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# NEW OBSERVATIONS FROM THE ANDRE LAKE AREA (NTS 23I/12), WESTERN LABRADOR: TECTONIC RELATIONSHIPS IN THE HINTERLAND OF THE NEW QUÉBEC OROGEN

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## ABSTRACT

*This report presents preliminary results of new 1:50 000-scale mapping in the Andre Lake area (NTS 23I/12), in the hinterland of the Paleoproterozoic New Québec Orogen (NQO). The map area spans three lithotectonic zones separated by west-verging thrust faults. The western and central zones comprise supracrustal rocks of the Kaniapiskau Supergroup (KS) and associated pretectonic gabbro sills, deformed into regional-scale upright folds related to southwest- to west-directed shortening. In the central zone, a basement complex, comprising presumed Archean orthogneiss and possibly Paleoproterozoic granite, is exposed in the core of a large north-plunging anticline. Later, west-directed thrusting focused along the flanks of this basement complex produced greenschist-facies ductile fabrics in the granite and adjacent rocks of the KS. The eastern zone, the McKenzie River domain (MRD), is underlain by Archean orthogneiss and Paleoproterozoic tonalites. Deformation in the MRD began at amphibolite facies, and included a component of east–west shortening and strike–slip shearing. Final juxtaposition with the KS by west-directed thrusting produced intense mylonitic fabrics in gneisses adjacent to the KS. The overall pattern of deformation in the area is related to regional-scale, broadly east–west dextral transpression during collision between the Superior Craton and the Core Zone. Paleoproterozoic magmatism in the area may be related to post-collisional crustal thickening, or possibly a pre-collisional magmatic arc within the MRD.*

## INTRODUCTION

The Andre Lake area (NTS 23I/12) lies in the hinterland of the New Québec Orogen (NQO; Figure 1), which together with the Core Zone and Torngat Orogen, comprises the southeastern segment of the Paleoproterozoic Trans-Hudson Orogen (THO; Hoffman, 1988). Formation of the NQO is generally ascribed to eastward subduction of the Manikewan Ocean and later tectonic accretion during terminal collision between the Superior Craton and the Core Zone, representing the final stage in the formation of the southeastern THO (*e.g.*, James and Dunning, 2000; Wardle *et al.*, 2002; Corrigan *et al.*, 2009). However, the tectonic evolution of the NQO is only loosely constrained. Questions remain concerning the crustal structure of the orogen, the provenance and tectonic affinity of certain supracrustal and basement units, and the precise timing of Hudsonian deformation, metamorphism, and magmatism.

This report presents an update on a multi-year study aimed at addressing some of these issues through regional mapping and geochronology, and is based on fieldwork completed in summer of 2018. The overarching aim of the project is to develop a robust tectonic model for the southeastern THO in Labrador, in part, to provide a foundation for geologists working in the economically important Labrador Trough. The Andre Lake area was chosen for a regional, 1:50 000-scale, mapping study based on previous mapping and recently obtained geophysical data, which demonstrate the presence of reworked Archean basement rocks and associated regional-scale structures essential to understanding the tectonic evolution of the NQO.

The report begins with an overview of the NQO and regional stratigraphy to familiarize readers with the large-scale structure of the orogen, and highlight some of the outstanding problems. This is followed by a geological description emphasizing the tectonic and metamorphic history of the Andre Lake area. The brief discussion places these observations in a regional context and outlines future work.

### LOCATION AND PREVIOUS WORK

The Andre Lake map area (NTS 23I/12) lies approximately 85 km east-southeast of Schefferville, Québec, and is accessible only by helicopter or float plane. Helicopter-supported ground traverses, based out of the McGill Subarctic Research Station in Schefferville, were completed by a single, two-man team comprising the author and student assistant Benjamin MacDougall. Topographically, the map area

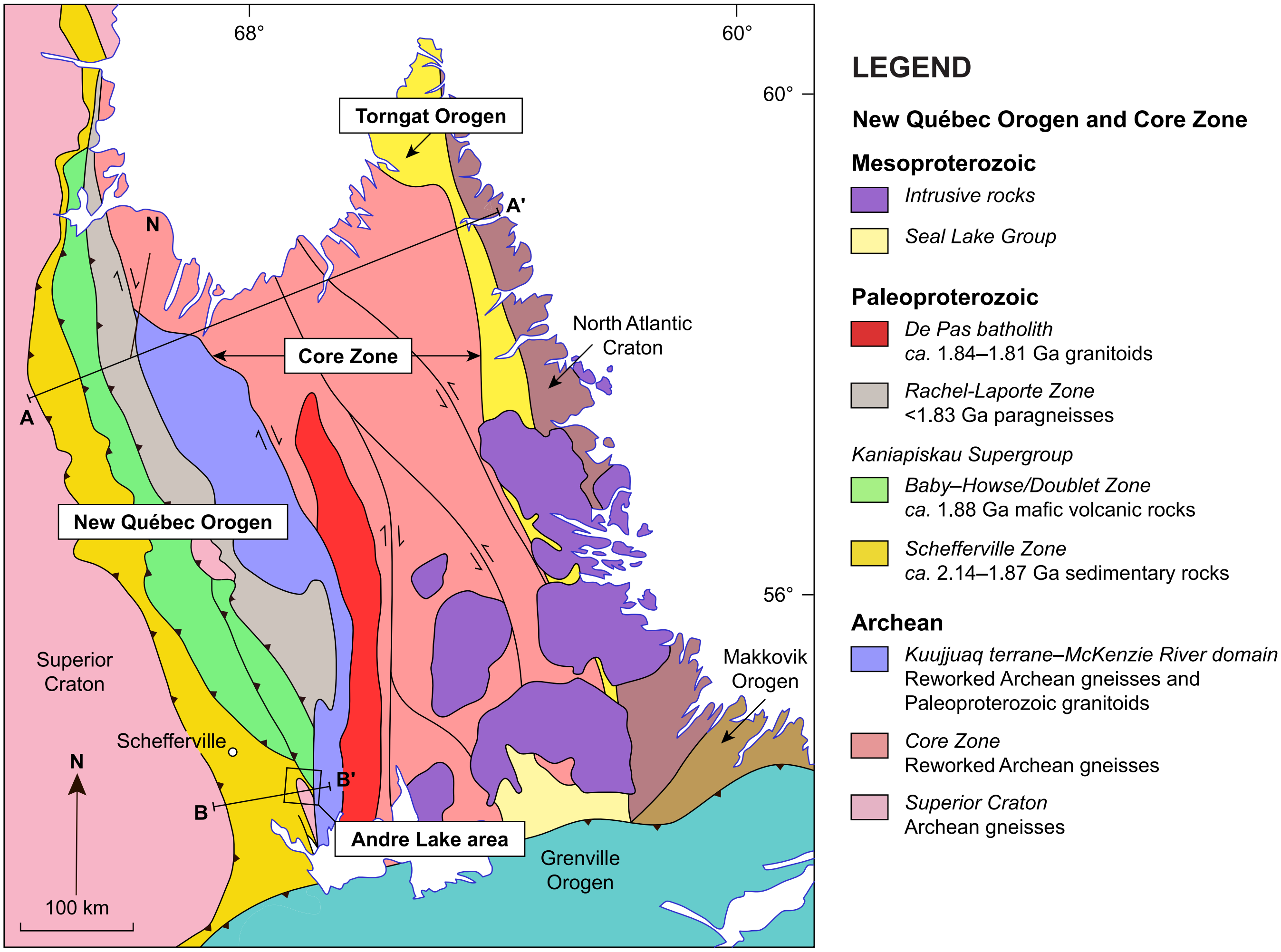



**Figure 1.** *Simplified geological map showing distribution of main lithotectonic domains within the NQO, modified from Wardle* et al. *(2002) and Corrigan* et al. *(2018). Lines A–A' and B–B' correspond to schematic cross-sections shown in Figure 2. The Andre Lake area is situated in the southern (Labrador) part of the orogen, at the contact between rocks of the Kaniapiskau Supergroup and the McKenzie River domain.*

is characterized by a few, generally north–south-trending ridges formed by more resistant rock types (*e.g.*, iron formation and gabbro), separated by broad, low-lying areas. The map area contains several large lakes, and is heavily vegetated. Bedrock exposure is poor, reaching maybe 1–2%. The accompanying map therefore makes extensive use of geophysical data interpretation.

Mapping in the Andre Lake area started in the 1940s and focused on assessing the potential for base-metal mineralization (Moss, 1942) and high-grade (>50% Fe) iron-ore deposits (Dufresne, 1950). Regional mapping by the Geological Survey of Newfoundland and Labrador began in the 1970s (Wardle, 1977, 1979). Data from this work was included in a regional, 1:100 000-scale compilation map of the geology of the Labrador Trough (Wardle, 1982).

## REGIONAL GEOLOGY

### TECTONIC OVERVIEW OF THE NEW QUÉBEC OROGEN

Formation of the New Québec Orogen is generally attributed to the closure of the Manikewan Ocean and later continent–continent collision between the Superior margin and an upper plate comprising the Core Zone and, to the east, the North Atlantic Craton (James and Dunning, 2000; Wardle *et al.*, 2002; Corrigan *et al.*, 2009). Prior suturing of the Core Zone and North Atlantic Craton took place *ca.* 1870 Ma (Wardle *et al.*, 2002), resulting in formation of the Torngat Orogen. Terminal Superior–Core Zone collision is thought to have taken place by *ca.* 1820 Ma (Wardle *et al.*, 2002), but may have been later in the south (*see* below).

Readers seeking a paleogeographic reconstruction are referred to Corrigan *et al.* (2009).

The NQO is interpreted at the crustal scale as a west-verging orogenic wedge, with late, out-of-sequence thrusts separating major lithotectonic zones (Figure 2A; Wardle *et al.*, 2002). In the foreland of the orogen, supracrustal rocks originally deposited on, or proximal to, the Superior passive margin from *ca.* 2170–1870 Ma (the Kaniapiskau Supergroup; KS) are deformed into a fold-and-thrust belt overlying Archean Superior basement (Wardle, 1982; Clark and Wares, 2005). This belt corresponds, on the accompanying map (Figure 1) and cross-sections (Figure 2A, B), to the Schefferville and Baby–Howse/Doublet zones, which have been grouped here for simplicity. Deformation in the foreland sequence is generally thin skinned, but folding and thrusting have led to the local exposure of basement rocks toward the hinterland, an example of which, the Snelgrove Lake basement complex, (Figure 2B) is described later. Metamorphism of the KS increases in grade gradually from west to east, reaching approximately greenschist to lower-amphibolite facies. The timing of deformation and metamorphism of the foreland sequence is not well constrained, owing to a general lack of datable units, but a single age of *ca.* 1813 Ma obtained from an undeformed monzonite intrusion near Nachipacau Lake (about 225 km northwest of Schefferville) suggests that thrusting had ceased by that time (Machado *et al.*, 1997). A more detailed subdivision focusing on structural zones in the foreland of the orogen is provided by Clark and Wares (2005).

The eastern boundary of the KS is marked in the Québec segment of the orogen by the Rachel Fault, a steeply east-dipping thrust (Figure 2A; Moorhead and Hynes, 1990; Wardle *et al.*, 2002). East of this fault, the Rachel–Laporte Zone (Figure 1) comprises amphibolite-facies metasedimentary rocks and reworked Archean basement deformed into a series of basement-cored fold nappes (Moorhead and Hynes, 1990; Wardle and Van Kranendonk, 1996). Once thought to represent a higher grade equivalent of the KS, recent detrital geochronology instead points to *ca.* 1840–1830 Ma plutonic rocks within the adjacent Kuujjuaq terrane and Core Zone as the probable sources of the Rachel–Laporte metasedimentary rocks (van der Leeden *et al.*, 1990; Henrique-Pinto *et al.*, 2017). The underlying basement gneisses have yielded ages ranging from *ca.* 2883–2690 Ma (Machado *et al.*, 1989; James and Dunning, 2000; Rayner *et al.*, 2017), and some of these complexes may represent nappes derived from the underthrusting Superior crust during collision (Rayner *et al.*, 2017). The U–Pb monazite ages of *ca.* 1790–1780 Ma probably represent amphibolite-facies metamorphism of the Rachel–Laporte Zone (Machado *et al.*, 1989).

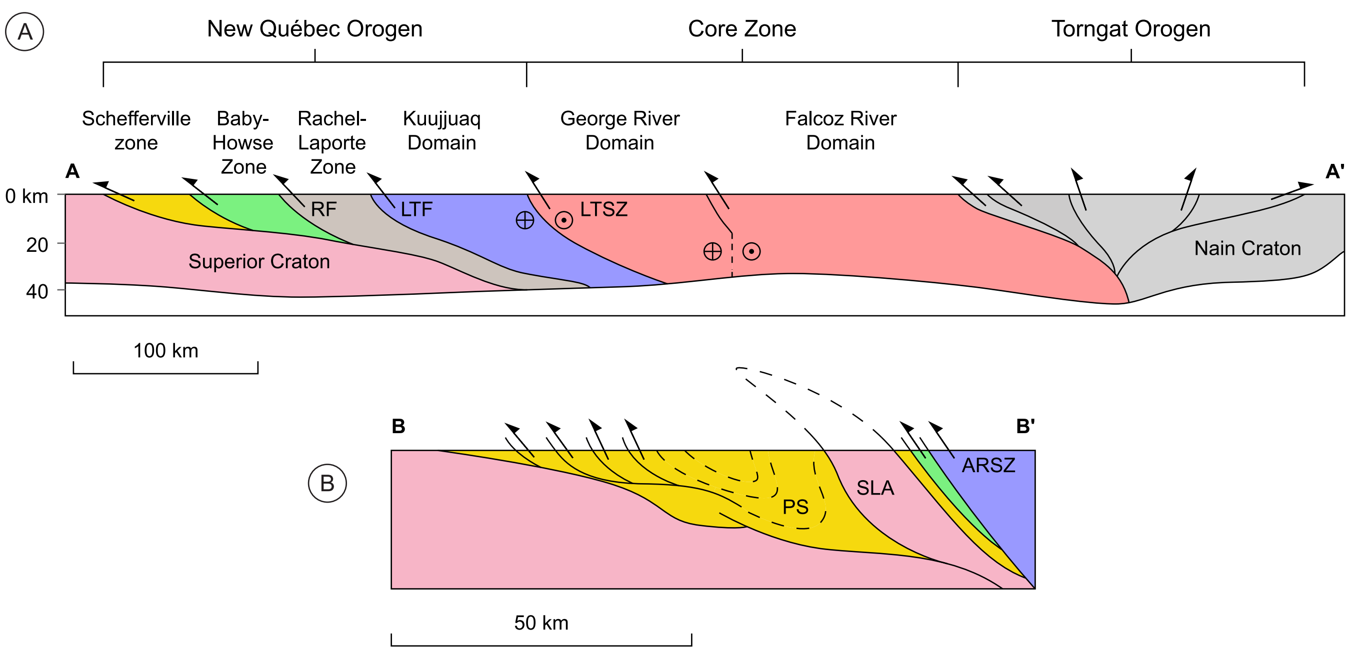



**Figure 2.** *Schematic cross-sections through the NQO illustrating basic crustal structure of orogen. Colouring of domains for both sections is as in Figure 1. A) Cross-section corresponding to line A–A' (Figure 1), modified from Wardle* et al. *(2002). RF = Rachel fault; LTF = Lac Turcotte fault; LTSZ = Lac Tudor shear zone; B) Cross-section corresponding to line B–B' (Figure 1), modified from Wardle* et al. *(1995). Note different scale.* See *text for description of main structural features. PS = Petitsikapau synclinorium; SLA = Snelgrove; ARSZ = Ashuanipi River shear zone.*

The easternmost part of the NQO is represented by the Kuujjuaq terrane, referred to in Labrador as the McKenzie River domain, (Figure 1), a high-grade Archean gneiss terrane with local Paleoproterozoic cover (James *et al.*, 1996; Rayner *et al.*, 2017). The boundary between the Kuujjuaq terrane/McKenzie River domain and rocks to the west is an east-dipping thrust having a component of dextral strike–slip motion, referred to as the Lac Turcotte Fault in Québec and the Ashuanipi River shear zone in Labrador.

Protolith ages from the Kuujjuaq terrane–McKenzie River domain indicate components of *ca.* 2776–2696 Ma crust (James and Dunning, 2000; Rayner *et al.*, 2017), suggesting derivation from the Superior craton. Proterozoic plutonic rocks are widespread in the northern part of the terrane, and have been dated at *ca.* 1845–1833 (Machado *et al.*, 1988; Perreault and Hynes, 1990; Rayner *et al.*, 2017). The latter are similar in age to inferred arc-like calc-alkaline rocks of the De Pas batholith, dated at *ca.* 1840–1810 Ma (James *et al.*, 1996) suggesting that the Kuujjuaq terrane–McKenzie River domain may have been situated in an upper plate position by this time. In Labrador, deformed tonalite intrusions are found locally, and have been dated at *ca.* 1815–1802 Ma (James and Dunning, 2000), although their tectonic significance (*e.g.*, pre- *vs.* syn-collisional magmatism) remains unclear. The areal extent of these intrusions appears to be minor compared with those in the northern part of the terrane, although this may, in part, be due to poor exposure. Metamorphic ages from the Kuujjuaq terrane–McKenzie River domain range from *ca.* 1830–1805 Ma (Machado *et al.*, 1988; James and Dunning, 2000), and point to earlier metamorphism in the north. The reason for this discrepancy is not clear, although it may point to diachronous collision. More data from the McKenzie River domain are needed to constrain its pre- to syn-collisional tectonic and magmatic history.

The Core Zone (Figures 1 and 2) comprises a collage of at least three Archean crustal blocks with sparsely preserved Proterozoic cover sequences, intruded by the De Pas batholith, and is separated from the Kuujjuaq terrane–McKenzie River domain by the Lac Tudor shear zone (*e.g.*, Wardle *et al.*, 2002; Corrigan *et al.*, 2018). These internal Core Zone domains are separated by north–south-striking, crustal-scale shear zones related to overall dextral transpression between the Superior Craton and the Core Zone. For a comprehensive overview of the Core Zone and overall southeastern THO, readers are referred to Wardle *et al.* (2002) and Corrigan *et al.* (2018).

To summarize, the NQO can be viewed as an orogenic wedge comprising a series of west-verging thrust sheets separated into three primary lithotectonic domains. These are:

1) a foreland fold-and-thrust belt comprising low-grade supracrustal rocks deposited on or proximal to the Superior passive margin (the KS);

2) the Rachel–Laporte Zone, comprising high-grade metasedimentary rocks probably deposited in a forearc environment on a basement of unclear affinity; and

3) the Kuujjuaq terrane–McKenzie River domain, a high-grade Archean gneiss terrane of probable Superior affinity possibly representing a ribbon continent accreted to the Core Zone prior to terminal collision.

These main lithotectonic domains are separated by crustal-scale west-verging thrust faults, some of which appear to have accommodated a component of strike–slip displacement related to overall dextral transpression during Superior–Core Zone collision (Wardle *et al.*, 2002; Corrigan *et al.*, 2018). The present report focuses on work conducted in the hinterland of the NQO in western Labrador, where rocks of the KS are in tectonic contact with reworked Archean gneisses of the McKenzie River domain along the Ashuanipi River shear zone.

## REGIONAL STRATIGRAPHY AND GEOCHRONOLOGICAL CONSTRAINTS

### KANIAPISKAU SUPERGROUP

Supracrustal rocks of the Kaniapiskau Supergroup (KS) underlie a considerable portion of the Andre Lake area. Regionally, the KS comprises 3 depositional cycles (Figure 3), the lower two are intruded by two generations of mafic sills with MORB-like geochemical signatures (Findlay *et al.*, 1995), referred to collectively as the Montagnais sills. Cycle 1 begins with a rift sequence comprising terrestrial and shallow-marine sandstones (Seward Group) overlain by a passive margin sequence that includes the turbidites and carbonates of the Swampy Bay and Attikamagen groups in addition to associated basalts. Rifting of the Superior margin began before 2169 ± 4 Ma, the age of a gabbro sill intruding the Seward Group at the base of Cycle 1 (Rohon *et al.*, 1993). The Swampy Bay Group is dated at 2142 +4/-2 Ma based on the age of a crosscutting rhyolite dyke (Clark, 1984).

Cycle 2 comprises the Ferriman Group and, to the east, its time correlative, the Doublet Group (Findlay *et al.*, 1995; Figure 3). The Ferriman Group is locally unconformable with underlying Cycle 1 rocks (Clark and Wares, 2005), but appears conformable throughout much of western Labrador, including the present field area. Its stratigraphy records a second transgressive sequence, with shallow-marine sedimenta-

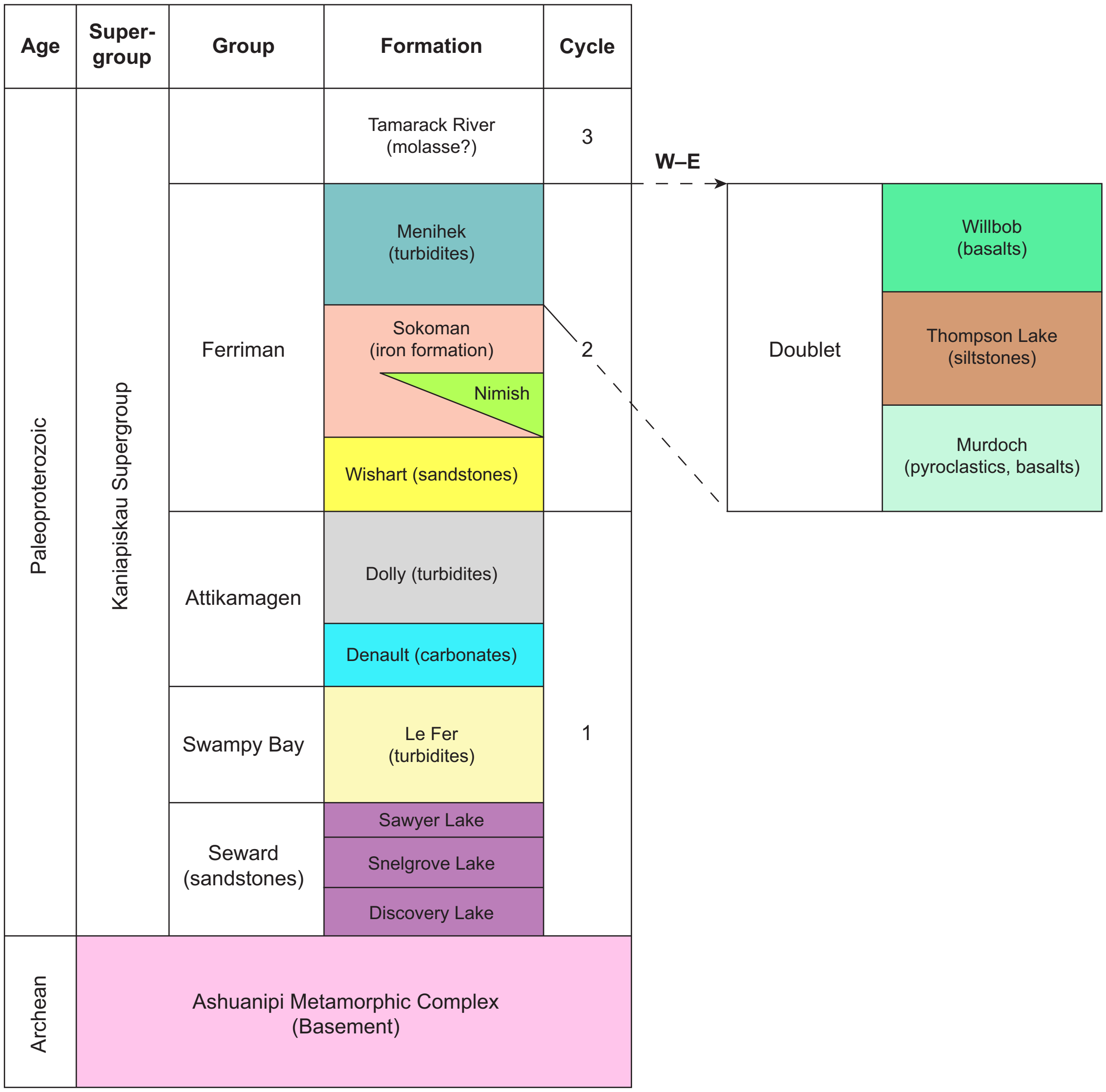



**Figure 3.** *Simplified stratigraphy of the Kaniapiskau Supergroup (KS), modified from Conliffe (2017). Colours same as in Figure 4. The Doublet Group lies to the east of the Ferriman Group and is considered time-correlative with the Menihek Formation.*

ry rocks passing into deeper water turbidites, iron formation, and local andesite–basalt flows (Clark and Wares, 2005). The Doublet Group, meanwhile, comprises a sequence of mostly volcanic and associated volcanoclastic sedimentary rocks in addition to turbidites and local iron formation (Clark and Wares, 2005). It is inferred, based on local stratigraphic relationships and geochronology, to be correlative with the Menihek Formation at the top of the Ferriman Group (Findlay *et al.*, 1995).

The timing of Cycle 2 deposition is constrained by an age of 1880 ± 2 Ma for a carbonatite dyke interpreted as contemporaneous with deposition of the Sokoman Formation (Ferriman Group; Chevé and Machado, 1988). Findlay *et al.* (1995) reported a similar age of 1878 ± 1 Ma for felsic volcanic rocks of the Nimish Formation, which are intercalated with the Sokoman Formation. The age of the Doublet Group is less well constrained, but Rohon *et al.* (1993) obtained a Pb–Pb age of 1885 ± 65 Ma from the Willbob Formation basalts, supporting the correlation with the upper Menihek Formation (Figure 3; Findlay *et al.*, 1995). Further geochronological constraints are provided by the voluminous mafic sills (part of the Montagnais sills) that intrude Cycle 2. A glomeroporphyritic gabbro cutting the Menihek Formation yielded an age of 1878.5 ± 0.8 Ma (Findlay *et al.*, 1995; Bleeker and Kamo, 2018), whereas a gabbro sill at the top of the Hellancourt Formation, in the middle of Cycle 2, yielded a younger age of 1874 ± 3 (Machado *et al.*, 1997). The tectonic setting of Cycle 2 sedimentation is discussed in detail by Skulski *et al.* (1993), who suggested deposition and associated magmatism took place in a pull-apart basin, analogous to the Gulf of California, developed in response to plate-scale oblique convergence between the Superior margin and the Core Zone.

Cycle 2 rocks are unconformably overlain by synorogenic molasse deposits of the Cycle 3 Tamarack River Formation, inferred to reflect collision of the Superior Craton with the Core Zone during the Trans-Hudson orogeny (Hoffman, 1988; Clark and Wares, 2005). The latter have not been dated, but are gently deformed into upright folds of inferred Hudsonian age (Ware and Wardle, 1979). Cycle 3 rocks are not exposed in the study area.

### McKENZIE RIVER DOMAIN

Geochronological data are available only for the southern part of the McKenzie River domain exposed near the Smallwood Reservoir (James *et al.*, 1996). The dominant component is the Flat Point gneiss, a tonalitic orthogneiss dated at 2776 ± 7 Ma, cut by deformed mafic dykes and late, variably deformed granitic leucosome. A younger supracrustal sequence, the Lobstick Group, is exposed near the Smallwood Reservoir. Contacts between the Lobstick Group and Flat Point gneiss are tectonic, and original stratigraphic relationships are not preserved (James *et al.*, 1996). Monazite from a pelitic migmatite in the Lobstick Group yielded an age of 1805 ± 3 Ma, interpreted as the timing of upper amphibolite-facies metamorphism (James and Dunning, 2000). The Flat Point gneiss is locally intruded by north–south-trending metamorphosed gabbro bodies ranging from m- to several-km-scale in width. The latter have not been dated. Both, the Flat Point gneiss and Lobstick Group, are intruded by late, variably deformed tonalite dykes, dated at 1815 ± 3 Ma and 1802 +9/-14 Ma, respectively (James and Dunning, 2000).

## CURRENT WORK IN THE ANDRE LAKE AREA

Mapping in summer of 2018 focused on improving the current understanding of the structural/tectonic evolution of the Andre Lake area. Numerous oriented samples were collected and will form the basis of future geochronological, microstructural, and petrological study. The objective(s) of this work will be to better characterize the timing of Hudsonian tectonism and magmatism in reworked Archean basement rocks locally exposed beneath the KS and within the McKenzie River domain. The following is a synopsis of the geology based on existing work (*e.g.*, Wardle, 1979) and new observations and structural data collected in 2018.

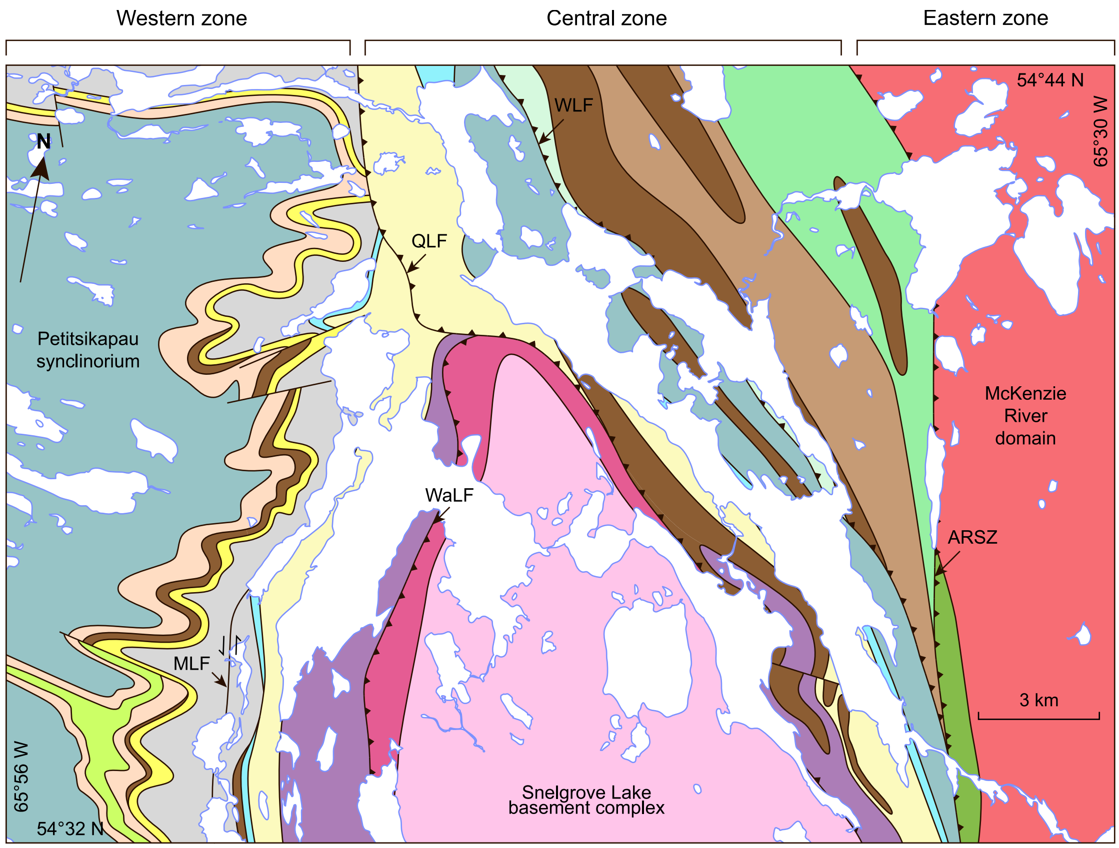
### GEOLOGICAL SUMMARY OF THE ANDRE LAKE AREA

Figure 4 shows a simplified geological map that divides the Andre Lake area into three primary structural zones separated by roughly north–south-trending faults. The stratigraphy of the KS is simplified for clarity, but, in general, the distribution of rock units varies little from previous depictions (Wardle, 1982); new outcrop observations and recent geophysical data have refined the geology. Corresponding aeromagnetic data are shown in Figure 5, along with the traces of major structures discussed below. Readers are referred to Wardle (1979) for detailed rock descriptions.

#### Western Zone

The western zone is underlain by a west-facing supracrustal sequence comprising Cycle 2 and parts of Cycle 1 of the KS and representative rocks are shown in Plate 1. The best exposures are found as scattered outcrops on a north–south-trending ridge underlain primarily by the Sokoman Formation iron formation (Plate 1A, B) and interbedded andesitic flows conglomerates of the Nimish Formation (Plate 1C, D). A laterally extensive gabbro sill, tentatively correlated with the Montagnais sills, locally separates the Sokoman Formation from the underlying quartzites and siltstones of the Wishart Formation, also exposed along the ridge. To the east of the ridge, the sequence is underlain by a considerably thicker, but less exposed, section of siltstone assigned to the Dolly Formation, and finally a thin sequence of dolomite representing the Denault Formation. West of the ridge, lie the stratigraphically higher slates of the Menihek Formation (Plate 1E), which are also poorly exposed.

Structurally, the western zone represents the nose of the regional-scale Petitsikapau synclinorium, the axis of which swings northwestward west of the map area. Kilometre-scale folds with east–west axial traces related to formation of the synclinorium are found throughout the western zone, and are clearly indicated in the aeromagnetic data (Figure 5), where highs correspond to the Sokoman Formation. Related outcrop-scale folds are common (Plate 1F), plunging moderately to the west ($F_1$ in Figure 6A), and an associated, steeply north-dipping axial-planar cleavage ($S_1$ in Figure 6A) is found in most metasedimentary units interbedded or associated with the iron formation. The nose of the synclinorium is truncated by the Mina Lake fault in the south and Quartzite Lake fault in the north; both are east-dipping thrusts with an inferred component of strike-slip motion (Wardle, 1979).




## LEGEND

### Kaniapiskau Supergroup

*Montagnais sills*
Medium-grained, equigranular gabbro

**Ferriman Group**

*Menihek Formation*
Bluish-grey siltstone, slate

*Nimish Formation*
Andesite, volcanic conglomerate

*Sokoman Formation*
Iron formation, black silstone

*Wishart Formation*
Sandstone, interbedded siltstone

**Attikamagen Group**

*Dolly Formation*
Grey-laminated silstone

*Denault Formation*
Dolomite, marble (central zone)

*Le Fer Formation*
Slate (western zone), phyllite (central zone)

**Seward Group**

*Undifferentiated Seward Group*
Sandstone, pebble sandstone, conglomerate

**Doublet Group**

*Willbob Formation*
Pillow basalt, basalt, minor tuff

*Thompson Lake Formation*
Banded siltstone, black slate

*Murdoch Formation*
Chlorite phyllite, siltstone, basalt

### Basement

**Snelgrove Lake basement complex**

Paleoproterozoic(?) granite

Archean(?) orthogneiss, local garnet amphibolite

**McKenzie River domain**

Amphibolite

Undifferentiated Archean migmatitic orthogneiss (Flat Point gneiss), Paleoproterozoic(?) tonalite, amphibolite

**Figure 4.** *Simplified geological map of the Andre Lake area. The geology is based on previous mapping (Wardle, 1982) with preliminary modifications based on observations made in 2018.* See *text for discussion of main structural/lithological zones. ARSZ = Ashuanipi River shear zone; MLF = Mina Lake Fault; QLF = Quartzite Lake Fault; WaLF = Wade Lake Fault; WLF = Walsh Lake Fault.*

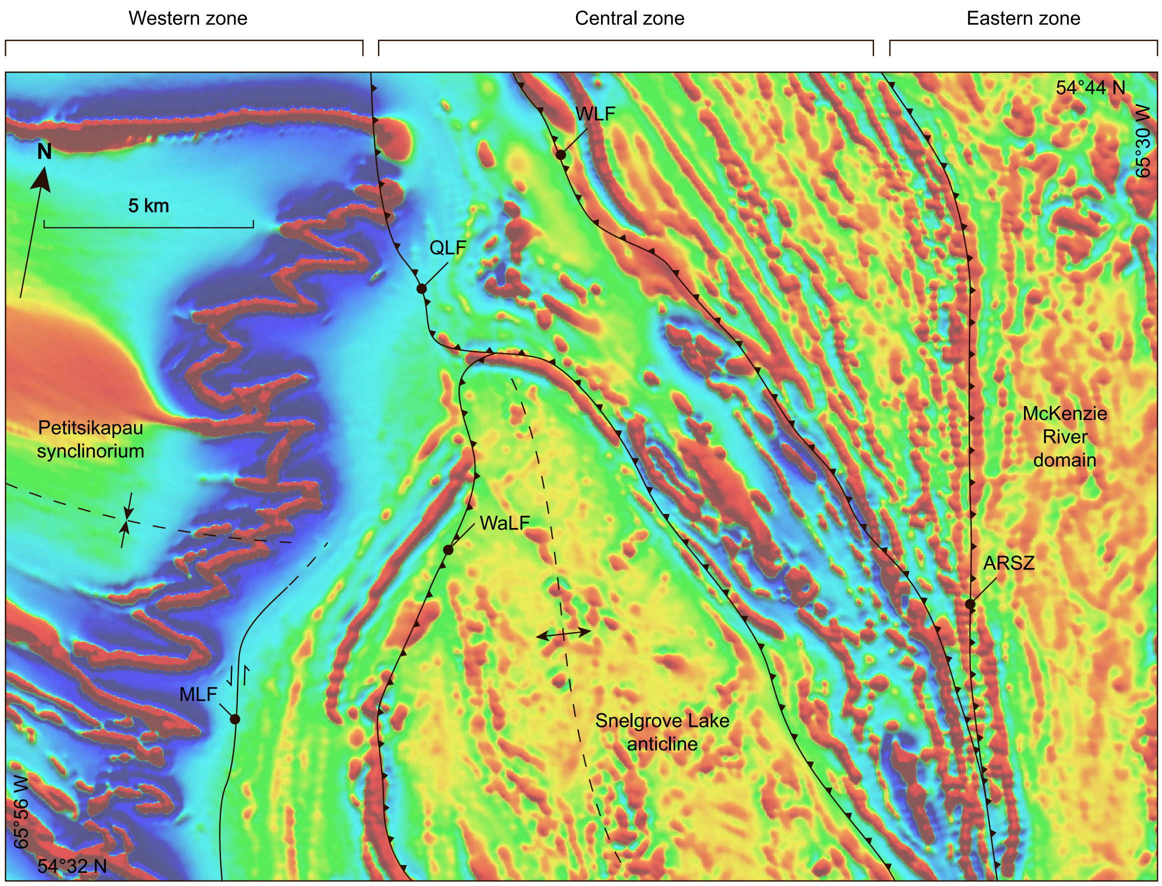



**Figure 5.** *Aeromagnetic data (first vertical derivative) from the Andre Lake area showing traces of major structures described in text. ARSZ = Ashuanipi River shear zone; MLF = Mina Lake Fault; QLF = Quartzite Lake Fault; WaLF = Wade Lake Fault; WLF = Walsh Lake Fault.*

Metamorphic grade throughout this zone is low, reaching sub- to lower greenschist facies, based on field observations. The Menihek Formation and compositionally similar meta-sedimentary units are characterized by a well-developed slaty cleavage, but contain no discernable porphyroblasts. Further characterization awaits thin-section analysis.

### Central Zone

The central zone extends from the Mina Lake and Quartzite Lake faults in the west to the Ashuanipi River shear zone in the east (Figure 4). The zone is underlain by generally north–south-striking supracrustal rocks representing cycles 1 and 2 of the KS and associated Montagnais sills, which form a north-plunging anticline (the Snelgrove Lake anticline, Wardle, 1979) with a central basement exposure referred to here as the Snelgrove Lake basement complex (SLBC). On its western side, the SLBC is flanked by terrestrial to shallow-marine sandstones of the Seward Group (Plate 2A), representing the base of Cycle 1. The overlying Le Fer to Dolly formations were mapped up to the Mina Lake Fault (Wardle, 1979), but exposure is poor. The contact between the Seward Group and the SLBC is the Wade Lake Fault, mapped farther south as a steeply east-dipping thrust. This fault is not exposed in the map area, but chloritized sandstones of the adjacent Seward Group exhibit a schistosity as well as deformed granitic clasts indicating west-side-down motion (Plate 2B). These sandstones dip steeply to the west, implying that the Wade Lake Fault was back-rotated, possibly during later motion along the Mina Lake Fault. Granites near the western edge of the SLBC are moderately mylonitized, supporting the interpretation that this is a tectonic contact.

On its eastern side, the SLBC is separated from orthoquartzites and siltstones of the Seward Group by the Quartzite Lake Fault, an inferred east-dipping thrust. As with the Wade Lake Fault, it is not exposed in the map area, but the more pelitic members of the adjacent Seward Group exhibit strong shearing presumably associated with motion along it. Eastward, the quartzites pass into stratigraphically higher phyllites of Le Fer Formation (Plate 2C), and then finally into the Denault (Plate 2D) and Menihek formations of Cycle 2. The intervening Dolly to Sokoman formations

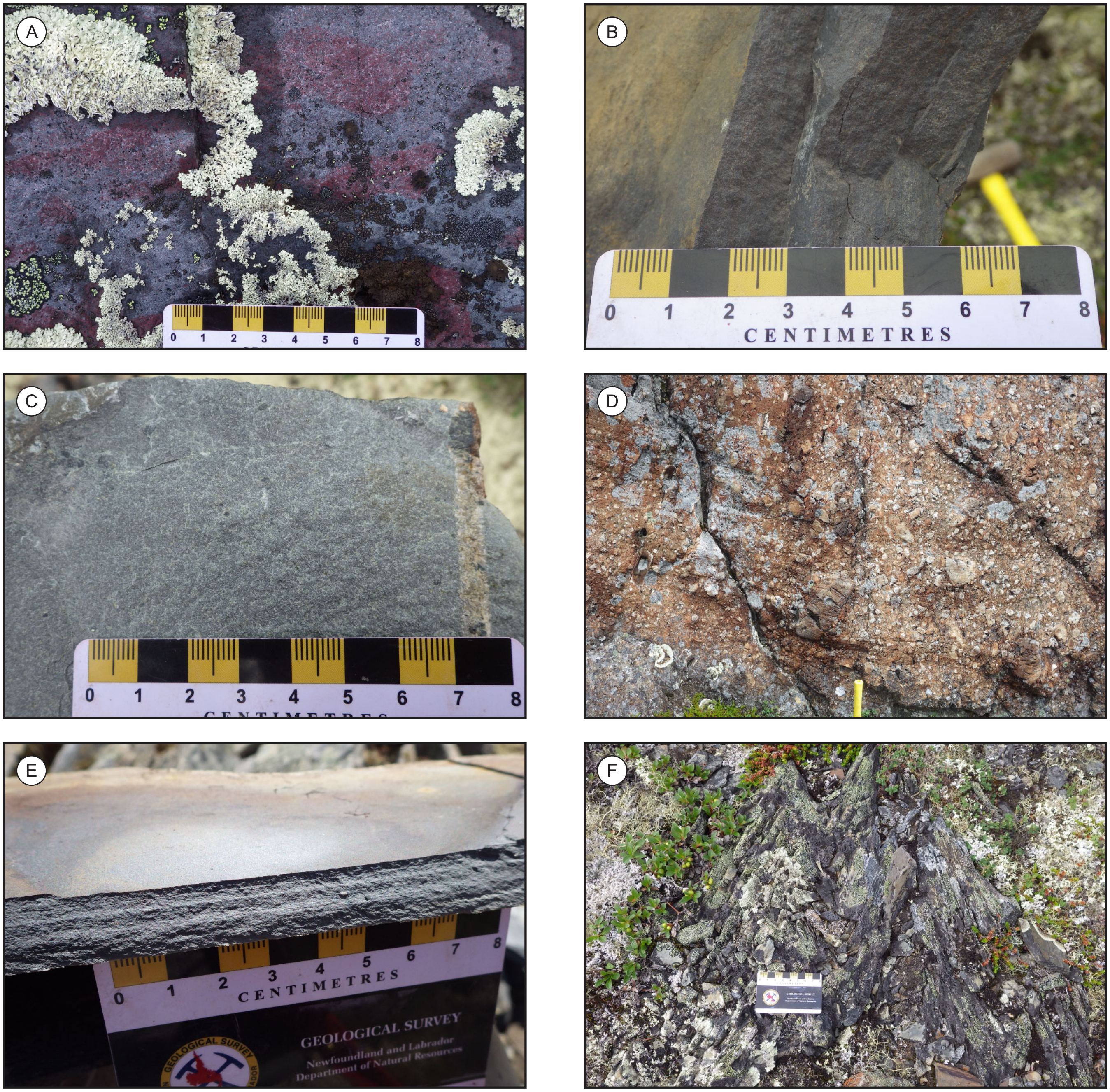



**Plate 1.** *Field photographs from the western zone. A) Cherty iron formation of the Sokoman Formation, with irregular jasper nodules; B) Silicate-facies iron formation of the Sokoman Formation; C) Fine-grained, intermediate volcanic rocks of the Nimish Formation; D) Andesite-bearing volcanic conglomerate of the Nimish Formation; E) Slate of the Menihek Formation; F) Outcrop-scale folds (axes trend east–west) developed in siltstones of the Dolly Formation.*

do not appear along the eastern margin of the SLBC. Wardle (1979) attributed this gap in deposition to the existence of a paleo-high corresponding to the axis of the Snelgrove Lake anticline that existed from Denault–Sokoman formation times, which might have separated a shallow inland sea in the west from a shelf–slope environment dominated by shale deposition to the east.

In the northeastern part of the central zone, the Walsh Lake Fault, an east-dipping thrust, separates rocks assigned to the Menihek Formation from rocks of the Doublet Group, including siltstones of the Thompson Lake Formation and basalts of the overlying Willbob Formation. Both the fault and units are extremely poorly exposed, but can be traced from observations farther north following a series of aero-

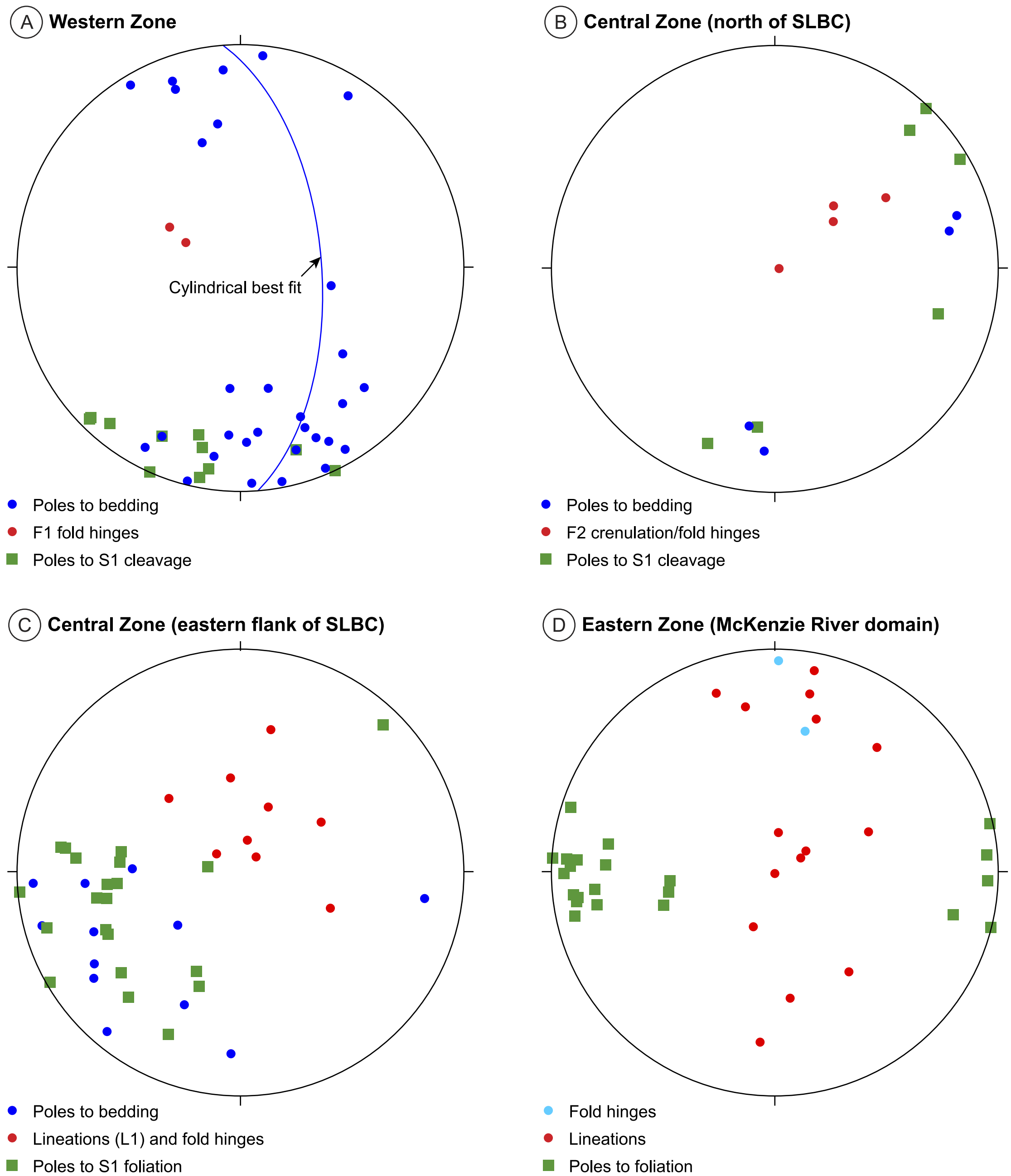



**Figure 6.** *Equal-angle stereographic plots of structural measurements from the Andre Lake map area. A) Structural data from the western zone. Blue line shows the cylindrical best fit to bedding and approximates the regional fold axis, which plunges moderately to the west; B) Data from the central zone, in the Le Fer Formation phyllites north of the Snelgrove Lake basement complex (SLBC); C) Data from central zone, in various units east and northeast of the SLBC; D) Data from the McKenzie River domain (eastern zone).*

magnetic anomalies that swing from southeast- to south-trending approaching the Ashuanipi River shear zone (Dumont *et al.*, 2010).

The SLBC itself is poorly exposed, offering only a few scattered outcrops. What was seen suggests the complex is underlain by migmatitic orthogneisses, locally undeformed granites (Plate 2E), and garnet amphibolites. The orthogneisses are similar in character to those exposed in the foreland of the orogen, and are thus presumed to be of Superior affinity. The western side of the SLBC and part of its northeastern flank appear to be underlain by granite that is

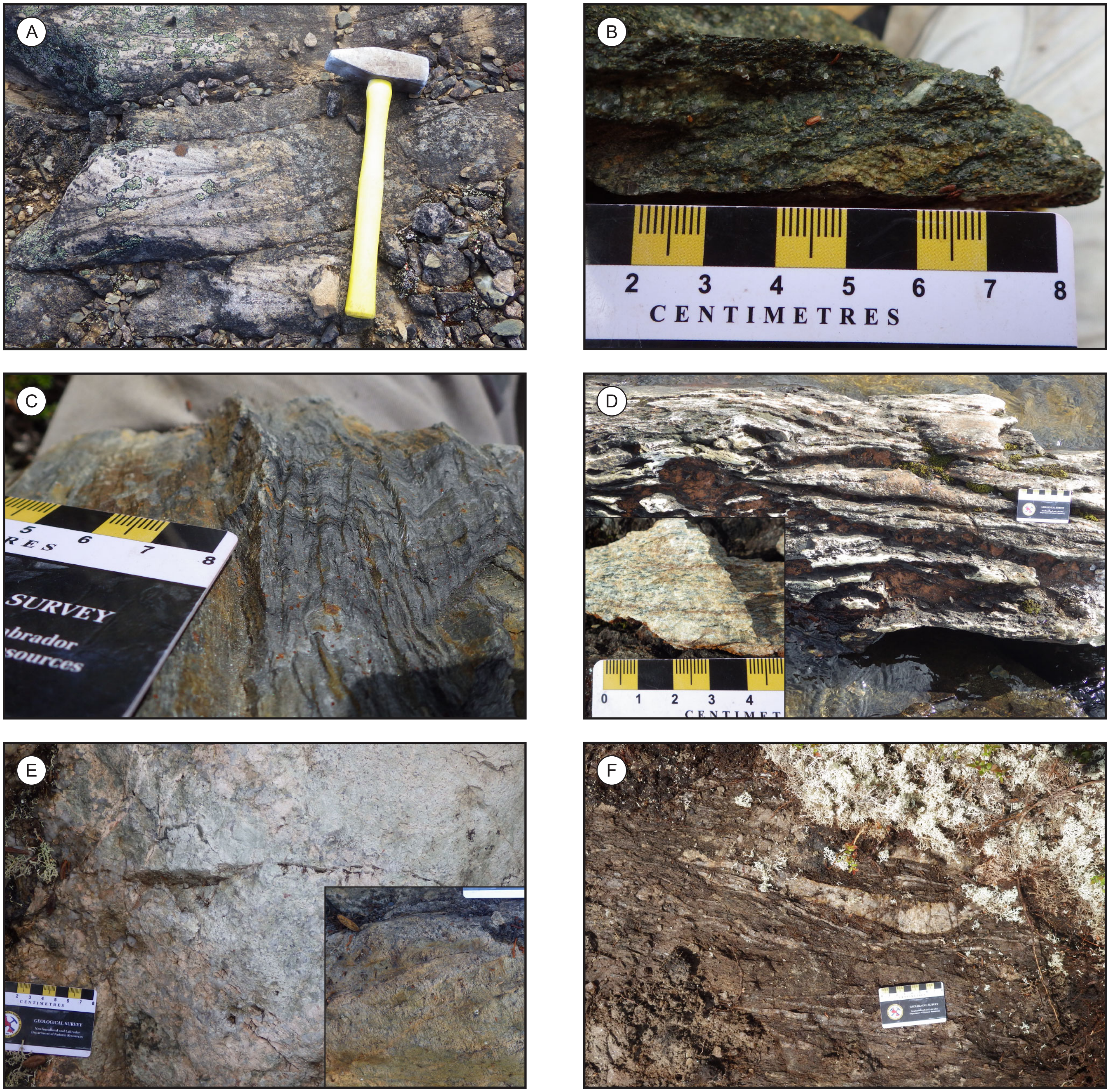



**Plate 2.** *Field photographs from the central zone. A) Undeformed, crossbedded sandstone of the Sawyer Lake Formation (Seward Group); B) Sheared, chloritized sandstone of the Snelgrove Lake Formation (Seward Group), from near the inferred contact with mylonitized granites of the SLBC. Note the deformed granite clast, indicates west-side-down motion along the Wade Lake Fault; C) laminated biotite-phyllite of the Le Fer Formation. Note the crenulations (second generation) and associated, weakly developed cleavage; D) Sheared dolomite from the eastern flank of the SLBC; inset shows detail of rock fabric; E) Undeformed granite from the SLBC; inset shows mylonitic fabric (defined by elongate quartz ribbons) found adjacent the Wade Lake Fault; F) Sheared biotite phyllite with quartz with quartz segregations, from the more pelitic member of the Sawyer Lake Formation (Seward Group) on the eastern flank of the SLBC.*

locally undeformed but becomes mylonitic (Plate 2E, inset) toward the contact with the Seward Group sandstones. Wardle (1979) speculated that this granite was Paleoproterozoic, which if true, means it has important implications for reconstructing the tectonic history of the basement underlying the KS. Samples were collected in 2018 to test this hypothesis and characterize the nature of this magmatism.

Deformation in the central zone appears to have occurred at higher grade than in the western zone, resulting in penetrative ductile fabrics in most rock types. North of the SLBC, where the Quartzite Lake Fault swings west and then north, a prominent, generally bedding-parallel schistosity ($S_1$ in Figure 6B) follows the trend of the fault. This fabric is overprinted by a prominent crenulation ($F_2$ in Figure 6B), with down-dip axes that trend perpendicular to the fault, swinging from moderately northeast plunging just north of the SLBC, to east plunging west of Montgomery Lake. The regional significance of the late crenulation fabric is not yet clear, but was attributed by Wardle (1979) to late strike–slip motion along the Mina Lake and Quartzite Lake faults.

Rocks along the eastern side of the SLBC also locally preserve strong ductile fabrics (Plate 2D, F), except for the quartzites and larger gabbro bodies, the latter generally having sheared margins. Pelitic units typically exhibit a well-developed schistosity defined by biotite and/or muscovite, which locally wraps garnet porphyroblasts in the Le Fer Formation. Foliations in this region trend north–south, swinging northwestward in the north of the map area ($S_1$ in Figure 6C). Ductile lineations plunge moderately northeast ($L_1$ in Figure 6C) and are associated with isoclinal $F_1$ folds.

Further analysis is required, but these features are presumably the result of an early phase of east–west shortening that formed the Snelgrove Lake anticline and later thrust faults, followed by overprinting deformation during formation of the Ashuanipi River shear zone (*see* below). In the SLBC, outcrop-scale deformation related to Hudsonian collision is only observed within the mylonitized granites along the western side of the complex, and farther south (Wardle, 1979, 1982) where the dominant foliation parallels the bounding faults.

Metamorphism of the KS supracrustal rocks generally reached greenschist facies in the central zone, but appears to increase in grade from west to east. North of the SLBC, phyllites of the Le Fer Formation contain mm-scale biotite porphyroblasts, changing to cm-scale garnet porphyroblasts along the eastern edge of the SLBC, the latter pointing to deformation at lower-amphibolite facies. Metamorphic grade was higher in the SLBC, as demonstrated by the preservation of garnet in amphibolite, but whether this metamorphism is Archean or Hudsonian in age is not yet known.

### Eastern Zone

The boundary of the eastern zone, marked by the Ashuanipi River shear zone, separates greenschist-facies rocks of the KS in the west, from polydeformed basement rocks including reworked Archean orthogneisses, km-scale amphibolite bodies, and deformed granitoids in the east. Originally named the “Eastern Basement complex” by Wardle (1979), these rocks were later assigned to the McKenzie River domain by James *et al.* (1996), although the latter work was focused farther south.

The McKenzie River domain is primarily underlain by deformed migmatitic orthogneisses of granodioritic to tonalitic composition, tentatively correlated with the Flat Point gneiss of James and Dunning (2000), identified farther south within the domain. The gneisses are heterogeneous, and their history complex. The oldest apparent component is a broadly granodioritic metatexite (Plate 3A), with a foliation defined by several-cm-thick leucosomes surrounded by a biotite (and locally) hornblende restite. Amphibolite bodies (Plate 3B) and bands, from several cm to m thick, are common, and are interpreted based on observations farther north to represent transposed dykes (Wardle, 1979). These dykes are especially common in gneisses near the contact with the KS, where they have been strongly transposed by the late mylonitic fabric (Plate 3C). Wardle (1979) hypothesized that these amphibolite bodies were equivalent to the Montagnais gabbro sills intruded throughout the KS, but this remains to be tested using geochronological and geochemical data. One larger north–south-trending amphibolite body, measuring several km wide, crops out at the contact with the adjacent KS rocks.

Subsequent partial melting/magmatism is evident in numerous small crosscutting granitic melts and tonalite intrusions (Plate 3D, E), which have been pulled into the dominant north–south foliation, as well as deformed granitic pegmatites, and local posttectonic garnet-bearing granitic dykes (Plate 3F). The areal extent of the tonalite intrusions is unknown owing to poor exposure, although they appear to be subordinate to the Archean migmatite.

The structure of the McKenzie River domain in the map area is controlled by the Ashuanipi River shear zone. The dominant fabric is a steeply dipping north–south-trending foliation (Figure 6D) that has transposed the early, presumably, Archean migmatitic fabric as well as later intrusions/melts, and is therefore interpreted as Hudsonian. The intensity of strain increases toward the contact with the adjacent rocks of the KS. In eastern exposures, farther from the contact, Archean migmatitic fabrics are mostly preserved but have undergone localized shearing, associated, in some instances, with dextral kinematic indicators. In contrast,


**Plate 3.** *Field photographs from the eastern zone/McKenzie River domain. A) Granodioritic metatexite. Dark bands are biotite-rich zones interpreted as restite. Note late upright folds; B) Close-up of foliated amphibolite body hosted by metatexite; C) Mylonitized gneiss with alternating amphibolite and tonalite layers. The amphibolite layers are interpreted to represent transposed dykes. Note dextral shear sense; D) Deformed metatexite cut by pegmatite. The pegmatite cuts north–south isoclinal folds in quartzofeldspathic layers interpreted to represent Archean leucosome, but is pulled into the dominant foliation, and is therefore likely (late) syntectonic with respect to Hudsonian deformation. Note dextral shear sense; E) Close-up of weakly foliated tonalite intrusion. These bodies are common in in the southern part of the map area near the Ashuanipi River shear zone, and are often mylonitic; F) Strongly sheared metatexite with north–south folds, cut by posttectonic, granitic dyke.*

western exposures are dominated by mylonitized gneisses, and associated tonalite/amphibolite bodies have strong mylonitic fabrics. Outcrop-scale folds are common, most plunging shallowly northward (Figure 6D). The latter are generally isoclinal, but later open folds having similar north-trending plunges were also observed. Ductile lineations, typically defined by aligned biotite and quartzofeldspathic rods, range from steeply down-dip to subhorizontal (Figure 6D). Whether this reflects multiple generations of lineations or the effects of heterogeneous strain is unclear, although multiple overprinting lineations were not observed together in a single outcrop. Kinematic indicators are also rare. Some outcrops exhibit shallow lineations associated with dextral kinematic indicators, whereas other zones exhibit steep lineations with unclear kinematics. Further micro-structural examination is clearly required, but these features are in general consistent with previous suggestions that the Ashuanipi River shear zone accommodated dextral transpressive motion between the KS and the McKenzie River domain (Wardle, 1979; James *et al.*, 1996).

## DISCUSSION AND FUTURE WORK

The Andre Lake area records a complex geological history that began with rifting and deposition of the KS along the eastern margin of the Superior Craton, and culminated in continent–continent collision between the Superior Craton and the Core Zone. This collision manifests in the western and central zones by regional-scale folds, including the Petitsikapau synclinorium and the Snelgrove Lake anticline, and later west-verging thrust faults (*e.g.*, the Quartzite Lake Fault). Folding and thrusting in these zones took place at greenschist to lower-amphibolite facies, indicating relatively shallow burial. Deformation in the McKenzie River domain began at amphibolite facies, as suggested by the local persistence of hornblende in the dominant fabric, and limited but widespread partial melting. Final juxtaposition of the McKenzie River domain and KS likely included a significant amount of vertical offset (east-side-up) along the Ashuanipi River shear zone. The *ca.* 1805 Ma age of metamorphism from the McKenzie River (James and Dunning, 2000) domain provides an upper age constraint on the timing of this thrusting.

The overall pattern of deformation, with west-directed thrusts and north–south-trending folds, is consistent with regional tectonic models involving broadly east–west dextral transpressive collision between the Superior craton and Core Zone. The exception is the east–west trend of the Petitsikapau synclinorium in the western zone. The axis of the synclinorium swings northwestward west of the map area, and can probably be explained by an early phase of southwest-directed shortening followed by local rotation of the fold axis in the map area resulting from later strike–slip motion along the Mina Lake Fault and northern extension of the Quartzite Lake Fault (Wardle, 1979).

Future work will address the nature and timing of magmatism in the Andre Lake area via geochronology and isotope geochemistry. In the central zone, the origin of the SLBC granite remains unclear, but may be the result of crustal melting due to thickening of the underthrusting Superior basement during collision. As the granite is mylonitized, its age will also provide an upper bound on formation of the Snelgrove Lake anticline and associated thrusts.

Basement rocks on both sides of the Ashuanipi River shear zone are of probable Superior affinity, as suggested by mapping and previous geochronology (Wardle, 1979; James and Dunning, 2000). Tonalites in the McKenzie River domain, dated at *ca.* 1815 Ma, are within the range (*ca.* 1840–1810 Ma) of De Pas batholith magmatism in the southern Core Zone, and may represent a magmatic arc developed above an eastward-dipping subduction zone. New samples were collected and will be analyzed to test this hypothesis.

## CONCLUSIONS

New observations from the Andre Lake area in the hinterland of the New Québec Orogen highlight a complex tectonic history related to broadly east–west dextral transpression during the terminal Superior–Core Zone collision. The study area is divided into three lithotectonic zones separated by major west-verging thrust faults. The western and central zones comprise rocks of the Kaniapiskau Supergroup and underlying basement, inferred to have been accreted from the Superior passive margin. The eastern zone comprises the McKenzie River domain, an Archean gneiss terrane of probable Superior affinity, but which may have undergone a distinct pre-collisional tectonic history. Juxtaposition of the western–central and eastern zones took place after *ca.* 1805 Ma along the Ashuanipi River shear zone, which may represent a cryptic suture marking a site of past oceanic subduction.

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