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New multidisciplinary geological investigations in the Walmsley Lake area, southeastern Slave Province, Northwest Territories[1]

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Abstract

Geological mapping in the Walmsley Lake area, southeastern Slave Province, has defined relationships between metamorphism, deformation, and plutonism that suggest plutons similar to the Defeat suite in the Yellowknife domain were emplaced before or early during peak metamorphism and deformation (D_2). Younger two-mica granite units similar to the Prosperous suite in the Yellowknife domain are, at least in part, post-D_2. Fabric S_2 is the predominant fabric throughout the area, but the map pattern it defines is controlled primarily by northeast- and northwest-trending, upright, F_3 folds. Ice-flow studies identified three sets of striations, the early and late ones reflect ice-flow influenced by topography.

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Résumé

La cartographie géologique effectuée dans la région du lac Walmsley, dans le sud-est de la Province des Esclaves, a permis de définir les relations existant entre le métamorphisme, la déformation et le plutonisme. Ces relations semblent indiquer que des plutons semblables aux plutons observés dans la suite de Defeat dans le Domaine de Yellowknife ont été mis en place avant ou au début du métamorphisme maximal et de la déformation (D_2). Du granite à deux micas plus récent, semblable au granite de la suite de Prosperous dans le Domaine de Yellowknife, s'est formé, du moins en partie, après la déformation D_2. La fabrique S_2 est celle qui prédomine dans l'ensemble de la région, mais la configuration cartographique qu'elle définie est principalement contrôlée par des plis droits F_3 de direction nord-est et nord-ouest. Des études sur l'écoulement glaciaire ont permis de reconnaître trois ensembles de stries, parmi lesquelles les anciennes et les tardives indiquent que la topographie a influencé l'écoulement glaciaire.

INTRODUCTION

The multidisciplinary Walmsley Lake project, in the southeastern Slave Province, Northwest Territories, is being jointly undertaken and funded by the C.S. Lord Northern Geoscience Centre, Yellowknife, and the Geological Survey of Canada under the Targeted Geoscience Initiative (TGI). The goals of this project are to 1) produce integrated, digital bedrock and surficial maps (1:125 000 scale) for the Walmsley Lake area; 2) constrain regional tectonic events with U-Pb ages, to facilitate Slave-wide correlations; 3) refine crustal-evolution models for the southern Slave Province through U-Pb dating and tracer-isotope studies of granitoid rocks; and 4) link crust and mantle evolution in the southern Slave Province through the integration of geophysical imaging of mantle domains.

The integration of mapping, regional tracer-isotope analyses of granitoid rocks, U-Pb dating, and expanded geophysical transects will improve our understanding of the lithospheric-scale tectonic evolution of the southeastern Slave Province. When linked with the extensive geological framework and relatively well understood tectonic history of the Slave Province as a whole, this project is expected to lead to a better understanding of craton-scale tectonic controls on the generation and preservation of diamonds in the subcontinental mantle.

Regional mapping in the Walmsley Lake area (NTS 75N; **Fig. 1**) began in June 2000. This report summarizes preliminary mapping results of this three-year project. Two M.Sc. theses are supported by the project: one on the area's pressure-temperature-time history (Cairns) and the other on the petrogenetic history and mineral potential of a small greenstone belt in the northeastern corner of the map sheet (75N/16, Renaud et al., in press). Bedrock mapping in 2000 concentrated mainly on the northwestern part of the map sheet (75N/11, 12, 13, and 14).

The Walmsley Lake area was previously mapped at a scale of 1:250 000 by Folinsbee (1952) who subdivided the area into nine map units. Subsequent work elsewhere in the Slave Province has provided a broad geological framework for studies in the Walmsley Lake area, and recent mapping (e.g. Johnstone, 1993; Thompson et al., 1993; Kjarsgaard and Wyllie, 1994; Henderson et al., 1999) has upgraded the bedrock geology on adjacent map sheets.

REGIONAL GEOLOGICAL SETTING

The western part of the Slave Craton is composed of one or more blocks of Mesoarchean continental crust, structurally overlain by a succession of para-autochthonous, late Archean, submarine, tholeiitic to calc-alkalic volcanic rocks (*see* Bleeker et al., 1999). Evidence for Mesoarchean crust in the eastern Slave Province is lacking and late Archean volcanic rocks are largely juvenile (cf. Thorpe et al., 1992). The nature of the relationship between the western and eastern parts of the Slave Province is uncertain, but has previously been interpreted as a late Archean suture (e.g. Kusky (1983), Davis and Hegner (1992), Bleeker et al. (1999)). Late Archean volcanic rocks in the eastern and western Slave Province are overlain, both conformably and unconformably, by an extensive turbidite sequence (Bleeker et al., 1999). Regional deformation and syntectonic plutonism postdate deposition of the turbidite sequence. Late Archean metamorphic mineral assemblages define gently dipping, low-pressure, isothermal surfaces that coalesced during multiple pulses of heating during late Archean syntectonic plutonism (e.g. Bethune et al., 1999). Supracrustal rocks in the Walmsley Lake area formed as part of the juvenile late Archean terrane (cf. Thorpe et al., 1992) in the southeastern Slave Province (**Fig. 1**).

GEOLOGY OF THE NORTHWESTERN WALMSLEY LAKE SHEET (NTS 75N)

Supracrustal rocks

Metaturbidite underlies much of the area mapped in 2000 (**Fig. 2**). It ranges from subbiotite-grade to migmatitic rocks that contain abundant anatectic melt. Outside the cordierite isograd, graded bedding and other primary features are not uncommon. At higher metamorphic grades, younging indicators are less common, but graded bedding is preserved locally in both sillimanite- and cordierite-grade rocks, as an increase in porphyroblast concentration toward the more pelitic tops (**Fig. 3A**). Bedding is generally well preserved except in the most intensely migmatized rocks. Mafic rocks are rare within the supracrustal package, but east of Back Lake a narrow (2–3 m) unit of strongly foliated hornblende amphibolite is interlayered with the metaturbidite. This unit, which was traced for about 1.5 km, makes a useful marker horizon for tracing out folds of bedding and foliation.

Four isograds were mapped (**Fig. 2**). The regional cordierite-in isograd was pinned to within about 50 m in the northwestern map area. Cordierite porphyroblasts immediately inside the isograd are generally small (up to 6–7 mm) and are extensively replaced by biotite and/or muscovite. Within a few tens of metres, the porphyroblasts are up to 1 to 2 cm long and are present within both pelitic (muscovite-bearing) and semipelitic (muscovite-absent) beds. Andalusite occurs locally in pelitic beds within the regional cordierite zone; its first appearance is slightly upgrade from the cordierite-in isograd. Garnet occurs upgrade of andalusite; its distribution is controlled largely by bulk composition, and a regional, garnet-in isograd could not be mapped.

The regional sillimanite-in isograd is exposed along the northwestern side and north end of Back Lake (Fig. 2). Sillimanite first develops as tiny needles (fibrolite), commonly intergrown with quartz. Fibrolite also occurs as rims overgrowing andalusite and cordierite and together with biotite defines the S_2 foliation. Coarse-grained sillimanite blades do not occur until 1 km or more (in map view) beyond the isograd. The sillimanite isograd was traced continuously through the turbidite units, and intermittently through screens of metasedimentary rocks contained in the composite pluton south of Margaret Lake (Fig. 2).

The first appearance of melt is marked by millimeter-scale, foliation-parallel blebs of granitic material within pelitic beds (**Fig. 3B**). Whereas K-feldspar was not observed outside the melt-in isograd, muscovite is common. It is generally coarse grained and grows across the foliation, suggesting that it is a retrograde phase. It remains an open question whether the P-T path tracks above (higher P) or below the invariant point defined by the intersection of the melt-in and muscovite-out reactions. The melt-in isograd is difficult to map near the margins of large plutons, as veins and lenses of injected material from the pluton are difficult to distinguish from partial melt.

A second generation of cordierite in pelite occurs on the western side of the Zyena granite (**Fig. 2**). The pluton lies within the regional cordierite zone, and pelite immediately adjacent to it is characterized by brownish cordierite rims overgrowing cordierite porphyroblasts formed during peak regional metamorphism (**Fig. 3C**). The rims are up to 3 mm wide and occur within 2 km of the pluton. Locally the cordierite rims were observed to overgrow the main S_2 foliation.

Fabric elements in supracrustal rocks

Three sets of structural elements have been distinguished within the supracrustal rocks. The first deformation event (D_1) is characterized by an early, penetrative foliation (S_1), locally preserved as aligned biotite, muscovite, and quartz inclusion trails within cordierite and andalusite porphyroblasts (**Fig. 3D**). Although S_1 could be distinguished in numerous outcrops, it could not be traced over large areas. In the lowest grade rocks, changes in facing direction are interpreted to result from F_1 folds, as S_2 transects both limbs (Fig. 2). However, no F_1 fold hinges were recognized.

Structures associated with D_2 are the predominant fabric elements in most outcrops. The S_2 fabric is a slatey cleavage outside the regional cordierite isograd, and is a well developed schistosity at higher metamorphic grade. Where present, cordierite and sillimanite are aligned in S_2, although locally porphyroblasts grow across the foliation, indicating that mineral growth outlasted D_2 shortening in some areas. Tight to isoclinal folds of bedding (F_2) are widespread in the metaturbidite. At low metamorphic grade, they are most easily recognized by reversals in younging direction. The S_2 fabric parallels the axial surface of F_2 folds, and S_2/S_0 intersection lineations parallel F_2 fold axes, suggesting folding and foliation development are related. Furthermore, porphyroblasts are commonly parallel to F_2 fold axes, suggesting that D_2 accompanied peak metamorphism. On the basis of these observations, reversals in angular relationship between bedding and S_2 were used to map F_2 folds in higher grade rocks where younging is not well preserved. Because of later refolding, F_2 fold hinges have various orientations.

The third deformation event (D_3) consists of upright, open, northeast- and northwest-trending folds of S_2, rare crenulations, and an associated crenulation cleavage (S_3). The S_3 fabric is defined by coarse-grained biotite in metaturbidite and locally deforms sillimanite, indicating that it postdated sillimanite growth. The relative timing of northeast- and northwest-trending F_3 folds is currently unknown, and these folds are designated F_{3NE} and F_{3NW}. Third-generation upright cross folds define undulating dome-and-basin patterns at scales ranging from a few centimetres to tens of kilometres, including the regional map pattern defined by S_2. The diorite to quartz diorite pluton south of Back Lake (Fig. 2) is a thin (<1 km), flat-lying sheet folded, along with bedding and S_2 in the surrounding country rocks, into an asymmetric basin. Regional-scale folds of isograds coincide with F_3 folds of S_2 in metaturbidite.

At several localities, outcrop-scale, isoclinal, recumbent folds of the peak metamorphic fabric (S_2) were observed. At one locality these folds are cross-folded by both sets of F_3 folds. It is currently unclear whether this is a significant folding event that also occurs at a regional scale.

Plutonic rocks

Pretectonic and early syntectonic diorite to granodiorite

Hornblende±biotite diorite to granodiorite

Folinsbee (1952) mapped two small plutons of hornblende diorite south and east of Margaret Lake (**Fig. 2**). These plutons are part of a widespread unit ranging from hornblende±biotite diorite to biotite granodiorite that is well exposed around Anarin Lake (subsequently referred to as 'Anarin plutons'). This unit is multiphase, with abundant cognate enclaves that typically contain a foliation approximately parallel to S_2. The Anarin plutons contain a metamorphic foliation (S_2), and locally biotite tonalite was observed crosscutting S_2 in screens of biotite psammite (**Fig. 3E**), suggesting that they may be syn-D_2. However, external pluton contacts invariably parallel S_2–S_0 and therefore, the plutons could largely predate D_2. Contacts with the surrounding metaturbidite are characterized by mixed zones of lit-par-lit diorite to granodiorite sheets and metaturbidite.

Leucogranodiorite

A shallowly east-dipping sheet about 400 m thick of coarse-grained leucocratic granodiorite on the east side of Back Lake (Fig. 2) has been informally named the 'Back granodiorite'. The pluton is distinguished by large (up to 1 cm), brownish-yellow, anhedral quartz grains and brown titanite. Its contact with the host metaturbidite is sharp and parallels the thermal-peak fabric (S_2) and S_0. The pluton has a discernible foliation, although it contains less than 5% biotite; it is tentatively interpreted as an evolved phase of the Anarin plutons.

Biotite±muscovite leucogranite

Two spatially associated granite units are grouped together in this unit. The first is a fine- to medium-grained, foliated (S_2), two-mica granite with biotite defining the foliation, but with muscovite crosscutting the foliation (tentatively interpreted to be a subsolidus phase); the second is a medium- to coarse-grained biotite±minor muscovite monzogranite that is locally weakly foliated (S_2). Both occur as moderately northeast-dipping sheets in the composite pluton that transects northern Back Lake (**Fig. 2**), and both cut S_2 and S_0 (which are parallel) in adjacent sillimanite-grade metaturbidite (**Fig. 3F**). They also occur together in the pluton on the east side of Munn Lake and in the small round body south of Box Lake. Both units are interpreted to have been emplaced late during the main D_2 event.

Biotite monzogranite

This unit is pink-weathering, fine to medium grained, and weakly to moderately foliated. Coarser-grained K-feldspar-megacrystic varieties are generally unfoliated. This unit occurs as shallowly to moderately dipping sheets that range from centimetres to hundreds of metres thick. Within the large composite pluton between Margaret and Anarin lakes, sheets of this unit crosscut the peak metamorphic fabric and contain a sheet-parallel foliation defined by biotite and, locally, a weak shape fabric in quartz, which may be a fabric synchronous with emplacement. This unit also intrudes metaturbidite south of Back Lake, where it occurs as well foliated (S_2) sheets parallel to S_2/S_0.

Injection migmatite

Near the southwest end of Back Lake and east of southern Margaret Lake (**Fig. 2**) is a very heterogeneous unit composed of varied proportions of metasedimentary rocks and lit-par-lit granitoid phases centimetres to tens of metres thick. This unit is collectively referred to as 'injection migmatite'. The neosome component of the migmatite ranges from biotite-hornblende-quartz diorite to leuco-syenogranite, sheeted parallel to S_2–S_0. Near Margaret Lake, metamorphic assemblages in the metasedimentary component suggest temperature conditions below those required to form anatectic melts, and the neosome is interpreted to be intrusive. However, in migmatite south of Back Lake, small veinlets of granitic material are present within pelitic beds only, and are interpreted as in situ partial melt (**Fig. 3B**). Contacts between metaturbidite, migmatite, and granitoid bodies are gradational, and therefore it is commonly difficult to distinguish between granitoid with abundant partially digested metasedimentary derived schleiren and injection migmatite.

Late syntectonic to post-tectonic granite

Green apatite-bearing two mica leucomonzogranite

A unit of leucocratic, fine- to medium-grained, white-weathering monzogranite occurs throughout the map area. It contains minor muscovite and biotite (3–8% combined), and accessory turquoise apatite. A blue mineral, tentatively identified as lazulite, occurs locally in pegmatitic phases. This unit is typically massive or weakly foliated and makes up the predominant phase of four elliptical, stock-like plutons, two west of Montours Lake, one between Zyena and Box lakes, and a fourth east of Margaret Lake. It also occurs as a minor component within several other plutons. The Zyena granite is spatially associated with the post-thermal peak cordierite overgrowths in the metaturbidite west of Zyena Lake.

Garnet-bearing two-mica monzogranite

This granite, informally named the ‘Reid granite’, is the predominant phase of a composite pluton that occurs within cordierite-grade metaturbidite southeast of Reid Lake. The pluton contains up to 10% biotite+muscovite and accessory, 0.5 to 1 cm diameter, red to purplish garnets. The Reid granite is unfoliated, although the pluton does contain a foliated two-mica component with unknown relationship to the Reid granite. A dark reddish-weathering, fine-grained, unfoliated biotite tonalite was observed locally; its relationship to the other units is unknown. Contacts of the Reid granite are not well exposed, although on the northwest margin, at map scale, the Reid granite cuts S_2 in the metaturbidite. On the southeast margin, minor F_{3NE} folds in adjacent metaturbidite are at a high angle to the contact, but exposure is insufficient to determine if it cuts or is folded by F_3.

K-feldspar megacrystic granite

On the western edge of the map area, north of Reid Lake, is a distinctive, white-weathering, K-feldspar-megacrystic monzogranite with up to 5% biotite and no tectonic foliation. The contact of the pluton is sharp and transects bedding, foliation (S_2), and the regional cordierite isograd. It also appears to cut the axial trace of an F_3 fold, although the fold could not be traced continuously to the contact. These features suggest the K-feldspar megacrystic granite is one of the youngest map units and postdates the bulk of regional shortening.

Monzogranite to syenogranite pegmatite

Most granitoid bodies contain abundant pegmatite, although pegmatite also locally forms discrete bodies. It is typically muscovite-rich, but also contains biotite, garnet, and tourmaline locally. Garnet- and tourmaline-bearing pegmatite typically occurs within metasedimentary rocks. Where pegmatite crosscuts the metamorphic fabric at a high angle, there is commonly a dextral offset of the metamorphic fabric across the dyke. In general pegmatite does not appear to have undergone much deformation, although a small muscovite-garnet-bearing dyke at the south end of Zyena Lake does contain a penetrative foliation. This dyke cuts S_2 in the metaturbidite at a high angle, but also contains a foliation of uncertain generation.

Proterozoic dykes

At least three sets of diabase dykes are present and crosscut fabrics in host rocks. One set strikes east-northeast (about 080°) and occurs within subvertical normal faults of the same orientation. Along one such fault valley, a dyke is variably foliated, suggesting emplacement before or during fault movement. On the basis of orientation, dykes of this set are correlated with the ca. 2.23 Ga Mackay swarm (LeCheminant et al., 1996). A second set of diabase dykes strikes north-northeast and is interpreted to be part of the ca. 2.21 Malley swarm (LeCheminant et al., 1996). Both swarms are typically weakly metamorphosed such that feldspars are distinctly greenish. A third dyke set strikes northwest and, from the strong, positive magnetic signature and fresh ophitic texture, can be correlated with the ca. 1.27 Ga Mackenzie swarm (LeCheminant and Heaman, 1989).

A pyroxenite body of uncertain age was identified east of Back Lake, near the south end. It is exposed in only one outcrop in an area with extensive Quaternary cover and its size and shape are therefore unknown. The unit comprises coarse (1–2 cm) clinopyroxene and is characterized by a distinctive, crumbly, brown, weathered surface. It may be correlative with small peridotite plutons mapped by Henderson et al. (1999) to the east, north of Clinton-Colden Lake, which were interpreted to be Proterozoic.

A single lamprophyre intrusion was found within the Back granite on the east side of Back Lake. The lamprophyre is not well exposed, but on the basis of other lamprophyre occurrences in the Slave Province, it is presumed to be a dyke, likely of Proterozoic age.

Surficial geology

Within the northern Walmsley Lake area, glacial ice-flow studies have outlined three different sets of striae. The early and late striation sets in the Walmsley–Fletcher lake area indicate that ice-flow was to the northwest, and was likely controlled by a topographic low in that area (**Fig. 4**). In the northwest corner of the map sheet, the early striae suggest that ice flow was toward the southwest and was controlled by a topographic low along Box, Back, and Margaret lakes (Fig. 4).

Economic potential

On the basis of observations from the northwestern Walmsley Lake area, the potential for base- or precious-metal occurrences appears to be low. Rocks of volcanic origin are sparse, no iron-formation was identified within metaturbidite, and quartz veins are generally uncommon. Rare gossanous zones are present. No new mineralized occurrences were observed, although the Fox gold showing south of Box Lake (Folinsbee, 1952) was examined and resampled. Mineral potential of a small volcanic belt in the northeast corner of the map sheet is part of an M.Sc. thesis reported on elsewhere (Renaud et al., in press).

In contrast to the area's metal potential, its gem potential is considered to be high. Beryl, spodumene, and lazulite have been observed in muscovite pegmatite between Zyena and Reid lakes by Folinsbee (1952) and during the present study. Several diamondiferous kimberlite bodies occur within the Walmsley Lake sheet (e.g. Tuzo pipe owned by De Beers), and a number of companies are actively exploring for diamonds. The ice-flow patterns documented above will provide a regional framework for more detailed studies by diamond exploration companies.

DISCUSSION

The introduction of the Central Slave Basement Complex and the Central Slave Cover Group (Bleeker et al., 1999) has led to the recognition of a consistent, late Archean tectonic history across the south central Slave Province. Late Archean deformation in the central Slave Province is characterized northeast-trending F_1 and north-northwest-trending F_2 folds that control the regional structural topology (Bleeker et al., 1999). A third folding event occurs in localized domains and includes both northwest- and northeast-trending structures (Davis and Bleeker, 1999). The timing of D_1 is bracketed between 2660 Ma, the age of the Burwash Formation turbidite (Bleeker and Villeneuve, 1995), and 2624 Ma, the age of a crosscutting Defeat suite pluton (Davis and Bleeker, 1999). Peraluminous two-mica granite of the Prosperous suite (ca. 2595 Ma) is interpreted to be syn-D_2 (Davis and Bleeker, 1999), although the exact time of initiation and duration of D_2 remain poorly constrained. In the Walmsley Lake area, S_1 is only preserved as inclusion trails within porphyroblasts formed during peak metamorphism and, thus, the timing of D_1 relative to dateable events (i.e. plutonic) is unknown. Hornblende±biotite diorite to granodiorite plutons (lithologically similar to the Defeat suite) are interpreted to be early syn-D_2 and predominantly syn-peak metamorphism, although field relationships do not preclude them from being largely pre-D_2. Uranium-lead dating will help solve this problem. At least locally, two-mica granite postdates D_2 and peak metamorphism, in contrast to its syn-D_2 nature in the Yellowknife area. Although the predominant fabrics in the Walmsley Lake area are related to D_2, the map pattern is strongly affected by post-D_2 deformation: primarily upright, northwest- and northeast-trending F_3 cross folds. Uranium-lead dating will help constrain the absolute timing of deformation and metamorphism in the Walmsley Lake area and determine how regional events there correlate with those in the central Slave Province.

Mesoarchean basement is confined to the west and central Slave Province (Baragar and McGlynn, 1976; Bleeker et al., 1999) and it has been suggested previously that the boundary with juvenile late Archean crust in the east is a north-trending, late Archean suture (ca. 2.7 Ga; e.g. Kusky (1989), Davis and Hegner (1992), Bleeker et al. (1999)). Epsilon-Nd isotopic signatures of crustally derived granitoid rocks are a proxy for the location of this boundary at depth. In the central Slave Province, the location of the isotopic boundary suggests that the Mesoarchean crust dips east and extends some distance beneath the juvenile late Archean crust (Davis and Hegner, 1992). From parallelism with its known surface extent and one known locality of Mesoarchean fragments within a kimberlite pipe (B. Davis, unpub. data, 1999), the ε_{Nd} boundary at depth in the southern Slave Province is projected to occur in the Walmsley Lake area (**Fig. 1**).

In the Lac De Gras area (Fig. 1), the eastern margin of Mesoarchean basement at depth coincides roughly with both a magnetotelluric conductive anomaly (Jones et al., 2000; Fig. 1) and an ultradepleted harzburgitic layer at 80 to 120 km depth in the mantle (Griffin et al., 1999). A genetic relationship between the suture and the mantle anomalies has been suggested previously (e.g. Jones et al., 2000). However, these mantle anomalies are also found just north of a proposed domain where Defeat-type plutonism is distinctly older (2630–2620 Ma) than elsewhere in the Slave Province (2619–2610 Ma; van Breemen et al., 1992; Davis and Bleeker, 1999; **Fig. 1**). If the purported older plutonic domain is confirmed by U-Pb dating, it would define a northeast-trending belt across the southern Slave Province (Fig. 1). Thus, an alternative hypothesis is that the mantle anomalies are related to this crustal domain that is at a high angle to, and younger than, the purported ca. 2.7 Ga suture. Part of the uncertainty in the relationship between the mantle anomalies and crustal domains is the current lack of constraints on the orientation and extent of the mantle anomalies; this problem is being addressed by the geophysical component of the Walmsley Lake project (*see* Jones, in press, for details).

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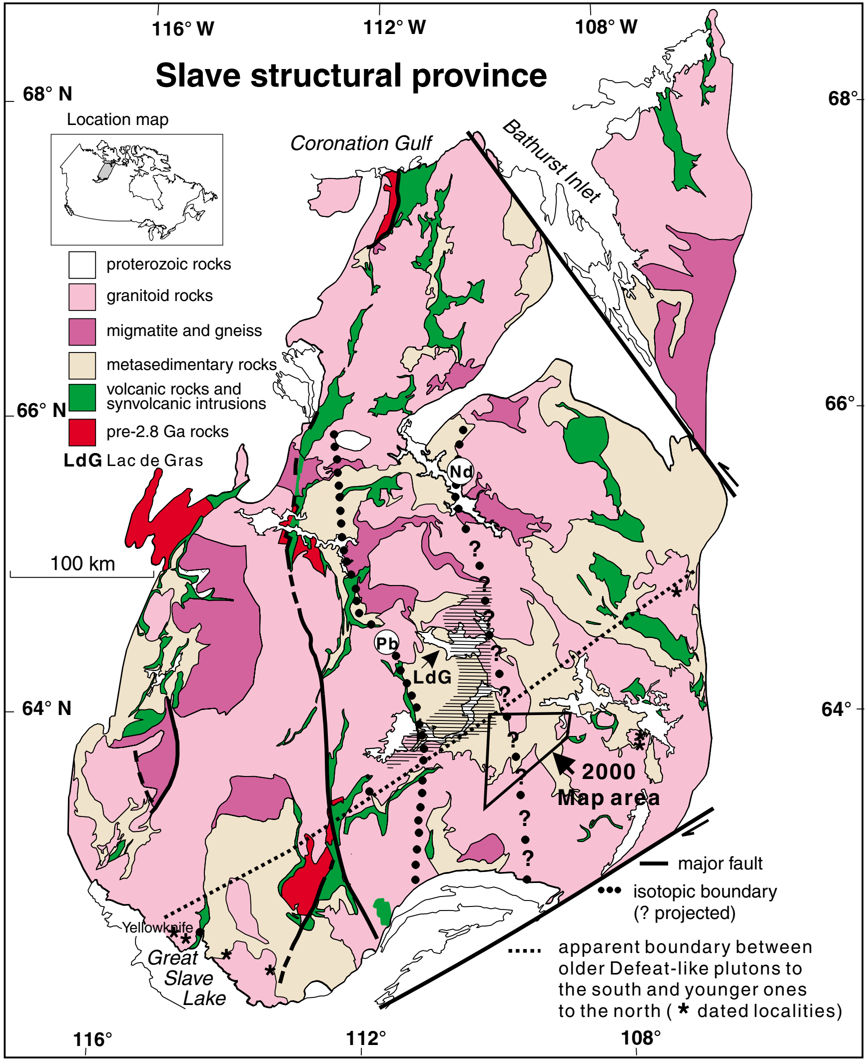


Figure 1. Simplified geology of the Slave structural Province showing the Walmsley Lake map area, isotopic boundaries, the proposed northern extent of older Defeat-like plutons, and the area currently known to be underlain by anomalously conductive mantle (horizontal hatch).

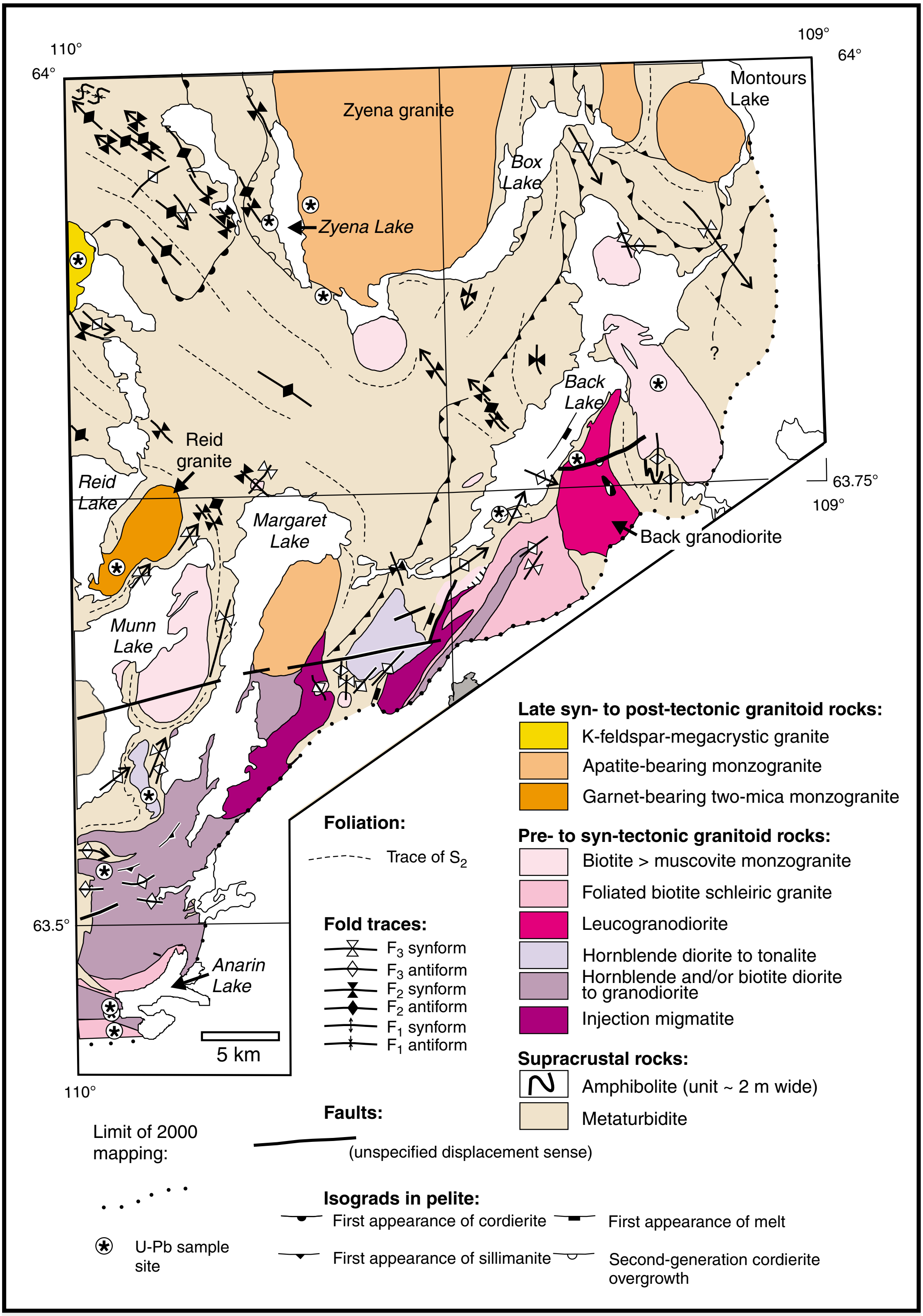


Figure 2. Simplified geological compilation map of the northwestern Walmsley Lake area, Northwest Territories (NTS sheet 75N).

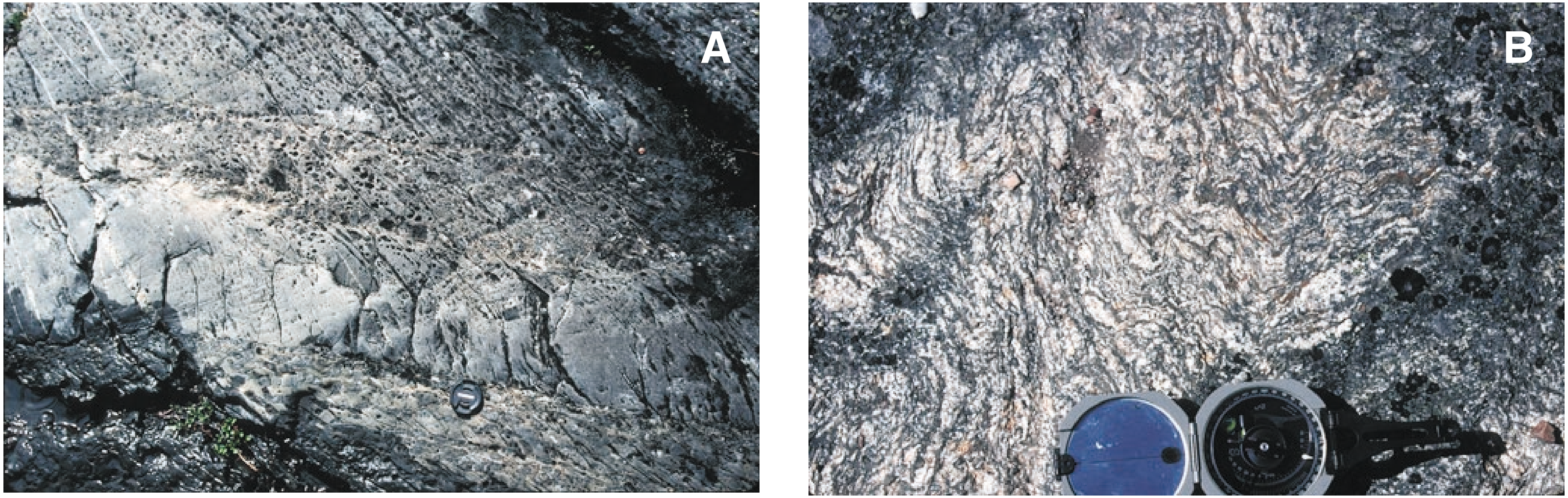
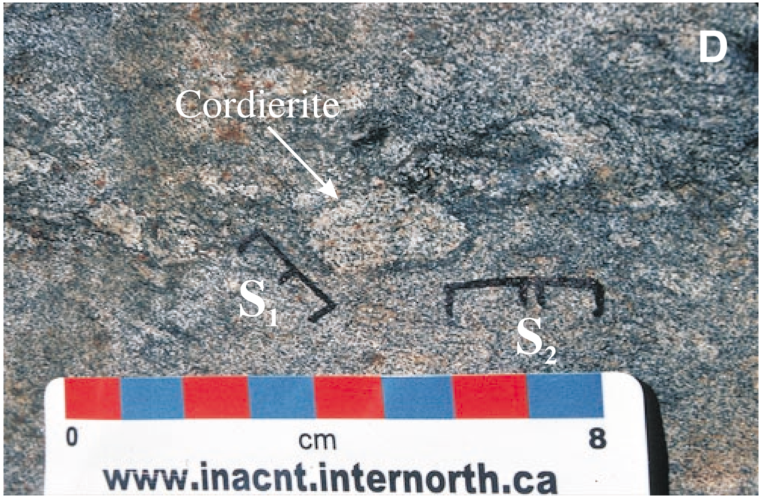


Figure 3. Field photographs. **A)** Cordierite-grade metaturbidite with cleavage refraction and variations in porphyroblast density indicating stratigraphic top toward the top of the photo; **B)** paragneiss with abundant in situ leucosome defining the S_2 fabric, folded by F_3 folds; **C)** cordierite-grade semipelite showing peak metamorphic cordierite overgrown by a second episode of cordierite growth.



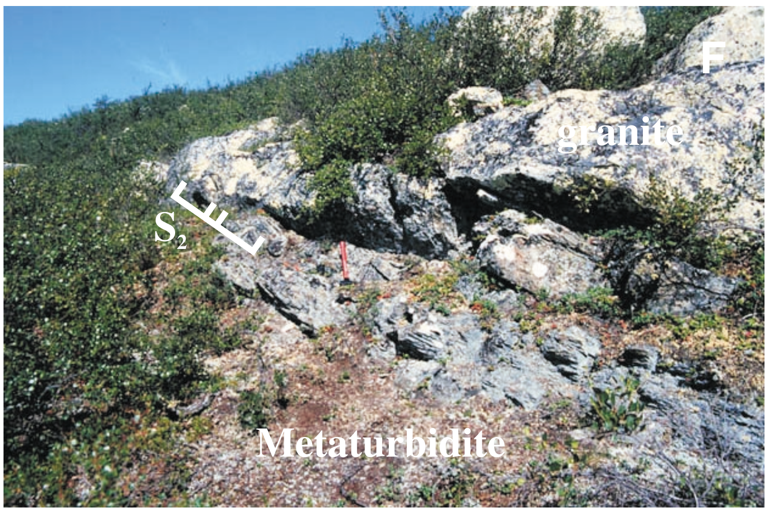


Figure 3. Field photographs. **D)** cordierite porphyroblast with S_1 inclusion trails at and angle to the main S_2 foliation; **E)** weakly foliated biotite tonalite Anarin pluton cutting S_2 foliation in psammitic screen; **F)** foliated two-mica granite sheet cutting S_2–S_0 in sillimanite-grade metaturbidite.

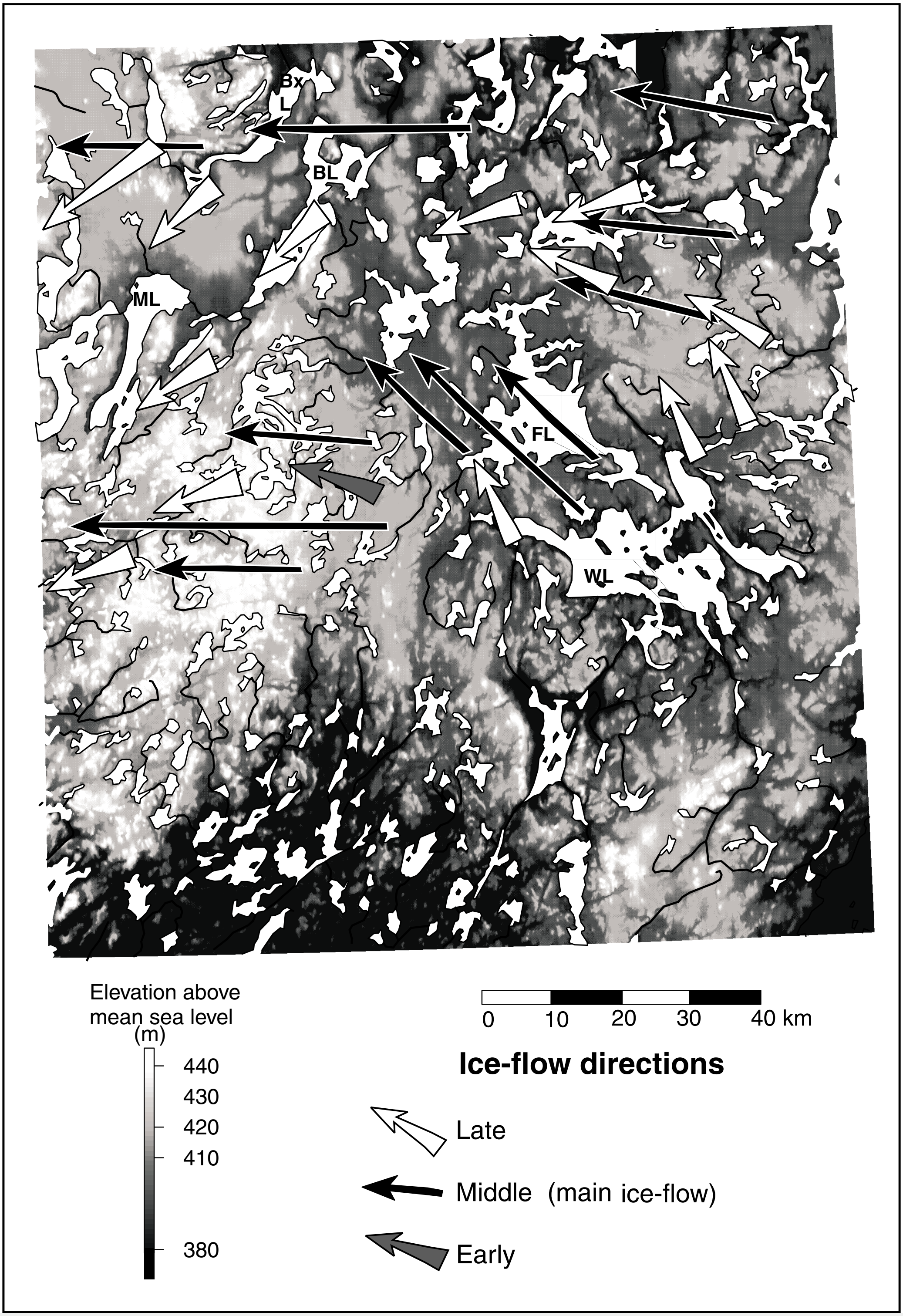


Figure 4. Compilation of ice-flow indicators for the northern Walmsley Lake area, superimposed on a digital elevation model. Abbreviated lake names are as follows: BL, Back Lake; BxL, Box Lake; FL, Fletcher Lake, ML, Margaret Lake; WL, Walmsley Lake.