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GEOLOGY OF THE SOUTHEASTERN CHURCHILL PROVINCE, WESTERN LABRADOR

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ABSTRACT

The Southeastern Churchill Province in western Labrador comprises Archean gneisses, and variably deformed Paleoproterozoic meta-igneous rocks of the De Pas batholith. The Archean rocks consist of tonalitic and granodioritic migmatitic gneisses, mafic gneiss (gabbroic and anorthositic gneiss), and minor paragneiss. The oldest unit is the paragneiss, which is intruded by the precursor magmas of the tonalitic and granodioritic rocks. The De Pas batholith is composed of charnockitic gneiss, and variably deformed orthopyroxene monzodiorite, gabbronorite and perthitic K-feldspar- and plagioclase-megacrystic charnockite and mangerite. The charnockitic gneiss is the only unit of the De Pas batholith that exhibits a regional penetrative tectonic fabric. The other units in the De Pas batholith are deformed only within discrete shear zones but otherwise have equigranular textures or magmatic foliation. A coronitic gabbronorite, containing pyroxene and having coronas of garnet and amphibole, is exposed in the western half of the map area. All units except the coronitic gabbronorite were deformed in north-striking dextral shears that have been overprinted by northwest-striking sinistral shears and northeast-striking dextral shears. Mineralization in the area is restricted to late-stage brittle faults, where rocks display local alteration associated with the growth of quartz, epidote, and magnetite and give anomalous scintillometer total-count values, up to 700 counts per second. The Michikamats syenite and monzonite ring dyke complex, outside the 2010 study area, was investigated and sampled to assess it's potential for rare-earth elements but no assays are yet available.

INTRODUCTION

The second year of a three-year, 1:50 000-scale bedrock mapping project was completed during the summer of 2010 in the northern half of NTS map area 23I, in western Labrador (Figure 1). The goal of this project is to create a comprehensive bedrock map accompanied by a supporting whole-rock geochemistry, geochronology and a mineral-resource-potential database. The project is part of a joint Geo-mapping for Energy and Minerals (GEM) project conducted in concert with the Géologie Québec and the Geological Survey of Canada. A high-resolution airborne magnetic survey was completed in the area by the Geological Survey of Canada (Dumont, 2009a, b, c, d). Géologie Québec has completed complementary mapping on the Québec side of the border concurrent with the Geological Survey of Newfoundland and Labrador work. In Labrador, mapping was carried out primarily in NTS map areas 23I/14 and 23I/15 and the northern halves of 23I/11 and 23I/10 (Figures 1, 2). Detailed geological mapping was completed with a five-man field crew conducting systematic traverses by foot, boat and helicopter.

The study area is located in western Labrador, 120 km east of Schefferville, Québec, 150 km north-northwest of

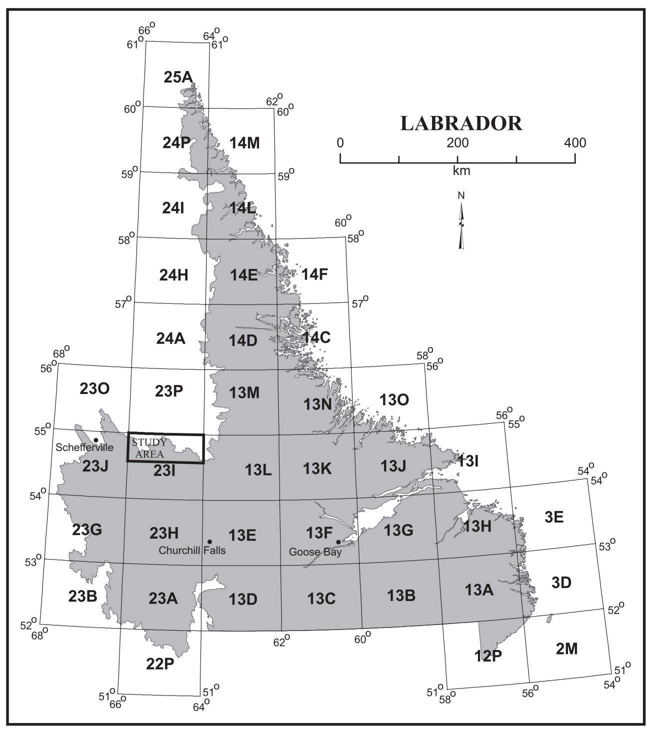

Figure 1. *Index map of Labrador showing location of Crossroads Lake study area within NTS map areas 23I.*

Churchill Falls, and 350 km northwest of Happy Valley-Goose Bay (Figure 1). Access to the area is by float plane or helicopter. The physiography of the area is dominated by numerous lakes and extensive swamplands, especially in the western half of NTS map areas 23I/14 and 11. The largest lakes are Crossroads, Vezina, Knox, and Lac Le Sueur, which are connected by small rivers and streams (Figure 2). The centre of the map area is dominated by small, isolated, 100-m-high, bald hills separated by boggy ground. Forest cover in the field area ranges from thick spruce and alder to more open country, in which trees dot a landscape of extensive caribou moss.

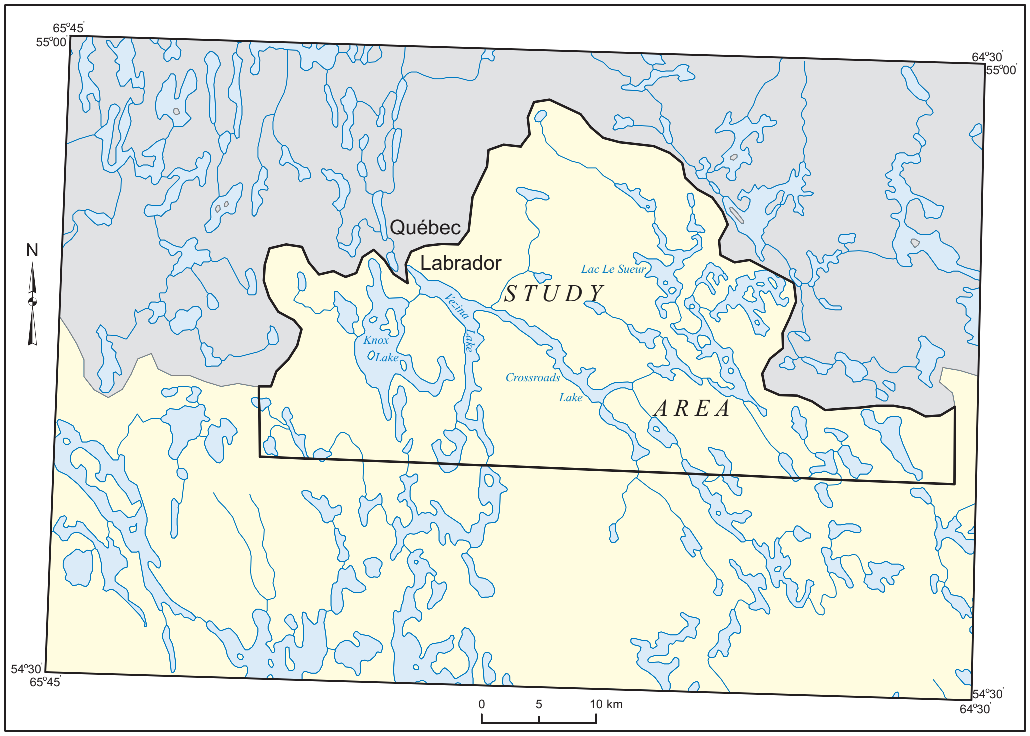

Figure 2. *Location map of the field area and major water bodies.*

PREVIOUS WORK

The initial regional mapping (at 1" = 4 mile-scale) in the area was undertaken by Wynne-Edwards (1960) and Emslie (1963). They identified the fundamental geological subdivisions and rock types in the area. Subsequent work at 1:100 000-scale, by D. James and others placed the rock units into a contemporary tectonostratigraphic framework of the Southeastern Churchill Province (*see* below) and the first year's examination of the area for the present project (Valley, 2010) further refined the earlier interpretations of James *et al.* (1993, 1996, 2003) and James and Dunning (2000).

REGIONAL GEOLOGY

The Southeastern Churchill Province (SECP) in western Labrador is a 300-km-wide, north-trending and tectonically assembled group of terranes that link the Archean Superior Craton of Laurentian North America, to the west, with the Archean Nain Province to the east (Figure 3). The SECP is primarily a set of Paleoproterozoic orogens consisting of reworked Archean and Paleoproterozoic intrusive rocks (*e.g.*, Wardle *et al.*, 1990; James *et al.*, 1993, 1996). The SECP is thought to be an extension of the Rae Province, which forms part of the Trans-Hudson Orogen in northern and western Canada and follows the margins of the Superior Craton (*e.g.*, Hoffman, 1988, 1990).

The SECP is divided into 3 main tectonic divisions: the New Québec Orogen in the west, a Core Zone in the centre, and the Torngat Orogen in the east (Figure 3). The New Québec Orogen consists of a west-verging, fold-and-thrust belt that developed primarily in Paleoproterozoic sedimentary and volcanic rocks and along the eastern edge of the Superior Province (James *et al.*, 2003). The Core Zone is a composite terrane of Archean orthogneisses and Paleoproterozoic intrusive rocks including the De Pas batholith, the latter of which is an elongate, 500+ km plutonic belt in the western part of the zone (*e.g.*, Van der Leeden *et al.*, 1990; James and Dunning, 2000). The Torngat Orogen is a doubly verging wedge of juvenile Paleoproterozoic sedimentary rocks deformed during oblique collision of the Nain Province with the Core Zone.

The Core Zone is best exposed on the north side of Smallwood Reservoir and Michikamau Lake (Figure 4), the locations of the most detailed mapping and data collection by James *et al.* (1993, 1996) and James and Dunning (2000). They extrapolated their geological interpretations of the section 70 km north to the present study area, where exposures are more limited.

The work by James *et al.* (1996) resulted in the subdivision of the Core Zone into 3 main lithotectonic groups or domains (Figure 4). These are the McKenzie River, Crossroads and Orma domains. The McKenzie River domain consists primarily of high-grade Archean tonalite gneiss con-

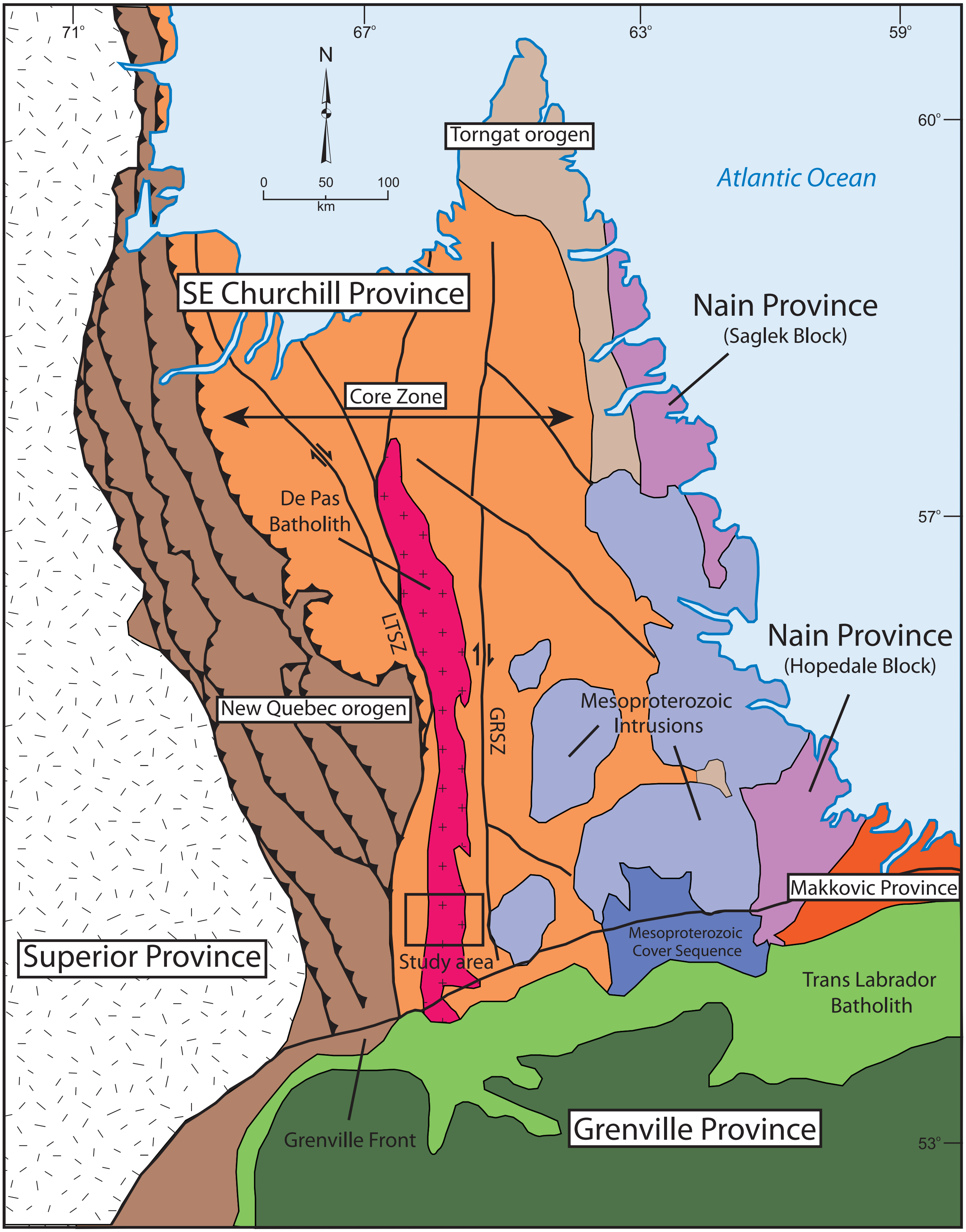

Figure 3. *Generalized geological map of Labrador and eastern Québec showing major tectonic subdivisions and the location of the study area. LTSZ = Lac Tudor shear zone, GRSZ = George River shear zone. Modified from James* et al. *(1996).*

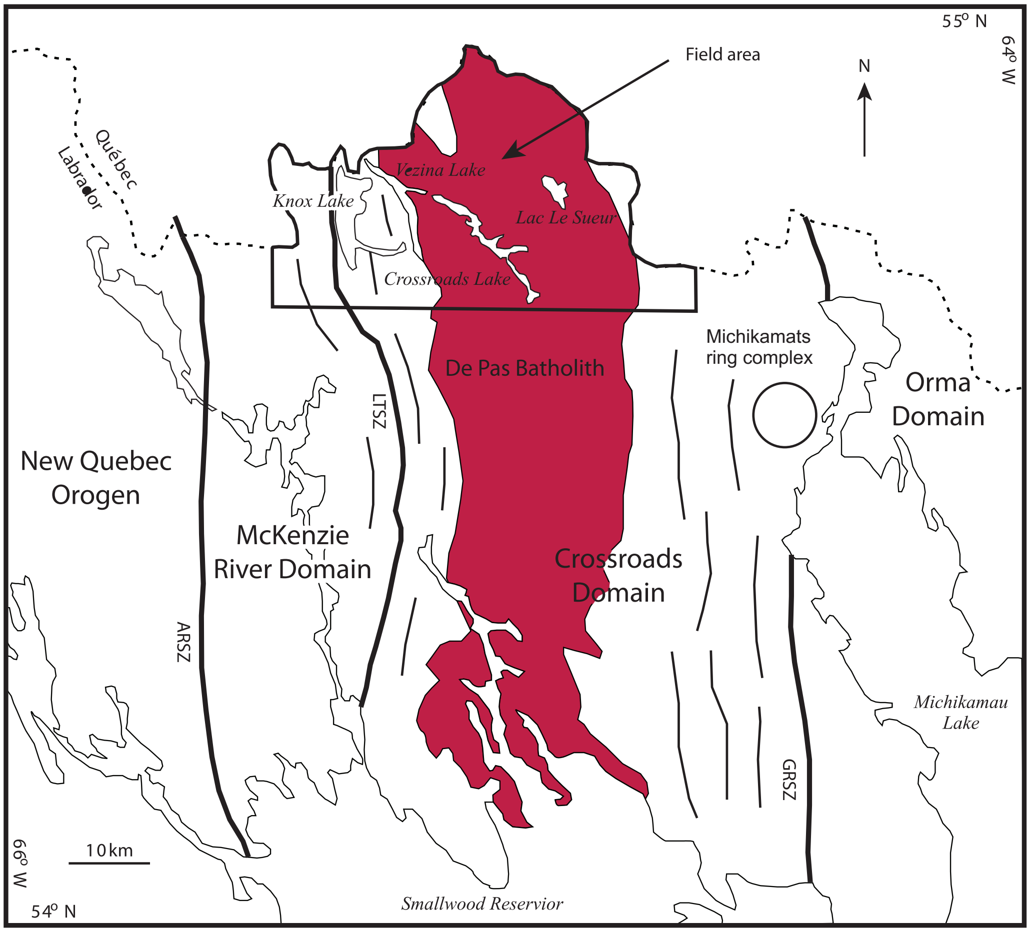

Figure 4. *Location of 2009–2010 survey area in relation to the main lithotectonic subdivisions and structural features of the Southeastern Churchill Province in western Labrador. ARSZ = Ashuanipi River shear zone; LTSZ = Lac Tudor shear zone; GRSZ = George River shear zone (after James* et al.*, 1996).*

taining minor metamorphosed supracrustal rocks and gabbro and it is located primarily on the western side of the Core Zone. The tonalite gneiss yielded a U–Pb (zircon) crystallization age of 2776 ± 5 Ma (James and Dunning, 2000). The McKenzie River domain is separated on its western side from rocks of the New Québec Orogen by the Ashuanipi River shear zone, and on its eastern side is separated from the Crossroads domain by the Lac Tudor shear zone (Figure 4). Both shear zones show evidence for dextral transpression and east-over-west reverse displacement (James and Dunning, 2000). The Crossroads domain consists of reworked Archean granite–greenstone terranes, minor supracrustal rocks, and Paleoproterozoic megacrystic granitoids of the 1835–1810 Ma De Pas batholith (James *et al.*, 1996). The Crossroads domain is bounded on the east and separated from the Orma domain by the transcurrent George River shear zone (Figure 4). The Orma domain consists primarily of Neoarchean orthogneisses and older supracrustal rocks. The McKenzie River and Crossroads domains have been affected by high-grade Paleoproterozoic (1820–1775 Ma) metamorphism and deformation but this thermotectonic event has not been identified in the Orma domain (James *et al.*, 2003).

GEOLOGY OF THE SOUTHEASTERN CHURCHILL PROVINCE

The 2009–2010 survey area lies completely within the Core Zone of the SECP and straddles the Crossroads and the McKenzie River domains (Figures 3, 4 and 5). The mapped units can be divided into two main groups: those of probable Archean age and those belonging to the Proterozoic De Pas batholith. Additional minor units include coronitic gabbronorite of uncertain age and numerous crosscutting mafic and felsic dykes. The high-resolution airborne aeromagnetic and radiometric surveys of Dumont (2009a, b, c, d) and Dumont *et al.* (2010) were used to interpret structures and rock type (Figure 6) where outcrop is lacking.

ARCHEAN ROCKS

The Archean suite of rocks is exposed on the east and west sides of the De Pas batholith (Figure 5). These rocks are interpreted as Archean based on the U–Pb zircon ages obtained by James and Dunning (2000) from similar rocks to the south of the survey area. Additionally, De Pas batholith magmas have intruded and crosscut an older tectonic fabric that is not found in the rocks of the batholith. The fabric must be older than the 1835–1800 Ma batholith (James and Dunning, 2000). The Archean group includes paragneiss, mafic gneiss, granodiorite and tonalite orthogneisses and gabbroic anorthosite.

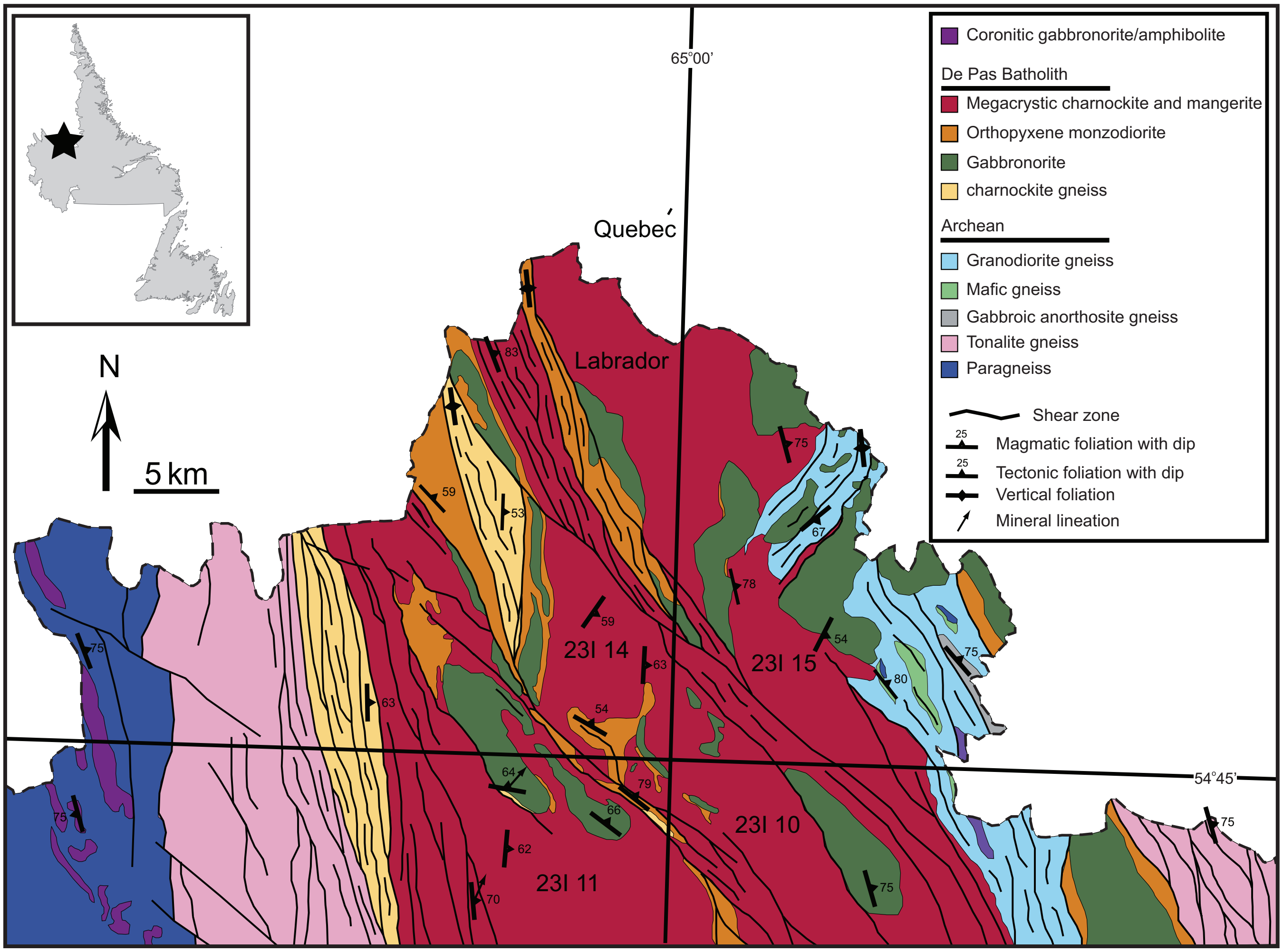

Figure 5. *Geological map of the Southeastern Churchill Province, western Labrador.*

Paragneiss

The oldest rocks in the field area are quartzofeldspathic and garnet-bearing migmatite paragneiss (Plate 1). The quartzofeldspathic gneiss crops out in the western most part of the map area whereas garnet-bearing quartzofeldspathic gneiss is exposed east of the De Pas batholith (Figure 5). The quartzofeldspathic paragneiss is coarse grained, white- to grey-weathering and contains alternating layers rich in biotite, quartz and K-feldspar. Compositional layering ranges in width from a 0.3 to 0.5 cm to 3 cm. Deformed layers of quartzite or recrystallized vein quartz, up to 20 cm wide, are abundant. Quartz and K-feldspar form porphyroblasts and layers of biotite, muscovite and chlorite ± plagioclase ± garnet. The K-feldspar-bearing layers are typically stretched or folded and the porphyroblasts are rotated (Plate 1A, B). The quartzofeldspathic gneiss in western parts of the map area has been intruded by the coronitic gabbronorite, but its relationship to other units has not been determined.

The garnetiferous migmatite was found only east of the De Pas batholith and is associated with the mafic gneiss (*see* below). The unit is dark-grey, rusty-weathering and contains abundant plagioclase- and garnet-rich leucosomes 0.5 to 3 cm in width. The garnet–migmatite gneiss contains quartz, plagioclase, biotite and garnet ± K-feldspar ± kyanite ± sillimanite. Magnetite is abundant where the garnet–migmatite has been altered by fluids. The garnetifereous migmatite is locally associated with mafic gneiss (Figure 5) and has been intruded by Archean (?) granodiorite and tonalite. The De Pas batholith has intruded the paragneiss and the De Pas granitoids contain abundant sillimanite and garnet at the contact.

Mafic Gneiss

Mafic gneiss is found east of the De Pas batholith in association with granodiorite gneiss and paragneiss (Figure 5). The mafic gneiss is rock-grey to grey-green on fresh and

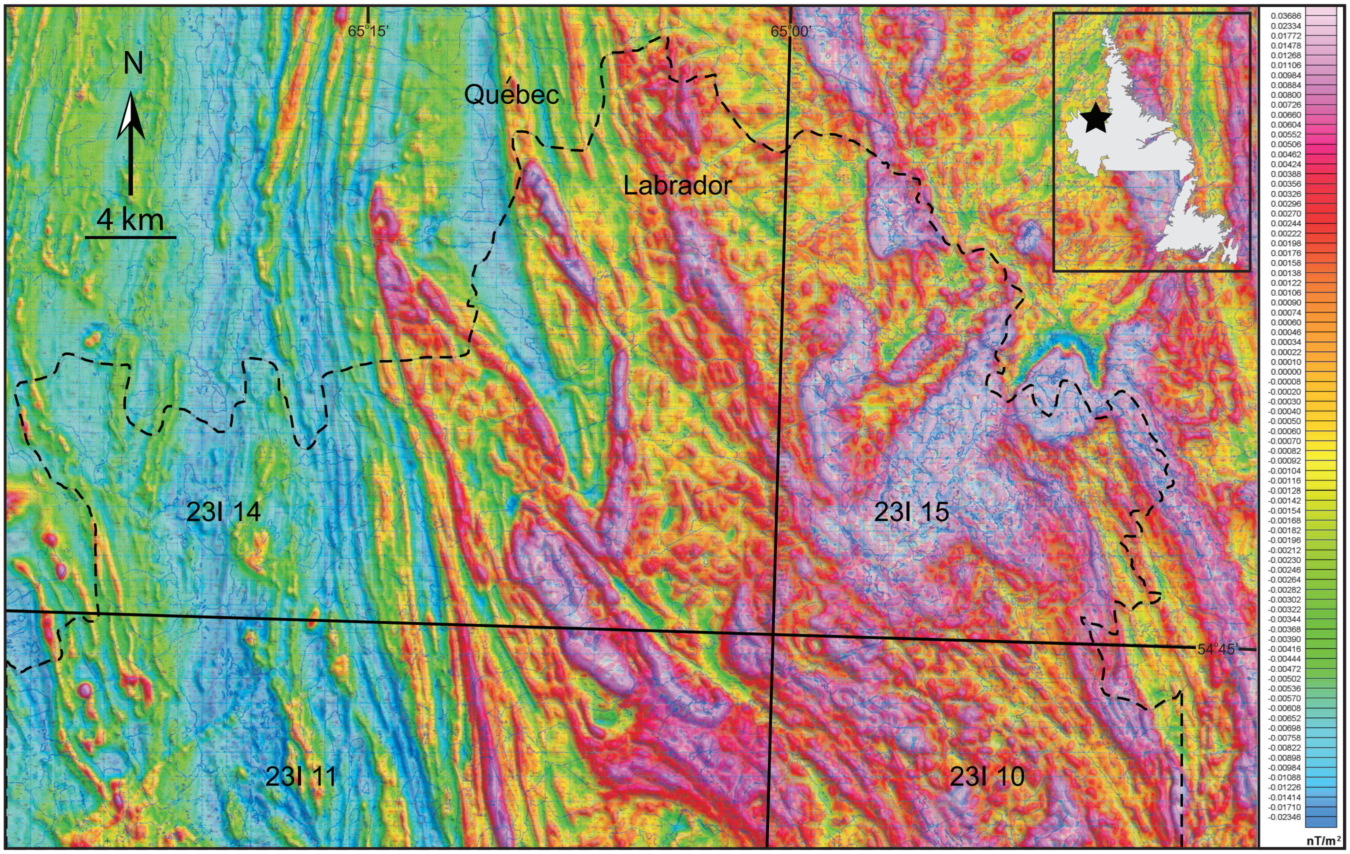

Figure 6. *Residual total magnetic field map of the Crossroads Lake area, western Labrador. Red end of spectrum – magnetic highs; blue end of spectrum – magnetic lows. The 2009–2010 project area is outlined in black.*

weathered surfaces, and comprises plagioclase, clinopyroxene, amphibole, magnetite, orthopyroxene ± K-feldspar ± quartz. Alternating layers rich in plagioclase and clinopyroxene–amphibole are 2 to 5 mm wide. The mafic gneiss locally contains veins of granodiorite and it is also found as blocks within the granodiorite gneiss (Plate 2A, B). It contains a fabric that predates intrusion of the granodiorite, but the two units were subsequently deformed together.

Gabbroic-anorthosite and Leucogabbroic Gneiss

White- to grey-weathering gabbroic-anorthosite gneiss and leucogabbro gneiss are exposed east of the De Pas batholith (Figure 5). Blocks or layers of gabbroic anorthosite are widely distributed within darker grey, more mafic gneiss (Plate 2C, D). The gabbroic-anorthosite contains the assemblage plagioclase, biotite, amphibole, clinopyroxene and magnetite ± orthopyroxene ± K-feldspar ± quartz and patches or clots of mafic minerals are common (Plate 2D). The more mafic gneisses contain a higher proportion of amphibole, orthopyroxene and clinopyroxene. No relationships to the other rocks in the map area were observed, but the unit is present within the Archean-aged group of rocks and is tentatively assigned to the Archean assemblage.

Granodioritic Gneiss

The granodioritic gneiss is the most prevalent rock type within the Archean group of rocks in the map area. The unit is present throughout the area east of the De Pas batholith and consists of orange- to white-weathering granodiorite and lesser amounts of granitic and tonalitic gneiss or migmatitic gneiss. The granodiorite gneiss contains quartz, varying proportions of K-feldspar and plagioclase, biotite, magnetite, and chlorite ± muscovite ± amphibole. Leucosomes weather more orange relative to the rest of the rock and mafic-rich layers can appear rusty (Plate 3A, B). Compositional layering is typically a few millimetres thick and leucosomes are around a centimetre in width.

The precursor magmas of the granodioritic gneiss have intruded both the paragneiss and mafic gneiss units. The granodiorite was then intruded by the gabbronorite and megacrystic granitoids of the De Pas batholith. Within shear zones, rotated blocks of granodioritic gneiss are found in attenuated layers of megacrystic charnockite.

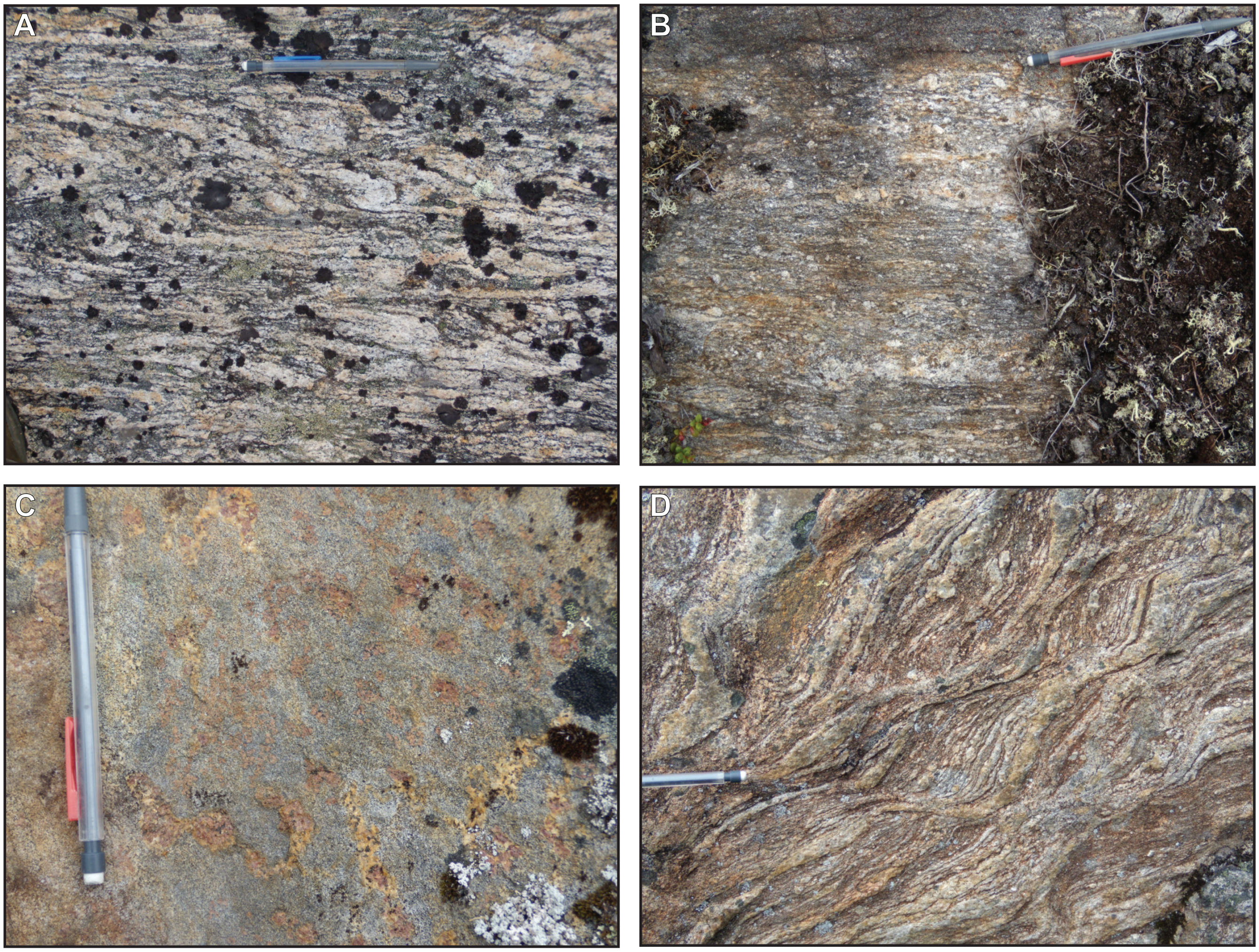

Plate 1. *Archean paragneiss. A) Typical appearance of Archean paragneiss in the western part of the map area (note "z" folds showing north-south dextral shear sense). B) Paragneiss from the eastern part of the study area containing K-feldspar porphyroblasts. C) Garnet-bearing migmatitic paragneiss from the eastern part of the study area. D) Garnet–kyanite paragneiss; note dextral shear sense indicators oriented northeast-southwest.*

Tonalitic Gneiss

Tonalitic gneiss is found in the easternmost part of the map area and is interpreted to be present west of the De Pas batholith based on the airborne magnetic survey and exposure to the south of the map area (*e.g.*, James *et al.*, 1996). This unit is undated in the field area but probably corresponds to the tonalite orthogneiss dated by James and Dunning (2000) at 2704 ± 15 Ma. The unit is grey on fresh and weathered surfaces and typically has a strong millimetre-wide compositional banding composed of varying proportions of mafic and felsic minerals (Plate 3C, D). The mineral assemblage comprises quartz, plagioclase, biotite, magnetite, titanite ± K-feldspar (the last typically as a compositional layer with quartz). The tonalite gneiss is mylonitic or migmatitic and contains deformed mafic and felsic dykes that crosscut an earlier fabric; in addition, the gneiss has dykes and quartz veins (Plate 3D). This unit is in tectonic contact with the monzodiorite of the De Pas batholith, but its relationship to the other assumed Archean rocks subdivisions of the De Pas batholith is not clear.

DE PAS BATHOLITH

The De Pas batholith occupies the centre of the map area, forming a north-trending body approximately 30 to 40 km wide (Figures 4, 5). Components of the De Pas batholith include charnockite gneiss, monzodiorite, gabbronorite and megacrystic charnockite and mangerite. Evidence of magma mingling includes gabbronorite, as inclusions, within a more felsic host. Feldspar megacrysts form the megacrystic mangerite or charnockite, within blocks of mafic rocks, and an intimate association of mangeritic and charnockitic rocks, at outcrop scale. Most of the units, regardless of being felsic or

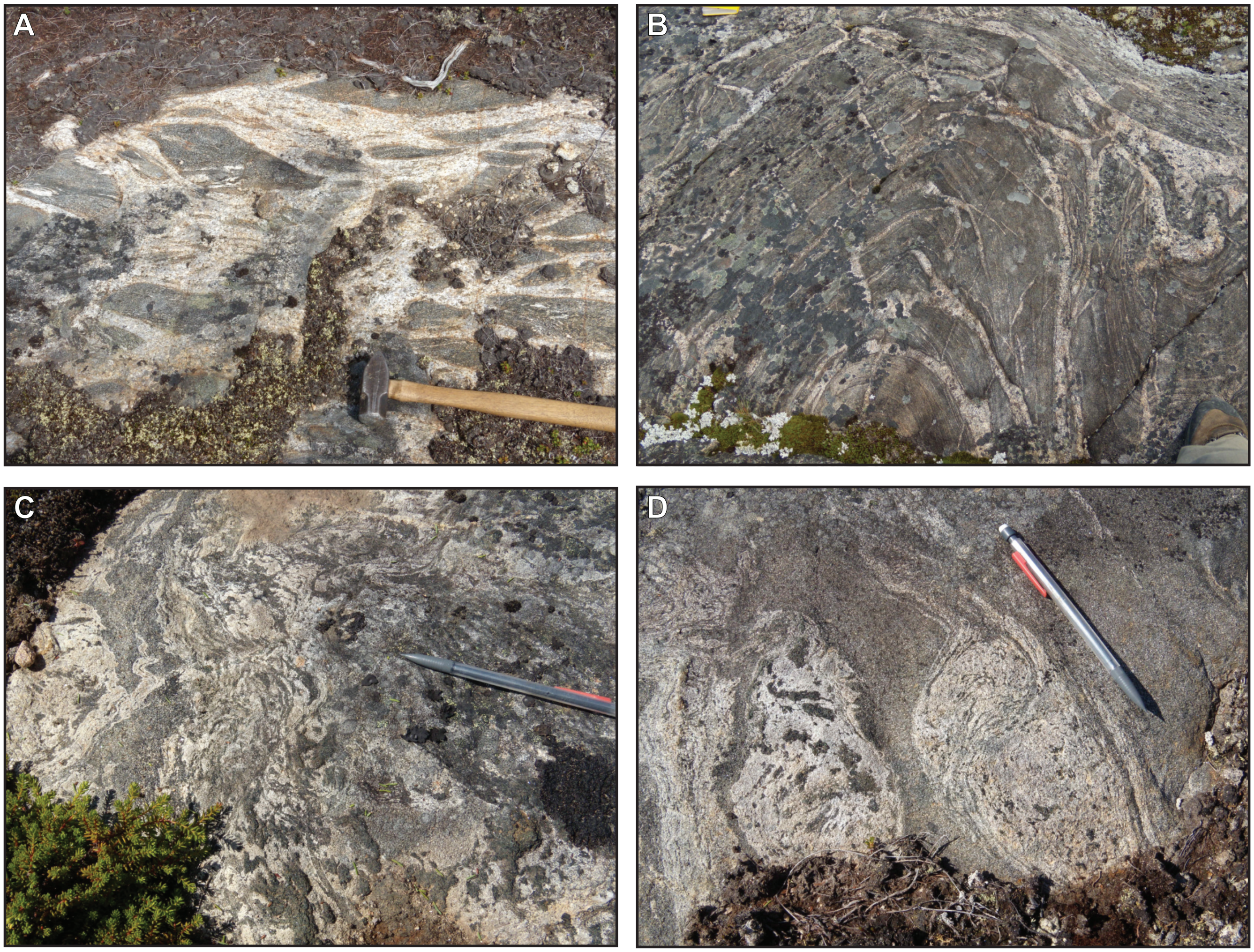

Plate 2. *Mafic rocks of the Archean group. A, B) Typical Archean mafic gneiss intruded by granodiorite and subsequently deformed. C, D) Outcrops of mixed gabbroic anorthosite and gabbroic gneiss.*

mafic rocks, contain orthopyroxene as a primary igneous mineral. The De Pas batholith is variably deformed but only the charnockite gneiss exhibits a ubiquitous tectonic fabric. The other units are deformed only in discrete shear zones but otherwise contain the original magmatic fabrics and textures.

Charnockitic Gneiss

White-grey to orange-yellow-weathering, fine- to medium-grained charnockite gneiss, orthopyroxene-bearing granodiorite (opdalite) gneiss and orthopyroxene tonalite (enderbite) are exposed in the western half of the De Pas batholith (Figure 5). These rocks were designated as Archean granitoids by James *et al.* (1996) based on U–Pb zircon ages from the Smallwood Reservoir area, but preliminary U–Pb geochronology indicates that the protolith age is ~1837 Ma. The unit is highly deformed, contains a distinctive quartz-ribbon lineation and is generally migmatitic or mylonitic (Plate 4A, B). More than one generation of leucosome may be present. Mafic layers and 'dismembered' mafic dykes locally make up a significant portion of the unit; ultramafic rocks are rare. The dominant mineral assemblage of the charnockite gneiss is quartz, K-feldspar, plagioclase, orthopyroxene, clinopyroxene, biotite and minor magnetite. The mafic layers are dominated by plagioclase, amphibole and clinopyroxene.

No definitive relationship between the charnockite gneiss and the adjacent units was observed. Outcrops of charnockitic gneiss, alternate with orthopyroxene monzodiorite, gabbronorite and the megacrystic charnockite–mangerite suite in the area of the contact. These zones of repeated succession may be tens to hundreds of metres wide having no clear evidence that the contact is intrusive or tectonic.

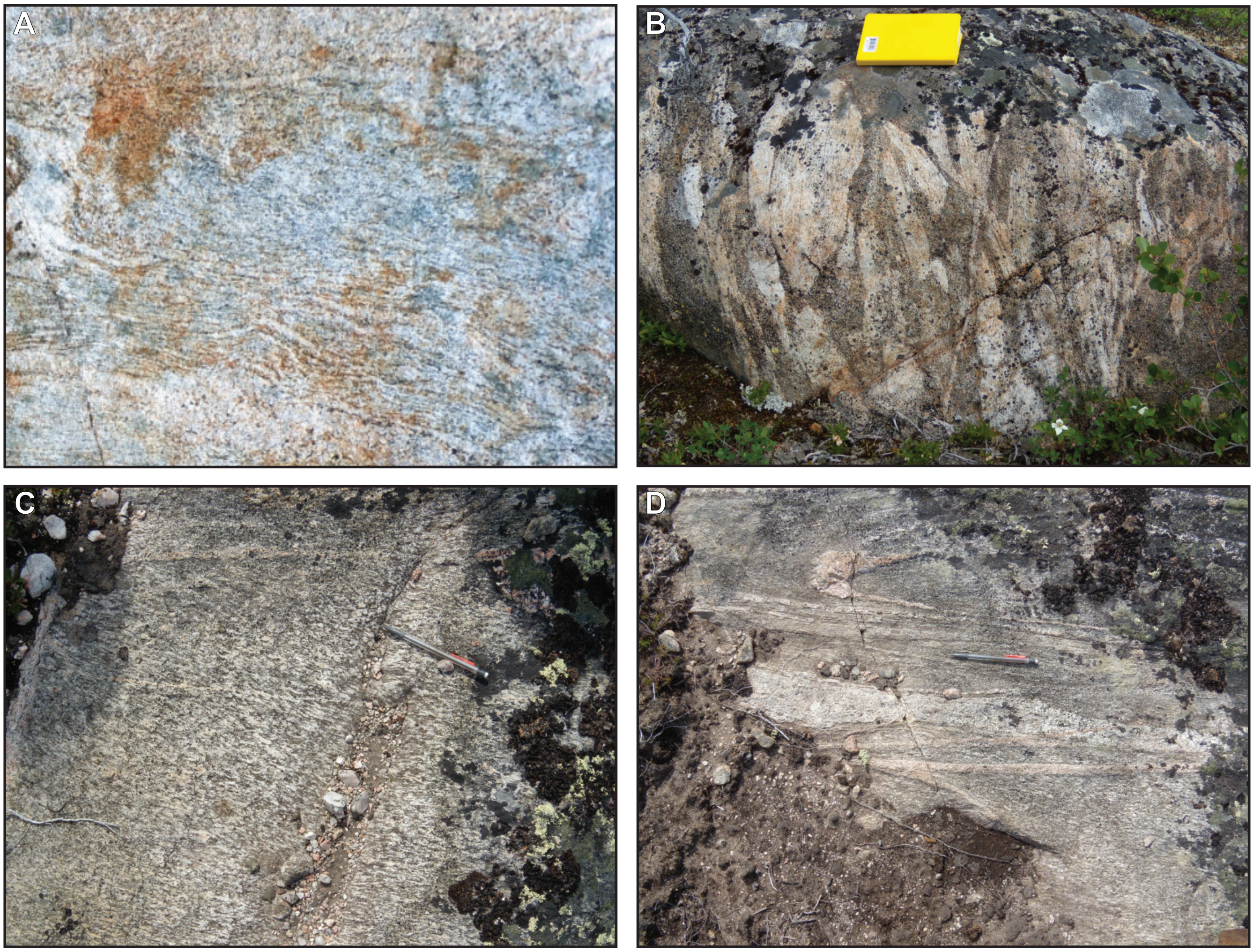

Plate 3. *Felsic rocks of the Archean group. A) Archean granodiorite gneiss. B) Archean granodiorite gneiss intruded by gabbronorite of the De Pas batholith. C, D) Typical Archean tonalite gneiss. Textures range from mylonitic to migmatitic. Note folded felsic dyke or leucosome in 3D.*

Orthopyroxene Monzodiorite (Jotunite)

The orthopyroxene monzodiorite unit is exposed throughout the De Pas batholith (Figure 5). The unit is white-grey- to orange-weathering, fine to medium grained, and contains abundant mafic enclaves. These enclaves are typically elongate or appear to be dismembered and may be the remnants of mafic dykes (Plate 4C, D). The dominant mineral assemblage of the monzodiorite is plagioclase, clinopyroxene, amphibole, orthopyroxene, K-feldspar and variable amounts of quartz. The foliation is defined by a preferred orientation of the mafic minerals, but where mafic minerals are lacking, the texture is equigranular.

The age of the orthopyroxene monzodiorite is not known but enclaves or blocks of the unit are found in the Paleoproterozoic megacrystic charnockite–mangerite (*see* below) suggesting the megacrystic rocks are younger. Furthermore, mafic enclaves are found only within the monzodiorite suggesting that the monzodiorite had been intruded by mafic dykes prior to emplacement of the megacrystic charnockite–mangerite. Additionally, blocks of monzodiorite within the megacrystic charnockite contain mafic enclaves whereas the host charnockite does not, further strengthening the argument for the crystallization of the monzodiorite and the emplacement of a mafic dyke swarm prior to intrusion of the charnockite. The relation between the monzodiorite and the gabbronorite (*see* below) is less certain. Despite the monzodiorite and gabbronorite being closely associated, no contacts were seen. However, if the gabbronorite is contemporaneous with the megacrystic charnockite–mangerite, as suggested below, then the gabbronorite must be younger than the monzodiorite.

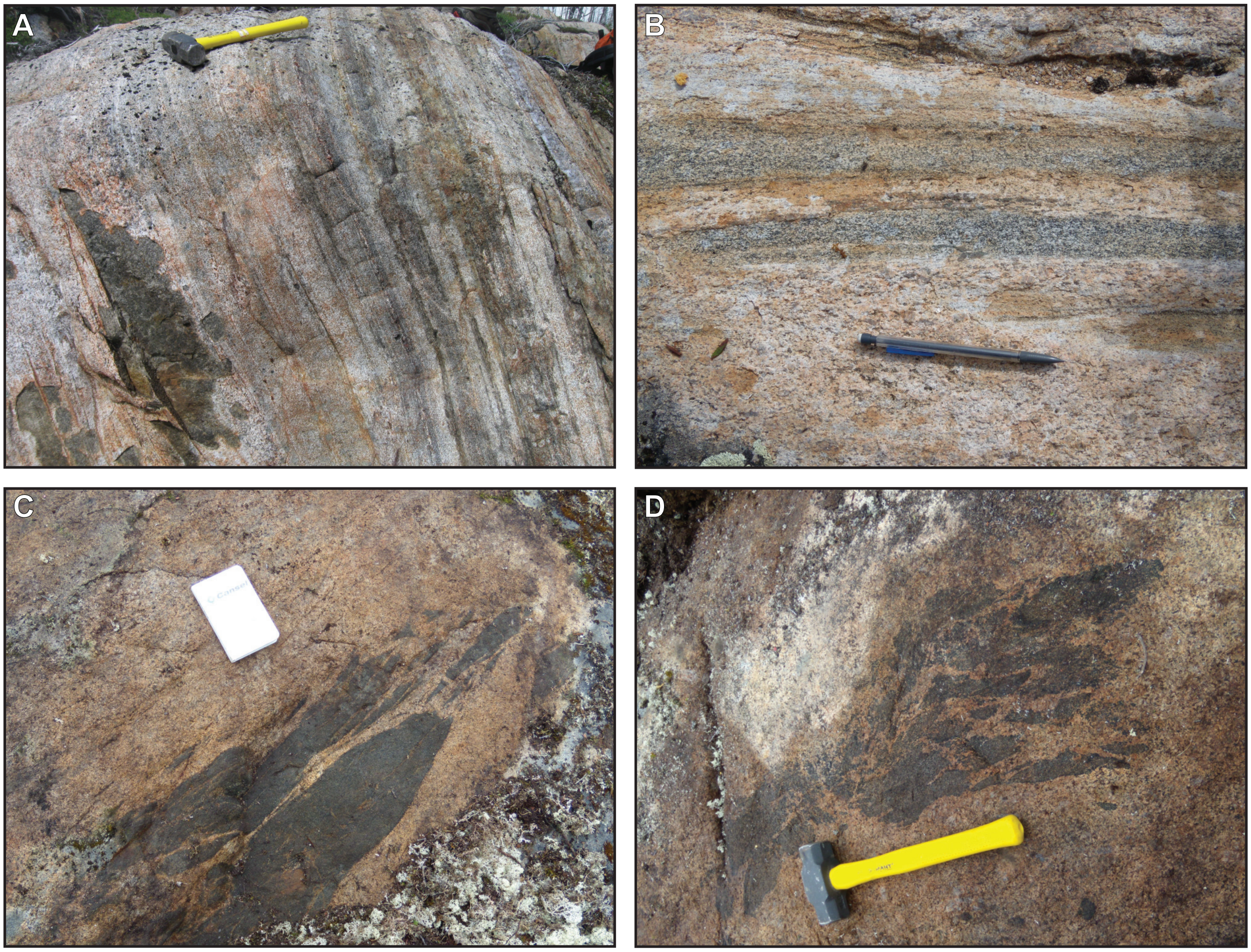

Plate 4. *De Pas batholith. A, B) Charnockite gneiss containing deformed mafic dykes or layers. C, D) Orthopyroxene monzodiorite having elongate mafic enclaves or layers*

Gabbronorite

Gabbronorite (and minor proportions of gabbro and diorite) is found throughout the De Pas batholith. The unit can be correlated with the high magnetic anomalies in the aeromagnetic survey (Dumont, 2009a, b, c, d) and this geophysical signature has been used to define the extent of the unit where outcrop is lacking (Figures 5 and 6). The gabbronorite is mainly mesocratic, but locally leucocratic and it displays textures that range from porphyritic to equigranular and generally has a migmatite-like appearance (Plate 5A, B). However, this migmatite-like appearance is the result of the injection of mangerite into the gabbronorite or magma mixing and not *in-situ* melting (Plate 5C). The gabbronorite displays widespread evidence for magma mingling with the megacrystic mangerite (Plate 5C, D).

The mineral assemblage is plagioclase, clinopyroxene, orthopyroxene, biotite and amphibole with minor apatite, K-feldspar and quartz. Parts of the gabbronorite adjacent to the mangerite veins have been recrystallized to pods or clots of clinopyroxene and magnetite.

Gabbronorite outcrops are coincident with high aeromagnetic signatures (with some exceptions) and show that the gabbronorite bodies lie within or near major shear zones (Figures 5 and 6). The shape of these gabbronorite is lensoid and may be indicative of stretching in the direction of shearing along north-, northwest-, and northeast-striking shear zones.

Megacrystic Charnockite and Mangerite

Megacrystic and coarse-grained charnockite and mangerite are the dominant rock types in the De Pas batholith. They can be present in a single outcrop and locally grade into orthopyroxene-free granodiorite, monzonite and granite. Both rock types weather rusty-orange to pink, but on

Plate 5. *Gabbronorite of the De Pas batholith. A) Porphyritic gabbronorite containing large laths of orthopyroxene. B) Equigranular gabbronorite being intruded by megacrystic mangerite. C) Intrusion breccia or magma mingling of gabbronorite (dark rock) and megacrystic mangerite (light rock). D) Evidence for magma mingling: feldspar megacrysts from mangerite "float" in gabbronorite matrix. Vein of mangerite at right side of photo.*

fresh surfaces the charnockite is pink to orange whereas the mangerite is tan to light-grey (Plate 6A, B). The dominant mineral assemblage for the charnockite is quartz, perthitic feldspar, amphibole, orthopyroxene, magnetite, clinopyroxene and minor plagioclase and biotite. Early formed mafic minerals are magnetite and orthopyroxene, the latter commonly rimmed by amphibole and biotite. Amphibole replacement of the orthopyroxene is nearly complete in some rocks. The mineral assemblage for the mangerite is similar but has little or no quartz, the dominant feldspar is plagioclase or antiperthite, and K-feldspar is a minor component.

Feldspar megacrysts (locally up to 5 cm in length) in the mangerite and charnockite vary in abundance from 30 to <1% (Plate 6A). The mafic mineral content is typically 5 to 10% but may locally exceed 20%. Clinopyroxene is generally present in small quantities, but increases in abundance near the contacts of the gabbronorite and mafic enclaves or pyroxene-rich pods are found locally in both the charnockite and the mangerite.

Flow banding (defined by the alignment of feldspar megacrysts), which parallels the regional tectonic fabric, is widespread. Magmatic layering may be present in the form of alternating megacryst-rich and megacryst-poor layers or alternating perthite-rich and plagioclase-rich layers. The tectonic fabric in the megacrystic charnockite is generally weak to non-existent (Plate 6A, B), except in shear zones where the rock has been transformed into a feldspar augen gneiss (Plate 6C). Deformed mafic dykes are abundant in, and around, these shear zones.

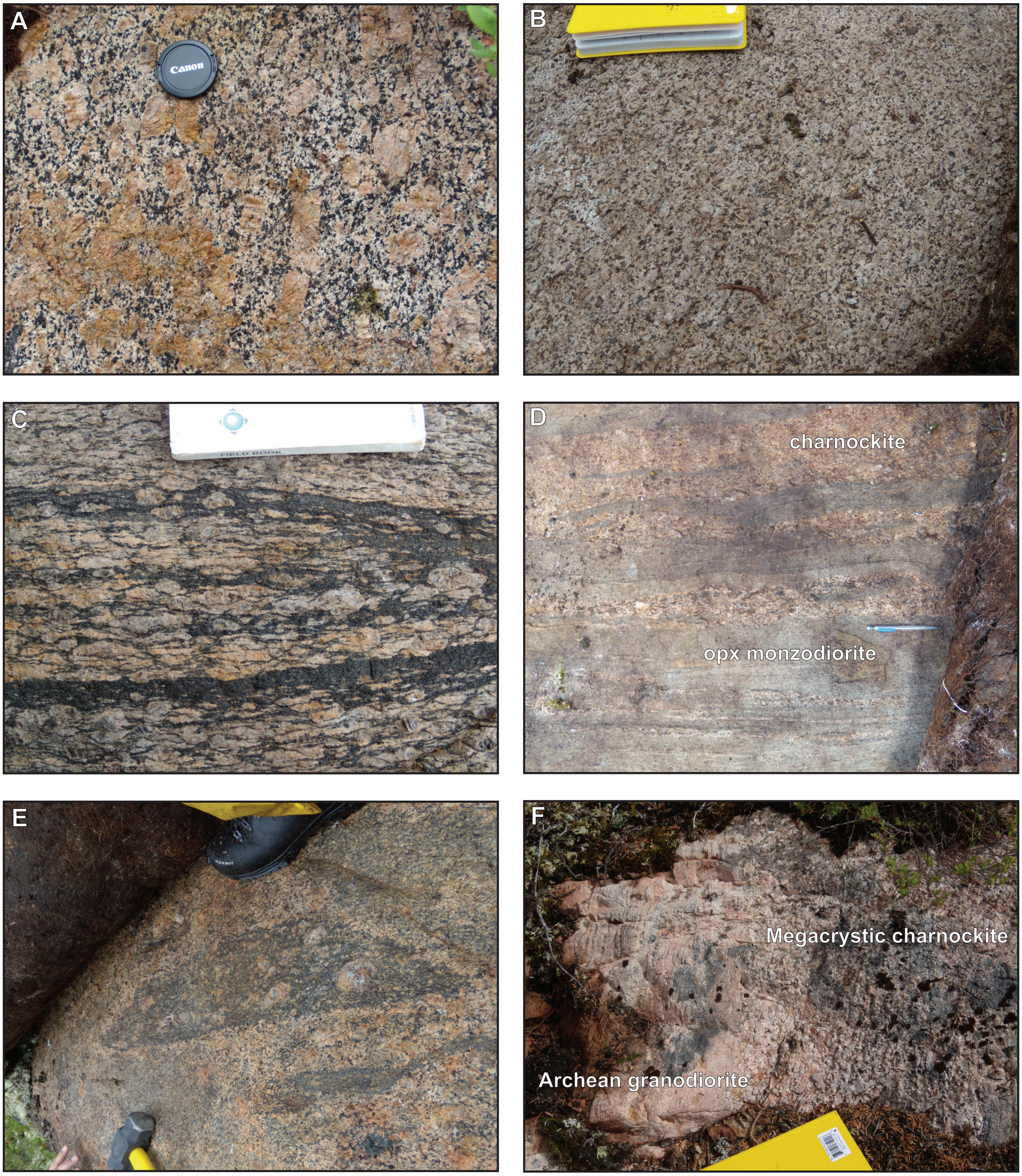

Plate 6. *De Pas batholith. A) Typical megacrystic charnockite showing perthitic feldspar megacrysts in a groundmass of orthopyroxene, clinopyroxene quartz, feldspar and magnetite. B) Typical coarse-grained mangerite. C) Augen gneiss derived from megacrystic charnockite in a regional shear zone. D) Photo illustrating that the megacrystic charnockite and orthopyroxene monzodiorite were deformed after intrusion of the charnockite into the monzodiorite. Pencil is parallel to the gneissic fabric. E) Outcrop illustrating magma mingling between megacrystic charnockite and gabbronorite. Note that gabbronorite enclave contains abundant perthite megacrysts derived from the charnockite. F) Contact between the Archean granodiorite gneiss and megacrystic charnockite. Both units are deformed by a northeast-striking shear zone near Lac Le Sueur.*

The charnockite and mangerite exhibit both intrusive and tectonic contacts with the orthopyroxene monzodiorite and gabbronorite units (Plates 5C, D and 6D). The monzodiorite, for example, forms blocks within the megacrystic charnockite–mangerite, is separated from the megacrystic charnockite–mangerite by 3- to 4-m-wide shear zones, and has been intruded by the megacrystic charnockite–mangerite and then deformed (Plate 6D). The gabbronorite shows evidence of being contemporaneous with the charnockite and mangerite because enclaves of gabbronorite (having diffuse edges) appear in the megacrystic unit and the gabbronorite contains feldspar megacrysts (Plate 5C, D). Additionally, the mangerite and the charnockite are typically contaminated with mafic minerals at the contact with the gabbronorite (Plate 6E). Contacts between the megacrystic unit and the Archean group of rocks are rarely exposed in eastern parts of the map area (Figure 5), but the megacrystic charnockite can be seen as having intruded into the Archean granodiorite (Plate 6F). Rotated blocks of Archean granodiorite occur in the megacrystic charnockite near the same locality. Both the charnockite and granodiorite were subsequently deformed.

CORONITIC GABBRONORITE–AMPHIBOLITE

Coronitic gabbronorite and amphibolite form small hills that rise sharply out of the surrounding wetlands on the western side of the map area (NTS map area 23I/14; Figure 5). The gabbronorite is variably deformed, having a primary igneous texture and a subhorizontal foliation. In some outcrops, the coronitic gabbronorite has been altered to amphibolite, has been wholly recrystallized and contains a steeply dipping foliation. Both rock types have a high magnetic signature (Figures 5 and 6) suggesting that the two rock types are connected, although their mineral assemblages are quite different. The coronitic gabbronorite consists of plagioclase, orthopyroxene and clinopyroxene. Coronas of green amphibole typically separate clinopyroxene and plagioclase, and garnet forms coronas between opaque minerals and plagioclase. Other fine-grained, unidentified intergrowths between orthopyroxene and plagioclase are present. The amphibolite, on the other hand, consists primarily of amphibole, scapolite, calcite and quartz indicative of significant alteration. Ilmenite has been partly replaced by rutile, and remnants of plagioclase are present. This mineral assemblage indicates that the rock has undergone near complete recrystallization, and very little remains of the original mineral assemblage. The coronitic gabbronorite must postdate most of the deformation as it shows minimal evidence for deformation.

The lack of outcrop precludes determination of the relationship between the gabbronorite–amphibolite unit and the other units in the map area but it occurs as sills or dykes in the Archean paragneiss. The textural and metamorphic contrasts between the gabbronorite and its host gneisses suggest that the former is significantly younger than, and likely intrudes, the paragneiss. The coronitic gabbronorite in the western part of the map area is texturally and mineralogically distinct from the gabbronorite farther east in the De Pas batholith and the two are unlikely to be related.

DYKES

Dykes of uncertain origin and age occur throughout the map area. They are dominantly granitic pegmatite, but rare, fine-grained mafic dykes are also present. These dykes are typically east-striking, range in width from a few centimetres to 50 cm, and crosscut all previously mentioned rocks with the exception of the coronitic gabbronorite and amphibolite. Additionally, tonalite dykes up to 3 m wide and over 2 km in length are present west of Lac Le Sueur (Figure 4). These dykes are subparallel to the local foliation but crosscut individual feldspar megacrystic layers in the charnockite. Fluid alteration is commonly associated with these dykes (*see* below).

MICHIKAMATS RING COMPLEX

The Mesoproterozoic Michikamats ring (dyke) complex located outside the study area near the northeast corner of Smallwood Reservoir (Figure 4) was investigated and sampled to assess its potential for rare-earth elements. The ring complex was first outlined by the most recent high-resolution airborne magnetic survey that was completed in the area by the Geological Survey of Canada (Dumont *et al.*, 2010). The complex comprises variably altered monzonitic to syenitic rocks and preliminary observations suggest that magnetic highs from the aeromagnetic survey correspond to the syenite, whereas magnetic lows are associated with the monzonite. The mineral assemblage of the syenite comprises primary perthitic feldspar, clinopyroxene, olivine and zircon and an alteration-related assemblage of albite, amphibole, magnetite, iddingsite and quartz. The monzonite mineral assemblage consists of plagioclase, clinopyroxene, olivine, microcline, zircon and orthopyroxene, as well as albite, amphibole, iddingsite, magnetite and hematite ± quartz that are related to fluid alteration. The presence of replacement albite and minor arfvedsonite suggests that alteration involved Na-rich fluids. Preliminary geochemical data suggest that the monzonite contains elevated values of lanthanum (250 ppm) and cerium (570 ppm). Additional geochemical studies and assays are being undertaken to further assess the alteration patterns and rare-earth element contents of these rocks.

STRUCTURE

The rocks of the map area are transected by north-striking shear zones that were subsequently overprinted by northwest- and northeast-striking shear zones (Figures 5 and 6). The De Pas batholith is sandwiched between two major north-striking shear zones and internally preserves a north-striking tectonic or magmatic fabric (flow banding). The west side of the batholith is marked by a region of north-striking shear zones at least 10 km wide. These shear zones are focused mainly in the charnockite gneiss of the De Pas batholith (Figures 5 and 6) but extend into the megacrystic charnockite to the east and most likely into the McKenzie River domain to the west. These shear zones are perhaps a manifestation of the main Lac Tudor shear zone in the field area (James *et al.*, 1996; Figures 3 and 4) and map patterns and rare kinematic indicators suggest that these are of dextral, transpressional type (Figure 5, Plate 7). The main George River shear zone lies approximately 15 km to the east of the map area (Figures 3 and 4). North-striking shear zones within the eastern Archean tonalite unit most likely mark the western edge of the George River shear zone and mark the eastern extent of the De Pas batholith (Figures 5 and 6). Kinematic indicators were not observed in these eastern shear zones, but map patterns suggest that these shear zones also experienced dextral transpression (Figures 5 and 6).

There are two main northwest-striking shear zones within the De Pas batholith. These shear zones are 1 to 3 km wide and crosscut some of the north-striking shear zones. Northwest-directed, sinistral shearing is evident from the deflection of the north-striking fabric at both the outcrop and map scale (Figure 5, Plate 7C). The aeromagnetic survey patterns (Figure 6) suggest that there may be additional northwest-oriented, unexposed, shear zones in the McKenzie River domain. Northeast-striking shear zones are less obvious at the map scale, but are present in outcrops throughout the eastern half of the map area. Movement on these northeast-striking shear zones is consistently dextral (Plate 7D). One large northeast-striking shear zone is well developed between the east side of Lac Le Sueur and the Québec border. This shear zone is 1 to 2 km wide and juxtaposes Archean granodiorite gneiss, megacrystic charnockite and gabbronorite.

Most foliations in the map area (tectonic and magmatic) are north striking except near northwest- and northeast-striking shear zones and all dip to the east or are vertical. Much of the De Pas batholith contains little or no fabric. The dominant mineral lineation, where present, plunges to the northeast regardless of whether the lineation is associated with north-striking shear zones or northwest-striking shear zones, but the lineations do not provide a sense of the direction of shear. Folds, where structural measurements can be taken, are rare in the map area. In some of the shear zones, intensely stretched isoclinal folds or ones having ‘z’ and ‘s’ symmetry are present (Plate 7). The Archean rocks locally contain recumbent folds and preserve an early west-striking fabric not found in rocks of the De pas batholith (Plates 1D, 7F).

Late brittle faults and associated fluid alteration are found around Lac Le Sueur. Fluid alteration typically involves epidote veining, quartz and magnetite alteration and local anomalous ‘total count’ scintillometer readings up to 700 counts per second verses 50 to 70 counts per second background. The fluid alteration has overprinted megacrystic charnockite, gabbronorite, Archean granodiorite and Archean paragneiss. As a result of the alteration, these rocks are red- to orange-weathering, and in some outcrops their tectonic fabric is obscured by recrystallization (Plate 8A, B). Tonalite dykes are associated with a similar type of alteration in the same area around Lac Le Sueur, but do not occur in the outcrops where brittle deformation is evident.

SUMMARY AND DISCUSSION

The Southeastern Churchill Province in western Labrador comprise variably deformed and exposed meta-igneous rocks and metasedimentary rocks. Rock units in the field area include two main suites: an Archean group comprising granitoid and mafic gneisses and minor paragneiss, and the Proterozoic De Pas batholith composed of charnockite and tonalite gneiss, orthopyroxene monzodiorite, gabbronorite, and megacrystic charnockite and mangerite. A minor unit of coronitic gabbronorite has been locally altered to amphibolite. The two main suites are deformed along north-, northwest-, and northeast-striking shear zones. The coronitic gabbronorite is relatively undeformed. North- and northeast-striking shear zones record dextral shearing whereas northwest-striking shear zones record sinistral shearing. The Archean group locally preserves an older fabric not identified in the De Pas batholith.

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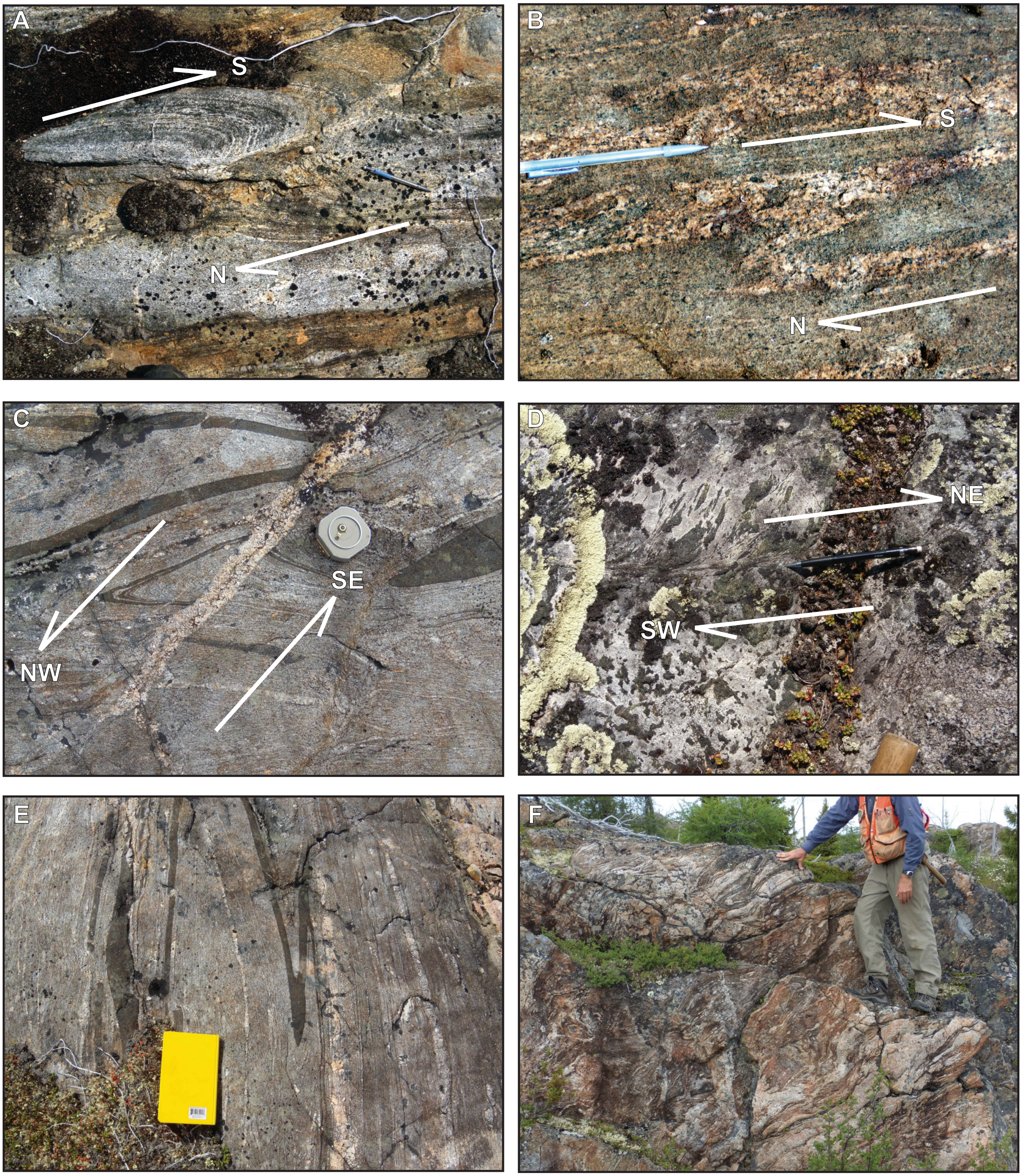

Plate 7. *Structure and deformation. A, B) Kinematic indicators of dextral shearing in (A) charnockite gneiss and (B) mixed megacrystic charnockite and orthopyroxene monzodiorite, from a north-striking shear zone in the De Pas batholith. C) Sinistral offset along a northwest-striking shear zone in the Archean granodiorite; note that a small pegmatite vein lies within the shear zone). D) Northeast-striking shear zone in Archean gabbroic anorthosite. E) Attenuated isoclinal folds of dykes in sheared Archean granodiorite. Shear zone shown here is north striking. F) Overturned folds in Archean paragneiss.*

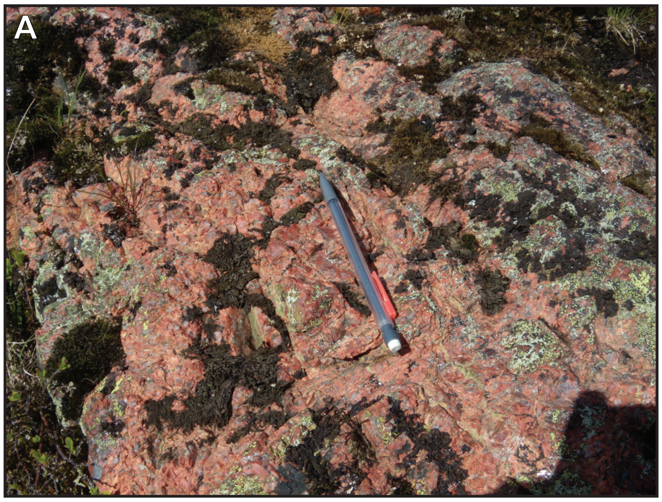

Plate 8. *Fluid alteration. A) Alteration of megacrystic charnockite by quartz-, epidote-, and iron-rich fluids. B) Fluid alteration has erased part of the fabric of the Archean granodiorite gneiss (top-right corner of photo).*

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