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THE PALEOPROTEROZOIC VOLCANO-SEDIMENTARY ROCKS OF THE AILLIK GROUP AND ASSOCIATED PLUTONIC SUITES OF THE AILLIK DOMAIN, MAKKOVIK PROVINCE, LABRADOR (NTS MAP AREA 13J/14)

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ABSTRACT

In the Monkey Hill area (NTS map area 13J/14), 1:50 000-scale mapping has further defined the lithological units that occur within the Aillik domain of the Makkovik Province. Regional bedrock mapping focused on characterizing the Aillik Group (previously called the Upper Aillik Group), a package of Paleoproterozoic volcano-sedimentary rocks that occur throughout the map area. The Aillik Group is intruded by abundant, deformed and undeformed, Paleoproterozoic intrusive suites. The area is also characterized by metre-scale, syn- and post-deformational mafic dykes and post-deformational aplitic dykes. The Adlavik Brook fault zone bisects the Monkey Hill map area and, volcano-sedimentary rocks are preserved primarily north of this fault.

The ca. *1883–1856 Ma Aillik Group comprises an upper greenschist- to lower amphibolite-facies volcano-sedimentary sequence that includes felsic tuff, flow-banded to non-banded rhyolite, volcaniclastic breccia/conglomerate, tuffaceous sandstone, thin-bedded to laminated sandstone and siltstone, and lesser components of basalt (with locally preserved pillow selvages), and mafic tuff. Minor amounts of Post Hill Group (previously called the Lower Aillik Group), dominantly the Kitts Pillow Lava formation, are preserved in the map area. Paleoproterozoic intrusive suites include syn-volcanic quartz–feldspar-porphyritic granites, (*ca. *1858 Ma),* ca. *1802–1800 Ma foliated plutonic rocks of the Long Island Quartz Monzonite and the Kennedy Mountain Intrusive Suite,* ca. *1800–1795 Ma weakly foliated to massive plutonic rocks of the Numok and Lanceground intrusive suites and the Big River Granite, as well as Labradorian (*ca. *1650–1640 Ma) plutonic rocks of the Monkey Hill and the Adlavik intrusive suites. Regional-scale folding controls the distribution of volcano-sedimentary units in the region and late faulting further complicates the geology.*

The study area lies within the Central Mineral Belt of Labrador, an area that has been previously known to host an abundance of base-metal and uraniferous mineral occurrences. Several mineral occurrences (not recorded in Mineral Occurrence Data System) were documented as a result of this study, aiding to further illustrate the economic potential of the region.

INTRODUCTION

The 2008 field season marked the second year of a multi-year, 1:50 000-scale, bedrock-mapping project that has the goal of mapping and interpreting the geology of the Aillik domain of the Makkovik Province. The Aillik domain, which is one of three domains that divide the Makkovik Province, is dominated by Paleoproterozoic metasedimentary and metavolcanic supracrustal sequences (Aillik Group) and by Paleoproterozoic intrusive suites (Kerr *et al.*, 1996). The outcome of this project will be a detailed, comprehensive, GIS-integrated geological map and associated database, which will be a valuable asset and tool for mineral exploration and land-use planning. The 2008 field season covered the entire Monkey Hill area (NTS map area 13J/14; *see* Figure 1), which is contained entirely within the Central Mineral Belt of Labrador (Ryan, 1984), an area known for its abundant and varied base-metal and uraniferous mineral occurrences. The Aillik Group, as originally mapped, was divided into an upper and lower Group (Kranck, 1939; King, 1963; Marten, 1977; Clark, 1979); however, recent work (Ketchum *et al.*, 2002), which included lithological, geochronological and geochemical studies, re-defined the group as the Aillik Group (previously Upper Aillik Group) and the Post Hill Group (previously Lower Aillik Group). Regional bedrock mapping focused on characterizing the Aillik Group, as well as the abundant Paleoproterozoic plutonic suites that intrude the group. The Aillik

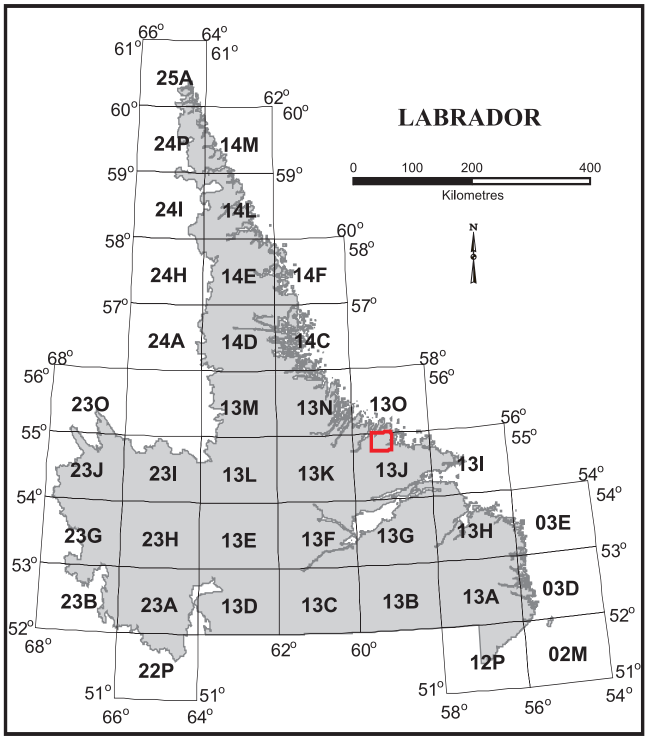


Figure 1. *Index map of Labrador showing the location of the NTS 13J/14 Monkey Hill study area.*

domain also contains abundant pre- and post-deformational mafic dykes that intrude the entire map area. In areas with rare outcrops of bedrock (*i.e.*, in the Adlavik Brook flood plain) the regional extent of the geology units were postulated. This preliminary report is based on data from the 2008 field-mapping season.

PREVIOUS WORK

Most of the early geological studies in the area were carried out by the Geological Survey of Canada, representing reconnaissance-scale geological mapping surveys (Kranck, 1939, 1953; Douglas, 1953; Christie *et al.*, 1953). Since the discovery of uranium and molybdenite mineralization in the region in 1954, many studies have focused on the mineral potential of the area (*e.g.*, Beavan, 1958; Gandhi *et al.*, 1969; Gandhi, 1978; Evans, 1980; MacDougall, 1988; MacKenzie, 1991; Wilton, 1996). The Newfoundland and Labrador Department of Natural Resources completed a 1:100 000-scale mapping survey of the region that resulted in several published reports and articles (Bailey, 1981; Gower *et al.*, 1982; Gower and Ryan, 1987). The timing and geochemistry of the Paleoproterozoic intrusive suites in the area have also been studied (Kerr, 1989, 1994; Kerr *et al.*, 1992; Barr *et al.*, 2001). Other research has focused on the structural evolution of the area (Sutton *et al.*, 1971; Marten, 1977; Clark, 1979) and on the timing and tectonic evolution of the Makkovik Province (Kerr *et al.*, 1996; Ketchum *et al.*, 1997, 2001, 2002; Culshaw *et al.*, 2000; Barr *et al.*, 2007). More detailed studies focused on Aillik Group rocks in the Big Island–Rangers Bight area (Sinclair, 1999; Sinclair *et al.*, 2002). The mafic dykes that occur throughout the area have also been examined (King, 1963; King and MacMillan, 1975; Hawkins, 1976; Foley, 1982; Malpas *et al.*, 1986; Tappe *et al.*, 2006). The major findings of these relevant studies are summarized below.

REGIONAL GEOLOGY

OVERVIEW

The Makkovik Province is part of the Paleoproterozoic accretionary orogen that is bounded to the northwest by the Archean Nain Province and to the south by the Mesoproterozoic Grenville Province (Figure 2). It is divided into three domains, namely (from northwest to southeast), the Kaipokok, the Aillik and the Cape Harrison domains (Kerr *et al.*, 1996). The Kaipokok domain consists of reworked Archean gneiss of the Nain Province, overlying Paleoproterozoic metavolcanic and metasedimentary supracrustal sequences of the Moran Lake and the Post Hill groups, and Paleoproterozoic granitoid intrusions (Kerr *et al.*, 1996; Ketchum *et al.*, 2001) and is interpreted as the foreland zone of the Makkovik Province (Kerr *et al.*, 1996). The boundary between the Kaipokok and Aillik domains is marked by several high-strain shear zones that cumulatively comprise the Kaipokok Bay shear zone (defined by Ketchum *et al.*, 1997; *cf.*, Kaipokok Bay structural zone of Kerr *et al.*, 1996; Culshaw *et al.*, 2000). The Aillik domain is dominated by Paleoproterozoic metasedimentary and metavolcanic supracrustal rocks (Aillik Group) and Paleoproterozoic intrusive suites (Kerr *et al.*, 1996). The Cape Harrison domain is dominated by syn- and posttectonic Paleoproterozoic intrusive suites, a package of reworked orthogneiss (Cape Harrison Metamorphic Suite), and rare enclaves of supracrustal rocks interpreted as being correlative with the Aillik Group (Gower and Ryan, 1986; Kerr *et al.*, 1996). The boundary between the Aillik domain and the Cape Harrison domain is obscured by abundant plutonic intrusions and may be transitional at deeper crustal levels (Kerr *et al.*, 1996). The Aillik and Cape Harrison domains are interpreted as being part of a composite arc to rifted-arc terrane that formed prior to, and after, the start of accretion to the Nain cratonic margin (Ryan, 1984; Culshaw *et al.*, 1998; Kerr *et al.*, 1996). The accretion of this juvenile terrane marked the initiation of the 1.9–1.71 Ga Makkovikian orogeny, resulting in the development of a regional penetrative tectonic fabric, regional-scale shear zones and greenschist- to amphibolite-facies metamorphism (Gandhi *et al.*, 1969; Sutton, 1972; Marten, 1977; Clark, 1979; Gower *et al.*, 1982; Kerr, 1994; Ketchum *et al.*, 1997, 2002; Culshaw *et al.*, 2000). Syn- to post-orogenic granitic plutons occur throughout and

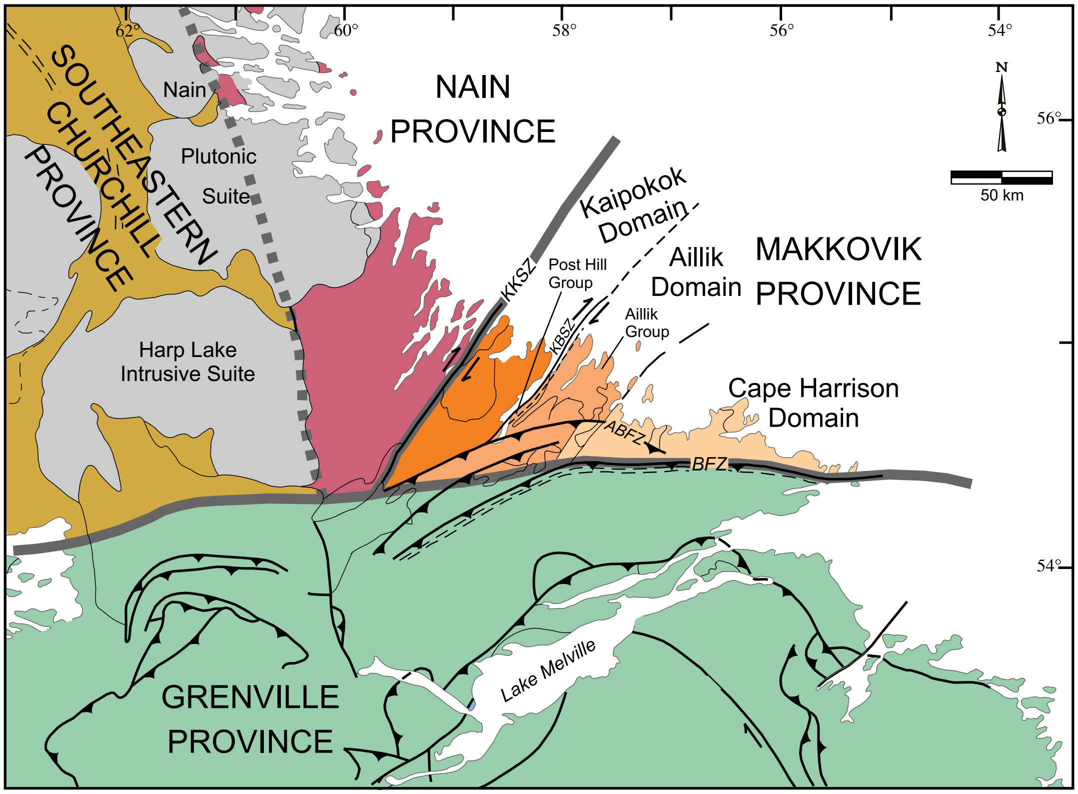


Figure 2. *A simplified tectonic framework of south-central Labrador; the map highlights the three domains of the Makkovik Province: the Kaipokok, Aillik and Cape Harrison domains (simplified after Wardle* et al.*, 1997). KBSZ - Kaipokok Bay shear zone; KKSZ - Kanairiktok shear zone; BFZ - Benedict fault zone; ABFZ - Adlavik Brook fault zone.*

a number of late, major, east–west-trending faults also occur throughout the Makkovik Province; these are interpreted to be affects of Labradorian or Grenville orogeny (Gower *et al.*, 1980). These include the Adlavik Brook fault zone and Benedict fault zone (Figures 2 and 3). In the study area, the Adlavik Brook fault zone is interpreted to have a transcurrent displacement of at least 18 km (Gower *et al.*, 1982) to possibly as great as 30 km (Kerr, 1994).

The Aillik domain is composed mostly of the ca. 1883–1856 Ma Aillik Group (Schärer *et al.*, 1988; Hinchey and Rayner, 2008), a supracrustal assemblage of metavolcanic and metasedimentary rocks (Figure 3). The group is intruded by granitoid plutons, including *ca.* 1858 Ma syn-volcanic intrusions (Hinchey and Rayner, 2008) and younger suites that range from *ca.* 1800 to 1630 Ma (Kerr, 1994). The Aillik Group structurally overlies the Post Hill Group, a highly strained, amphibolite-facies, supracrustal sequence, which, in turn, structurally overlies Archean gneiss that forms the basement to the lowest members of the Post Hill Group (Culshaw *et al.*, 1998, 2000; Ketchum *et al.*, 2001).

The Post Hill Group is composed of deformed and metamorphosed siliciclastic and mafic volcanic rocks (Marten, 1977; Gower *et al.*, 1982). Two of the lower quartzite units within the Post Hill Group contain only Archean detrital zircons and are interpreted as being deposited on the Nain craton after the *ca.* 2235 Ma episode of rifting and initiation of a passive margin (Ketchum *et al.*, 2001). The overlying mafic volcanic rocks, termed the Post Hill amphibolite, contain thin horizons of intermediate tuff, one of which has a U–Pb zircon date of 2178 ± 4 Ma (Ketchum *et al.*, 2001). A stratigraphically higher package of psammitic and semipelitic metasedimentary rocks was deposited after ca. 2013 Ma, based on the youngest detrital zircon age (Ketchum *et al.*, 2001). This range in ages indicates that deposition of the Post Hill Group occurred over a >165 m.y. period, prior to the onset of the Makkovikian orogeny.

The Aillik Group comprises interbedded sandstone and siltstone, conglomerate, tuffaceous sandstone, felsic tuff, rhyolite, volcanic breccia, and lesser mafic volcanic rocks and volcaniclastic sedimentary rocks. The group is deformed and metamorphosed and has syn-volcanic porphyritic granite intrusions. The stratigraphy of the Aillik Group is complicated by lithological units that are not laterally continuous, and the structure is locally complex resulting in the repetition of stratigraphy (Hinchey, 2007).

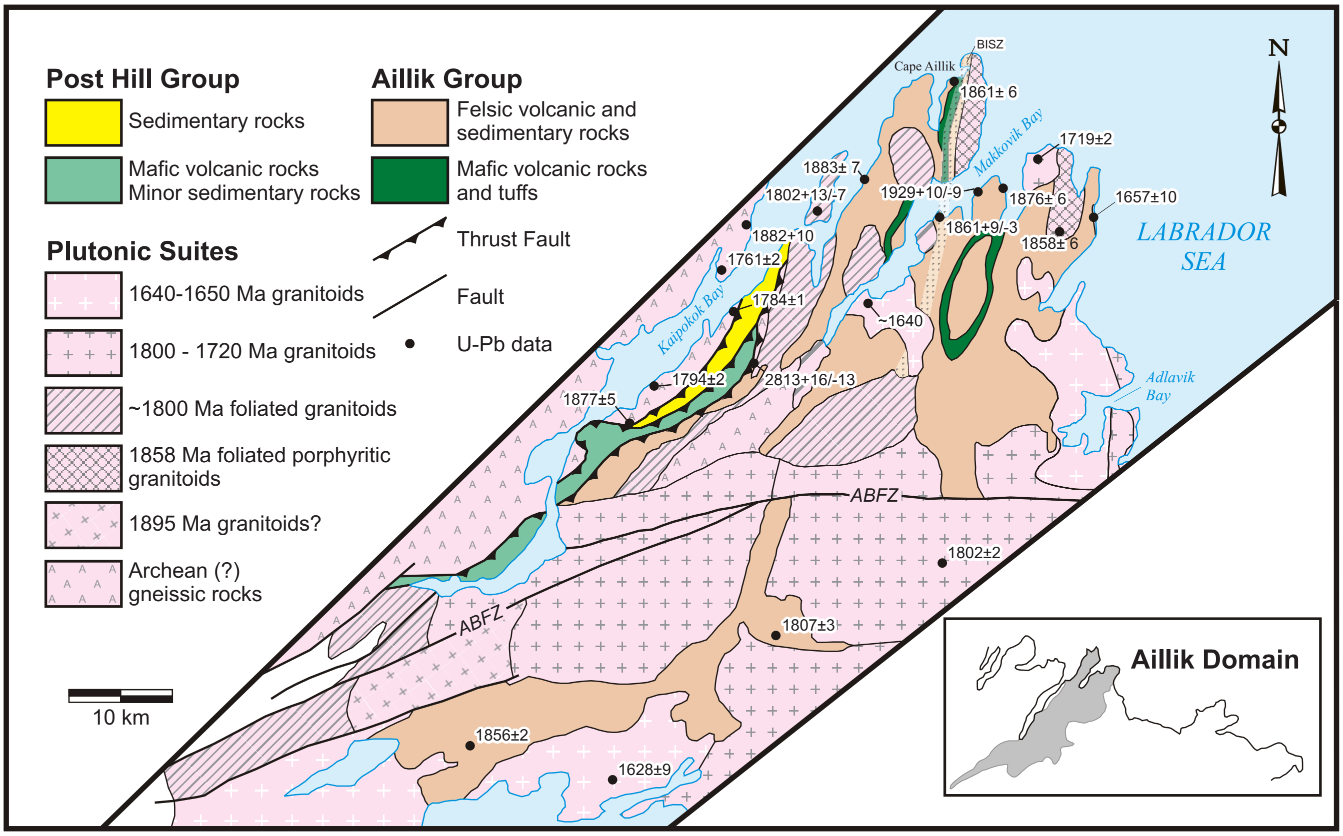


Figure 3. *A simplified geological map of the Aillik domain, Makkovik Province (modified after Kerr* et al.*, 1996). Locations of U-Pb zircon dates are plotted; data are from Schärer* et al. *(1988); Kerr* et al. *(1992); Ketchum* et al. *(1997, 2002); Sinclair* et al. *(2002); Cox* et al.*, 2003; and Hinchey and Rayner (2008). BISZ - Big Island shear zone; ABFZ - Adlavik Brook fault zone.*

The U–Pb zircon ages for felsic volcanic rocks within the Aillik Group include an age of 1856 ± 2 Ma from an ash-flow tuff at Michelin Ridge, an age of 1861 +9/-3 Ma from a rhyolite flow at Ranger Bight, and a much younger age of 1807 ± 3 Ma from a quartz–feldspar porphyry, collected from White Bear Mountain (Schärer *et al.*, 1988; *see* Figure 3 for approximate locations of the U–Pb data sites). The younger ca. 1807 Ma age suggests that not all of the porphyries are co-magmatic with felsic volcanism, and in light of the widespread ca. 1800 Ma igneous activity in the area, it is likely that the dated porphyry is related to the younger magmatic event (Sinclair *et al.*, 2002; Hinchey, 2007; Hinchey and Rayner, 2008). In addition, Hinchey and Rayner (2008) reported three dates from the Aillik Group, including, 1) a felsic tuff from Aillik Bay that yielded a date of 1861 ± 6 Ma; 2) a rhyolite from the eastern side of Kaipokok Bay that yielded a date of 1883 ± 7 Ma; and 3) a rhyolite from Ford's Bight area that yielded a date of 1876 ± 6 Ma (Figure 3). These new U–Pb zircon dates for felsic volcanic rocks have extended the timing of the initiation of volcanism to *ca.* 1883 Ma. Thus, incorporating the minimum errors on the U–Pb dates, the Aillik Group must have been forming for at least 18 m.y.

Sinclair *et al.* (2002) reported a U–Pb zircon age of 1929 +10/-9 Ma for the Measles Point Granite, a deformed porphyritic granite exposed along the southeast coast of Makkovik Bay (Figure 3). The significance of this age has been questioned (Hinchey, 2007) because the Measles Point Granite is interpreted as a sill-like, hypabyssal, foliated granite that is lithogeochemically similar to, and spatially associated with, the felsic volcanic rocks of the Aillik Group, which are reported (Shärer *et al.*, 1988; Hinchey and Rayner, 2008) to be approximately 70 Ma younger. Hinchey (2007) suggested, based on field evidence the intrusions are interfolded with the Aillik Group, that the porphyritic granites are syn-volcanic, hypabyssal intrusions requiring them to have formed synchronous with, or shortly after, volcanism. A U–Pb date from a folded porphyritic granite yielded an age of 1858 ± 6 Ma (Hinchey and Rayner, 2008) supporting this interpretation. A sample from the Measles Point Granite, proper, is currently being processed for U–Pb zircon analysis.

The Aillik domain is intruded by several Paleoproterozoic magmatic suites that are divisible into three broad groupings that have ages of *ca.* 1800 Ma, *ca.* 1720 Ma and *ca.* 1650 Ma (Kerr *et al.*, 1992; Kerr, 1994). The *ca.* 1800 Ma intrusions are interpreted as being concomitant with the amphibolite-facies, regional transpression attributed to the latter phases of the Makkovikian orogeny that deformed the host rocks (Gower and Ryan, 1986; Ketchum *et al.*, 2002) and variably foliated the plutonic intrusions (Kerr *et al.*, 1992). The *ca.* 1720 Ma suites are undeformed and thought to represent the final orogenic pulse of the Makkovikian orogeny (Ketchum *et al.*, 2002), and the *ca.* 1650 Ma intrusions are non-foliated and may represent a far-field effect of the Labradorian orogeny (Kerr *et al.*, 1992).

Initial mapping in the region suggested that the principal structural elements in the Aillik Group are large, upward-facing, gently plunging folds that have axial-planar fabrics, synchronous with upper greenschist- to lower amphibolite-facies metamorphism (Clark, 1979; Gower *et al.*, 1982). In addition, a <1-km-wide, steeply southeast-dipping structure, informally called the Big Island shear zone (Ketchum *et al.*, 2002; *cf.*, the Ranger Bight slide of Clark, 1979; the 'straight zone' of Culshaw *et al.*, 2000), extends from the south of Cape Makkovik through to Big Island and southward inland (Figure 2). These structural elements are interpreted as a regional D_3 event resulting from sinistral transpression during the westward thrusting of the Aillik Group (Culshaw *et al.*, 2000). This D_3 deformation event is unique to the Aillik Group and may reflect the northwestward transport of these rocks. This interpretation is supported by the intrusion of a distinctive suite of abundant metadiabase dykes into the Aillik Group but which are absent from the structurally underlying Archean rocks (Culshaw *et al.*, 2000).

To explain the distribution of the rocks, the structural relationships and the range in ages, Hinchey (2007) and Hinchey and Rayner (2008) noted that the fold pattern and structural history of the Aillik Group must be more complex than previously interpreted. Hinchey (2007) suggested that the Aillik Group in the Makkovik Bay area is characterized by regional-scale, dominantly tight to isoclinal, moderately plunging, up-right to overturned folds (F_1 locally; regional D_3 of Culshaw *et al.*, 2000) that were subsequently refolded (F_2 locally). The Big Island shear zone is thought to represent one of a series of ductile shear zones that excised part of the Aillik Group (Hinchey, 2007), with another parallel shear zone possibly occurring at Pomiadluk Point. The direction of fold vergence of the regional folds changes about the Big Island shear zone. West of the Big Island shear zone, folds verge to the northwest whereas, east of the shear zone folds verge to the northeast (Hinchey, 2007).

GEOLOGY OF THE MONKEY HILL MAP AREA

Below is a description of the lithological units in the Monkey Hill area (NTS map area 13J/14). All units are shown on Figure 4.

Archean Orthogneiss (Unit 1)

Within the map area, Unit 1 is interpreted as reworked Archean gneiss. This unit is restricted in aerial extent, occurring only in the northeastern section and in the area directly southeast of Swell Lake (Figure 4). The unit comprises a locally migmatitic, grey, quartzofeldspathic orthogneiss that is typically highly strained, and strongly foliated. It contains 1- to 3-cm-thick compositional banding. Within the migmatitic layers, leucosome can constitute up to 25 percent of the unit. This unit also contains folded and boudinaged amphibolite dykes that are typically 5 to 20 cm wide.

VOLCANO-SEDIMENTARY ROCKS

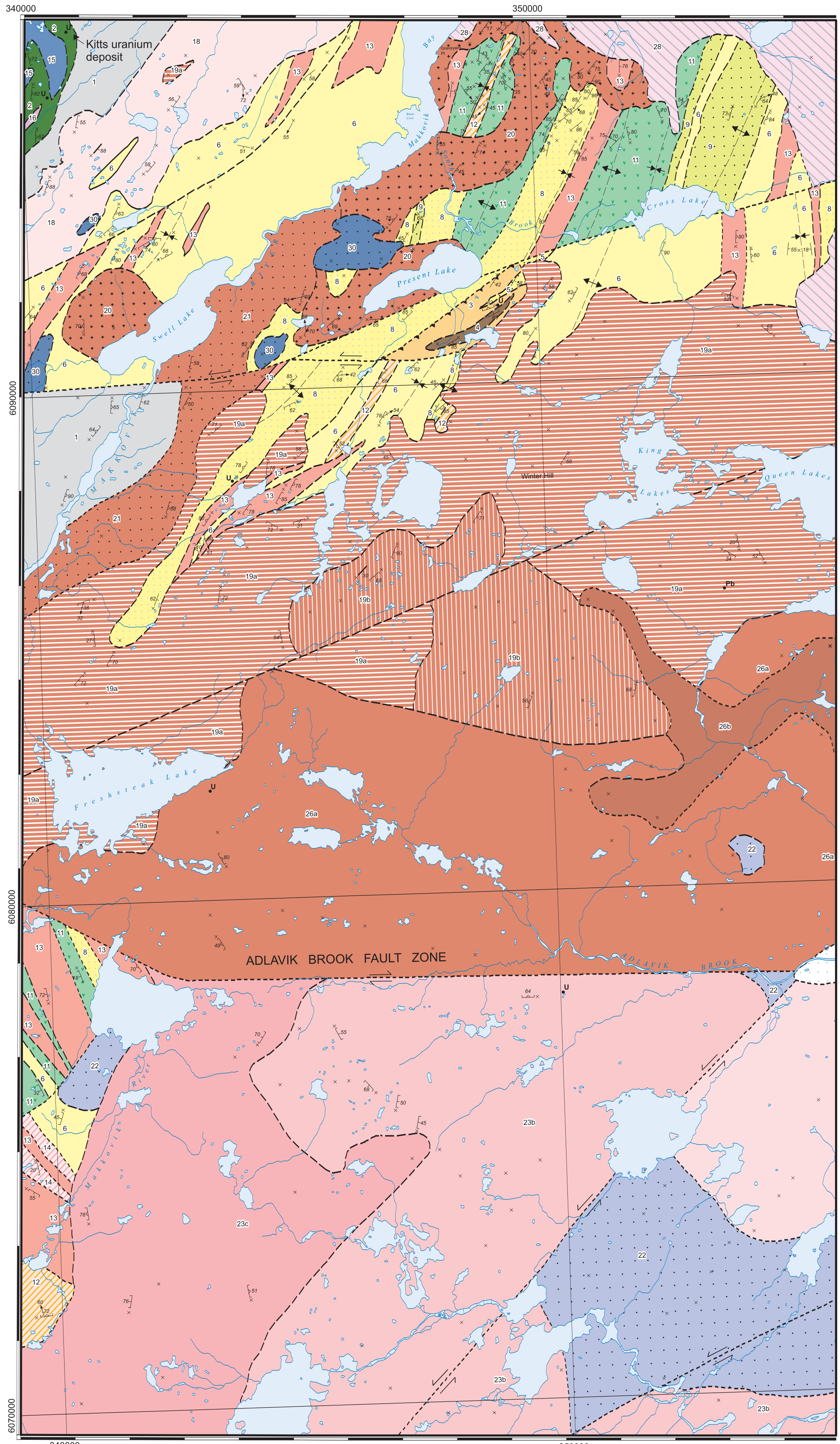
Post Hill Group (Unit 2)

The Post Hill Group is restricted in geographic exposure and outcrops only in the far northeast of the map area (Figure 4). The nature of the contact between the Post Hill Group of the Kaipokok domain and the Aillik Group of the Aillik domain is obscured in the map area by the Long Island Quartz Monzonite intrusion. Only one mappable unit of the Post Hill Group is documented and it comprises a deformed metabasalt (Unit 2) that represents part of the Kitts Pillow Lava formation (Marten, 1977).

The metabasalt has been foliated, flattened and recrystallized (Plate 1). The intensity of this deformation is variable throughout, with some exposures preserving relatively pristine pillow metabasalt. The unit is a fine-grained metabasalt that is metamorphosed to amphibolite facies and locally retrogressed to chlorite facies. Occasional relict chilled margins are preserved on the pillows, as is interstitial quartzite, which is interpreted to be recrystallized chert. Horizons of psammite and minor pelite and argillite occur within this unit as discontinuous 0.5- to 2-m-wide beds. In the map area, this unit is cut by a fine- to medium-grained gabbro referred to as the Kitts metagabbro (Unit 15). Millimetre-scale quartz veins, are also preserved, crosscutting the metabasalt unit. Rust-weathering, uranium- and sulphide-rich horizons occur throughout the unit; including the Kitts uranium deposit, in the northeast of the map area.

Post Hill Group Correlatives (?) (Units 3, 4 and 5)

Previously assigned to the Aillik Group (Gower *et al.*, 1982), a thin package of rocks outcropping to the east of Present Lake (referred to as the Present Lake sequence) appears, at least superficially (on the basis of similar lithology, style of deformation, and grade of metamorphism), to


340000
350000
Kitts uranium
deposit
Swell Lake
Present Lake
Cross Lake
Winter Hill
King Lakes
Queen Lakes
Freshsteak Lake
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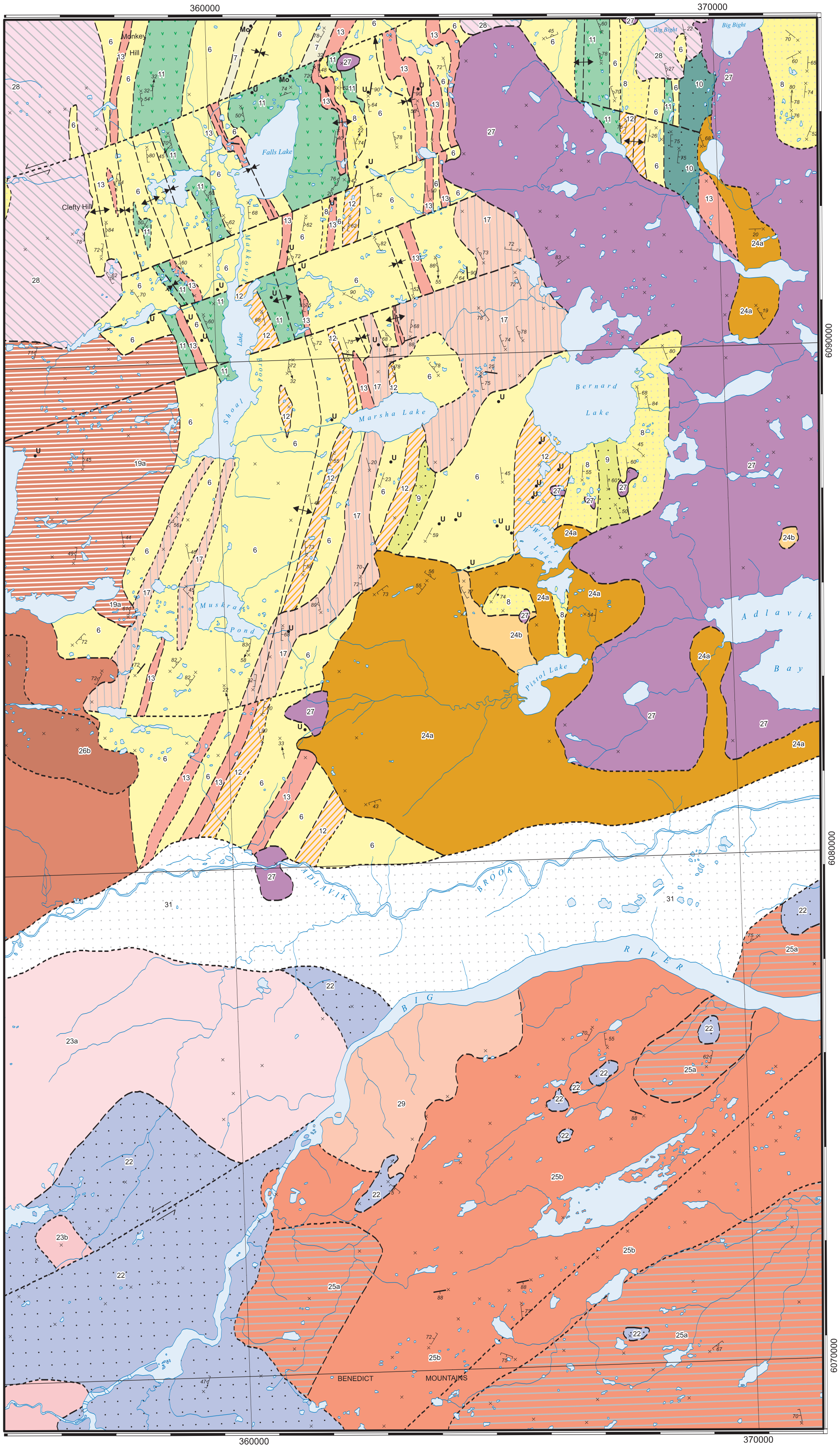

Figure 4. *A preliminary geological map of the Monkey Hill area (NTS 13J/14).*

PLEISTOCENE - RECENT

31 Fluvioglacial and glacial gravels and sand

PALEOPROTEROZOIC

INTRUSIVE ROCKS

Unclassified units - no stratigraphic order implied

30 Medium- to coarse-grained, biotite-bearing gabbro, non-foliated, massive

29 Medium- to coarse-grained, biotite-hornblende granodiorite, massive, undeformed, locally plagioclase porphyritic (possible equivalent of Numok Suite or fine-grained Big River granite)

Non-foliated intrusions ca. 1650 - 1640 Ma

Monkey Hill Intrusive Suite (ca. 1640 Ma)

28 Fine- to medium-grained, biotite monzogranite to syenogranite with minor quartz monzonite, leucocratic, locally plagioclase porphyritic

Adlavik Intrusive Suite (ca. 1650 Ma)

27 Medium-grained (locally coarse-grained) gabbro, includes leucogabbro and minor melanogabbro, biotite-bearing, locally plagioclase porphyritic

Non-foliated to weakly foliated intrusions ca. 1802 - 1795 Ma

Freshsteak granitoid

26b Fine- to medium-grained, biotite-hornblende granodiorite, massive, leucocratic, equigranular, rarely plagioclase porphyritic

26a Fine- to medium-grained, biotite-hornblende quartz monzonite to monzodiorite, massive, leucocratic, locally plagioclase porphyritic

Big River Granite (ca. 1802 Ma)

25b Coarse-grained, magnetite- and flourite-bearing, biotite monzogranite, K-feldspar phenocrysts preserve occasional pseudo-rapakivi texture, locally slightly foliated

25a Coarse- to very coarse-grained, magnetite-bearing, hornblende-biotite monzogranite to syenogranite, locally varying to quartz syenite, K-feldspar phenocrysts preserve occasional pseudo-rapakivi texture, locally slightly foliated

Lanceground Intrusive Suite

24b Fine- to medium-grained, massive, biotite granodiorite to locally monzogranite, undeformed

24a Pistol lake granite: pink to buff, medium- to coarse-grained, hornblende syenogranite to quartz syenite

Numok Intrusive Suite (ca. 1801 Ma)

23c Pink-brown, medium- to coarse-grained, hornblende-biotite (± clinopyroxene) syenogranite to syenite, weakly to moderately foliated, locally potassium feldspar porphyritic

23b Medium- to coarse-grained, massive, biotite-hornblende quartz monzonite to monzonite, locally porphyritic (K-feldspar), weakly foliated in areas, locally crumbly in appearance (due to presence of clinopyroxene and possible relict fayalite?)

23a Coarse-grained, magnetite-biotite quartz monzonite to monzonite, non-foliated

Unnamed intrusion

22 Fine- to medium-grained, biotite-bearing gabbro to locally leucogabbro, massive, occurs as xenoliths in Big River Granite and Numok Intrusive Suite

Moderately to strongly foliated intrusion ca. 1802 - 1800 Ma

Kennedy Mountain Intrusive Suite (Units 19-21 ca. 1800 Ma)

21 Fine- to medium-grained, monzodiorite to granodiorite, foliated, locally plagioclase porphyritic, occurs in the Swell Lake area

20 Medium- to coarse-grained, biotite monzogranite with minor syenogranite, locally foliated, often fluorite-bearing: possible northern extension of the Cross Lake granite?

19b Cross Lake granite: medium- to coarse-grained, biotite-bearing, hornblende monzogranite to granodiorite, foliated

19a Cross Lake granite: medium- to coarse-grained, leucocratic, often fluorite-bearing, biotite monzogranite and minor syenogranite, locally foliated

Long Island Quartz Monzonite (ca. 1802 Ma)

18 Granodiorite, monzodiorite to quartz monzonite, plagioclase-porphyritic, leucocratic to melanocratic, moderately foliated

Syn- volcanic intrusions ca. 1850 - 1860 Ma

17 Foliated quartz feldspar porphyritic granite(s), recrystallized, fine-grained; locally appears highly altered

Pre- 1860 Ma intrusions

16 Quartz-feldspar-porphyritic granite, biotite-bearing, leucocratic, locally sheared

15 Kitts Metagabbro: Fine- to medium-grained metagabbro; amphiboles are tremolite to actinolite, locally coarse-grained

VOLCANIC AND SEDIMENTARY ROCKS

Aillik Group ca. 1880 - 1860 Ma (this group was previously termed the Upper Aillik Group, see Marten, 1977, and subsquently renamed Aillik Group by Ketchum *et al*, 2002)

14 Strongly altered, feldspar porphyry interpreted to represent altered rhyolite, pink-grey, foliated

13 Fine-grained, porphyritic to aphanitic rhyolite, locally flow-banded, includes minor felsic tuff, recrystallized

12 Banded felsic tuff, includes minor lapilli tuff, tuffaceous sandstone, and rhyolite, foliated, recrystallized

11 Fine-grained basalt, typically amphibolite grade, contains locally preserved calcite-epidote nodules, relict pillows, cut by quartz veins

10 Fine-grained, mafic tuff (hornblende schist) with minor basalt flows, foliated, metamorphosed

9 Polymictic, matrix-supported conglomerate, silica matrix, contains poorly sorted, subrounded clasts of dominantly pink to grey sandstone, tuffaceous sandstone and felsic tuff with minor foliated to non-foliated granite, quartzite, rhyolite, marble, basalt, mafic tuff and possible jasperoid

8 Thinly bedded to laminated arenaceous sandstone, interbedded with lesser siltstone, minor marble, commonly preserves primary structures; includes minor marble and tuffaceous sandstone

7 Polymictic conglomerate to tuffaceous conglomerate, interbedded (2 to 10 m scale) with tuffaceous sandstone; clasts are poorly sorted, subrounded and are dominantly tuffaceous sandstone and minor metasandstone, non-foliated granite, amphibolite, rhyolite, quartzite, marble and mafic tuff

6 Non- to weakly-bedded, tuffaceous to volcaniclastic sandstone; includes minor rhyolite flows, banded felsic tuff, and volcaniclastic breccia; pervasively altered

Figure 4. *Legend for map on pages 164 and 165.*

Figure 4. *Legend for map on pages 164 and 165.*

be more akin to the Post Hill Group. The Present Lake sequence may be part of the Post Hill Group, and was tectonically interleaved with the Aillik Group during thrusting associated with the Makkovikian orogeny.

This sequence comprises three units. The most abundantly preserved unit is an interbedded semipelite–quartzite unit (Unit 3), which is thin bedded (3 to 10 cm thick). The semipelite–quartzite unit contains rusty sulphide-rich horizons that are characterized by disseminated pyrite, uranium-bearing minerals and molybdenite. A uranium showing documented in this unit registered a scintillometer reading of ca. 6500 cps, in the vicinity of the MODS showing labelled Present Lake (National Mineral Inventory Number: 013J/14/U 004). Deformation is preserved in tight Z-folds that are most apparent in the quartzite horizons. The second unit is a banded iron formation (BIF; Unit 4), which comprises thin-banded (2- to 15-mm-thick), silica- and oxide-facies layers. The unit is composed of magnetite–hematite layers interbedded with quartzite and minor semipelitic (mudstone) layers. This unit also preserves small-scale isoclinal folds (Plate 2). Unit 5 is only exposed over an approximate 200-m-wide interval and consists of massive to weakly bedded orthoquartzite. The orthoquartzite is dominantly composed of quartz but is also sulphide-rich, with disseminated pyrite and molybdenite occurring throughout. Minor discontinuous diopside-rich layers and rusty horizons also occur throughout this unit. This unit contains layers of boudinaged amphibolite dykes and is interlayered with the pelite-quartzite of Unit 3.

No correlative units of BIF have been documented within the Aillik Group, making the tentative correlation with the Post Hill Group more plausible. In addition, this package of rocks is markedly similar to the BIF documented near the Kitts deposit, where Marten (1977) reported iron formation containing bands of magnetite and quartzite, associated with minor metasedimentary and metavolcanic layers. These banded chert units are documented as forming the western boundary of the Kitts Pillow Lava formation, are associated with uranium mineralization and are strongly deformed compared to the adjacent pillow lavas (Marten, 1977). The chert units appear to have localized strain and, in

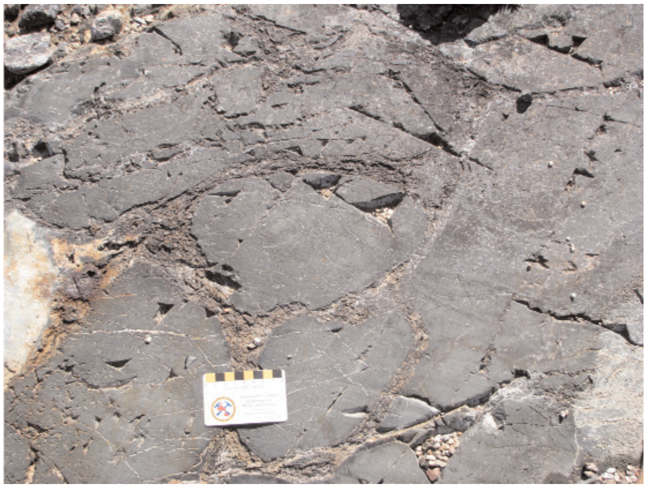

Plate 1. *Representative photograph of the Post Hill Group in the Monkey Hill map area. The metabasalt (Unit 2) represents part of the Kitts Pillow Lava formation, and the image illustrates deformed, foliated and recrystallized pillow lava.*

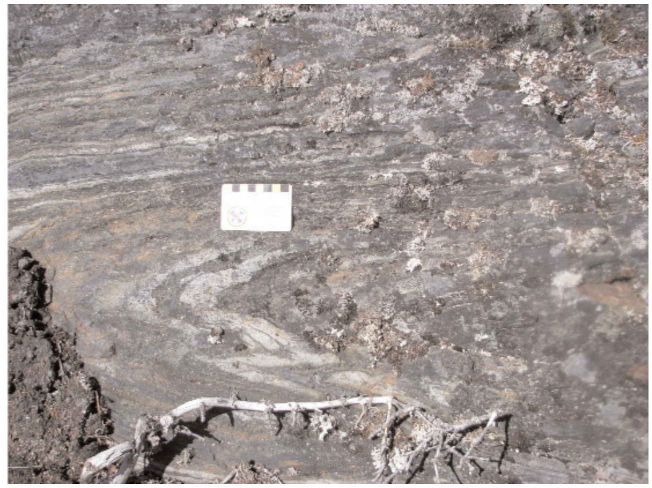

Plate 2. *Representative photograph of banded iron formation from the Present Lake area, interpreted to be correlative with part the Post Hill Group. The image shows tight- to isoclinal-folded banded iron formation with 2- to 15-mm-wide bands of magnetite-hematite interlayered with quartzite (Unit 4).*

the Present Lake area, this package of rocks may present a thrust sheet of the Post Hill Group interleaved within the Aillik Group.

Aillik Group

The Aillik Group comprises upper greenschist- to lower amphibolite-facies volcano-sedimentary units that include felsic tuff, flow-banded to non-banded rhyolite, volcaniclastic breccia and conglomerate, tuffaceous sandstone, thin-bedded to laminated meta-sandstone–siltstone, and lesser amounts of metabasalt containing locally preserved pillow selvages and mafic tuff (Figure 4). The Aillik Group is mainly exposed in the northern part of the map area, with only a thin sliver being exposed in the southwest. Deformation is marked by regional tight to isoclinal folds that refold an earlier generation of folds, and are bisected by later faulting that disturbs the continuity of the units. In the map area, the Aillik Group is intruded by abundant, variably deformed to undeformed granitoid suites.

Tuffaceous Sandstone (Unit 6)

Tuffite (Unit 6), dominantly tuffaceous sandstone, occurs predominantly in the Falls Lake to Muskrat Pond area, and also north of Shoal Lake. Unit 6 dominantly comprises a non- to weakly bedded sequence of tuffaceous to volcaniclastic sandstone and includes minor metre-scale rhyolite flows, felsic tuff horizons and volcaniclastic breccia. The tuffaceous sandstone is fine grained, buff to pink-grey, moderately to strongly foliated, recrystallized, and sugary textured. The foliation is defined by the alignment of mafic minerals, dominantly biotite. The unit is often silicified and this alteration is associated with rusty horizons, rich in sulphides and oxides, dominantly pyrite, molybdenite and magnetite. Where bedding is preserved, it is generally thin (2 to 10 cm thick), with local interbedded minor arenaceous sandstone and/or conglomerate. Deformation is preserved as tight folds within the unit, and the style of folding is most obvious when younger crosscutting mafic dykes are in-folded with the unit (Plate 3A).

Conglomerate (Units 7 and 9)

In the map area, the conglomeratic rocks are divided into two units (Units 7 and 9). Unit 7 is a conglomerate to tuffaceous conglomerate, interbedded with 2- to 10-m-thick beds of tuffaceous sandstone. This unit is limited in exposure, only occurring in the map area north of Falls Lake. The unit is polymictic and has clasts that are poorly sorted, subrounded, flattened and range from 1 to 15 cm in diameter. The clasts are dominantly tuffaceous sandstone and minor meta-sandstone, non-foliated granite, amphibolite, rhyolite, quartzite, marble and mafic tuff. The conglomerate is matrix-dominated, and a matrix composition rich in silica. The foliation is well developed and is defined by the alignment of clasts and alignment of biotite in the matrix.

Unit 9 is exposed north of Cross Lake in the north-central part of the map area. This unit is a light- to medium-grey, foliated, matrix-supported, polymictic conglomerate (Plate 3B). The clasts are poorly sorted, subrounded to rounded, and typically range from 2 to 20 cm in length. Clasts are dominantly pink to grey sandstone, tuffaceous sandstone and felsic tuff with minor foliated to non-foliated

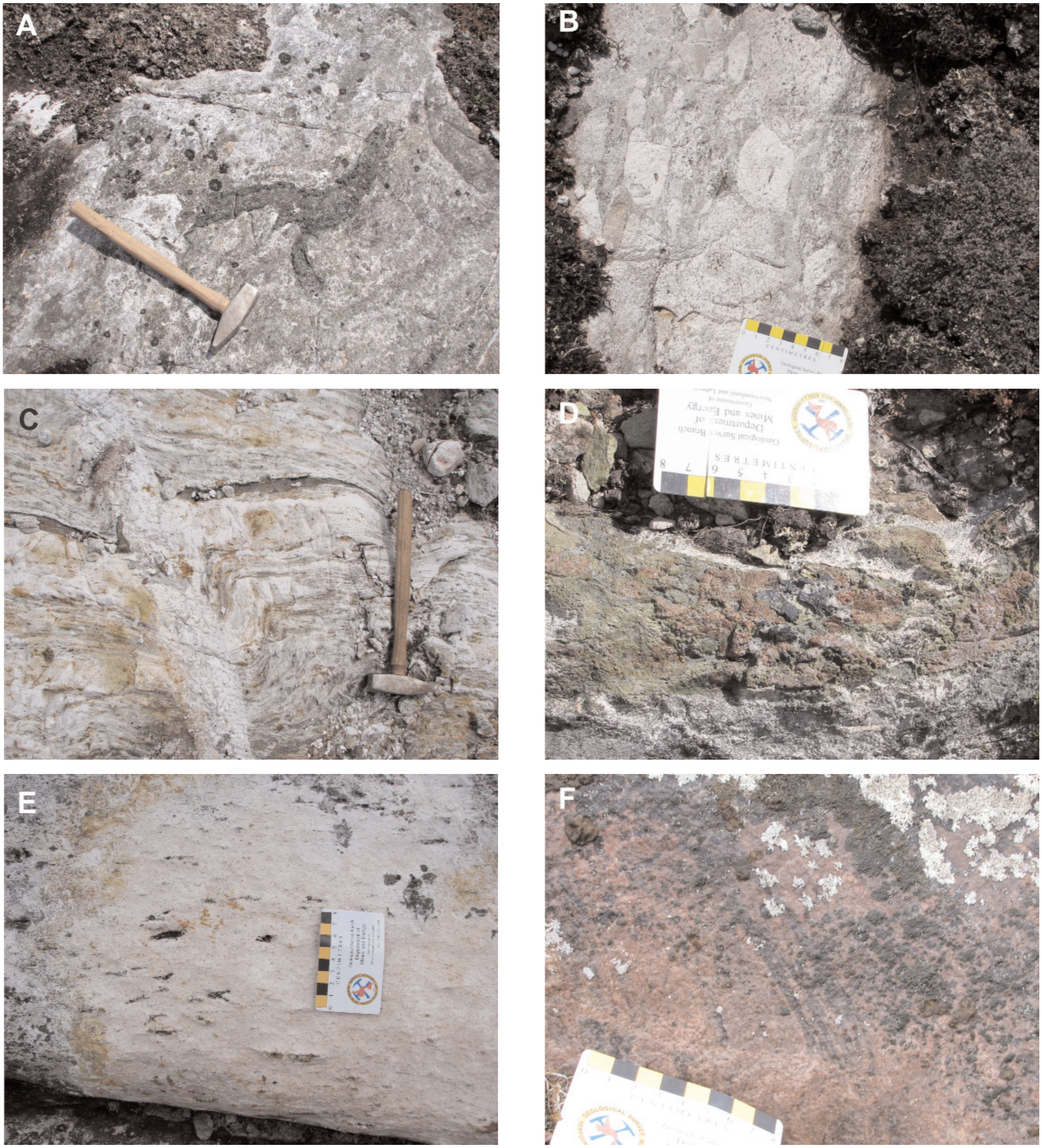

Plate 3. *Representative photographs of some rock types in the Aillik Group. A) Non- to weakly bedded tuffaceous to volcaniclastic sandstone (Unit 6) intruded by an amphibolite dyke that was subsequently tightly folded and boudinaged. B) Polymictic conglomerate containing subrounded clasts of foliated granite, sandstone, felsic and mafic tuff (Unit 9). C) S-folds in foliated, thin-bedded metamorphosed sandstone and siltstone (Unit 8) cut by a pegmatite granite dyke. D) Mineralized (molybdenite) epidote-titanite nodule hosted in basalt (Unit 11). E) Recrystallized, silicified felsic tuff containing cm-scale mafic pods (Unit 12). F) Pink-grey, aphanitic, flow-banded rhyolite (Unit 13).*

granite, quartzite, rhyolite, marble, basalt, mafic tuff and possible jasperoid. The matrix varies from fine- to coarse-grained sandstone. In addition, millimetre-scale alteration reaction rims occasionally surround the clasts. Locally, this unit grades into a volcaniclastic conglomerate. Unit 9 is moderately to highly strained, containing attenuated clasts and matrix minerals defining the foliation and lineation.

Sandstone–Siltstone (Unit 8)

Unit 8 comprises thin-bedded to laminated, grey, green and pink, metamorphosed, arenaceous sandstone interbedded with lesser siltstone. The unit is most commonly preserved southeast of Makkovik Bay and, to a lesser extent, to the east of Big Bight (Figure 4). The sandstone is fine to medium grained and is typically thin bedded (2 to 10 cm thick). The composition is dominantly feldspathic arenite and lesser lithic arenite and quartz arenite. The interbedded siltstones are dark brown to dark grey, fine to medium grained, and composed of biotite, muscovite, quartz and feldspar. Unit 8 commonly preserves primary crossbedding and ripple marks and locally preserves load casts, mudcracks and graded bedding. The unit is recrystallized and the foliation is often bedding parallel and generally defined by the alignment of biotite and muscovite. Epidote alteration is commonly preserved in this unit. Deformation and cm-scale, tight to isoclinal folds are observed in this unit south of Present Lake (Plate 3C).

Mafic Volcanic Rocks (Units 10 and 11)

Metamorphosed mafic volcanic rocks occur as thin belts and two units are distinguished: 1) a less abundant, moderately deformed, fine-grained mafic tuff (hornblende schist; Unit 10), and 2) a more abundant, fine- to medium-grained, moderately to strongly deformed basalt (amphibolite) that contains minor mafic tuff (Unit 11). The basalt unit occurs throughout the map area; whereas, the mafic tuff unit is restricted in distribution to the area southwest of Big Bight.

Unit 10 is a fine-grained, green-grey mafic tuff (hornblende schist) and minor metabasalt. The mafic tuff locally contains 1- to 4-mm-long aligned biotite and/or hornblende that define the foliation. Chlorite porphyroblasts that are 1 to 2 mm wide occur throughout the unit. Thin, 5-m-wide, metabasaltic flows occur within this unit. The mafic tuff locally displays epidote alteration and is cut by 2- to 5-cm-thick quartz veins.

Basalt (Unit 11) is fine to medium grained, foliated, moderately to highly strained, typically of amphibolite grade (locally retrogressed to chlorite grade) and contains a well-developed tectonic fabric defined by the alignment of amphibole and biotite. Locally, this unit displays epidote alteration, a schistosity, relict vesicular texture and minor mm-scale quartz–chlorite–epidote veining. Relict pillow textures are preserved in this unit, and in areas of low strain they are only weakly deformed, with the long axes varying in length from 15 to 50 cm. Interstitial quartzite locally occurs in this unit and represents recrystallized chert. In well-exposed areas, thick homogenous layers of basalt are typically up to 20 m wide, although they can, locally, be wider, and likely reflect primary basaltic flows as indicated by basal chilled margins. Some horizons contain flattened nodules, 2 to 10 cm in length, containing aggregates of calcite, feldspar and epidote. Disseminated pyrite occurs throughout this unit and sulphide-mineralized nodules, containing molybdenite, covelite, and pyrite, are found to the west of Cross Lake (Plate 3D).

Felsic Tuff (Unit 12)

Unit 12 comprises predominantly metamorphosed, foliated felsic tuff and minor lapilli tuff, tuffaceous sandstone and rhyolite. This unit is pink-grey to white, foliated, compositionally banded, locally displays graded bedding and has a fine-grained matrix (Plate 3E). The felsic tuff is typically well bedded and includes both crystal and lithic varieties. This unit often contains clasts of darker coloured, cognate material that typically range from 1 mm to 4 cm in length and are attenuated, defining a lineation. The crystal tuffs have a fine- to coarse-grained matrix, and rare phenoclasts of quartz and feldspars are preserved. Disseminated biotite, pyrite, rutile and magnetite are found throughout the unit. Pervasive potassic alteration has commonly obliterated the primary textures.

Rhyolite (Units 13 and 14)

Unit 13 is a porphyritic to equigranular rhyolite that occurs throughout and also includes minor 5- to 20-m-wide felsic tuff layers (Figure 4). The rhyolite is pink to medium grey, recrystallized, and has a grain size that ranges from fine grained to aphanitic and is locally porphyritic (Plate 3F). The rhyolite commonly occurs as flows that are 5 to 30 m thick. Locally, flow banding is preserved and is accentuated by variable resistance to weathering. The bands are discontinuous, ranging from 1 to 2 mm in thickness, are 5 to 15 cm long, and are darker in colour reflecting a concentration of magnetite and biotite. Porphyritic rhyolite commonly occurs as horizons within non-porphyritic rhyolite. The phenocrysts are feldspar and/or quartz, typically forming 5 to 15 percent of the rock, and range in length from 1 to 5 mm. This unit is commonly cut by cm-wide mineralized quartz veins.

Unit 14 comprises strongly altered feldspar porphyry that is interpreted to be a rhyolite. The unit is a pink-grey, foliated, potassic-altered rock. It occurs in 20- to 100-m-wide exposures. It contains quartz and feldspar phenocrysts that are 0.5 to 4 mm long and subrounded. This unit is restricted in distribution and occurs only in the area south and southwest of Freshsteak Lake.

INTRUSIVE ROCKS

Pre-1860 Ma Intrusions

Kitts Metagabbro (Unit 15)

The Kitts metagabbro (Unit 15) outcrops as linear, sill-like bodies in the far northwest corner (Figure 4) and comprises a weakly to moderately deformed, equigranular, fine- to medium-grained metagabbro containing local coarser grained zones. The metagabbro is composed of tremolite-actinolite and feldspar and retains a relict igneous texture (Plate 4). In the map area, this unit has intruded the Kitts Pillow Lava formation and is cut by mm-scale quartz veins.

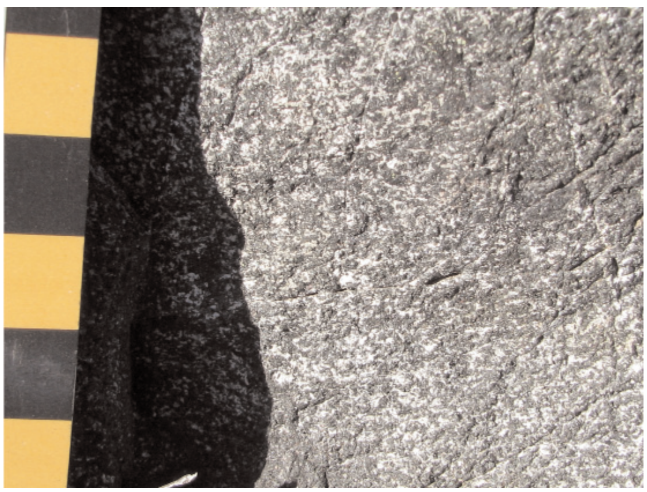

Plate 4. *Representative photograph of the pre-1860 Ma Kitts metagabbro (Unit 15), which is composed of recrystallized amphiboles (tremolite to actinolite) but retains a relict igneous texture.*

Quartz–feldspar-porphyritic Biotite Granite (Unit 16)

Unit 16 intrudes the mafic pillow lava of the Kitts Pillow Lava formation, as a 50- to 100-m-wide linear intrusion that occurs in the far northwest corner (Figure 4). This unit is a fine-grained, leucocratic, quartz–feldspar–porphyritic, biotite granite. The feldspar and quartz phenocrysts are 1 to 4 mm wide and are euhedral to subhedral in shape. The granite is foliated, and recrystallized. Although this unit has intruded the Kitts Pillow Lava formation, the margins of the intrusion are sheared and intrusive contacts are rarely observed. This unit is interpreted to be an equivalent of the quartz porphyry of Marten (1977) that was mapped farther to the west as having intruded both the Kitts metagabbro and the Kitts Pillow Lava formation. This unit may also be synchronous with a quartz–porphyritic granite sill from drillcore that has a preliminary U–Pb date of *ca.* 1880 Ma (G. Sparkes, personal communication, 2009).

Syn-volcanic Intrusions ca. 1860-1850 Ma

Porphyritic Granite (Unit 17)

Unit 17 consists of foliated, porphyritic granite(s) and occurs primarily in the northwest (Figure 4). It comprises pink- to medium-grey, fine- to medium-grained, variably foliated, locally lineated, recrystallized porphyritic granite(s) (Plate 5). The quartz and feldspar phenocrysts are euhedral to subhedral and typically 1 to 10 mm in length. Locally, this unit contains ellipsoidal mafic-oxide pods of biotite, magnetite and amphibole that are typically 2 to 8 cm long, 1 to 4 cm thick, and account for less than 2 percent modal abundance of the rock. Accessory phases of magnetite and biotite occur throughout the unit. Locally, the porphyritic granite is altered, preserving altered feldspar and rusty, discontinuous sulphide horizons that are rich in pyrite. The foliation is weakly to moderately developed in the porphyritic granite(s), is parallel to the regional foliation, and is defined by the alignment of biotite, feldspar phenocrysts and the mafic pods.

The porphyritic granite is preserved in regional-scale synclines and anticlines, and is infolded with the Aillik Group, suggesting that it originally occurred as sheets or sill-like bodies within the volcanic sequences. The contacts of the unit with the Aillik Group are often foliation parallel, highly deformed and sheared, and intrusive contacts are only rarely observed. Rare xenoliths of highly strained volcanic rocks, interpreted to be Aillik Group equivalents, are found near the margins of the granite.

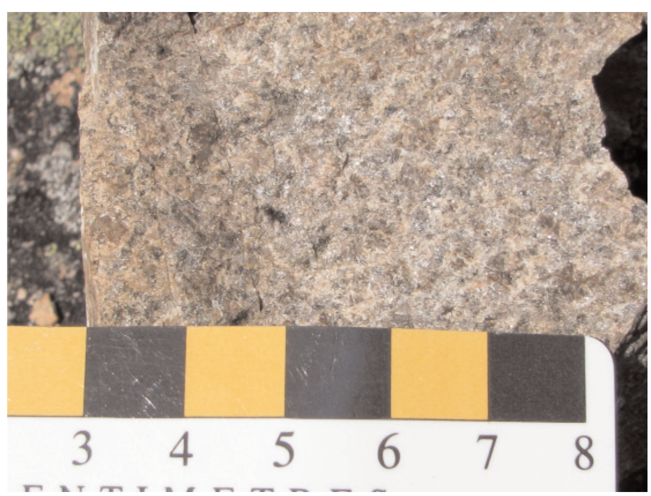

Plate 5. *Representative photograph of the* ca. *1858 Ma recrystallized foliated, quartz–feldspar-porphyritic granite (Unit 17).*

Based on these field relationships, this unit is inferred to have been emplaced as a high-level granite intrusion(s). This unit includes the foliated porphyritic granite dated (U–Pb date of 1858 ± 6 Ma) in the Makkovik map area to the north by Hinchey and Rayner (2008). This unit is interpreted to be correlative with the Measles Point Granite of Sinclair *et al.* (2002). Sinclair *et al.* (2002) noted that, the similar major- and trace-element chemistry and similar structural history of the Measles Point Granite and the felsic volcanic rocks of the Aillik Group, coupled with the granite's fine-grain size and emplacement as sill-like bodies, are consistent with the interpretation of the(se) granite(s) originating as a hypabyssal intrusion(s). However, Sinclair *et al.* (2002) also noted that these observations are in conflict with the U–Pb zircon age of 1929 +10/-9 Ma for the Measles Point Granite. The approximately 50 m.y. age difference between the Sinclair *et al.* (2002) dated porphyritic granite and the younger, *ca.* 1883 to 1856 Ma rhyolites of the Aillik Group, does not support a co-magmatic relationship. To resolve the interpretation of the age date from the foliated porphyritic granite, a sample from the location where Sinclair *et al.* (2002) dated the Measles Point Granite is being processed for U–Pb zircon analysis.

Strongly to Moderately Foliated Intrusions ca. 1802–1800 Ma

In the map area, *ca.* 1800 Ma, strongly to moderately foliated intrusions consist primarily of the Long Island Quartz Monzonite (Unit 18) and the Kennedy Mountain Intrusive Suite, which comprises several distinct intrusive bodies and phases (Units 19a-b, 20 and 21). Each of these units is described in detail below.

Long Island Quartz Monzonite (Unit 18)

The Long Island Quartz Monzonite (Unit 18) occurs only in the far northwest corner of the map area. The definition of the unit remains largely unchanged from that of Gower *et al.* (1982) and Kerr (1994). The Long Island Quartz Monzonite is weakly to moderately foliated, locally plagioclase-porphyritic, leucocratic to melanocratic, and varies in composition from granodiorite, through monzodiorite to quartz monzonite. Unit 18 is medium grained, and contains plagioclase phenocrysts that are typically 1 to 5 mm in length (Plate 6A). Accessory phases of biotite, hornblende and magnetite occur throughout the unit. Flattened mafic enclaves occur locally within the unit and are typically 2 to 15 cm wide and 3 to 20 cm long, and can vary in abundance from 1 to 10 percent of the exposure. The variably developed foliation is defined by the alignment of mafic minerals and, when present, the mafic enclaves. A U–Pb zircon age of 1802 +13/-7 Ma was determined for the Long Island Quartz Monzonite (Kerr *et al.*, 1992), to the north of the map area.

Kennedy Mountain Intrusive Suite (Units 19a-b, 20 and 21)

The Kennedy Mountain Intrusive Suite occurs as stocks and sheets throughout the northwestern quadrant of the map area. Here, there are four main divisions of this intrusive suite, *viz.*, Units 19 a-b, 20 and 21. Units 19a and 19b consist of two mappable phases of the Cross Lake granite. Unit 20 comprises several smaller yet unnamed granite plutons that have been intruded to the northwest of Cross Lake. A less extensive, yet unnamed pluton comprises Unit 21, and has been tentatively correlated with the Kennedy Mountain Intrusive Suite. A U–Pb zircon age of 1801 ± 2 Ma was reported by Barr *et al.* (2007) for the granite intrusion at Kennedy Mountain, the type location for this suite, which occurs to the north of the map area.

The Cross Lake granite is dominantly a medium- to coarse-grained, locally foliated, leucocratic, often fluorite-bearing, biotite monzogranite including minor syenogranite (Unit 19a; Plate 6B). Unit 19a is locally feldspar porphyritic containing euhedral phenocrysts that are typically 0.5 to 1 cm long. Accessory biotite (~3-5%) occurs throughout the pluton and defines the variably developed foliation. A minor, yet mappable phase of medium-grained, weakly foliated, leucocratic, hornblende monzogranite to granodiorite (Unit 19b) is also included within the Cross Lake granite. Locally, within Unit 19b, plagioclase phenocrysts are 5 to 8 mm wide. Unit 19b contains accessory phases of hornblende (3%), biotite (1 to 2%), and magnetite (0.5 to 1%), and these mafic minerals define the variably developed foliation. This intrusion commonly displays a pervasive potassic alteration. Pegmatite dykes have intruded all phases of the Cross Lake granite.

Unit 20 predominantly occurs to the south of Makkovik Bay and a smaller intrusion occurs to the northwest of Swell Lake. It is petrographically very similar to the Cross Lake granite and may represent a northern extension of the pluton. The unit is a coarse- to medium-grained, locally foliated, homogeneous, equigranular, biotite monzogranite to syenogranite (Plate 6C); it is mostly fluorite bearing and potassic altered and contains epidote veins, especially in close proximity to late faults. Late pegmatite dykes and minor quartz veins have intruded this unit.

Unit 21 occurs southeast of Swell Lake and consists of fine- to medium-grained, foliated, monzodiorite to granodiorite (Plate 6D). This unit locally contains feldspar phenocrysts that are 0.5 to 1 cm long. Accessory phases are hornblende, biotite and magnetite. The foliation is moderately developed, being defined by the alignment of mafic minerals and feldspar phenocrysts. Rare, cm-scale, mafic pods of finer grained material occur near the margins of the pluton. Pegmatite dykes intrude throughout the pluton.

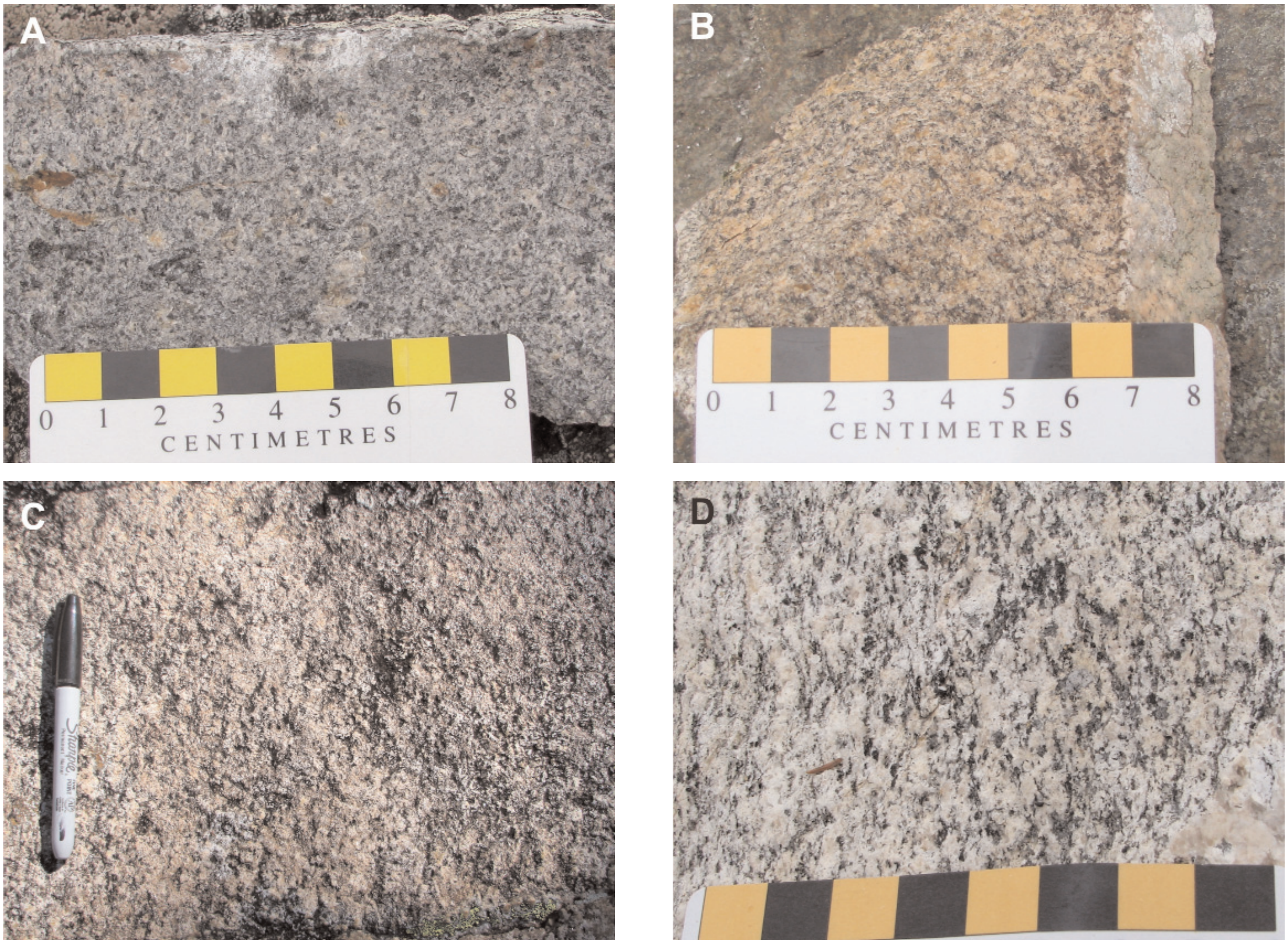

Plate 6. *Representative photographs of the ca. 1800 Ma strongly to moderately foliated intrusive suites in the Monkey Hill map area. A) Biotite quartz monzonite of the Long Island Quartz Monzonite containing plagioclase phenocrysts that is typically 1 to 5 mm in length (Unit 18). B) Foliated magnetite-biotite syenogranite from the Cross Lake granite (Unit 19a), Kennedy Mountain Intrusive Suite. C) Medium-grained, locally foliated, biotite monzogranite to syenogranite from the Kennedy Mountain Intrusive Suite (Unit 20). D) Foliated, medium-grained, biotite granodiorite from the Kennedy Mountain Intrusive Suite (Unit 21).*

Non-foliated to Weakly Foliated Intrusions ca. 1802–1795 Ma

There are several different plutonic suites and individual intrusions that are classified in this subsection of intrusive units. These include a yet-unnamed gabbro (Unit 22), the Numok Intrusive Suite (Units 23a-c), the Pistol Lake granite (Units 24a-b), which is part of the Lanceground Intrusive Suite, and the Big River granite (Units 25a-b). Each of these units is described in detail below.

Gabbro (Unit 22)

Unit 22 occurs in the south-central part of the map area. It is a fine- to medium-grained, massive, locally biotite-bearing gabbro that locally varies to leucogabbro. The gabbro is mostly equigranular, although distinct zones are porphyritic containing plagioclase phenocrysts that are 2 to 8 mm long. The unit is cut by late shear zones, faults with epidote alteration and late pegmatite dykes. Xenoliths of gabbro, interpreted to be equivalents of this unit, occur within the Big River granite (Unit 25) and Numok Intrusive Suite (Unit 23; Plate 7A).

The Numok Intrusive Suite (Units 23a-c)

The Numok Intrusive Suite occurs in the southwest quadrant of the map area, south of the Adlavik Brook fault zone. There are three mapped phases of this suite in the area, *viz.*, biotite–magnetite quartz monzonite and monzonite (Unit 23a), biotite–hornblende quartz monzonite and monzonite (Unit 23b) and biotite–hornblende syenogranite and

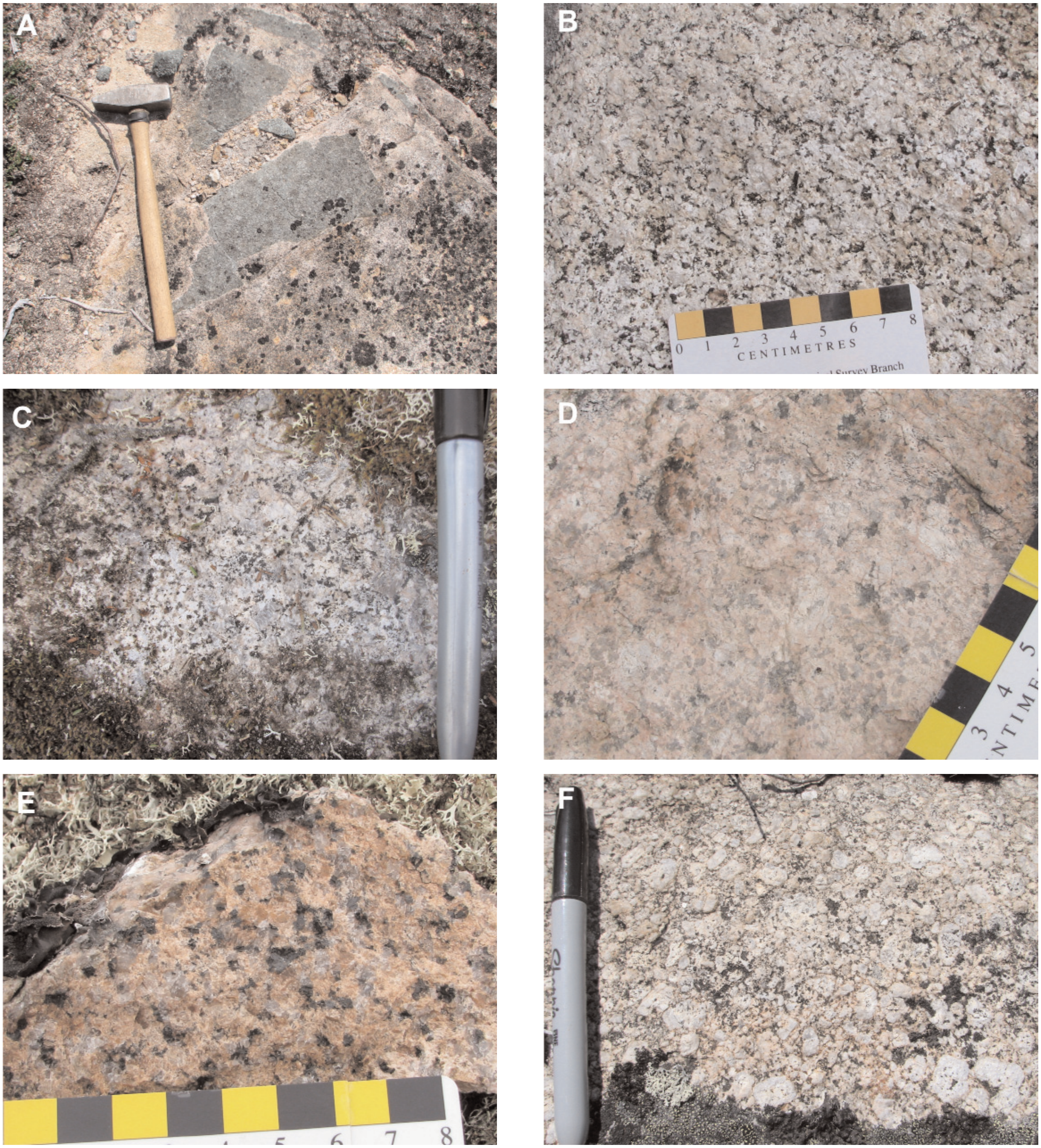

Plate 7. *Representative photographs of the ca. 1802-1975 Ma undeformed to weakly foliated intrusive suites in the Monkey Hill map area. A) Xenoliths of gabbro (Unit 22) within the biotite-hornblende monzogranite of the Big River granite (Unit 25b). B) Coarse-grained, massive, magnetite-biotite quartz monzonite to monzonite of the Numok Intrusive Suite (Unit 23a). C) Medium- to coarse-grained, massive, biotite-hornblende quartz monzonite to monzonite of the Numok Intrusive Suite (Unit 23b) containing euhedral feldspar phenocrysts. D) Medium- to coarse-grained, biotite-hornblende syenogranite of the Numok Intrusive Suite (Unit 23c). E) Coarse-grained, hornblende syenogranite of the Pistol Lake granite (Unit 24a). F) Coarse-grained, hornblende-biotite monzogranite of the Big River granite containing phenocrysts of plagioclase mantled by K-feldspar preserving a pseudo-rapakivi texture.*

syenite (Unit 23c; Figure 4). Each phase is described below. The Numok Intrusive Suite, in the map area, has been correlated to a lithologically similar intrusion northeast of the current study area, in the Adlavik Islands, and these two intrusive bodies have been interpreted as disrupted halves of an originally continuous pluton that was offset by the Adlavik Brook fault zone (Kerr, 1994). Although no geochronological data exits for the southwestern zone of the Numok Intrusive Suite (in this study map area), the northeastern Numok Intrusive Suite gave a U–Pb age of 1801 ± 2 Ma (Kerr *et al.*, 1992). A detailed study of the northeastern intrusion is required in order to evaluate any variations in lithologies and to correlate with the three mapped phases in the southwestern intrusion.

Unit 23a is a coarse-grained, massive, biotite–magnetite quartz monzonite to monzonite (Plate 7B) and is found only in the south-central portion of the map area. Accessory biotite (~2-5%) forms euhedral crystals 2 to 4 mm in length. Disseminated magnetite occurs throughout the unit. Euhedral to subrounded feldspar phenocrysts are found locally and range in size from 1 to 2 cm.

Unit 23b is a medium- to coarse-grained, massive, biotite–hornblende quartz monzonite and monzonite (Plate 7C). Accessory hornblende is euhedral and accounts for 4 to 6% of the rock, whereas biotite is euhedral to subhedral and accounts for 2 to 4% of the rock. Accessory phases of clinopyroxene and possible relict olivine are also present. Euhedral feldspar phenocrysts occur locally and range in length from 1 to 3 cm. This unit is mostly undeformed, and unaltered; however, near faults, it can display a moderate foliation, sugary texture and potassic alteration. Development of this foliation is interpreted to be related to the northeast-trending faults, which may have initially been more ductile.

Unit 23c is a medium- to coarse-grained, biotite–hornblende syenogranite to syenite (Plate 7D). Hornblende occurs as subhedral to euhedral laths ranging in abundance from 2 to 8%; biotite accounts for 2 to 3%. Potassium feldspar phenocrysts occur locally and are 1 to 2 cm long. Accessory phases of clinopyroxene are also present. The unit has a locally developed foliation, which is defined by the alignment of mafic minerals, and is likely related to the extensive faulting in the area.

The Lanceground Intrusive Suite (Units 24a-b)

In the map area, the Lanceground Intrusive Suite (Kerr, 1994) comprises only the Pistol Lake granite (*sensu lato*; Unit 24a) as well as a newly correlated granodiorite (Unit 24b). These intrusive bodies occur in the east-central part of the map area. The Pistol Lake granite includes the main pluton surrounding the informally named Pistol Lake (west of Adlavik Bay), as well as a satellite pluton that occurs to the northeast.

The Pistol Lake granite (Unit 24a), which is a medium- to coarse-grained, massive hornblende syenogranite to quartz syenite (Plate 7E) is pink-grey and weathers to a medium pink. Hornblende crystals are euhedral to subhedral, are 1 to 4 cm in length and range in abundance from 2 to 8%. Accessory phases of magnetite (1 to 2%) also occur in this unit. The foliation is variably developed, with portions of the intrusion appearing undeformed, while the margins are moderately to strongly foliated. Locally, the intrusion is cut by cm-scale epidote-rich veins and cm-scale quartz veins.

Unit 24b is a fine- to medium-grained, massive, biotite granodiorite to, locally, monzogranite. Feldspar phenocrysts are locally preserved, and are typically 1 to 2 cm long. Biotite and magnetite occur as accessory phases with modal abundances ranging between 3 to 4% and 1 to 2%, respectively. The unit is medium grey on fresh surfaces and weathers pink-grey. The foliation is locally weak to moderately developed.

The Big River Granite (Units 25a-b)

The Big River granite occurs in the southeast (Figure 4). There are two units within this granite, *viz.*, hornblende–biotite monzogranite to syenogranite (Unit 25a) and a biotite monzogranite (Unit 25b).

Unit 25a is a coarse- to very coarse-grained, massive, hornblende–biotite monzogranite to syenogranite, and locally is a quartz syenite (Plate 7F). This unit is characteristically feldspar porphyritic, containing phenocrysts of plagioclase that are commonly mantled by K-feldspar preserving a pseudo-rapakivi texture. Euhedral to subhedral crystals of hornblende (1 to 3%) and biotite (3 to 5%) occur throughout this unit. Accessory phases of magnetite (1%) occur locally. Although, typically coarse to very coarse grained and undeformed, this unit displays transitional zones, tens of metres wide, which are finer grained and foliated. Locally, these zones display epidote veins and potassic alteration. Generally, these zones are northeast trending and are interpreted as faults and high-strain zones that are oblique to the east-trending Adlavik Brook fault zone and the Benedict fault zone, located to the south of the map area (Figures 2 and 3).

Unit 25b is a coarse-grained, porphyritic, biotite monzogranite. Biotite occurs as euhedral to subhedral grains and typically comprises 2 to 8% of the rock. Disseminated magnetite (1%) and fluorite (1%) occur throughout the unit, which is pink-grey on fresh surfaces and weathers light-grey. This unit is also feldspar porphyritic, containing phe-

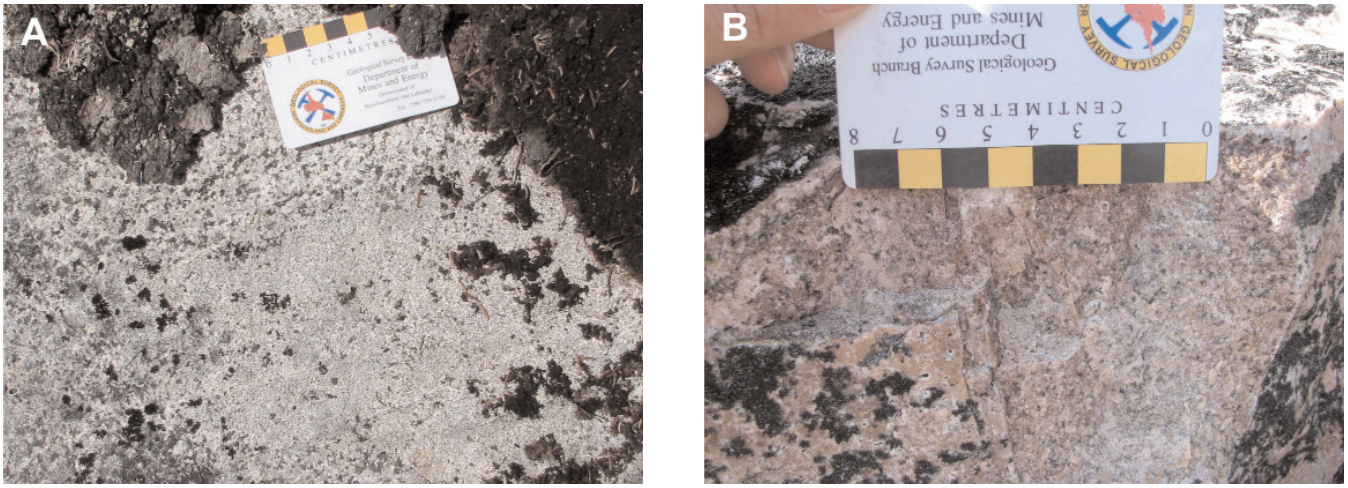

Plate 8. *Representative photographs of the Freshsteak granitoid in the Monkey Hill map area. A) Medium-grained, massive, leucocratic, biotite-hornblende quartz monzonite to monzodiorite (Unit 26a). B) Medium-grained, biotite-hornblende granodiorite (Unit 26b) containing plagioclase phenocrysts that range in size from 3 to10 mm.*

nocrysts ranging from 2 to 5 mm in length, and occasionally displays the same pseudo-rapakivi texture as described for Unit 25a. In close proximity to the northeast-trending faults, this monzogranite also displays a finer grain size and the development of a local foliation.

Freshsteak Granitoid (Units 26a-b)

The Freshsteak granitoid (Unit 26) occurs to the east of Freshsteak Lake, in the west-central map area. There are two mapped phases of this intrusion; the predominant phase is a biotite–hornblende quartz monzonite to monzodiorite (Unit 26a) and the less extensive phase is a biotite–hornblende granodiorite (Unit 26b). The extent of this pluton in the area is unknown due to significant glacial and forest cover that obscures the boundaries of much of the pluton. There are no U–Pb geochronological constraints on this unit, but it is correlated with the ca. 1800 Ma intrusions based, on Sr isotopic composition and geochemistry (Kerr, 1994).

Unit 26a is a fine- to medium-grained, massive, leucocratic, biotite–hornblende quartz monzonite to monzodiorite (Plate 8A). The unit varies from equigranular to plagioclase porphyritic with phenocrysts being 1 to 2 cm in length. Biotite and hornblende occur as euhedral to subhedral crystals and each has modal abundance of 4 to 10%. The unit appears mainly undeformed and a foliation is rarely found. Late, undeformed granite pegmatite dykes intrude this unit.

Unit 26b is a fine- to medium-grained, massive, leucocratic, equigranular biotite–hornblende granodiorite (Plate 8B). Biotite is subhedral, fine grained, ranges from 1 to 3 mm in length, and makes up 2 to 5% modal abundance. Hornblende is euhedral, lath shaped, ranging from 2 to 5 mm in length and makes up 2 to 10% modal abundance. Plagioclase phenocrysts are rarely documented, but when present, range in length from 3 to 10 mm. Disseminated magnetite occurs throughout the unit and weak igneous compositional layering is occasionally observed in outcrop.

Non-foliated Intrusions ca. 1650-1640 Ma

Labradorian (ca. 1650–1640 Ma) intrusions include the Adlavik Intrusive Suite (Unit 27) and the Monkey Hill Intrusive Suite (Unit 28). The Adlavik Intrusive Suite has intruded the Aillik Group, the porphyritic granite intrusions and the Pistol Lake granite. A sample of the Adlavik Intrusive Suite, from 6 km east of the map area in Adlavik Bay, was analyzed for U–Pb zircon by Kerr *et al.* (1992) and yielded a date of 1649 ± 1 Ma. Based on intrusive relationships observed along the coast, Kerr (1994) interpreted the Monkey Hill Intrusive Suite to be younger than the Adlavik Intrusive Suite. Each of these suites is described below.

Adlavik Intrusive Suite (Unit 27)

The Adlavik Intrusive Suite (Unit 27) mainly occurs as a large pluton in the northeast with several small satellite intrusions in the vicinity of the large pluton. The intrusive suite comprises a massive, undeformed, locally porphyritic, coarse- to medium-grained gabbro that locally varies to leucogabbro and minor melanogabbro (Plate 9A). The main mineral phases are plagioclase and pyroxene. Accessory biotite is euhedral and forms up to 4% of the unit. Locally developed plagioclase phenocrysts are 2 to 4 mm in length. Igneous compositional layering is locally preserved at the outcrop scale. This unit is cut by late granite pegmatite dykes and late epidote-rich dykelets.

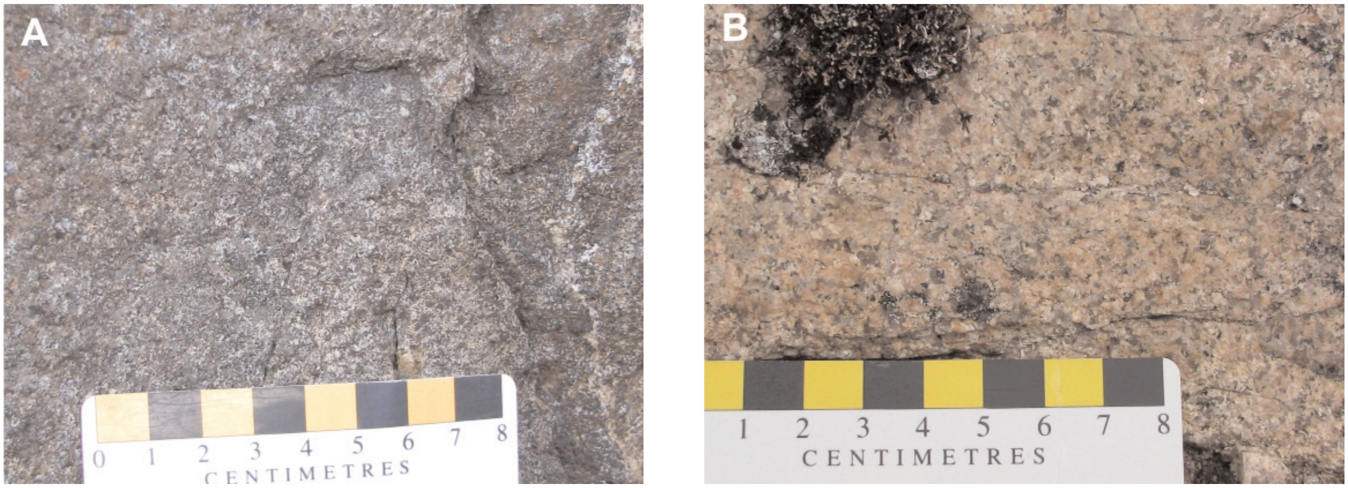

Plate 9. *Representative photographs of the ca. 1650–1640 Ma Labradorian non-foliated intrusive suites in the Monkey Hill map area. A) Medium-grained, massive gabbro of the Adlavik Intrusive Suite (Unit 27). B) Fine- to medium-grained, leucocratic, locally plagioclase porphyritic, biotite monzogranite of the Monkey Hill Intrusive Suite (Unit 28).*

Monkey Hill Intrusive Suite (Unit 28)

The Monkey Hill Intrusive Suite (Unit 28) occurs to the north and east of Cross Lake. It comprises fine- to medium-grained, leucocratic, locally plagioclase porphyritic, biotite monzogranite to syenogranite and minor quartz monzonite (Plate 9B). Locally developed plagioclase phenocrysts are 1 to 2 cm long. Accessory biotite, chlorite, hornblende, fluorite and magnetite occur throughout the suite. The unit is massive and homogeneous, except near contacts, where inclusions of country rock are locally entrained. This suite has intruded the Aillik Group and the foliated Kennedy Mountain Intrusive Suite, including the Cross Lake granite.

Unclassified Units – No Stratigraphic Order Implied

While the following units remain unclassified, it is anticipated that further petrographic and geochemical studies will elucidate the origin of these plutonic rocks. The two unclassified units consist of a foliated biotite–hornblende granodiorite (Unit 29), and an undeformed hornblende gabbro (Unit 30).

Unit 29 occurs in the southeast corner, south of Big River. It is characterized as a medium- to coarse-grained, massive, undeformed, locally porphyritic biotite–hornblende granodiorite (Plate 10). Plagioclase phenocrysts are locally developed and vary from 2 to 6 mm in length. Hornblende occurs as lath-like crystals that are 2 to 5 mm in length, and forms 4 to 5% of the unit. Biotite occurs as euhedral grains and forms 2 to 4% of the unit. Accessory magnetite is disseminated throughout the unit. Although rocks in the area have previously been mapped as the Adlavik Intrusive Suite (Kerr, 1994), this unit seems more lithologically similar to phases of the Numok Intrusive Suite. It is, however, equally possible that this granodiorite may also be related to the Big River Granite.

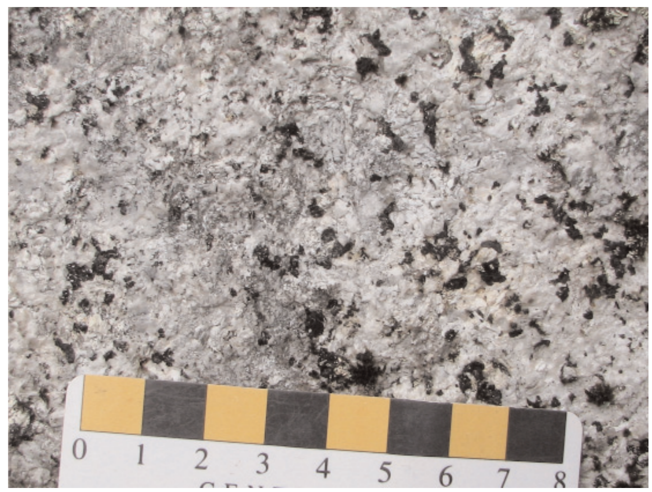

Plate 10. *Representative photograph of the unclassified, medium-grained, porphyritic biotite–hornblende granodiorite (Unit 29) from the Monkey Hill map area.*

Unit 30 occurs as small intrusions (less than 1 km wide) and flat-lying dykes in the area surrounding Swell Lake. The unit is characterized as a medium- to coarse-grained, massive, undeformed gabbro. Accessory phases of biotite (2 to 5%) occur throughout the unit. Disseminated pyrite occurs locally. Locally developed plagioclase laths give the rock an ophitic texture. These gabbro dykes may be satellite intrusions of the Adlavik Intrusive Suite.

Dykes

There are several generations of dykes in the map area. Dykes appear to be less abundant here compared with that to the north (NTS map area 13O/03). It may be simply that dykes are less abundant in the area, but alternatively, could be a function of the recessive weathering of the dykes, thus making them less obvious, in combination with, the current map area having relatively less exposure due to its location inland. None of the documented dykes in the area are of mappable size at the current scale of mapping

Felsic dykes in the area include, a) fine-grained, m-wide, aplite dykes, largely found within the Aillik Group, and b) granite pegmatite dykes that occur throughout and are most abundant near the stocks and sheets of the major intrusive suites. There are several phases of mafic dykes that both pre- and postdate deformation in the area. There are at least two suites of metamorphosed, recrystallized, and folded and boudinaged amphibolite dykes. One suite is characterized by having recrystallized feldspar phenocrysts, whereas the other suite is a fine-grained, garnet amphibolite. These dykes range in width from 30 cm to greater than 12 m. Undeformed mafic dykes include, a) fine-grained, diabase dykes with chilled margins and local phenocrysts, b) net-veined, medium-grained, gabbroic dykes and, c) brown-weathering, plagioclase-megacrystic diabase dykes.

PLEISTOCENE to RECENT

Unit 31

In the flood plain of the Adlavik Brook, much of the bedrock is covered by fluvioglacial and glacial gravel and sand (Unit 31). Every effort was made to extend the bedrock mapping as far as possible. In areas with rare outcrops of bedrock the regional extent of the geology units were postulated. However, in areas close to the river (especially in the eastern side of the map area), no outcrop was exposed and thus the area is mapped as gravels and sands. The edges of Unit 31 do not mark the extent of fluvioglacial sands and gravels, rather the extent of any (no matter how small) outcrop.

STRUCTURAL INTERPRETATIONS

DEPOSITIONAL ENVIRONMENT OF THE AILLIK GROUP

Previous work has suggested that the depositional environment of the Aillik Group is transitional from a shallow-marine environment, represented by bedded sandstone–siltstone and conglomerate units, to a marginal marine or subaqueous environment represented by felsic tuffs and epiclastic sediments composed of reworked felsic volcanic material (Gower *et al.*, 1982; Hinchey, 2007). In the Monkey Hill area, this interpretation continues to be supported by field evidence, which includes, a) preservation of ripple marks and crossbedding within the thin-bedded sandstone-siltstone units, b) preservation of pillow basalt and of vesicular textures in both the metabasalt and mafic tuff, c) the presence of polymictic conglomerate, and d) the presence of abundant reworked felsic volcanic material within the sedimentary sequences. Although the metabasalt and mafic tuff units form a viable marker horizon within the Aillik Group, their location within the stratigraphic column is complex and varies across locations. These relationships highlight the complex and variable stratigraphy within this package of rocks. This further illustrates the suggestions by Hinchey (2007) and Hinchey and Rayner (2008) that the previous interpretations (Gower and Ryan, 1987) of a division between the early and late sequences can not adequately explain the distribution of units in the area.

PRELIMINARY INTERPRETATION OF THE STRUCTURAL EVOLUTION OF THE AILLIK GROUP

Regional mapping has illustrated that deformation in the Aillik Group is more complex than previously interpreted (Gower *et al.*, 1982) and much of the Aillik Group is folded by regional-scale, tight to isoclinal, moderately plunging, generally north- to northeast-striking, upright to overturned folds that were subsequently refolded (Hinchey, 2007). Evidence for three generations of folding is found throughout the Monkey Hill map area. Outcrop-scale, fold interference patterns have been documented (Plates 2, 3A and C), but the large-scale map patterns are not as obvious in the Monkey Hill area as they are in the Makkovik map area (NTS 13O/03) to the north. This is primarily due to the fact that the Aillik Group rocks in the Monkey Hill area have been dissected by abundant faults that have significantly altered the distribution of units. Most of the map-scale-size folds are gently to moderately plunging, open to tightly refolded, regional-scale isoclinal folds (*see* map area around Falls Lake; Figure 4). The Aillik Group has been deformed by at least three phases of folding and the map-pattern distribution of Aillik Group units is largely controlled by regional-scale isoclinal folds.

PRELIMINARY STRUCTURAL INTERPRETATIONS OF THE PLUTONIC SUITES

With the exception of the porphyritic, syn-volcanic granites, all of the plutonic rocks appear to postdate regional F_2 folding in the area. Although some of the *ca.* 1800 Ma plutons have acquired the regional penetrative fabric, indicating they intruded synchronous to latter stages of deformation, they do not appear to be folded. Most of the post-

Makkovikian, northeast-trending faults appear to cut all of the plutonic units except the *ca.* 1650–1640 Ma Labradorian suites that appear to have escaped most this faulting/shearing event(s). The Adlavik Brook fault zone marks a major displacement that dissects the map area. Motion along this fault has been postulated to have some 18 km of dextral displacement (Gower *et al.*, 1982) or 20 to 30 km of displacement (Kerr, 1994). The rocks south of the Adlavik Brook fault zone are coarse-grained plutons, and volcanic rocks are found only near the western edge of the map area. The nature and style of the preserved rocks south of the Adlavik Brook fault zone suggest that these rocks were exhumed from a deeper structural level than those to the north of the fault zone.

MINERALIZATION

The volcano-sedimentary rocks host a multitude of promising mineral occurrences, dominated by uranium and molybdenite showings, as well as galena, pyrite, magnetite, chalcopyrite and covellite occurrences. Since the discovery of uranium and molybdenite mineralization in the mid-1950s, several studies have focused on the mineral exploration and potential of the area (*e.g.*, Beavan, 1958; Gandhi *et al.*, 1969; Marten, 1977; Gandhi, 1978; Evans, 1980; MacDougall, 1988; MacKenzie, 1991, and Wilton, 1996).

Samples from many of the previously known, as well as the newly documented mineral occurrences, were collected for assay as part of this regional mapping study and the results will be published once the analyses are completed. Uranium and molybdenite mineralization is found throughout the area with occurrences being concentrated, a) in the Falls Lake–Shoal Lake–Bernard Lake area, b) around Present Lake, and c) in the exposures of the Post Hill Group in the northwest map area. However, mineralization is not restricted to these areas and a variety of mineral showings occur throughout the map area. The dominant styles of mineralization include, a) discontinuous rusty horizons, which are sulphide-rich and enriched in uranium-bearing minerals, occur throughout the Aillik Group and the *ca.* 1858 Ma quartz–feldspar-porphyritic granite(s), b) sulphide-rich (galena, covellite, molybdenite), diopside–feldspar±calcite±epidote pods within the metabasalt unit, c) pegmatitic granite dykes that contain tourmaline, fluorite, covellite, and magnetite-rich zones, and d) quartz veins containing either disseminated molybdenite, galena, titanite, pyrite and tourmaline or fracture coatings of fine-grained molybdenite and galena. Many mineral occurrences have previously been documented in the area, and several new showings were identified during field mapping including several uranium occurrences as well as mineralized pegmatite veins. The abundant mineral occurrences in the Monkey Hill area illustrate the regions significant economic potential.

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