, biotitic to quartzo-feldspathic, locally garnetiferous, minor phyllite*
- **Um** — *Ultramafic rocks characterized by amphibolite-facies metamorphic assemblages including cummingtonite(?), orthoamphibole(?), garnet and magnetite, massive or with polyhedral jointing, possible pillows*
- **Ah** — *Amphibole granofels, layering or bedding commonly largely obliterated by overgrowths of medium to coarse grained porphyroblastic green amphibole, also coarse grained garnet, in some cases layering is defined by garnet and amphibole concentration, commonly associated with banded iron-formation, foliation variably developed locally giving an amphibole-augen gneiss, interpreted as metamorphosed mixed silicate-facies iron-formation and volcanogenic detritus*
- **If** — *Banded iron-formation, mostly oxide facies with chert and magnetite-rich laminations, local silicate-facies and carbonate-bearing iron-formation, locally sulphidic with rusty weathering*
- **Fch** — *Cherty felsic tuffs with iron-formation interbeds, fine grained to aphanitic, thinly bedded, banded iron-formation interbeds (1 cm to 1 m width) locally comprise up to 50% of outcrop, local plagioclase phenocrysts or crystal clasts*
- **Fiv** — *Felsic to intermediate metavolcanic volcanic rocks, plagioclase porphyritic crystal and lapilli tuffs, minor debris-flow deposits that include epiclastic detritus, local schists*
- **Miv** — *Mafic to intermediate metavolcanic rocks, massive to foliated, includes fine grained to porphyritic flows and medium grained subvolcanic(?) intrusions, porphyritic flows commonly have 5-8 mm plagioclase phenocrysts and amphibole pseudomorphs of pyroxene(?) randomly dispersed in a fine grained matrix*
- **Sl** — *Slate to phyllite, thinly bedded, locally with chloritoid-kyanite-muscovite-chlorite bearing assemblages*

- - - - - character of contact unknown - - - - -

Quartzite and conglomerate

- **Qwk** — *Biotitic quartzite and quartz-rich wacke transitional to, or associated with, orthoquartzite*
- **Qz** — *Orthoquartzite, mostly white, but also grey, blue or pink, massive, jointed, or with micaceous interbeds (cm to 10's of cm thick), local cross-bedding defined by parting along bedding planes, commonly contains fuchsite as bright green flakes or fine grained imparting a greenish colour to micaceous beds, locally pyritic with rusty weathering*
- **Qcg** — *Polymictic and oligomictic conglomerate, in some cases transitional from one to the other, clasts include orthoquartzite, vein quartz, volcanic rocks, granite, and quartz-feldspar porphyry, rounded and ranging in size from pebbles to boulders (> 25 cm), matrix varies from white quartz-rich to grey micaceous to pyritic and dark or rusty in colour*

- - - - - unconformity - - - - -

Quartz-eye felsic volcanic rocks interbedded with komatiite

- **Fld** — *Debris-flow deposits dominated by felsic volcanic clasts, gradational up-section to conglomerate with mafic to intermediate and quartz-rich clasts*
- **Flq** — *Felsic volcanic rocks with quartz eyes varying from 0.5-1 cm ellipsoidal lenses of monocrystalline quartz to 0.5-5 mm euhedral quartz crystals, very sparse to 25% in white to grey or smoky, very fine grained to aphanitic matrix, 1-5 mm plagioclase phenocrysts common, includes monolithic lapilli tuffs and breccias, in some cases breccias contain lithic fragments of previously brecciated material, includes massive to strongly foliated quartz-eye muscovite schists*

Komatiite and associated rocks interbedded with felsic volcanic rocks

- **Km** — *Komatiitic flows, massive to layered, commonly with spinifex zones, polyhedral jointing, breccia zones, possible pillows, primary textures and structures pseudomorphed by greenschist-facies retrograde minerals, strongly magnetic*
- **Kms** — *Ultramafic schist characterized by talc, tremolite, serpentine, magnetite and/or Fe-carbonate, komatiitic protolith*
- **Dtm** — *Metadiorite and metagabbro, possibly more fractionated phases derived from komatiite, subvolcanic(?) locally strongly magnetic, typically medium to coarse grained massive with 50-80% prismatic amphibole, rarely schistose, local leucocratic varieties with diffuse mafic enclaves, local fine grained enclaves or inclusions(?) resemble komatiite, granitic veins and epidote-K-feldspar alteration in pods and on fractures common near contacts*
- **Mv** — *Mafic metavolcanic rocks, massive to foliated, local flattened pillows(?)*

Contact (defined, approximate, assumed)
Unconformity
Fault (defined, inferred)
Limit of mapping
Axial surface trace of fold (syncline, anticline)
Axial surface trace of fold (synform, antiform, unspecified)
Bedding (upright, top unknown)
Flow layering (upright, top unknown)
Mylonitic layering
Mineral schistosity
Crenulation cleavage
Kink bands (dextral, sinistral)
Fracture cleavage
Stretching lineation L > S
Mineral lineation
Bedding/schistosity intersection lineation
Crenulation axis
Folds of bedding/flow layering (axial plane, fold axis)
Folds of schistosity (axial plane, fold axis)
Gossan or sulphide zone
Mineral occurrences (see Table 1)

Geology by E. Zaleski, L. Wilkinson, and R. L'Heureux, N. Duke, University of Western Ontario, Department of Earth Sciences, 1998

Co-ordinated through the auspices of the Western Churchill NATMAP Project

Digital geological compilation by E. Zaleski, 1998

Digital cartography by L. Wilkinson, Continental Geoscience Division and P. M. O'Regan, Geoscience Information Division

Electrostatic plot produced by the Geoscience Information Division

OPEN FILE 3709

GEOLOGY

WOODBURN LAKE GROUP
MEADOWBANK RIVER AREA

KIVALLIQ REGION

NUNAVUT

Scale 1:50 000 - Échelle 1/50 000

Kilometres 1 0 1 2 3 4 Kilomètres

Universal Transverse Mercator Projection — Projection transverse universelle de Mercator

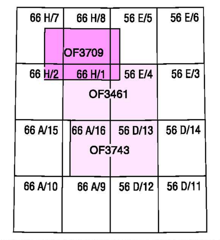
© Her Majesty the Queen in Right of Canada, 1999 — © Sa Majesté la Reine du chef du Canada, 1999

Any revisions or additional geological information known to the user would be welcomed by the Geological Survey of Canada

Digital base map from data compiled by Landsat TM, modified by the Geoscience Information Division

Some geographical names subject to revision
Traditional place names provided by Edwin Evo, John Avaala and Jacob Ikinilik, facilitated by Lucy Evo, Inuit Heritage Centre, Baker Lake

Proximity to the North Magnetic Pole causes the magnetic compass to be erratic in this area
Magnetic declination 1999, 0°51'W, increasing 8.4' annually



NATIONAL TOPOGRAPHIC SYSTEM REFERENCE AND INDEX TO ADJOINING GEOLOGICAL SURVEY OF CANADA MAPS

OPEN FILE
DOSSIER PUBLIC
3709
GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA
OTTAWA
07/1999

Recommended citation:
Zaleski, E., L'Heureux, R., Duke, N., Wilkinson, L. and Kerswill, J.A. 1999: Geology, Woodburn Lake group, Meadowbank River area, Kivalliq Region, Nunavut; Geological Survey of Canada, Open File 3709, scale 1:50 000.

Canada