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# GEOLOGICAL SETTING OF THE INGRID GROUP, LABRADOR

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## ABSTRACT

*Research this past summer (2018) represented the completion of the field work component of the Geological Survey of Canada–Geological Survey of Newfoundland and Labrador–Nunatsiavut collaborative project aimed at upgrading the geoscientific knowledge of, and stimulating mineral exploration in, the Hopedale region of Labrador. This project is supported by the Geomapping for Energy and Minerals (GEM) II program at Natural Resources Canada and the Geological Survey of Newfoundland and Labrador. The principal aims of GEM II are to assist in completing coverage of regional-scale geological maps across Canada's north, and to enhance knowledge in regions to gain a better understanding of the geological evolution of key parts of the Canadian Shield. The overall GEM-II project addresses the latter objective by targeting specific areas along a transect from the Churchill Province to the Nain Province.*

*One such area is the Ingrid group, an isolated package of supracrustal rocks including volcanic and coarse-grained detrital rocks of presumed Paleoproterozoic age. The group is exposed as a fault-bound block between the Churchill Province to the west and the Archean Nain Province to the east. It is composed of subaerial lavas and upward-coarsening polymictic conglomerate, and has been metamorphosed to the lower greenschist-facies conditions. The eastern part of the group is composed of coarse sandstone and mafic polymictic conglomerate that is in fault contact with Archean Nain Province. The western and southwestern part of the group is composed of mafic volcanic rocks, felsic sandstone and conglomerate, which are sheared and intercalated with protomylonite derived from metaplutonic gneisses of Churchill Province. The northern part of the group is truncated by felsic intrusive rocks of the Nain Plutonic Suite, although the contact is not exposed.*

*The age of the Ingrid group is not known. It is younger than the Kikkertavak dykes (2200 Ma) but older than the* ca. *1.87–1.85 Ga Torngat orogeny. The Torngat orogeny is a zone of intense transpression and high-grade metamorphism that resulted from the amalgamation of the Core Zone and the Nain Province that deformed and metamorphosed the Ingrid group. This project aims to resolve many outstanding questions as to the nature, timing and tectonic history of the Ingrid group by studying the geochronology, metamorphic history, geochemistry of volcanic rocks, as well as the mineral potential of the group.*

## INTRODUCTION

A transect from the Core Zone of the Churchill Province to the Hopedale Block of the Nain Province is the focus of a joint Geological Survey of Canada–Geological Survey of Newfoundland and Labrador–Nunatsiavut project. This area is tectonically complex, located at the junction of four tectonic domains bound by Archean to Paleoproterozoic orogens (Figure 1). These are the 3.3–2.8 Ga Hopedale Block, the 4.0–3.2 Ga Saglek Block, the 2.8–2.3 Ga Core Zone, and the 1.88–1.74 Ga Makkovik Province (James *et al.*, 2002; Ketchum *et al.*, 2002; Corrigan *et al.*, 2018).

The Hopedale and Saglek blocks jointly form the Nain Province (Stockwell, 1963) and are part of the larger North Atlantic Craton, which occurs in Greenland as well as northwest Scotland. The boundary between the Hopedale and Saglek blocks is assumed to be tectonic and of Neoarchean age; however, the exact location of the boundary has not been identified in the field (James *et al.*, 2002). Part of the current project included the acquisition of new aeromagnetic maps for the transect region, the results of which will be published in the spring of 2019.

The Churchill Province comprises the Core Zone that is separated from the North Atlantic Craton by the *ca.* 1.87–1.85 Ga Torngat orogeny (Figure 1). The Torngat orogeny is a zone of intense transpression and high-grade metamorphism that mainly affected the Tasiuyak gneiss, the Lac Lomier complex, and the eastern edge of the Core Zone (Wardle *et al.*, 2002). The Core Zone and North Atlantic

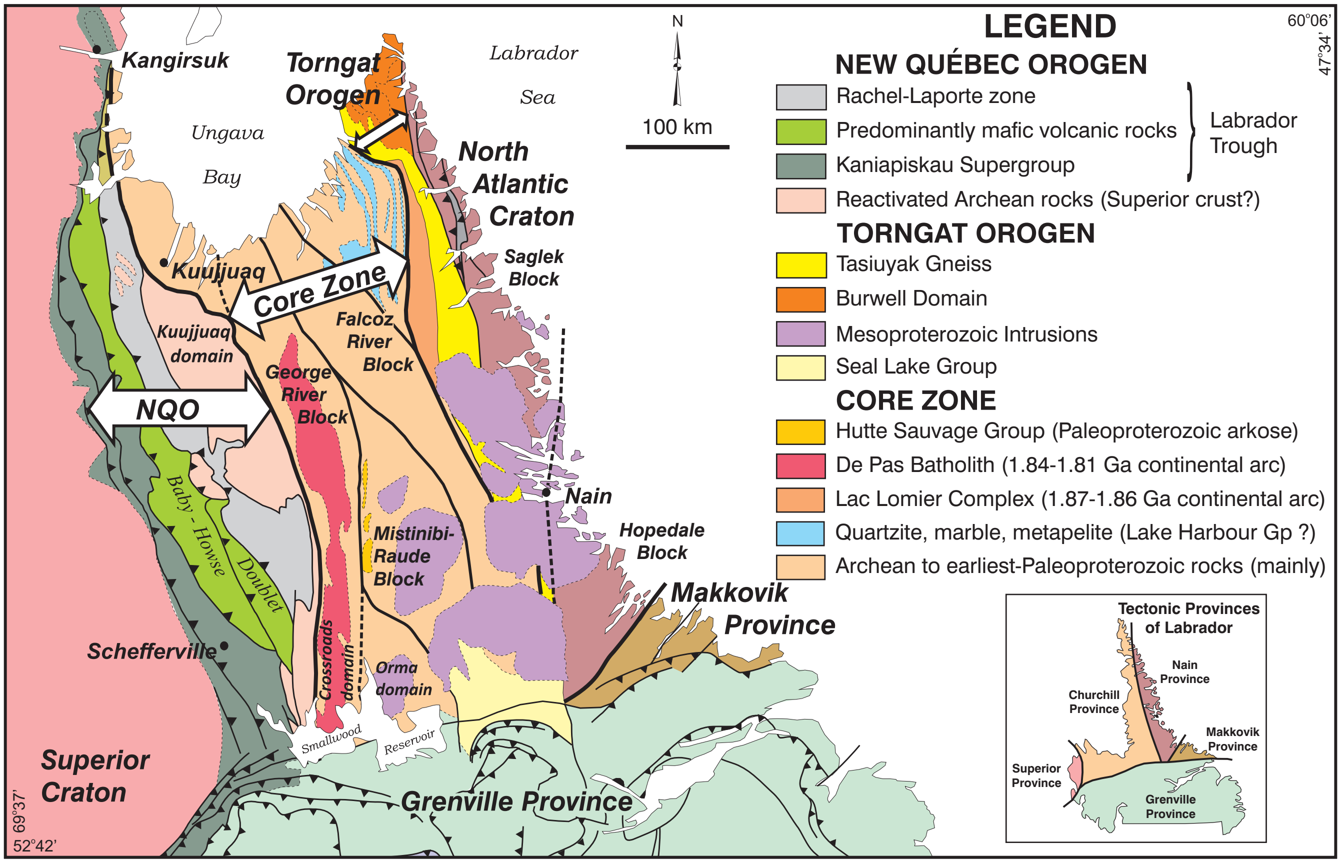

**Figure 1.** *Simplified geological map of the Precambrian Shield east of the Superior Craton in Québec and Labrador. Modified after James* et al. *(2003) and Corrigan* et al. *(2018).*

Craton are bounded to the south by the Makkovik Orogen, a region of crustal reactivation and terrane accretion that formed during the Paleoproterozoic (Ketchum *et al.*, 2002).

The study area is also the focus of voluminous AMCG-type magmatism during the Mesoproterozoic, with intrusion of the Harp Lake anorthosite, the Mistastin pluton, the Flowers River intrusive complex, as well as the Nain Plutonic Suite (Emslie, 1978). The focus of this report is the Ingrid group, which is an isolated package of supracrustal rocks exposed as a faulted block preserved between the Churchill Province to the west and the Archean Nain Province to the east (Figure 2).

## GEOLOGICAL SETTING

In Labrador, the North Atlantic Craton is referred to as the Nain Province and is composed of two major Archean crustal fragments, the Saglek and Hopedale blocks, which are inferred to have been juxtaposed in the late Archean (Connelly and Ryan, 1996; Wasteneys *et al.*, 1996; James *et al.*, 2002). The boundary between the Hopedale and Saglek blocks is inferred to occur along a poorly defined, north–northeast-trending high-strain zone and assumed to be Neoarchean (Connelly and Ryan, 1996; Wasteneys *et al.*, 1996; James *et al.*, 2002).

The area has been the centre of voluminous AMCG-type magmatism during the Mesoproterozoic (Emslie, 1978). This includes: a) the *ca.* 1460 Ma Harp Lake Intrusive Suite, which stitches the boundary between the southeast Churchill and Nain provinces and the Torngat orogen (Emslie, 1980); b) rocks of the long-lived, *ca.* 1351– 1292 Ma Nain Plutonic Suite (NPS; Hill, 1982; Ryan *et al.*, 1991; Thomas and Morrison, 1991), which intrudes along the boundary between the Saglek and Hopedale blocks; and c) the *ca.* 1293–1271 Ma Flowers River intrusive complex (Hill, 1982; Thomas and Morrison, 1991) which masks the Hopedale–Saglek boundary. All rocks of the region, with the apparent exception of the Flowers River intrusive complex, are cut by the northeast-trending, tholeiitic Harp dykes (Hill, 1982) dated at *ca.* 1273 Ma (Cadman *et al.*, 1993); however, the newly acquired geophysical survey data indicate that the Flowers River intrusive complex is cut by the Harp dykes.

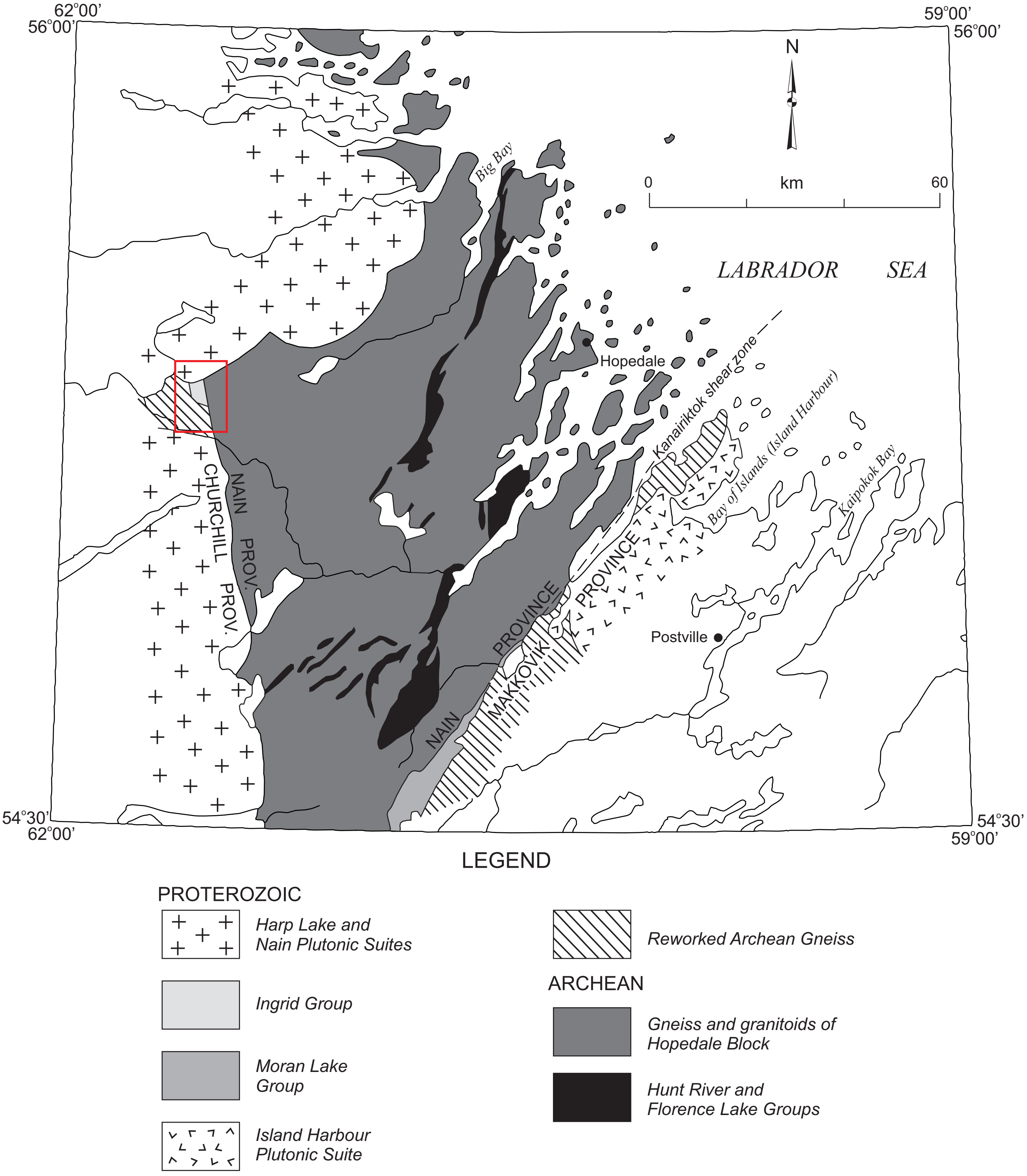

**Figure 2.** *Location of the Ingrid group relative to the major tectonic blocks and younger igneous suites. Red box shows the location of the Ingrid group.*

A detailed map of the Ingrid group was published by Ermanovics (1981; Figure 3). The lithological units remain unchanged from this mapping and the descriptions herein are based largely on the earlier work. This project will apply geochronology, geochemistry and isotopic geochemistry to correlate this belt with other prospective supracrustal belts in the region (*e.g.*, Moran Lake Group, Aillik Group).

## INGRID GROUP

An isolated area (2.4 by 0.8 km) of altered, schistose, andesitic rocks mapped by Taylor (1977, 1979) and interpreted as Proterozoic in age, was mapped in more detail and named the Ingrid group by Ermanovics (1981). These supracrustal rocks are exposed over an approximate 3 by 6 km area and are composed of subaerial lavas and upward-coarsening polymictic conglomerate that have been metamorphosed to the lower greenschist-facies conditions (Ermanovics, 1981), likely during the Torngat orogeny as mineral fabrics are more or less parallel to the latter.

The eastern part of the group is composed of coarse sandstone and mafic polymictic conglomerate that extends to the base of a fault juxtaposing the group against Archean gneiss of the Hopedale Block. The western and southwestern parts of the group are composed of mafic volcanic rocks and felsic greywacke sandstone and conglomerate. These rocks are sheared and intercalated with proto-mylonite derived from metaplutonic gneisses of the Churchill Province. The northern part of the group is truncated by intrusive rocks of the NPS. Although the contact with the NPS is not exposed, Ermanovics (1981, 1993), interpreted weak effects of contact metamorphism in rocks in the northernmost outcrops and in float in the intervening river valley, suggesting an intrusive contact.

Based on the field observations, Ermanovics (1981, 1993) divided the Ingrid group into six informal units as follows (Figure 3):

1) Felsic polymictic conglomerate; minor mafic volcanic conglomerate, sandstone, and purple siltstone; includes cobbles and boulders of felsic metaplutonic rocks. This unit has a thickness between 100 and 400 m (AIcf), and is confined to the southern part of the map area. Contacts with the surrounding volcanic rocks are not preserved, and are interpreted as fault contacts (Ermanovics, 1981). Bedding is 10–70 cm thick and graded bedding is locally preserved. The matrix is lithic (silt to sand) and the unit is poorly sorted (Plate 1A). Clasts include foliated granite, orthogneiss, massive gabbro, foliated granodiorite, shale, siltstone, quartzite, chert and limestone. Rare graded bedding indicates overturning to the east and west. Angular clasts of sedimentary rocks, such as bedded greywacke and black-laminated siltstone, are a minor but widespread component indicating a proximal sedimentary source rock that predates deposition of the conglomerate (Ermanovics, 1981, 1993).

2) Mafic volcanic conglomerate; minor felsic polymictic conglomerate, grit, sandstone, purple siltstone, and minor lavas; thickness 200 to 800 m (Alcm). This unit of coarse-grained, generally massive, mafic polymictic fragmental rocks (Plate 1B) has a mafic matrix and volcanic-derived gravels and boulder-sized clasts. Clasts also include metaplutonic rocks and rare siltstone, sandstone, greywacke, and felsic volcanic rocks (Ermanovics, 1981). Due to the angularity of the clasts, the volcanic material is interpreted to be locally derived and further supported by the presence of porphyritic basalt boulders in the conglomerates that are in contact with porphyritic basalt. This unit also contains rare intercalated sandstone beds that preserve overturned younging directions.

3) Felsic sandstone and minor purple siltstone and silty mudstone; minor dacite; minor polymictic conglomerate having a maximum thickness of 100 m (Als). This unit is composed of a heterogeneous mixture of arkosic greywacke, sandstone, purple siltstone, mudstone, polymictic conglomerate, and minor amounts of felsic (possibly volcanic) rocks (Plate 1C; Ermanovics, 1981). Primary features are locally preserved and include graded bedding, crossbedding, ball and flame structures, rip-up clasts and evidence of soft-sediment slumping. The unit is in gradational contact with felsic conglomerate (not map scale).

4) Porphyritic basalt, minor mafic to intermediate lavas and mafic volcanic conglomerate (Alpv). This unit has a maximum thickness of 200 m, and consists of alkaline–subalkaline volcanic rocks composed of moderately to highly fractionated porphyritic basalt (Ermanovics, 1981). Porphyritic basalt contains white, sericitized andesine phenocrysts and andesine + quartz aggregates (up to 1 by 3 cm) within a dark-green, nonmagnetic aphanitic matrix (Ermanovics, 1981).

5) Mafic to intermediate lavas, minor porphyritic basalt and mafic volcanic conglomerate and rare pillowed lavas (Almv). This unit has maximum thickness of 500 m. Massive basalts are medium grained to aphanitic, pale to dark green, and are locally finely schistose (Plate 1D). The rocks are weakly to strongly magnetic and contain scattered veins (up to 5 mm thick) of pyrite and calcite. Ermanovics (1981, 1983) reported three localities where pillow lavas were identified, with individual pil-

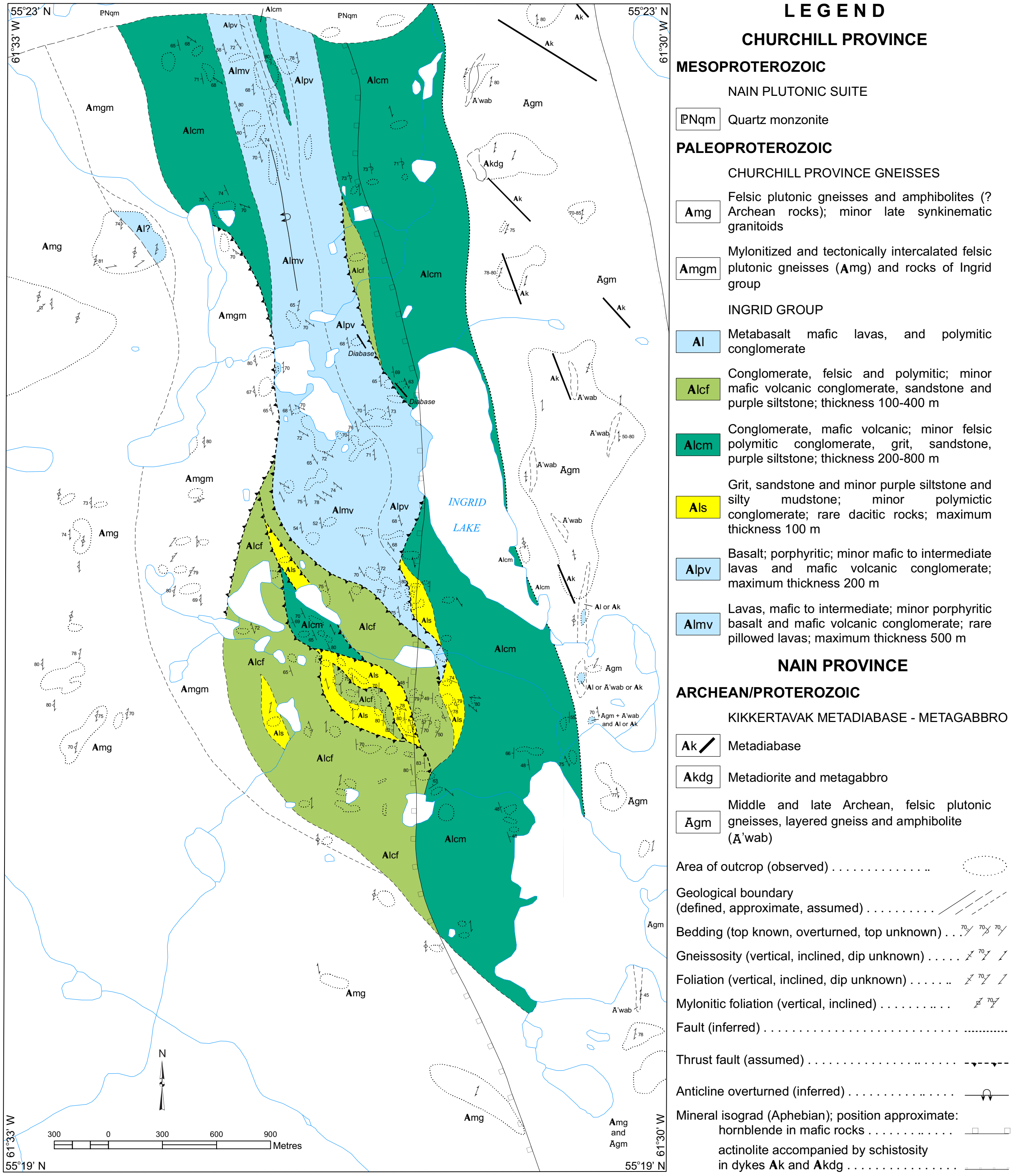

**Figure 3.** *Detailed geological map of the Ingrid group (after Ermanovics, 1993).*

**Plate 1.** *A) Poorly sorted, metaconglomerate with subrounded to angular clasts of felsic and mafic volcanic rocks and minor clasts of foliated granodiorite. The foliated granodiorite was sampled for geochronological study; B) Mafic conglomerate; C) Cherty, pink to mauve sandstone. Bedding is 2 to 10 cm thick; D) Weakly, foliated, fine-grained, greenschist-facies metabasalt. Foliation in the metabasalt is north–south and steeply dipping.*

lows ranging from 10 by 30 cm wide and up to 1 m long. Porphyritic basalt (Alpv) is also locally observed.

6) Mafic outliers are mapped as a separate unit (Al) as the relationship with the rest of the sequence is ambiguous. Several outliers of fine-grained, laminated amphibolite and layered orthogneiss occur within sheared quartzofeldspathic orthogneiss west of the Ingrid group (Figure 3). In addition, a thin veneer of mafic greywacke outcrops within the Archean rocks immediately east of the Ingrid group (Figure 3; Ermanovics, 1981, 1993). The contact between the eastern greywacke is not exposed.

## METAMORPHISM

Ermanovics (1993) reported metamorphic assemblages preserved in the Ingrid group as representative of lower greenschist-facies conditions. Metamorphic assemblages are best preserved in mafic units and in fine-grained sedimentary rocks. Metamorphism is accompanied by the development of a weak foliation. The western contact of the Ingrid group contains clasts that are stretched and deformed in parallelism with mylonitized Churchill Province gneisses. This metamorphism and deformation is interpreted as resulting from the Torngat orogeny (Ermanovics, 1981).

## TECTONIC EVOLUTION

Although not exposed, a well-sorted succession of epiclastic sediments is inferred based upon coarse clasts that are preserved in the conglomerates. This inference suggests deposition in a high-energy aqueous environment (Ermanovics, 1993). Rapid emergence of this succession would have given rise to intraformational rip-ups, soft-sediment slumping and large isolated clasts in finer grained beds that are observed in these units. Rapid deposition of coarse detritus, derived from Archean metaplutonic rocks, basalts and epiclastic sediments is interpreted to have occurred following emergence (Plate 2A; Ermanovics, 1993). The coarse, angular detritus occurs within unsorted, poorly defined beds of sandstone and minor argillaceous fine-grained sediment, typical of unstable depositional environment (Plate 2B).

Formational contacts, bedding, tectonic alignment of clasts, and metamorphic foliations, all strike north-northwest and parallel to the Nain–Churchill boundary and Churchill Province tectonic grain. Metamorphic foliation is generally parallel to bedding and may represent axial-planar foliations caused by folding (Ermanovics, 1981). Indicators of younging directions suggest an overturned succession (Plate 2C). Ermanovics (1993) suggested that the group is part of the nose of a recumbent fold, with downward-facing decollement folds on the lower limb, which is mylonitized and intercalated with mylonitic gneisses of the Churchill Province. Metamorphism and deformation would have occurred as part of the distal effects of the Torngat orogeny.

## AGE AND CORRELATION

The age of the Ingrid group is not well established. It is younger than the Kikkertavak dykes (2.2 Ga) but older than the *ca.* 1.87–1.85 Ga Torngat orogeny. The Torngat orogeny

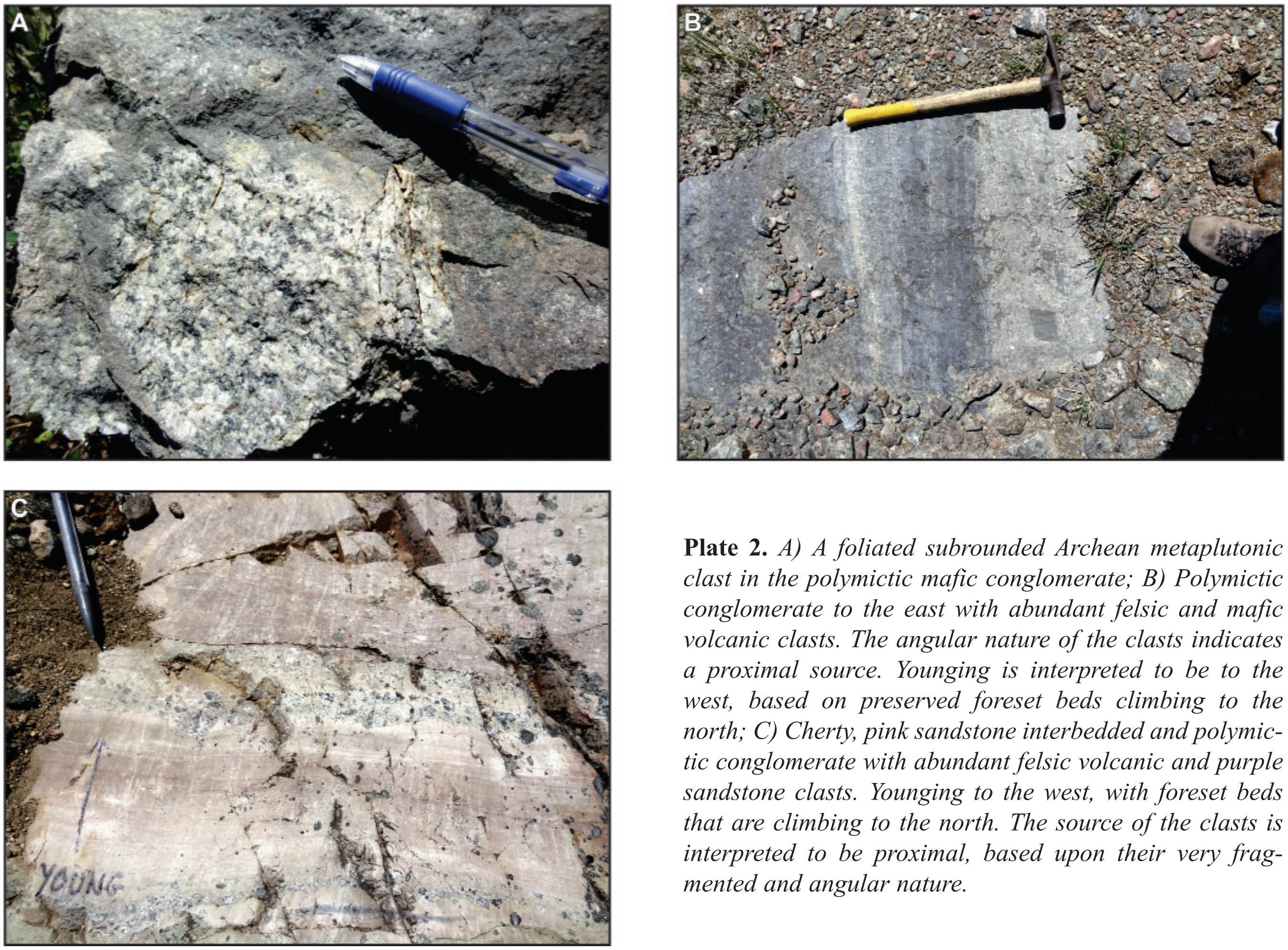

**Plate 2.** *A) A foliated subrounded Archean metaplutonic clast in the polymictic mafic conglomerate; B) Polymictic conglomerate to the east with abundant felsic and mafic volcanic clasts. The angular nature of the clasts indicates a proximal source. Younging is interpreted to be to the west, based on preserved foreset beds climbing to the north; C) Cherty, pink sandstone interbedded and polymictic conglomerate with abundant felsic volcanic and purple sandstone clasts. Younging to the west, with foreset beds that are climbing to the north. The source of the clasts is interpreted to be proximal, based upon their very fragmented and angular nature.*

is a zone of intense transpression and high-grade metamorphism that separates the Core Zone and the North Atlantic Craton (Figure 1). This orogenic event would have been responsible for the deformation and metamorphism preserved in the Ingrid group. The metamorphic grade increases to the west from the greenschist Ingrid group through to the Tasiuyak and Lac Lomier complex where upper granulite facies conditions are preserved. Basement rocks beneath and surrounding the Ingrid group do not appear to have acquired the same greenschist-facies metamorphic overprint, suggesting that the Ingrid group was emplaced as a nappe in thin-skin tectonic event.

## POTENTIAL CORRELATIVES

There are several Paleoproterozoic supracrustal sequences preserved in the study area. The Moran Lake and Post Hill (not shown on Figure 2 map) groups are comprised of siliciclastic sedimentary and mafic volcanic rocks, and are correlated on the basis of their similar stratigraphy and rock types (Marten, 1977; Wardle and Bailey, 1981). The Post Hill group contains a mafic metavolcanic unit in its lower tectonostratigraphy that was deposited *ca.* 2178 Ma, but units higher in the sequence were deposited after *ca.* 2013 Ma (Ketchum *et al.*, 2002). The Moran Lake Group remains undated, but is unconformably overlain by *ca.* 1850 Ma siliciclastic sedimentary rocks (Sparkes *et al.*, 2016), and is in thrust contact with the Nain Craton.

Younger supracrustal sequences are dominated by shallow-water to terrestrial sedimentary rocks and subaerial felsic volcanic rocks of the Aillik Group dated between 1883 and 1856 Ma (Schärer *et al.*, 1988; Hinchey and Rayner, 2008). The Bruce River Group sits unconformably upon the Moran Lake Group. The highest exposed stratigraphy within the Bruce River Group contains a felsic volcanic tuff that was dated *ca.* 1650 Ma (Schärer *et al.*, 1988; Sparkes *et al.*, 2016). However, a felsic tuff layer within the basal units of the sequence of the Bruce River Group produced an age of *ca.* 1850 Ma (Sparkes *et al.*, 2016), indicating the occurrence of an unrecognized fault or unconformity.

The Post Hill group, Aillik Group, the Bruce River Group, and Moran Lake Group are associated with economic mineral occurrences, generally consisting of uranium mineralization. The Aillik, Bruce River and Post Hill groups contain several uranium deposits (*e.g.*, Kitts, Michelin, Jacques Lake, Moran Lake Lower C deposits). In addition to uranium occurrences (*e.g.*, Armstrong deposits), the Moran Lake Group also contains an iron-rich breccia that has elevated values of gold and copper (Moran Lake Upper C Zone deposit; Sparkes *et al.*, 2016).

Establishing the age, as well as the geochemical and isotopic signature of the Ingrid group will allow for a robust comparison and potential correlation with the Paleoproterozoic supracrustal sequences preserved in the region. In turn, this will allow for potential mineralizing environments to be targeted based on the similarities between the belts.

## CONCLUSIONS

The Ingrid group is an isolated package of supracrustal rocks that include volcanic and coarse-grained detrital rocks. The group is exposed as a faulted block preserved between the Churchill Province to the west and the Archean Nain Province to the east. The group is composed of subaerial lavas and upward-coarsening polymictic conglomerate, and has been metamorphosed to the lower greenschist facies. The age of the Ingrid group is not well known. It is younger than the Kikkertavak dykes (2.2 Ga) but older than the *ca.* 1.87–1.85 Ga Torngat orogeny. The Torngat orogeny a zone of intense transpression and high-grade metamorphism that affected the Ingrid group. Future studies will explore the formation and mineral potential of the Ingrid group based on more abundant and precise U–Pb zircon and monazite ages, as well as new ground observations supported by high-resolution aeromagnetic data.

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