CHAPTER 10

EARLY LABRADORIAN GRANITOID AND ASSOCIATED ROCKS (P_{3B} 1710–1660 Ma)

Early Labradorian granitoid and associated rocks are considered on a terrane-by-terrane basis from north to south, namely Groswater Bay terrane, Hawke River terrane, Lake Melville terrane and Mealy Mountains terrane (Figure 10.1). If early Labradorian granitoid rocks occur in the Pinware terrane, they have yet to be found (but note that mid-Labradorian granitoid rocks are known in the Pinware terrane). Clarification is made here that, although these rocks are addressed in this manuscript after reviewing early Labradorian mafic and associated rocks, they are not necessarily younger – indeed it is certain that some of the mafic rocks addressed earlier are intrusions into the granitoid rocks. For the most part, age relationships between the two remain unknown.

The reader is likely to find description of early Labradorian granitoid gneiss on a terrane-by-terrane basis to be a bit repetitive and tedious. Overall, from one terrane to another, the granitoid gneisses are not greatly dissimilar, but neither are they completely alike. Subtle differences in features may have significance, and further work could demonstrate (or otherwise) presently unrecognized genetic con-

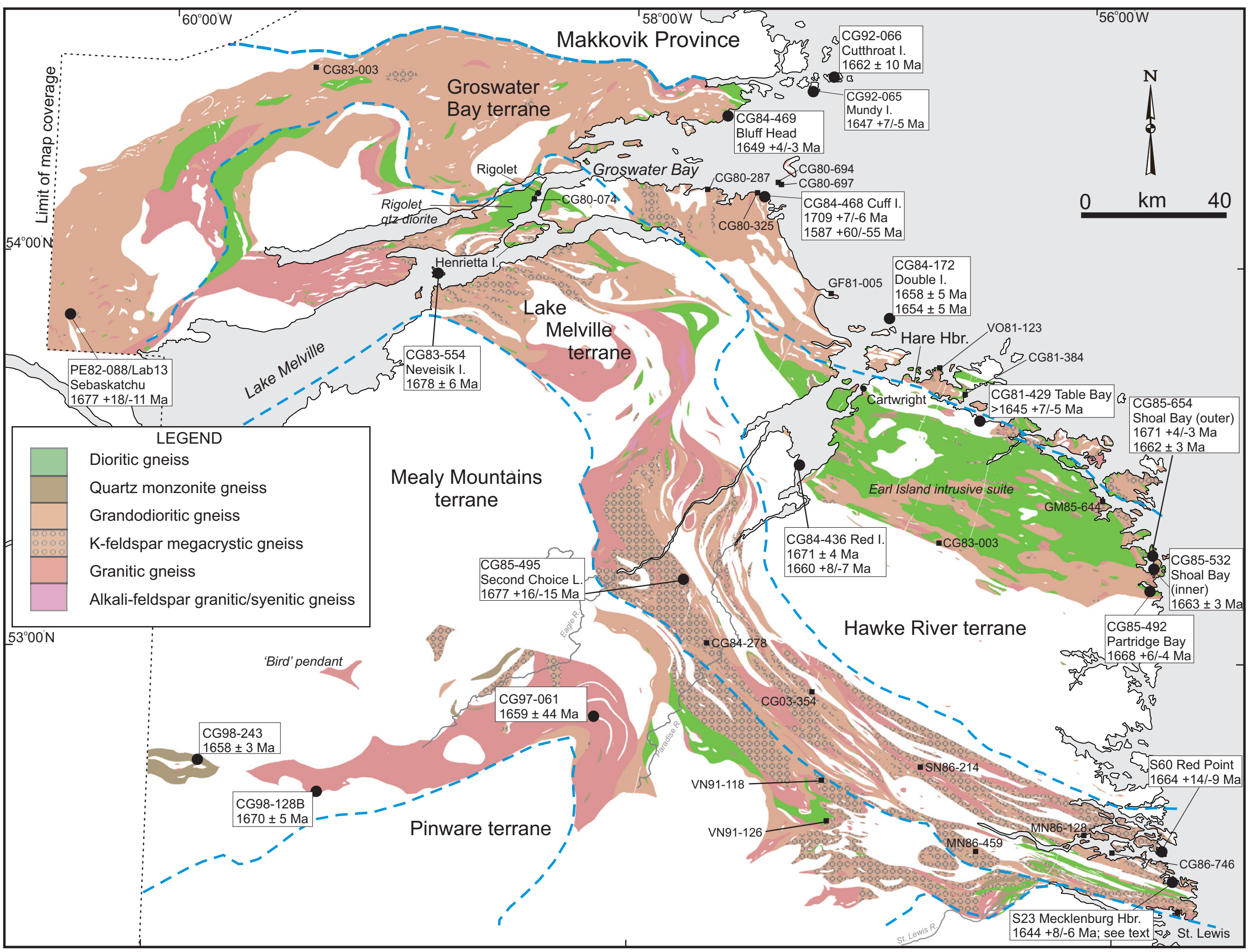


Figure 10.1. *Early Labradorian granitoid and associated rocks.*

trasts, and if none are found to exist, then it is easy enough to synthesize the separate descriptions. Within each terrane, the granitoid gneisses are described according to compositional types recognized, rather than to attempt subdivision to units (with some exceptions, *e.g.*, Earl Island intrusive suite; Rigolet quartz diorite). The reason for so doing is that these are very complex rocks (several types may be found in a single outcrop), so naming units would be largely meaningless.

Representative stained slabs (including many dated samples) are shown in Appendix 2, Slab images 10.1, 10.2, 10.3, 10.4, which correlate with the Groswater Bay, Hawke River, Lake Melville and Mealy Mountains terranes, respectively.

10.1 GROSWATER BAY TERRANE GRANITOID GNEISS

Groswater Bay terrane granitoid gneissic rocks have diorite, quartz diorite, granodiorite, monzodiorite, monzonite, quartz monzonite and granite compositions, and K-feldspar megacrystic variants. Notwithstanding that discrete lithological units are not readily mappable, areas can be identified that are dominated by a particular rock type (*e.g.*, Gower, 1986). The rocks have an ill-defined northern boundary with granitoid units of the Makkovik Province, and a somewhat better-defined southern boundary (but far from rigorous) with the Hawke River terrane and Lake Melville terrane.

The granitoid gneiss is known from the earliest geological investigations along the coast of Labrador (Lieber, 1860; Packard, 1891). Packard applied the term 'Domino gneiss', a term subsequently also used by Daly (1902), Kranck (1953) and Christie *et al.* (1953). The term 'Domino gneiss' has fallen into disuse, as it embraces several units, now separately identified. Stevenson (1970) mapped the inland extent of the granitoid gneiss in the Groswater Bay terrane, and was also the first to depict them as being distinct from the granitoid rocks of the Makkovik Province and the granitoid gneiss of the Lake Melville terrane (without using terrane nomenclature, which postdated his work). He described the granitoid gneiss in the Groswater Bay terrane as less highly deformed than the banded, migmatitic gneiss of the Lake Melville terrane. Stevenson also considered the Groswater Bay terrane gneiss to have a dominantly metasedimentary protolith – a position not shared by the author, although he acknowledges the presence of some supracrustal rocks. The Groswater Bay terrane granitoid gneisses were remapped by Gower (1980, 1984, 1986) and Gower *et al.* (1981, 1982b, 1985). They have been informally referred as Groswater Bay terrane gneiss for many years (*e.g.*, C. Gower, personal communication to P. Erdmer, 1982).

10.1.1 ISOTOPIC DATA

10.1.1.1 U–Pb

The U–Pb geochronological studies have demonstrated a range of early- to mid-Labradorian ages. Some younger ages should, more consistently, be grouped as mid- to late-Labradorian (next section), but the lack of any major time gaps between the oldest and youngest dates suggests a continuum that would be obscured by addressing them separately. The results are indicated in Figure 10.1 and are as follows:

i) The Cuff Island nebulitic granodiorite (Plate 10.1A, B), from the south side of east Groswater Bay, has an upper intercept of 1709 +7/–6 Ma, based on three discordant, multigrain zircon fractions and anchored by lower-intercept concordant titanite dated at 972 ± 4 Ma (Schärer *et al.*, 1986; CG84-468A). The upper intercept is interpreted to date time of intrusion. Banded granodioritic gneiss from the same outcrop (Plate 10.1C) yielded an imprecise date of 1587 +60/–55 Ma based on three zircon fractions close to a lower intercept (Grenvillian) intercept defined by 968 +7/–8 Ma titanite (Schärer *et al.*, 1986; CG84-468B). The Grenvillian Pb loss precluded rigorous interpretation of this upper intercept, which was merely reported as the average of inherited zircon ages. The geochronological data are consistent with field relationships that demonstrate that the fabric in the nebulitic granodiorite is truncated by a metamorphosed mafic intrusion (now correlated with the Adlavik-type intrusions, but earlier interpreted to be Michael gabbro; Plate 10.1D), whereas the banded granodiorite wraps around the mafic intrusion and has a concordant, tectonic (Grenvillian?) contact with it (Plate 10.1C). Gower and Owen (1984) interpreted the north-trending, west-dipping gneisses on the southern side of Groswater Bay as occupying a structurally unmodified area (since Makkovikian orogenesis) and hence preserving an essentially pre-Grenvillian history. The region might well be rewarding in the search for pre-Labradorian rocks in the eastern Grenville Province.

ii) The Sebaskatchu tonalitic gneiss, from the western Groswater Bay terrane, has an age of 1677 +18/–11 Ma, based on four collinear, near-discordant multigrain zircon fractions. The age is interpreted as the time of zircon crystallization (Schärer *et al.*, 1986; PE82-088/Lab 13).

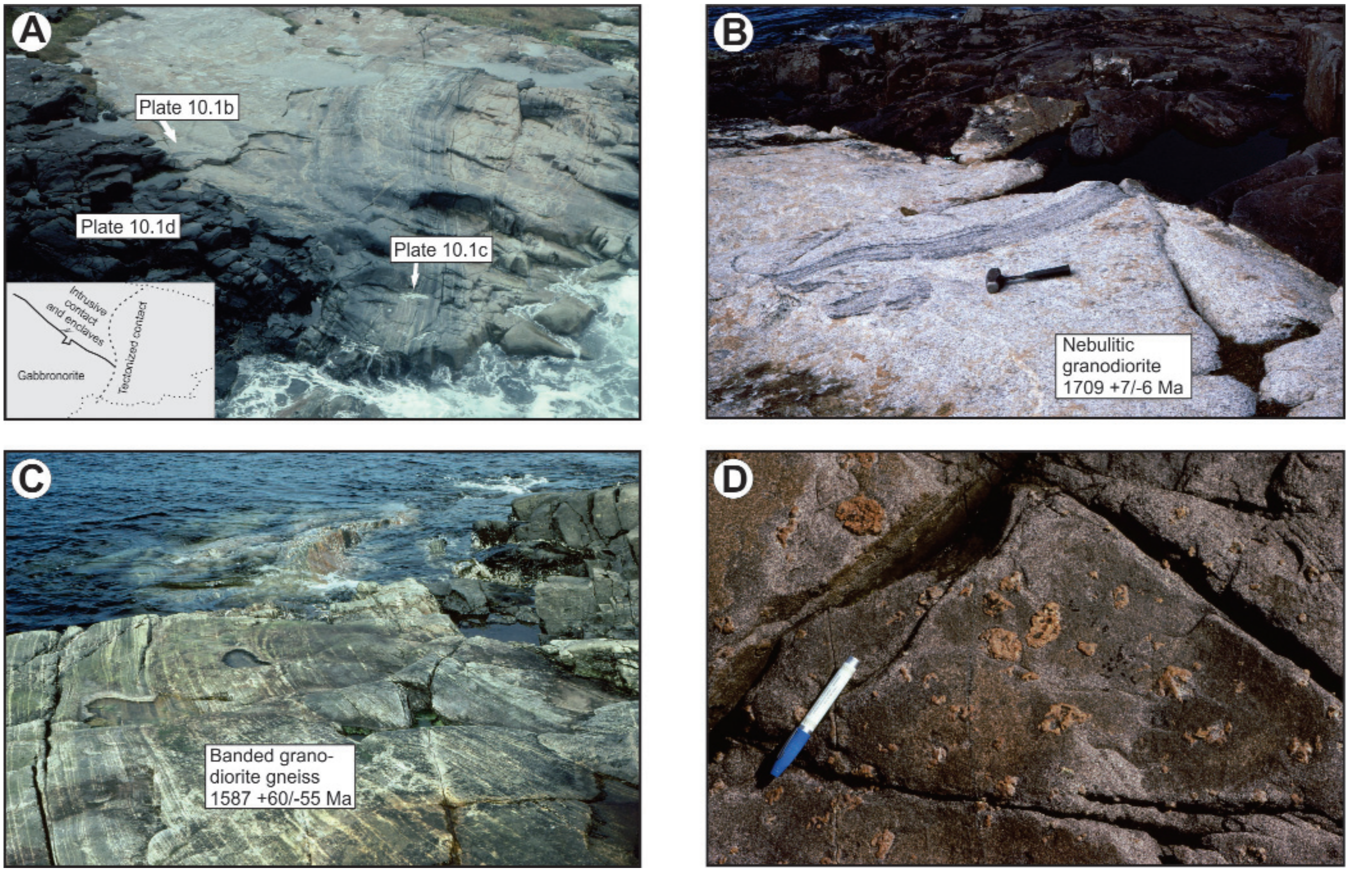


Plate 10.1. *Key U–Pb geochronology locality in Cuff Island area illustrating intrusive and tectonized contacts between granodiorite gneiss and a mafic intrusion. A. Aerial view of outcrop showing intrusive and tectonized contacts between mafic intrusion and granodiorite gneiss (CG84-468), B. Enclaves of metasedimentary(?) gneiss within nebulitic granodiorite and truncation by mafic intrusion (CG84-468), C. Banded granodiorite gneiss tectonically wrapping around mafic intrusion (CG84-468), D. Detail of mafic intrusion showing plagioclase phenocrysts (CG84-468).*

iii) A post-deformational melt pod from Cutthroat Island has an age of 1662 ± 10 Ma, based on four discordant titanite fractions, interpreted to date time of melting and to provide a younger time constraint on the time of mylonitization at the site (Krogh *et al.*, 2002; CG92-066A).

iv) From Double Island, in the southeastern part of the Groswater Bay terrane (Plate 10.2A–D), quartz diorite and granodioritic/tonalitic gneiss yield ages of 1654 ± 5 Ma and 1658 ± 5 Ma, respectively, each based on two near-concordant zircon analyses and anchored by concordant titanite dated to be 978 ± 4 Ma. The results are interpreted to define time of crystallization (Schärer *et al.*, 1986; CG84-172B, A).

v) From Bluff Head, on the north side of east Groswater Bay, a hornblende granodiorite has an emplacement age of 1649 +4/–3 Ma, based on five near-concordant zircon results and anchored by titanite dated to be 980 ± 4 Ma (Schärer and Gower, 1988; CG84-469).

vi) An aplite from Mundy Island, Smokey archipelago (Plate 6.4C) has an age of 1647 +7/–5 Ma, based on five zircon analyses, two of which are concordant (Kamo *et al.*, 1996; CG92-065C).

vii) An indirect constraint on the age of the granitoid gneiss is provided by alkali-feldspar granite from the Cartwright intrusive suite at Table Bay (CG81-429), which has an age of 1645 +7/–5 Ma. At the dated site, the alkali-feldspar granite clearly truncates the leucosome fabric of a tonalitic to granodioritic gneiss enclave, thus providing a minimum age of 1645 Ma for migmatization.

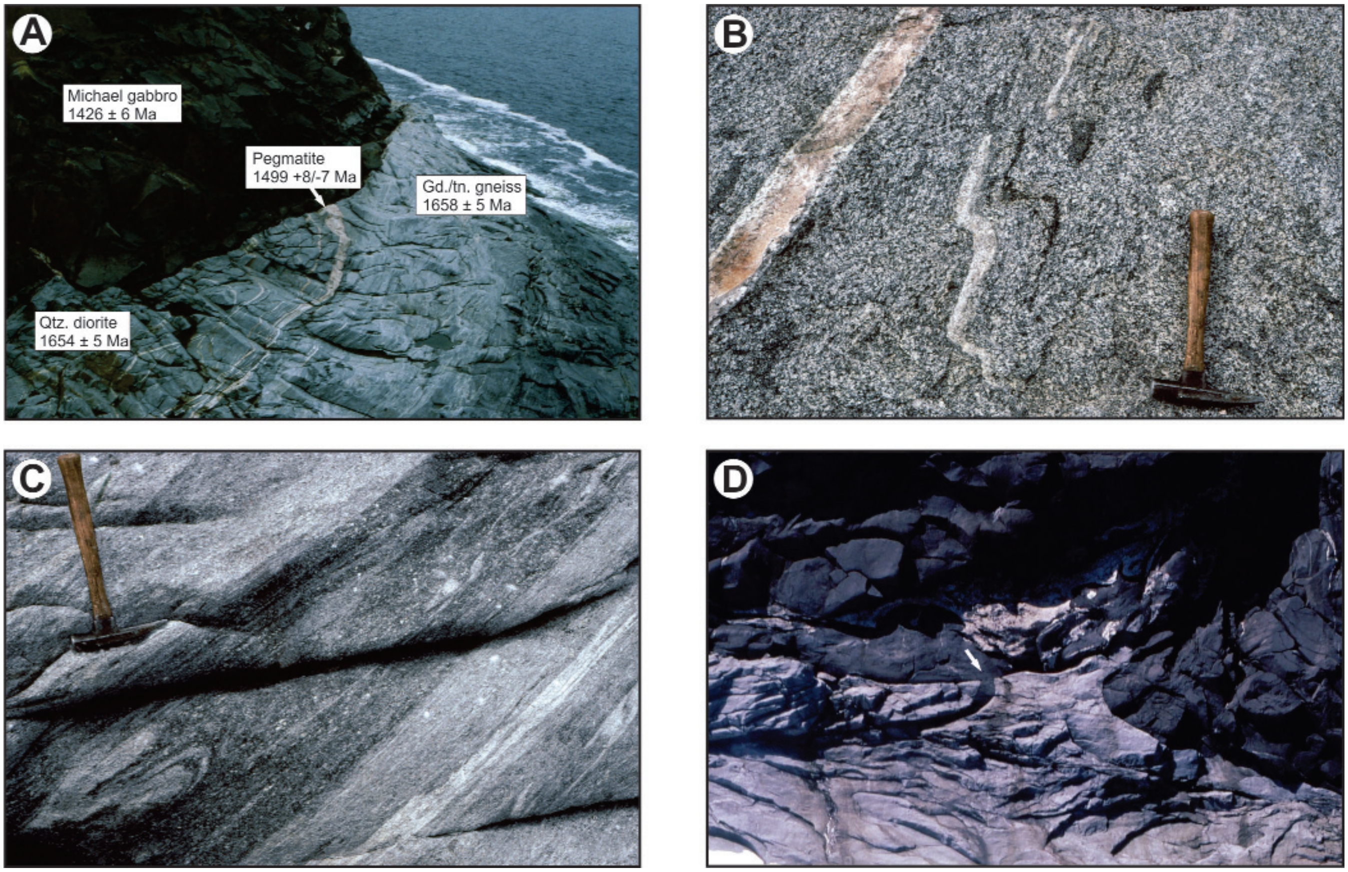


Plate 10.2. *Key U–Pb geochronology locality at Double Island illustrating field relationships with respect to younger units and detailed appearance of dated granitoid rocks (CG84-172). A. Overview of outcrop showing field relationships between dated units (CG84-172), B. Detail of quartz diorite showing enclaves and minor pegmatite which is to left of dated pegmatite in A (CG84-172), C. Granodiorite to tonalite gneiss with intrafolial folds (CG84-172), D. Granodiorite gneiss in boudin neck in Michael gabbro. Metamorphosed mafic dyke truncated by Michael gabbro at arrow (CG84-172).*

10.1.1.2 Sm–Nd

Sm–Nd isotopic data from Groswater Bay granitoid gneiss has been obtained by Brooks (1983; VO81-21A, B, VO81-539A, C, VO81-540) and Schärer (1991; CG84-172A, B, CG84-468A, B, CG84-469, PE82-088). In both studies, Rb–Sr data were also obtained and Schärer's (1991) study also included U–Pb ages. In keeping with the very small area sampled, Brooks (1983) obtained a very consistent dataset, all five samples having T_{DM} = 1851 to 1925 Ma and εNd (1.65 Ga) = +0.55 to +0.98, whereas Schärer's (1991) more regionally dispersed sites have a slightly broader range of T_{DM} = 1878 to 2110 Ma and εNd(1.65 Ga) = –1.36 to +0.77. Regressions were calculated by both Brooks and Schärer. Brooks's 5-point regression gave an age of 1681 ± 186 Ma and I_{Nd} = 0.51053 and Schärer's 14-point regression (which included similar gneiss from other terranes, except the Pinware terrane) gave an age of 1712 ± 66 Ma and I_{Nd} = 0.510448.

10.1.1.3 Rb–Sr

Prior to U–Pb geochronological studies, an attempt was made to date by Rb–Sr methods, granitoid gneiss from three areas in the Groswater Bay terrane. The first study involved four outcrops on the south side of Groswater Bay in the Cuff Island area (Brooks, 1982b; data stations CG80-333, CG80-337, CG80-348, CG84-468). Samples from the last-listed data station were subsequently dated by U–Pb methods and an age of 1709 +7/–6 Ma obtained (*cf.* Section 10.1.1.1). The Rb–Sr samples were subdivided into nebulitic granitoid rocks (8 samples) and homogeneous granitoid rocks (5 samples). No clear evidence of an age difference between the two was found. A regression that included all samples yielded an errorchron date of 1629 ± 68 Ma and I_{Sr} = 0.70287, which was interpreted to date the time of metamorphism. $I_{Sr(t)}$ values calculated for the individual samples for t = 1709 Ma (nebulitic granitoid rocks) and 1650 Ma (homogeneous granitoid rocks), yield a range $I_{Sr(t)}$ = 0.70037 to 0.70344 (Gower, 2010a; Groswater Bay map region).

In the second study, an attempt was made to date tonalitic to granodioritic gneiss from a cluster of four sites at Hare Harbour, east of Cartwright (Brooks, 1983; VO81-021, VO81-023, VO81-539, VO81-540). A regression based on six analyses yielded an errorchron of 1610 ± 50 Ma and I_{Sr} = 0.70302. $I_{Sr(t)}$ values calculated for the individual samples for t = 1650 Ma, yield a range $I_{Sr(t)}$ = 0.69658 to 0.70322 (Gower, 2010a; Groswater Bay map region).

The third study that included Rb–Sr isotopic data from Groswater Bay terrane granitoid gneiss (with comparable rocks from other terranes) was done by Schärer (1991; samples CG84-172A, CG84-172B, CG84-468A, CG84-469, PE82-088), who also obtained U–Pb and Sm–Nd information on the same samples. $I_{Sr(t)}$ values calculated for the individual samples for t = their U–Pb crystallization age, yield a range $I_{Sr(t)}$ = 0.70139 to 0.70469. When the data are regressed with similar gneiss from other terranes (none from the Pinware terrane), a pooled 14-point regression gave an age of 1617 ± 21 Ma and $I_{Sr(t)}$ = 0.70277.

Note that the three Rb–Sr studies show excellent consistency, in both age and I_{Sr}, but are *ca.* 30 to 40 million years younger than U–Pb interpreted emplacement ages.

10.1.1.4 Ar–Ar and K–Ar

The samples can be divided into two groups, based on whether they are older or younger than anticipated from U–Pb ages. Two samples fall into the 'older-than-expected' category. One is a K–Ar biotite date of 1895 ± 60 Ma (unpublished result obtained by the Geological Survey of Canada; sample SGJ68-105). The other is an Ar–Ar hornblende date of 1853 ± 12 Ma obtained by van Nostrand (1988; sample VAN84-018). The first site is 7 km west of comparable rocks seen at Bluff head, dated by U–Pb methods to be 1649 +4/–3 Ma (*cf.* Section 10.1.1.1), and the second is within the cluster of sites from which Brooks (1983) reported Sm–Nd and Rb–Sr dates of 1681 ± 186 Ma and 1629 ± 68 Ma, respectively. The 1895 and 1853 Ma dates would therefore seem to be anomalously old compared to crystallization ages, and to be explained as due to excess Ar. For whatever significance it might have, it is noted that they are similar to Sm–Nd T_{DM} ages obtained from granitoid rocks in the Groswater Bay terrane.

Eight samples fall into the 'younger-than-expected' group. The oldest age is a hornblende Ar–Ar total-gas date of 1364 ± 3 Ma from quartz diorite gneiss at Double Island (Gower, 2010a; Table Bay map region; R. Dallmeyer, personal communications, 2002, 2010; sample CG84-172A), known to have a U–Pb zircon age of 1654 ± 5 Ma. The 1364 ± 4 Ma date is very similar to a hornblende Ar–Ar total-gas date of 1337 ± 6 Ma from a metamorphosed mafic dyke (VAN84-017D) at the same locality (Plate 10.2D). The dyke is known from U–Pb data to have been emplaced between 1654 ± 5 Ma and 1499 +8/–7 Ma (Schärer *et al.*, 1986). The four next-oldest dates are all K–Ar dates from samples collected by Stevenson (1970) that yielded results of 1272 ± 45 Ma, 1175 ± 40 Ma, 1160 ± 40 Ma (all biotite) and 1080 ± 42 Ma (hornblende) (Wanless, 1970; Wanless *et al.*, 1972), followed by dates of 1021 ± 4 Ma and 971 ± 3 Ma (both hornblende, Ar–Ar; R. Dallmeyer, personal communications, 2002, 2010). The youngest date obtained is 944 ± 12 Ma (biotite, K–Ar; Grasty *et al.*, 1969). The data have been reviewed by Gower (2003), who demonstrated that there is a systematic decrease in Ar–Ar and K–Ar ages toward the interior of the eastern Grenville Province, and interpreted the results to be due to progressively increasing Grenvillian Ar loss.

Two other K–Ar results from Groswater Bay terrane granitoid rocks are excluded here. They are hornblende and biotite dates from a sample collected by Stevenson (1970; SG68-110). Stevenson originally interpreted the rock as paragneiss, but the author believes it to be monzonite based on field observation and thin section evidence (*cf.* Section 11.3.2).

10.1.2 FIELD AND PETROGRAPHIC CHARACTERISTICS (P_{3B}dr, P_{3B}gd, P_{3B}gp, P_{3B}gr, P_{3B}mq)

The most abundant rocks are dioritic to granodioritic, including megacrystic variants (collectively about 75% of outcrops), although many were termed tonalite during field work (subsequently corrected, based on stained slab characteristics). Of the remainder, roughly 15% are granite; about 5% monzodiorite, monzonite and quartz monzonite; and 5% syenite, quartz syenite and 'miscellaneous'. A possibility that cannot be completely dismissed is that a few rocks included here may have a psammitic protolith (*e.g.*, biotite–garnet gneiss at CG79-663, which was described in the field as having a 'sandy' feel – a very subjective criterion, but not completely meaningless in the author's opinion). The rocks are mostly dark-grey- to pale-grey-weathering, but may be creamy, buff, brown or pale-pink. They most commonly have medium-grained, recrystallized textures, but finer and coarser grained variants are also found. The rocks range from being relatively massive and homogeneous, through moderately to strongly foliated or gneissic. Gneissic fabrics are most typical. Gneissic banding varies from poor, streaky or lensy, to well defined and continuous. Banding may be broad or narrow, and individual bands diffusely gradational into adjacent bands or sharply defined. The gneissic banding is commonly deformed by folds of several generations, resulting in very complex fold interference patterns (Plate 10.3A, 10.3B). Outcrop-scale, north-

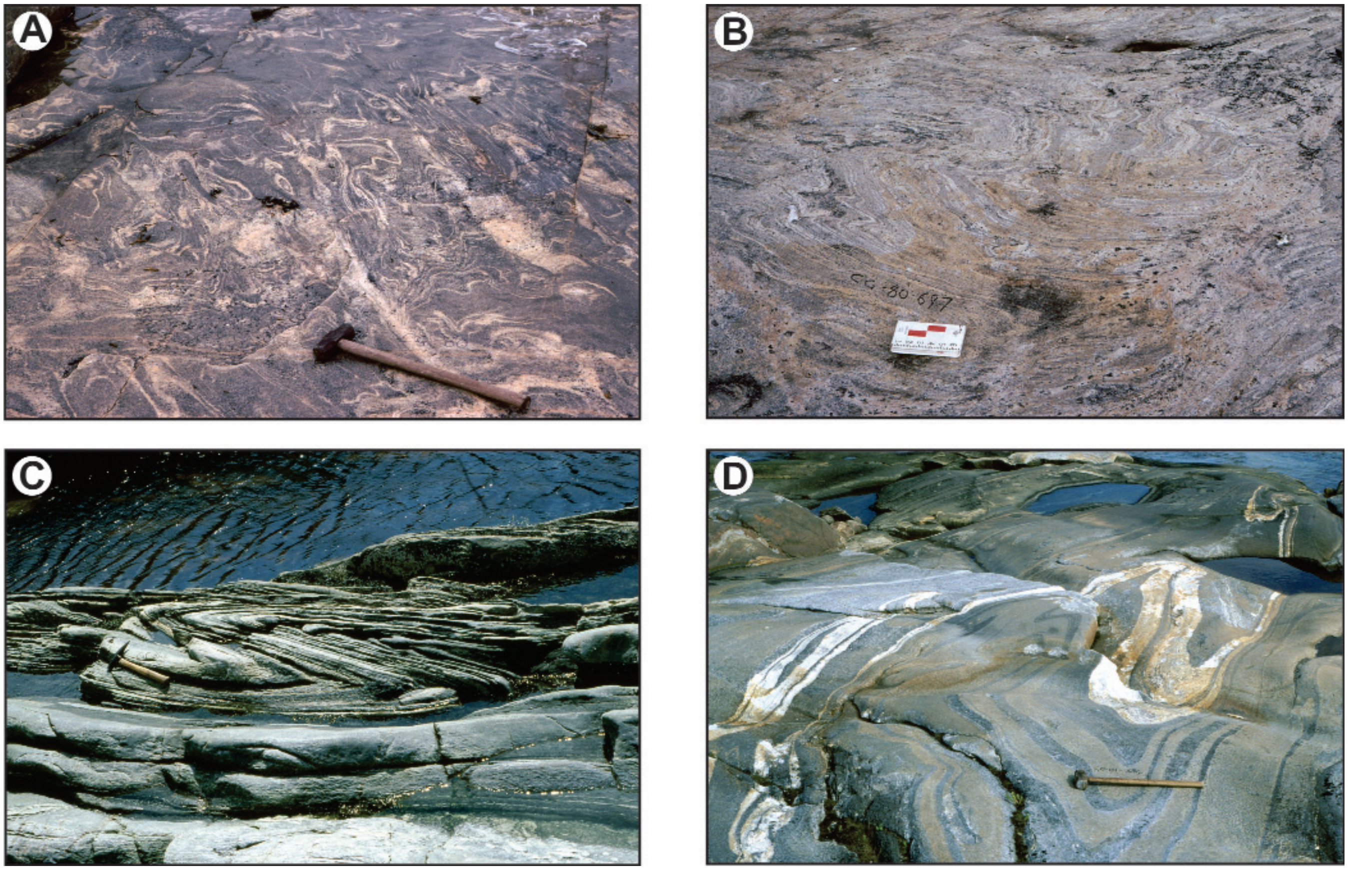


Plate 10.3. *Examples of folding in Groswater Bay terrane granitoid gneiss. A. Complex interference folds in granodiorite gneiss (CG80-287), B. Another example of interference folds (CG80-697), C. North-verging tight to isoclinal fold with shallowly dipping axial surface (GF81-005), D. Possible sheath folds in granodiorite gneiss. Note extreme attenuation of pegmatitic layers (CG81-384).*

verging isoclinal folds having shallowly dipping axial surfaces are characteristic of the unit (CG80-062, CG80-698, GF81-005) (Plate 10.3C). Sheath folds were interpreted at CG81-384 (Plate 10.3D).

Gneissic banding (covering the spectrum from agmatite to nebulite) in the Groswater Bay terrane gneiss is the product of interleaving of protoliths, and leucosome and restite products. Layers, pods, lenses, boudins, schlieren, schollen and skialiths of mafic material are a major aspect defining gneissic appearance. Most of the mafic material is amphibolitic or metagabbroic, but ranges from intermediate to ultramafic (ultramafic at VO81-082). In narrow veneers, mafic material is merely concentrations of biotite or hornblende. Leucosome is pale creamy or pinkish and typically forms 15–30% of the rock, but may be absent or more abundant, depending on protolith composition and metamorphic conditions experienced. It varies in character from incipient, irregular, quartzofeldspathic pods or thin, wispy, discontinuous streaks, to even and continuous bands, or large irregular masses. It is also typically recrystallized and may be fine, medium, or coarse grained. Mafic selvedges (enriched in biotite or amphibole) are common, but not universally present. Some stretched-out K-feldspar patches may represent pegmatite flattened to concordance.

The K-feldspar megacrystic variants share the same characteristics as the non-megacrystic types except for the megacrysts (normally fairly small, <2 cm across). Exceptions occur; for example at site CG80-058 where they reach 6 x 4 cm. They are commonly deformed to ellipsoids aggregates, or form attenuated augen (*e.g.*, 4 x 0.4 cm at CG80-229). At the time of mapping (early 1980s), they were not much examined for kinematic information, although rotated, top-to-the-north megacrysts were recorded at CG85-608. Larger-than-groundmass recrystallized K-feldspar clusters in some rocks might equally well be a metamorphic segregation effect, *vs.* relict megacrysts.

Repeated mention is made in field notes regarding hornblende in quartzofeldspathic leucosome segregations, where it commonly forms crystals up to about 3 cm in diameter (*e.g.*, CG79-802, CG80-325 – Plate 10.4A, CG80-732, CG81-712, GM85-633). The crystals are commonly poikilitic and tend to be euhedral. Alternatively, the rock may show a patchy appearance due to hornblende-rich and hornblende-poor areas, or have amphibolitic remnants rimmed by hornblende and enclosed by leucosome. Where subsequently deformed, the hornblende concentrations form streaked-out recrystallized clusters. The amphibole can be explained as due to incongruent, fluid-present, melting producing peritectic hornblende. A possible reaction is (*cf.* Reichardt and Weinberg, 2012):

Biotite + Plagioclase + Quartz + H_2O*-rich fluid = Hornblende ± K-feldspar + Melt*

Garnet was also regularly recorded in field notes, especially in the southern Groswater Bay terrane (*cf.* Gower, 1986). In many instances, the garnets are sparse and small, but that is not so everywhere. Garnets exceeding 1 cm in diameter are far from rare, and individual garnets up to 10 cm in diameter were recorded (*e.g.*, CG81-712). A 10-cm-diameter garnet cluster was noted at CG83-443 including individual garnets up to 2.5 cm. Garnet rimmed by hornblende was recorded at CG80-307. Clear evidence of melting reactions is well displayed at CG81-714 and VO81-123. In Plate 10.4B, attention is drawn to the correlation between size of garnet and size of its enveloping leucosome patch. The garnet can equally be explained as a product of similar incongruent melting reactions to that noted above, but under fluid-deficient conditions.

There are a few noteworthy points regarding other nonfelsic minerals. First, is the ubiquity of epidote, which is found in almost every sample. It is typically cored by allanite, which, in a few cases, shows multiple growth stages. Allanite is abnormally large at locality CG80-299. Second, is the dearth of pyroxene, which was nowhere seen as a peritectic phase in leucosome. Third, is the sporadic occurrence of mafic-mineral-depleted haloes around magnetite (*e.g.*, CG80-323). Fourth, is the scattered presence of scapolite in the southern Groswater Bay terrane.

In addition to locally derived leucosome, the Groswater Bay terrane granitoid gneisses are intruded by a wide range of aplitic, micrigranitic and pegmatitic dykes. Although

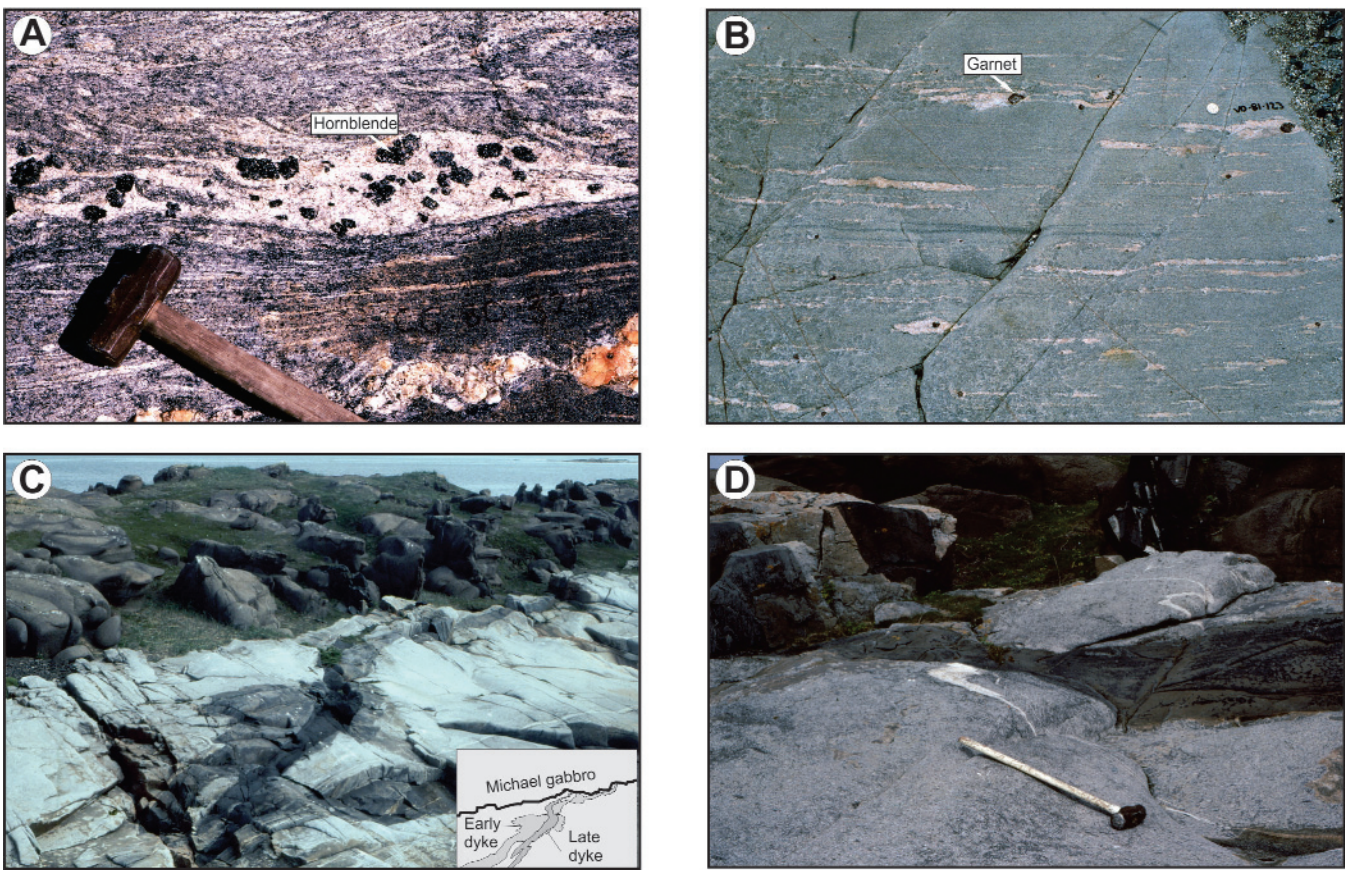


Plate 10.4. *Incongruent melting and mafic dykes in Groswater Bay terrane granitoid gneiss. A. Incongruent melting to give hornblende in quartzofeldspathic leucosome (CG80-325), B. Incongruent melting to give garnet in quartzofeldspathic leucosome; note correlation between size of garnet and leucosome (VO81-123), C. Quartzofeldspathic gneiss intruded by early grey mafic dyke, and later black mafic dyke; both truncated by Mechael gabbro (CG80-694), D. Detail of outcrop in C showing pegmatitic veinlet truncated by early grey mafic dyke (CG80-694).*

they commonly display discordance relative to pre-existing fabrics in the host rocks, they are characteristically deformed and recrystallized. The terrane is noteworthy for its lack of planar, posttectonic minor granitoid intrusions (in contrast to terranes farther south). The deformed minor granitoid intrusions that are present commonly show evidence of multiple injection phases, both pre- and postdating deformed and metamorphosed mafic dykes. The impression is gained for the existence of a close and intimate relationship between minor granitoid intrusions and mafic dykes. An example at CG79-676 shows already-deformed diorite intruded by microgranite, then a mafic dyke and then pegmatite, followed by further deformation. A similar set of relationships is seen at CG80-238.

Deformed and metamorphosed mafic dykes are hosted by Groswater Bay terrane granitoid gneisses in all parts of the terrane (Plate 10.4C–D). Several generations are present, the earliest being most deformed (*e.g.*, CG80-321). It is not known how many generations exist. In many places, a less-deformed mafic dyke is seen crosscutting a boudinaged, or otherwise shredded earlier dyke, barely recognizable for what it is, except for narrowly oblique discordance to host-rock fabric and(or) evidence of chilled margins. Most of the dykes are fine to medium grained, but some larger and coarser grained gabbroid bodies are present, and locally they grade into ultramafite (*e.g.*, CG80-280). Both plagioclase-phyric and non-phyric dykes were recorded at CG79-934. Net-veined mafic dykes are found sporadically – a well-exposed example occurs at CG79-786. Commonly, fabrics are weak in the interior of such bodies, but transposed into concordance at the margins with their host granitoid gneiss. The mafic dykes are also garnet-bearing, perhaps more commonly so than the granitoid gneiss.

Late-stage fracturing, shearing and brecciation are seen in places. These are accompanied by quartz veins and hematization, chloritization, epidotization and silicification. Such features correlate spatially with the Double Mer and Sandwich Bay graben, and are readily interpreted as products of Iapetus-related rifting.

In summary, the dioritic to granodioritic gneisses in the Groswater Bay terrane are fairly typical of migmatized TTG (tonalite–trondhjemite–granodiorite) suites. Features that deserve specific emphasis are: i) incongruent melting reactions producing hornblende and garnet, but not pyroxene, ii) ubiquity of epidote, iii) complex interplay between metamorphosed minor granitoid and mafic intrusions, iv) severe folding (isoclinal/recumbent), and v) lack of posttectonic, undeformed microgranite and pegmatite.

For a group of rocks having such a wide range of field characteristics and compositions, they have remarkably straightforward mineral assemblages. A total of 251 thin sections were examined, embracing the full spectrum of rock types present. Of the felsic minerals, all contain plagioclase, 97% contain K-feldspar and 98% contain quartz. Plagioclase was interpreted to be metamorphic in 40% of thin sections, igneous in 10% and a mixture of both in 50% – percentages that give an overall guide to the igneous/metamorphic state of the samples. A small proportion show weak to moderate zoning and a few have albitic margins. K-feldspar is overwhelmingly microcline. Of the mafic minerals, biotite is the most common, being present in 92% of thin sections. It is dominantly olive-green or green-buff, but some is buff-orange, or orange-brown. Amphibole is present in 60% of thin sections. It is mostly green to blue-green hornblende, except for minor actinolite/tremolite. The amphibole grains are commonly poikiloblastic and inclusions of quartz are common. Only six thin sections contain clinopyroxene (about 2%), and it is deemed to be of relict igneous origin in four of them. In a few thin sections, there are hints of the former presence of (probably igneous) clinopyroxene in the form of antigorite clusters in the cores of hornblende grains. Only one thin section contains (weakly pleochroic) orthopyroxene (CG61-641). Garnet is present is 30% of thin sections, commonly having amoeboid, poikiloblastic form and containing abundant quartz inclusions, and/or fewer inclusions of opaque minerals, biotite, and plagioclase. Most thin sections contain an opaque oxide and about 15% have some sulphide. Accessory minerals are muscovite, apatite, titanite, zircon, epidote, allanite (showing multiple growth stages and mantled by epidote (Photomicrograph 10.1A), chlorite (mostly after biotite), scapolite, carbonate and serpentine. Retrograde reactions evident are the breakdown of hornblende and biotite. A likely hornblende reaction, as interpreted from petrographic observation, is (Grapes and Hoskin, 2004):

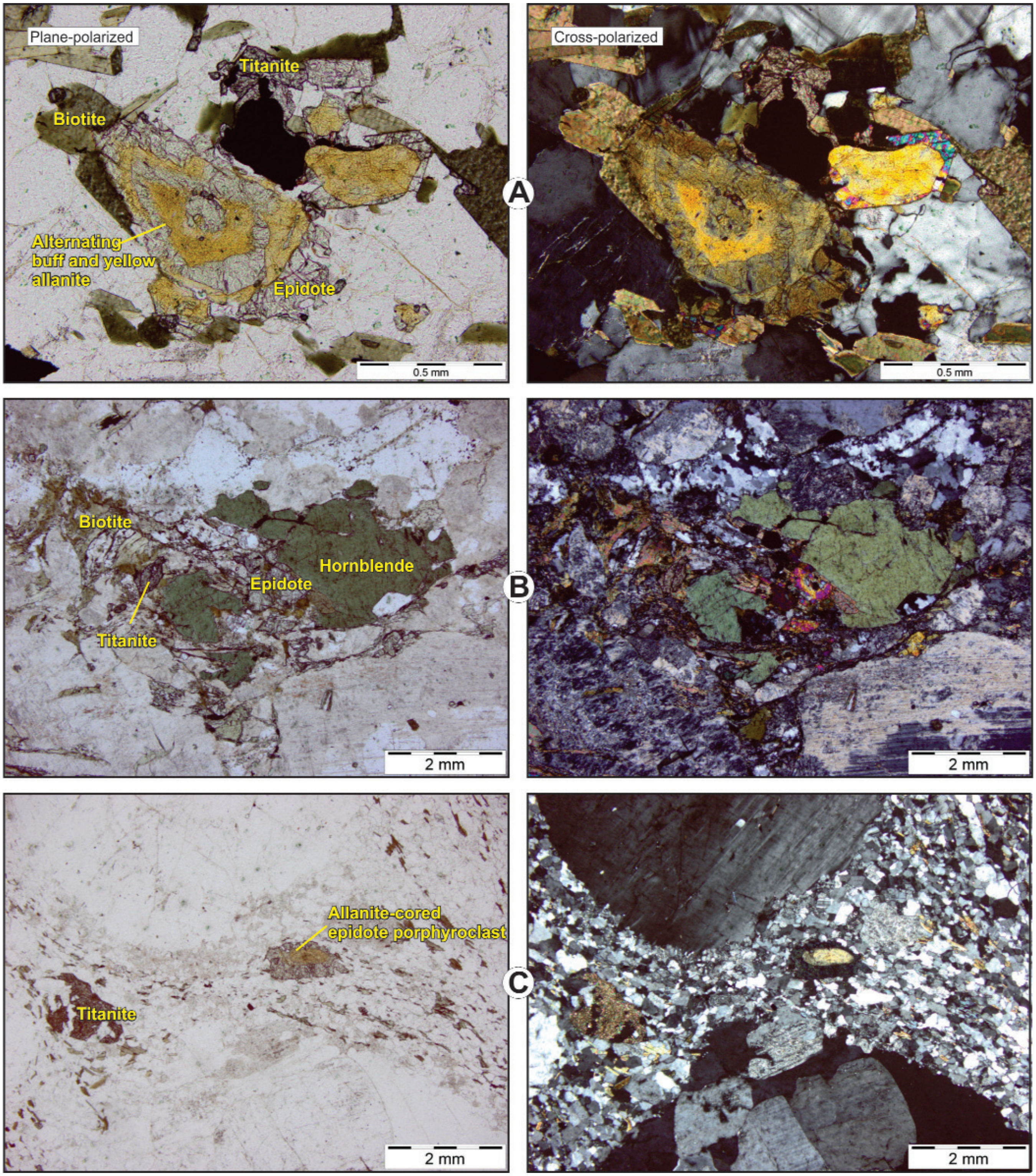
Hornblende + H_2O = *Epidote* + *Chlorite* + *Actinolite* + *Quartz.*

10.2 HAWKE RIVER TERRANE GRANITOID GNEISS (EARL ISLAND INTRUSIVE SUITE)

Rocks included as part of the Earl Island intrusive suite (EIIS) comprise mostly early to mid-Labradorian diorite, quartz diorite and granodiorite, with lesser mafic and other felsic rock types. Minor remnants of metasedimentary gneiss are also present. The rocks were not separately distinguished on the maps of Kranck (1953), Christie *et al.* (1953) or Eade (1962), and their present depiction is derived from mapping by Gower *et al.* (1982b, 1985, 1986b). The rocks were included by Gower *et al.* (1986b) as part of the lithotectonic Earl Island and Domino domains, without the rocks being themselves named (the Domino domain was later discarded and included as part of the Earl Island domain). Gower (1996) used the term ‘Earl Island granodiorite–diorite domain’, and Gower and Krogh (2003) referred to the ‘Earl Island quartz diorite’. Naming the unit as ‘Earl Island intrusive suite’ and detailed description of its constituent rock types are given here for the first time.

10.2.1 ISOTOPIC DATA

The age of the Earl Island intrusive suite, and various subsequent events that affected it, is well established through geochronological investigations at four key locali-



Photomicrograph 10.1. *Allanite and epidote in early Labradorian granitoid rocks in the Groswater Bay and Hawke River terranes. A. Multi-zoned allanite mantled by epidote in Groswater Bay terrane granitoid rock (CG83-003), B. Earl Island intrusive suite quartz diorite showing hornblende breakdown to epidote, biotite and titanite (incomplete reaction), Hawke River terrane (CG85-054), C. Allanite-cored epidote porphyroclast in mylonitized Earl Island intrusive suite granite, Hawke River terrane (GM85-644B).*

ties (CG84-436, CG85-492, CG85-532, CG85-654), ages from which were reported by Schärer and Gower (1988), Kamo *et al.* (1996), and Gower *et al.* (1992). Field relationships, U–Pb geochronological data and correlations are summarized in Table 10.1 and dating sites indicated in Figure 10.1. Field relationships at the key localities are illustrated in Plates 10.5A–C, 10.6 and 10.7A, B. Summarized in Table 10.1, four Labradorian events are recognized, each of which is defined by dates from three samples, thus providing a fairly rigorous geochronological framework. U–Pb zircon dating clearly establishes emplacement of the dioritic to granodioritic rocks at 1670 Ma at three data stations, and constrains it to pre-1663 Ma at the remaining locality. Granitoid rock emplacement at 1670 Ma was termed the Red Island magmatic event by Gower *et al.* (1992) after the locality where it was first dated (CG84-436). Field data show that minor granitoid intrusions predated the emplacement of an 'early' group of mafic dykes, which, along with the minor granitoid intrusions and their dioritic to granodioritic hosts, subsequently experienced high-grade metamorphism (including migmatization). The gneissic fabrics, and minor granitoid and early mafic intrusions, are truncated against a suite of unmigmatized mafic dykes, none of which have been dated by U–Pb methods. At data station CG84-436 (Plate 10.5), however, an unmigmatized mafic dyke is crosscut by an intermediate K-feldspar megacrystic dyke, which has a U–Pb emplacement age of 1660 Ma. This was also the time of emplacement of muscovite granite in the eastern part of the Earl Island intrusive suite that also discordantly intrudes older migmatized dioritic to granodioritic rocks. At one dated site (CG85-532), muscovite granite is intruded by a 5-m-wide metagabbroic dyke clearly display-

Table 10.1. Geological history of Earl Island intrusive suite based on field relationships, minor intrusions and U–Pb dating at four key localities

Event	Age	CG84-436	CG85-492	CG85-532	CG85-654
Early Labradorian granitoid rocks	1670 Ma	Hornblende biotite quartz diorite gneiss with mafic enclaves 1671 ± 4 Ma (zc) CG84-436A	Gneissic hornblende biotite quartz diorite with mafic enclaves 1668 +6/–4 Ma (zc) CG85-492A	Enclaves of hornblende quartz diorite in muscovite granite (CG85-532A)	Biotite hornblende tonalite/ granodiorite gneiss 1671 +4/–3 Ma (zu)
Early Labradorian minor intrusions		Recrystallized microgranite	Early deformed pegmatite		
Early Labradorian mafic dykes		Migmatized mafic dyke CG84-436B	Migmatitzed mafic dyke CG85-492B		
Early Labradorian migmatitic metamorphism					
Mid Labradorian mafic dykes		Unmigmatized mafic dyke (intrudes CG84-436B) CG84-436C	Unmigmatized mafic dyke (intrudes CG85-492B) CG85-492C		
Mid Labradorian granitoid intrusions	1660 Ma	Intermediate K-feldspar mega-crystic dyke (intrudes CG84-436C 1660 +8/–7 Ma (zu) CG84-436D		Muscovite granite 1663 ± 3 Ma CG85-532A	Muscovite granite 1662 ± 3 Ma (intrudes CG85-654A) CG85-654B
Mid-late Labradorian mafic dykes				Metagabbro dyke with chilled margins CG95-532B	
Mid-late Labradorian non-migmatitic metamorphism	1645 Ma	Deformation (could be later)	Metamorphism/titanite closure 1642 ± 4 Ma (t) CG85-492A	Metamorphism/titanite closure 1649 ± 4 Ma (t) CG85-532A	Metamorphism/titanite closure 1646 ± 2 Ma (t) CG85-654A
Late Labradorian non-migmatitic metamorphism	*ca.*. 1620–1615 Ma		Pegmatite (intrudes CG85-492C) 1622 ± 3 Ma (z, xu) CG85-492D		Amphibolite 1617 ± 14 Ma (t) CG85-654B,C Tonalite/granodiorite gneiss 1615 +34/–9 Ma (t) CG85-654A
Pinwarian imprint	*ca.* 1490 Ma				Amphbiolite (dyke?) *ca.* 1490 Ma (t) CG85-654B,C
Grenvillian imprint	*ca.* 890 Ma		Pb loss *ca.* 890 Ma (zl) CG85-492A		
Late-Precambrian imprint	*ca.* 510 Ma	Late-stage faulting and hematite fracture-filling 508 +38/–39 Ma (zl) CG84-436D			
Phanerozoic imprint	Various		Pb loss *ca.* 320 ± 3 Ma (zl) CG85-492A	Pb loss *ca.* 127 Ma (zl) CG85-532A	Pb loss *ca.* 425, 396 Ma (zl) CG85-654A,B

Abbreviations: c – concordant, l– lower intercept, t – titanite, u – upper intercept, x – xenotime, z – zircon

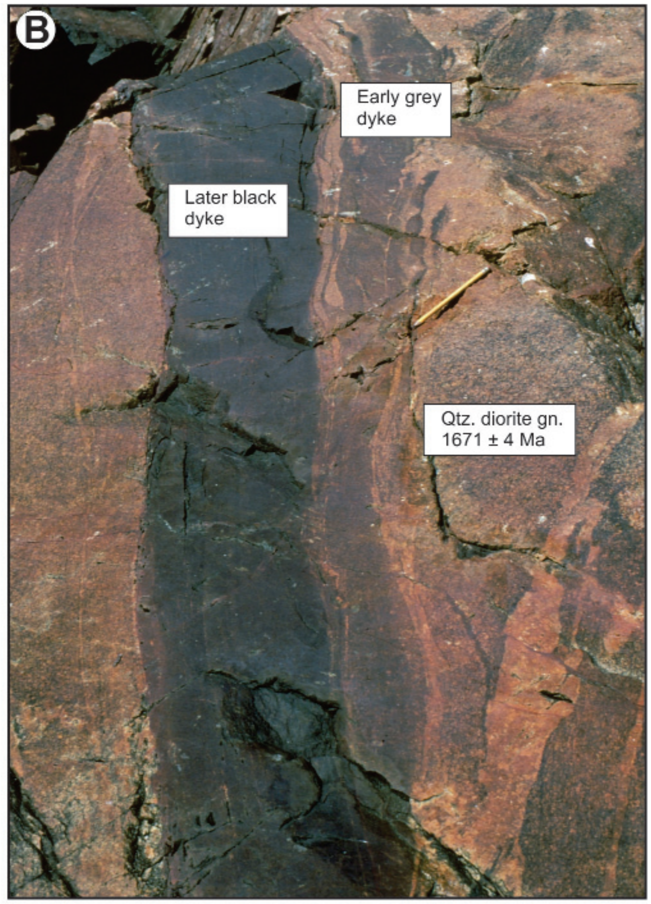


Plate 10.5. *Key U–Pb geochronology locality at Red Island in Hawke River terrane. The later black dyke can be traced without interruption across the outcrop (CG84-436). A. Overview of outcrop showing quartz diorite gneiss, later mafic dyke and locations of B and C, B. Quartz diorite gneiss, early grey migmatized dyke, and later black unmigmatized dyke, C. Later black unmigmatized dyke crosscut by intermediate K-feldspar megacrystic dyke.*

ing chilled margins against its host (close to, but not the same dyke as that illustrated in Plate 10.7B). Given its amphibolite-facies metamorphic state, the mafic dyke is inferred to predate widespread U–Pb closure in titanite at 1645 Ma in that area. Emplacement of pegmatite, dated to be 1622 Ma, and titanite closure in amphibole and tonalite/granodiorite gneiss at *ca.* 1615 Ma, document waning Labradorian magmatism and metamorphism. Pinwarian, Grenvillian, Neoproterozoic, and Phanerozoic events were all subsequently experienced, albeit weakly and recognized only sporadically.

In addition to dating the Earl Island intrusive suite, the U–Pb geochronological data serve to bring into focus two important points. The first point is demonstration of the difference between early to mid-Labradorian events (which are given the designator P_{3B}) and mid- to late-Labradorian events (which are given the designator P_{3C}). From a regional mapping perspective, the early Labradorian migmatitic metamorphism is taken as marking the boundary between the two time divisions. Thus migmatized and unmigmatized mafic dykes have generally been given P_{3B}d and P_{3C}d designators, respectively, by the author. Such a scheme works

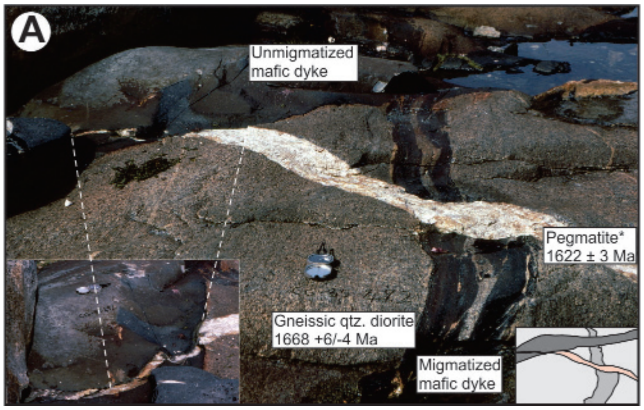


Plate 10.6. *Key U–Pb geochronology locality at Partridge Bay in the Hawke River terrane. The host gneissic quartz diorite was intruded by an early mafic dyke, followed by deformation and migmatization. The later mafic dyke postdated migmatization but was subsequently intruded by pegmatite. Inset is intended to better illustrate intrusive relationship of pegmatite into unmigmatized mafic dyke. *Actual dated pegmatite is farther west, but cuts the same unmigmatized mafic dyke (CG85-492).*

reasonably well in areas where later high-grade metamorphism is lacking (Hawke River terrane and parts of the Groswater Bay terrane), but is less satisfactory where Pinwarian or Grenvillian effects are severe (Pinware and Lake Melville terranes, respectively).

The second point is that the time boundary between P_{3B} and P_{3C} events is difficult to impose rigidly. For example, to the author, it seems reasonable to assign the *ca.* 1660 Ma granitoid rocks included in Table 10.1 to the Earl Island intrusive suite (P_{3B} rocks), even though they postdate the migmatitic event. The reasons for doing this are, i) spatial association, and ii) contrast with the slightly later P_{3C} 1650 Ma mafic and AMCG rocks in eastern Labrador (*e.g.*, White Bear Arm complex, Mealy Mountains intrusive suite). Going beyond the data, the author's thinking is that, if 1665 Ma represents the time of accretion of an outboard Labradorian arc, as suggested by Gower and Krogh (2002, 2003), then the muscovite granite could be a manifestation of the change from subduction to collisional orogenesis.

The Sm–Nd isotopic data have been reported for the four U–Pb dated samples (Schärer, 1991), plus five others (that were collected along the highway south of Cartwright; Hewitson, 2010; Moumblow, 2014). The data are summarized in Table 10.2. Calculations are based on the reported U–Pb age, or 1670 Ma if no date is available. The data show remarkable consistency in their near-chondritic εNd(t) values (–0.14 to +1.20) and in their T_{DM} ages (1989 to 1868 Ma), confirming the coherence of these rocks as a geological entity.

Schärer (1991) also obtained Rb–Sr isotopic data for the U–Pb-dated samples yielding values of $I_{Sr(t)}$ = 0.70242, 0.70277 and 0.70259 (samples CG84-436A, CG85-492A, CG86-654A; 't' being their U–Pb emplacement ages). Schärer analyzed the remaining dated sample (CG85-532A), but did not report the value that can be derived from it ($I_{Sr(t)}$= 0.70085).

10.2.2 FIELD CHARACTERISTICS

10.2.2.1 Diorite and Quartz Diorite (P_{3B}dr)

At the outset of this section, it is acknowledged that field identification of relatively similar granitoid rocks in the EIIS, especially dioritic and tonalitic/granodioritic rocks is prone to inconsistency and inaccuracy (partly related to pink hues caused by hematite alteration). The reader is assured however, that discrimination is backed up by several hundred stained slabs (for K-feldspar) and about 300 thin sections.

Diorite and quartz diorite are the most abundant rock types within the EIIS, comprising about 60–65% of the total surface area on the map. In contrast, they comprise about 45% of granitoid rocks according to field identifications and 38% of thin sections. The difference is explained as due to diorite being adopted as the default rock type in areas lacking exposure. The rocks typically weather mid to dark grey,

Table 10.2. Sm–Nd isotopic data for the Earl Island intrusive suite

Sample No.	Rock Type	Age Basis	εNd	T_{DM} (Ga)
CG04-157B	Monzodiorite	Regional correlation (Moumblow, 2014)	0.53	1.937
CG84-436A	Red Island hornblende quartz diorite	1671 ± 4 Ma U–Pb age (Schärer *et al.* (1986, same sample)	0.03	1.968
CG85-492A	Partridge Bay quartz diorite	1668 +6/–4 Ma U–Pb age (Schärer and Gower, 1988; same sample)	-0.14	1.989
CG85-532	Shoal Bay granite	1663 ± 3 Ma U–Pb age (Schärer and Gower, 1988; same sample)	0.39	1.931
CG85-654	Shoal Bay tonalite–granodiorite gneiss	1671 +4/–3 Ma U–Pb age (Schärer and Gower, 1988; same sample	0.11	1.966
RH-001	Diorite, quartz, biotite, hornblende, mylonitic	Regional correlation (Moumblow, 2014)	0.54	1.938
RH-002	Granodiorite, biotite, hornblende	Regional correlation (Moumblow, 2014)	1.20	1.900
RH-003c	Monzonite, quartz, biotite	Regional correlation (Moumblow, 2014)	1.15	1.868
RH-004a	Granite/monzonite, quartz, biotite	Regional correlation (Moumblow, 2014)	1.06	1.900

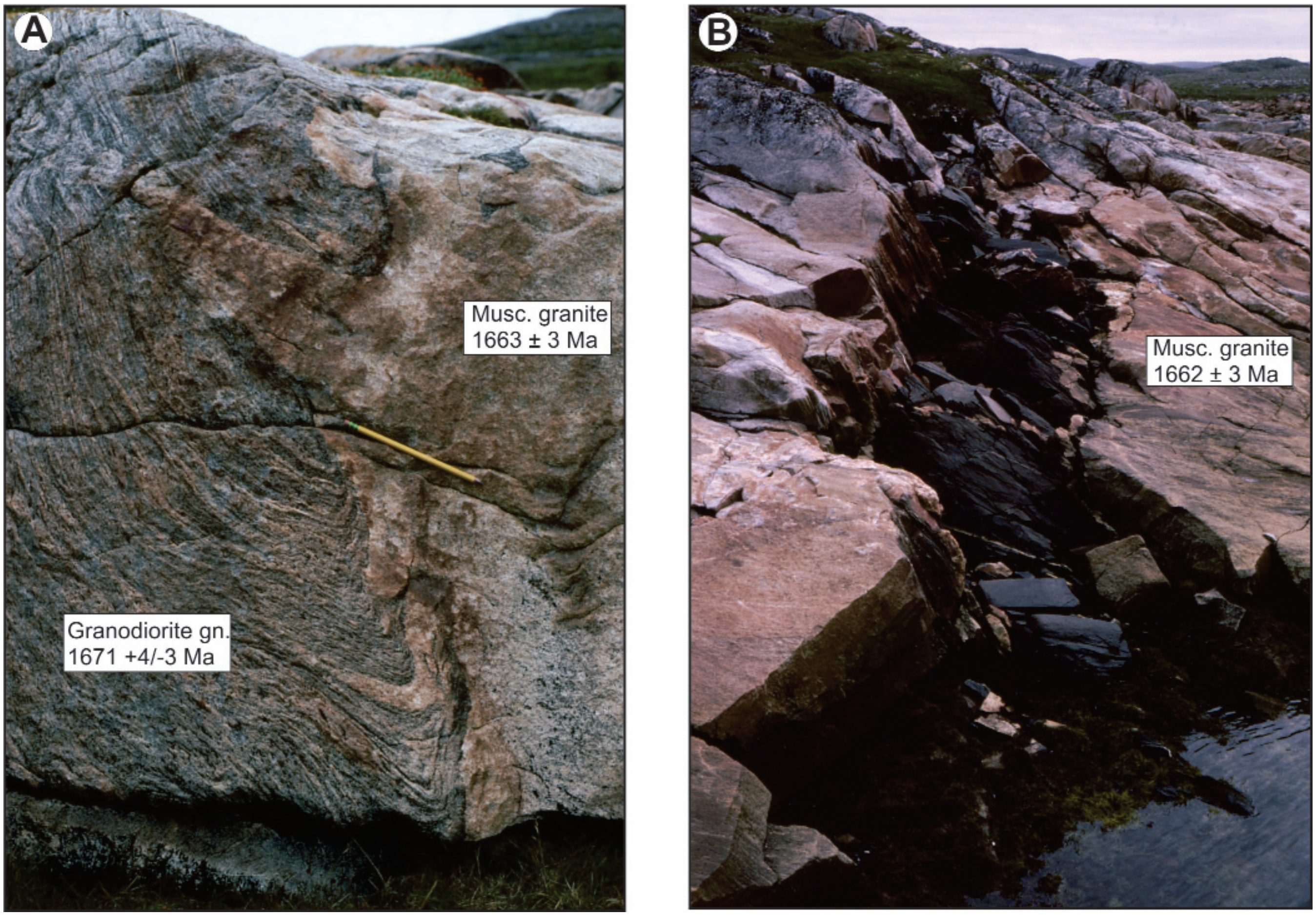


Plate 10.7. *Composite key U–Pb geochronology locality at Shoal Bay in Hawke River terrane based on two sampling sites 1.8 km apart. The muscovite-bearing granite was dated at both localities and is correlated (CG85-532 and CG85-654). A. Granodiorite gneiss discordantly intruded by muscovite-bearing granite (CG85-654), B. Muscovite-bearing granite intruded by unmigmatized mafic dyke (CG85-532).*

but may be light grey, pinkish, white, creamy brown, or have a ‘salt-and-pepper’ appearance. Grain size varies from fine to coarse, although a medium-grained, recrystallized character is normal. Deformational foliations vary from weak to strong, and are mylonitic in many places. Good examples of intensely mylonitized and strongly lineated rocks (giving top-to-the-north sense of shear) can be seen at CG04-156 and CG04-159.

The rocks generally exhibit some evidence of migmatization, but may have broad, homogeneous zones, or show poorly defined, diffuse banding. Migmatitic fabrics range from having rare leucosome to being well-banded gneiss. Leucosome occurs in a wide range of habits, including sparse and discontinuous to abundant, streaked-out, schlieric, schistose, contorted, discordant or concordant stringers, layers, lenses and irregular patches. Locally, a second leucosome, discordantly intruding the first, is present. Some of the leucosome or pegmatitic sweats contain large hornblende crystals (rarely, allanite or biotite; but not pyroxene). Also present are mafic-rich veneers, schlieren, clots or enclaves, variously dominated by biotite, amphibole, or, locally, epidote. In addition to the heterogeneity introduced through migmatization, there are many indications of variation in the initial protolith, which may include leucodiorite/leucoamphibolite and various more felsic granitoid rock types.

The status of mafic enclaves (whether xenoliths or former mafic dykes disrupted by deformation) is commonly equivocal. Where they occur as layers or trains of boudins they are more readily interpreted as former dykes, but their origin is indeterminate where they are simply contained in their host dioritic rocks as irregular, shredded, lensy, or flattened migmatized masses aligned parallel to the prevailing foliation. Their composition includes ultramafite (pyroxenitic; GM85-337, GM85-540, GM85-576, MC77-025, MC77-027, MC77-042), metagabbro, or melanocratic to leucocratic amphibolite, locally showing plagioclase-phyric or relict ophitic texture. Note that these enclaves could equally well be grouped with the unassigned ultramafic and mafic rocks described in the previous chapter (Sections 9.3 and 9.4), and may correlate.

Xenoliths of metasedimentary gneiss (generally pelitic) occur sporadically throughout the EIIS. Corundum-bearing pelitic gneiss occurs with muscovite schist at CG85-167 (Section 7.3.2).

Microgranite, pegmatite or quartz veins, pods and lenses are common in places, varying in width from less than 1 cm to several metres. The minor intrusions are variably recrystallized, deformed and dismembered. They pre- and postdate migmatization; pre- and postdate mafic dykes; and are, undoubtedly, of several different ages. Some carry unusually large epidote crystals (CG04-163), or biotite books (CG85-506). Hematite-stained, epidotized and/or chloritized veins and fractures are found throughout the body, commonly imparting a pink colour to the adjacent host dioritic rocks (or maroon to amphibolite). Breccia zones, characterized by hematite-, chlorite-, epidote- or silica-alteration, are seen in a few places.

10.2.2.2 Tonalite and Granodiorite (P_{3B}gd, P_{3B}gp)

Tonalite and granodiorite constitute 38% of granitoid rocks according to field identifications, and 33% according to thin sections. These rock types are most common in the southern part of the EIIS, although there is some suggestion from map patterns that they form alternating zones with the dioritic rocks farther north. Gower *et al.* (1985) considered that the granodiorite might be at a slightly higher structural level and infolded into the diorites as keels farther north. Both transitional and intrusive boundaries between dioritic and granodioritic rocks were seen in the field.

Tonalitic to (mainly) granodioritic rocks in the EIIS are similar in texture and fabric to the dioritic rocks and the description already given for the dioritic rocks can be applied to this subgroup also. There are no systematic differences in migmatitic state, nature of leucosome, restite, enclaves or minor intrusions. Some differences are that the rocks tend to be more commonly pinkish and have a lighter colour related to lower mafic-mineral content, especially with respect to amphibole. One significant difference is the presence of seriate to K-feldspar megacrystic textures in the granodioritic rocks, particularly in the eastern part of the EIIS. Commonly, the megacrysts are quite sparse and small (<0.5 cm), but reach up to 3 cm in diameter (*e.g.*, CG85-572, GF81-077, GF81-344). Subjectively, it seems that magnetite is more common in the granodioritic rocks.

10.2.2.3 Granite (P_{3B}gr)

Granite is not common in the EIIS, except at its eastern end. It constitutes 9% according to field identifications, but 20% of thin sections. The author guesses that granite is over-represented in the thin-section collection.

Throughout most of the EIIS, granite is simply a more quartz- and K-feldspar-rich variant of the granodiorite and probably represents little more than a differentiate of it. It is white, pink, or creamy brown, generally medium to coarse grained, schlieric banded in part, and forms mixtures with microgranite and pegmatite. Locally, it was termed syenite in the field, but stained slabs indicate that such a name is a misidentification caused by misleading hematite staining of plagioclase.

Especially in the Shoal Bay area, granite at the eastern end of the EEIS is distinct, in that it is unmigmatized and contains muscovite, along with chlorite, epidote and biotite. As illustrated in the geochronology section (Section 10.2.1), this rock type shows numerous contacts that discordantly truncate fabrics and minor intrusions in more typical EIIS migmatized dioritic and granodioritic rocks (Plate 10.7A). U–Pb geochronological data demonstrate that the muscovite granite is about 10 million years younger than the migmatized rocks it intrudes. Whether it should be classified as part of the EIIS is open to discussion (Section 10.2.1). Affinity between the two groups could be tested using whole-rock geochemical data. Note that the Nd isotopic data for muscovite granite sample CG85-532A shows no evidence of significant crustal contamination from appreciably older crustal sources.

10.2.2.4 Monzodiorite and Monzonite (P_{3B}mq)

Monzodiorite and monzonite are the least abundant rock types (8% – field identification; 9% – thin sections). Apart from composition, these rock types are similar to those previously described from the EIIS. Abundant mafic enclaves are noted at a few sites and K-feldspar megacrysts up to 2 cm across are also reported in field notes.

10.2.2.5 Mafic Dykes (P_{3B}d)

At least three generations of metamorphosed dykes have been identified; those predating migmatization (1670–1665 Ma), those postdating migmatization but predating 1660 Ma (1665–1660 Ma), and those postdating 1660 Ma but predating moderate- to high-grade metamorphism (1660–1645 Ma). This semi quantitative subdivision is probably an oversimplification. Equally plausible is that a continuum of Labradorian mafic dyking occurred, possibly extending beyond the time limits currently established. Metamorphosed mafic dykes are addressed more thoroughly in the next chapter.

10.2.3 PETROGRAPHY

The 284 thin sections of granitoid rocks assigned to the EIIS have been grouped as diorite, quartz diorite, tonalite, granodiorite, monzodiorite, monzonite and granite. Other associated rocks for which thin sections are available are mafic dykes, other mafic rocks (not demonstrably dykes), metasedimentary gneiss, mylonite and pegmatite. Some details of the 'other associated rocks' are given elsewhere in the text. In the descriptions given below, percentages of samples carrying specific minerals are given in places. These are not to be considered precise as their presence might have been missed during petrographic examination or overlooked when data were entered into the petrographic database.

Despite the wide range of granitoid rock compositions, the petrographic features of the rocks can be described collectively as many of them are shared by all rock types, and the differences that do exist are those that normally correlate with compositional variation. All the major silicate minerals (plagioclase, K-feldspar, quartz, biotite and hornblende) are judged to be partly relict igneous and partly metamorphic. Plagioclase is present in all the granitoid rocks as anhedral irregular to polygonal grains, moderately to severely altered, showing moderate to good twinning, except where masked by alteration. Albitic margins and/or myrmekite are present in some of the more K-feldspar-rich rocks. K-feldspar was not recorded in about 15% of the rocks (diorite, quartz diorite and tonalite). In the rest, it is mostly microcline, but noted to be poorly or untwinned in about 25% of samples. Relict perthite is present in some of the granodioritic/granitic rocks. Quartz is typically undulose, sutured or polygonal. It is absent in some dioritic rocks that are transitional into amphibolite. Biotite (or, in some rocks, chlorite after biotite) is present in all samples and roughly equally divided between orange-brown, buff, and olive-green types. Hornblende is present in about 55% of thin sections, ranging from leaf-green to blue-green. Some thin sections (*e.g.*, CG85-054, GM85-640A), show evidence of hornblende breakdown according to the generalized retrogression-to-greenschist-facies reaction: (Photomicrograph 10.1B)

Hornblende + Plagioclase = Biotite ± Chlorite ± Epidote ± Na-richer Plagioclase ± Opaque mineral ± Titanite

Of the less-abundant and non-secondary silicates, muscovite is the most significant. It occurs as a minor, sporadic mineral throughout the EIIS, but, restricting attention to samples where it is deemed to be igneous, its distribution shows a tight clustering in the east (Shoal Bay area and vicinity). Secondary white mica was recorded separately from muscovite (present in about 30% of samples), and interpretational overlap undoubtedly exists with muscovite deemed to be metamorphic. Pale-green clinopyroxene, interpreted to be igneous, occurs in two rocks (GM85-079, GM85-611B; monzodiorite and diorite, respectively), and garnet was noted in eleven samples (CG85-354, GF81-024, GF81-045A, GF81-047A, GM85-644B, LC85-110, VN85-583, VN85-601, VO81-400C, VO81-408, VO81-442). In sample GF81-045A, garnet appears to have developed at the expense of hornblende during mylonitization. Sample GF81-047A is also mylonitized showing porphyroclastic, zoned garnet. Based on petrographic data alone, concentration of garnet shows a good correlation with the northern border of the EIIS (Chapter 21). This might be interpreted as being related to uplift along the Hawke River terrane – Groswater Bay terrane during Grenvillian orogenesis, but as field notes indicate scattered garnet elsewhere in the EIIS, such a model is probably an oversimplification.

One of the most characteristic features of the EIIS mineral assemblages is the prevalence of epidote and allanite (in about 85% of samples), typically displayed in the well-known relationship of epidote mantling allanite. In some cases, allanite shows multiple growth stages (*e.g.*, GF81-058, GM85-623). Allanite-cored epidote occurs as porphyroclasts in mylonite (*e.g.*, GM85-644B, VN85-091), indicating that it predates major deformation (Photomicrograph 10.1C). The author is unsure whether the epidote is igneous or metamorphic, but, in any case, it is characteristic of the Groswater Bay and northern Hawke River terranes, being largely lacking in the more southerly terranes (Chapter 21).

Other accessory minerals present are opaque oxide and sulphide minerals (sulphide in about 20% of samples), apatite, titanite (commonly mantling an opaque oxide), zircon (commonly showing rims, or multiple zonation, *e.g.*, VN85-511), equivocally identified monazite, fluorite (LC85-101, GM85-559; both in the east) and secondary chlorite, white mica, carbonate, prehnite, pumpellyite and serpentine.

10.3 LAKE MELVILLE TERRANE GRANITOID GNEISS

The Lake Melville terrane granitoid gneissic rocks have a similar range of rock types as those in the Groswater Bay terrane, namely diorite, quartz diorite, granodiorite, monzodiorite, monzonite, quartz monzonite, granite and alkali-feldspar granite, but a major contrast is that K-feldspar megacrystic granitoid rocks are much more abundant in the Lake Melville terrane. The rocks have moderately well-defined boundaries with the Groswater Bay terrane, Hawke River terrane and Mealy Mountains terrane.

As for the Groswater Bay terrane granitoid gneiss, the Lake Melville terrane granitoid gneiss is known from the earliest geological investigations along the coast of Labrador (Lieber, 1960; Packard, 1891). Packard applied the term 'Domino gneiss' to both the Groswater Bay terrane and Lake Melville terrane granitoid gneiss, a term also used for both by Daly (1902), Kranck (1953), Christie *et al.* (1953) and Eade (1962). The term 'Domino gneiss' has fallen into disuse, as it embraces several units, now separately distinguished.

Stevenson (1970), in the Rigolet–Groswater Bay map region, was the first to depict the Lake Melville terrane granitoid gneiss as being distinct from that of the Groswater Bay terrane. He described the granitoid gneiss in the Lake Melville terrane as more highly deformed, more migmatitic, more porphyroblastic and injected by more granitic material than granitoid gneiss in the Groswater Bay terrane (conclusions with which the author broadly concurs – *see* comments at the end of this section). The Lake Melville terrane granitoid gneisses were mapped in stages at 1:100 000 scale by Gower (1984, 1986), Gower *et al.* (1981, 1982b, 1985, 1987, 1988), Erdmer (1983, 1984), and van Nostrand (1992).

The term 'Lake Melville terrane granitoid gneiss' is an informal term that has been in use for many years. Within it, two areas can be identified that are dominated by a particular rock type, in which case these have been addressed specifically, namely the Rigolet quartz diorite and the Western Lake Melville terrane megacrystic granitoid unit.

In the database for eastern Labrador, many of the rocks have been simply grouped as 'Lake Melville terrane granitoid'. These are mainly granodiorite or granite gneiss, but the group is not restricted to these rock types. In addition, categories were established for 'Lake Melville terrane megacrystic granitoid', 'Lake Melville terrane diorite', 'Lake Melville terrane alkali-feldspar granite', where the author felt that there was some merit in making a distinction. Readers, with some justification, might well regard such groupings as somewhat inconsistent – but such are the frustrations of the never-easy task of classifying orthogneiss.

10.3.1 ISOTOPIC DATA

10.3.1.1 U–Pb

Early- to mid-Labradorian gneissic granitoid rocks in the Lake Melville terrane have been dated at three localities. From northwest to southeast, these are Neveisik Island, Second Choice Lake and Red Point. Data from a fourth locality, at Mecklenburg Harbour, which is regarded as slightly anomalously young by the author, is also addressed (sites located on Figure 10.1).

A megacrystic granitoid rock from Neveisik Island (Plate 10.8A, B) has an age of 1678 ± 6 Ma, based on a regression of three discordant zircons, anchored by concordant titanite at a lower intercept of 1026 Ma (Schärer *et al.*, 1986; sample CG83-554). From Second Choice Lake, Schärer *et al.* (1986; sample CG84-495) dated a banded migmatitic gneiss (Plate 10.8C) to be 1677 +16/–15 Ma, based on two discordant zircon points and anchored by concordant monazite at a lower intercept of 1030 ± 2 Ma. From Red Point, Scott *et al.* (1993; sample S60) reported an age of 1664 +14/–9 Ma based on four near-concordant zircon analyses from a leucogranitic vein. Field relationships, showing that the leucogranitic vein transects amphibolite-facies sinistral strike-slip mylonitic fabrics but is itself deformed by ductile deformation, were interpreted to indicate that the leucogranitic vein was emplaced into an active shear zone.

From the fourth locality, Mecklenburg Harbour, Scott *et al.* (1993; sample S23A) obtained an age of 1644 +8/–6 Ma for a megacrystic granitoid rock (Plate 10.8D) based on four discordant zircon fractions (one nearly concordant). This date was questioned by Gower (1996) for several reasons, namely: i) neither the 1644 Ma upper intercept nor the *ca.* 890 Ma lower intercept are typical of the Lake Melville terrane, ii) the megacrystic granitoid rock is intruded by two phases of mafic dyke (including early very deformed dykes (*e.g.*, Plate 10.8D), a feature consistently associated with granitoid rocks having pre-1665 Ma ages elsewhere in eastern Labrador, and iii), at the same outcrop, Scott *et al.* (1993; sample S23D) dated a Grenvillian minor granitoid intrusion to be 1062 +5/6 Ma, but having inheritance of 1790 +142/–122 Ma. The inheritance is older than any dated rock from the Lake Melville terrane. Gower (1996) suggested regressing the data for the Labradorian megacrystic rock with that for the Grenvillian minor intrusion (arguing that the inheritance came from the megacrystic rock and was the cause of the Pb loss in the host rock), but D. Scott (personal communications, 1994, 1995), noted that such a model leads to zero probability of fit and that two additional fractions refined the upper intercept to 1644 +5/–3 Ma. The author has intransigently refused to modify his regional field and geochronological synthesis based on numerous dates in order to accommodate one inconsistent result, but such may still be necessary.

10.3.1.2 Sm–Nd

Sixteen samples of rocks interpreted to be early Labradorian felsic plutonic rocks have been analyzed from the Lake Melville terrane, eight of which are megacrystic and eight, non-megacrystic. Both show similar ranges of εNd values and T_{DM} ages. For the K-feldspar megacrystic rocks (CG03-354G, CG83-554, RM11-005, CG86-053B, CG86-285, CG86-746A, MN86-224, RH-008c) these are εNd = –0.15 to +2.30 and T_{DM} between 2025 and 1797 Ma, and for the non-megacrystic rocks (CG84-495A, RH-009, RH-015, RH-018, RH-019, RH-022, RH-028, SN86-023) the results are εNd = –0.35 to +3.58 and T_{DM} between 2034 and 1700 Ma. These values differ from those in the Groswater Bay and Hawke River terranes in that they include some higher εNd values and younger T_{DM} ages. Calculations are based on reported U–Pb ages, where available, except for the Mecklenburg Harbour sample, for which 1670 Ma was used. For the remaining samples, an age of 1660 or 1670 Ma was adopted.

10.3.1.3 Rb–Sr

Brooks (1984) attempted to date Lake Melville terrane gneissic granitoid rocks from the eastern part of Lake Melville (mainland 10 km west of Neveisik Island) utilizing eight samples collected from three closely spaced sites (CG83-555A, B, C; CG83-556A, B; CG83-557A, B, C). A regression based on analyses of all eight samples yielded an errorchron of 1547 ± 60 Ma and I_{Sr} = 0.703 $I_{Sr(t)}$ values cal-

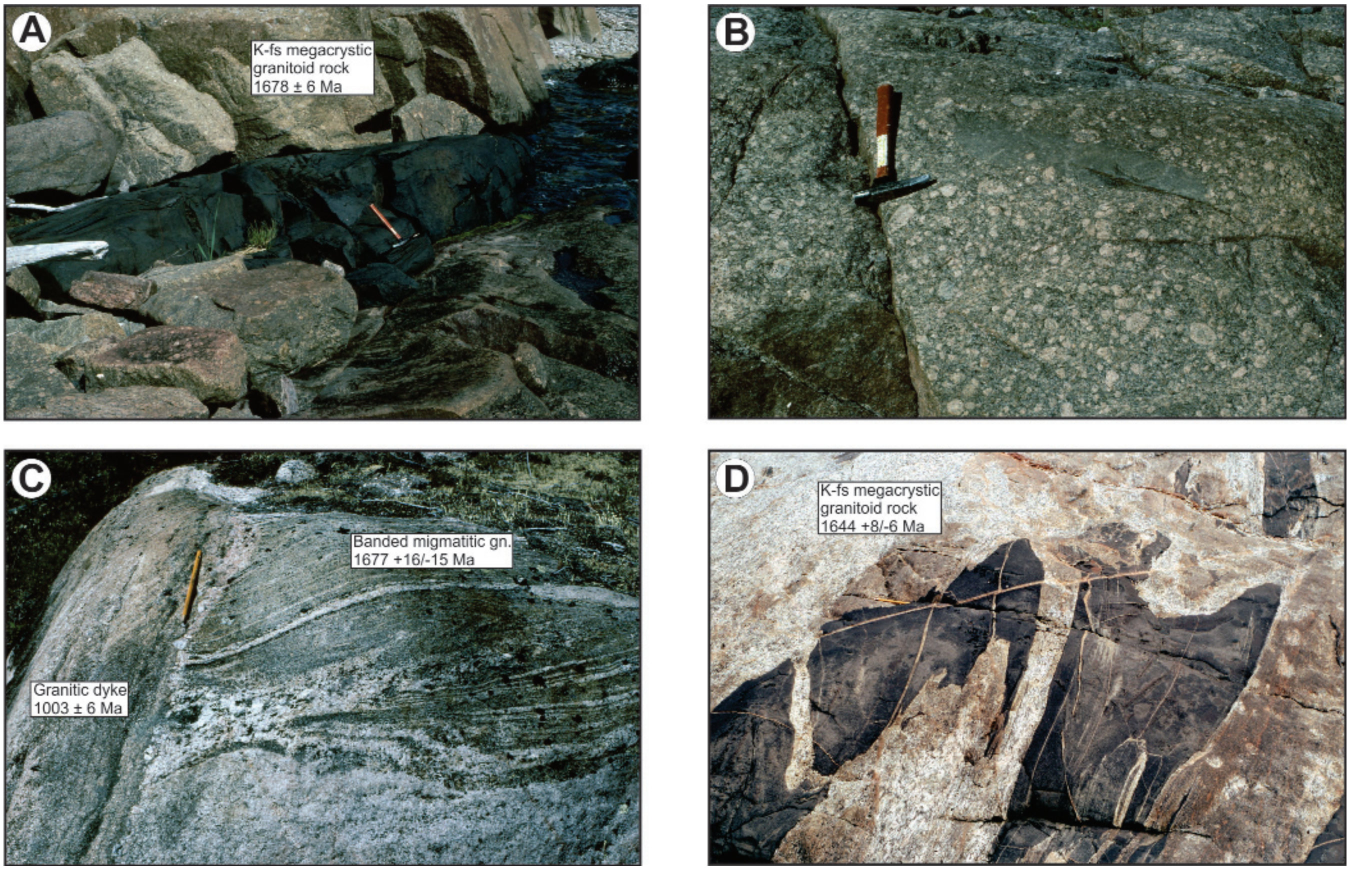


Plate 10.8. *Key U–Pb geochronology localities in Lake Melville terrane (Neveisik Island, Second Choice Lake and Mecklenburg Harbour). A. Neveisik Island K-feldspar megacrystic granitoid rock intruded by unmigmatized mafic dyke (CG83-554). B. Detail of Neveisik Island K-feldspar megacrystic granitoid rock, plus enclave (CG83-554), C. Granodioritic gneiss at Second Choice Lake discordantly intruded by granitic dyke (CG85-495), D. Mecklenburg Harbour. K-feldspar megacrystic granitoid rock intruded by boudinaged mafic dyke.* See *also Scott* et al. *(1993, Figure 6) (S23).*

culated for the individual samples for t = 1650 Ma, yield a range $I_{Sr(t)}$ = 0.68367 to 0.70344, plus one very anomalously low value of 0.63580 (Gower, 2010a; Rigolet map region). The errorchron age is nominally similar to a Paradise Arm pluton satellite at the mouth of Eagle River in the Hawke River terrane, which gave an errorchron date of 1555 ± 195 Ma.

The only other Rb–Sr data for Labradorian gneissic granitoid rocks from the Lake Melville terrane was reported by Schärer (1991) from Neveisik Island. The site has yielded a U–Pb age of 1678 ± 6 Ma. Using this result gives $I_{Sr(t)}$= 0.69783, thus supporting the implication of a short crustal history demonstrated by Brooks's multi-sample study.

10.3.1.4 Ar–Ar and K–Ar

No Ar–Ar or K–Ar data are available for Lake Melville terrane gneissic granitoid rocks. Some associated mafic rocks have been analyzed (Emslie *et al.*, 1984; van Nostrand, 1988; R. Dallmeyer, personal communication, 2002, 2010), and are mentioned in Section 9.4.1. All dates obtained are Grenvillian.

10.3.2 FIELD AND PETROGRAPHIC CHARACTERISTICS

In the Lake Melville terrane, gneissic granitoid rocks have similar compositional proportions to those in the Groswater Bay terrane. A difference, however, is that a higher proportion are K-feldspar megacrystic and/or augen gneiss (35% *vs.* about 20% for the Groswater Bay terrane).

10.3.2.1 Granodiorite to Granite Gneiss (Non-megacrystic) (P_{3B}gd, P_{3B}gr)

The rocks are white, creamy, pink, orange, ocherous (where pyritic), buff, pale-grey or dark-grey-weathering, reflecting both compositional variation and alteration. In particular, brick red-brown hematite alteration commonly gives some rocks a misleadingly syenitic appearance. The rocks vary from homogeneous and weakly foliated to well-banded gneiss. Streaky texture, lensy banding, flaser texture, nebulitic and straight gneiss are terms repeatedly applied. Mylonitic fabrics are sufficiently pervasive to be a defining characteristic. Slightly seriate to thoroughly porphyroblastic rocks, due to larger-than-groundmass K-feldspar, are common. These may be intermixed on a fine scale with more uniform granitoid rocks or form extensive swaths in their own right. Such rocks are typically fine grained and finely laminated. Drawn-out leucosome, K-feldspar-rich lenses and veins, stretched minerals, quartz ribbons and tectonic fish are all well represented. Kinematic features are readily found in all but the most severely deformed mylonitic rocks (mostly dextral or north-side-up). Complex, convoluted folding, including isoclinal and recumbent folding is characteristic and well displayed in outcrops along the shores of Lake Melville. Ptygmatic folds are common.

White or pink, aplitic to pegmatitic neosome is an integral part of Lake Melville granitoid gneiss, varying in abundance from a few percent up to about half of the rock. The form of the neosome varies according to deformation, from irregular patches in low-strain areas to highly attenuated pods and lenses in mylonitic zones. A range of grain sizes, from aplitic to pegmatitic is seen. Biotitic selvages are common. In a few cases, neosome is host to large hornblende or magnetite crystals (*e.g.*, CG80-040, CG80-041, NN80-146), or, more rarely, orthopyroxene (*e.g.*, CG84-153).

Intimately associated mafic material has the form of biotitic and/or hornblende-rich streaks, schlieren and schistose layers that grade into larger masses of amphibolite or metagabbro (some garnetiferous). These cover the spectrum from slivers and pods to concordant layers and larger boudinaged masses. The mafic component, in part, has a gneissic appearance due to interlayered concordant leucosome. The amphibolite may display diffuse margins with granitoid host rock, or show discordance to a pre-existing gneissosity. The discordance demonstrates that at least some of the amphibolite represents the remnants of former mafic dykes, of which at least two pre-metamorphic periods of dyking can be recognized (*e.g.*, CG80-145, CG80-147, CG80-148). The remnant dykes show open to tight folds. Less commonly, enclaves of pelitic or psammitic metasedimentary gneiss can be seen (CG03-290, VN91-056), although discrimination between an igneous and sedimentary protolith is not always certain.

A feature of Lake Melville terrane granitoid gneiss that deserves special emphasis is the abundance of aplite and pegmatite. As demonstrated by Scott *et al.* (1993), some pegmatite is Labradorian and was emplaced during deformation, but much was clearly emplaced during Grenvillian orogenesis (U–Pb dates by Schärer and Gower, 1988; Scott *et al.*, 1993; Wasteneys *et al.*, 1997; Corrigan *et al.*, 2000). The granitic minor intrusions display a wide range of size (up to 10s of metres wide) and habit, from concordant and extremely deformed, to discordant and pristine. At data station CG03-231, dismembered pegmatites form a series of porphyroclasts showing consistent dextral sense of displacement. Discordant pegmatite, of which there may be multiple phases (*e.g.*, VN84-324, VN84-504), is repeatedly recorded in field notes; some of the pegmatites show severe post-emplacement deformation. A few pegmatites have large hornblende (up to 3 cm across) or magnetite (up to 5 cm) crystals, which harkens back to similar features seen in gneiss neosome, and, indeed, both may present a continuum of geological process. Other minerals of note are fluorite (CG03-290), large allanite crystals (CG80-121, CG86-050), and garnet (up to 7 cm diameter – SN86-214; Plate 10.9A). Gneissic microgranite at CG86-319 contains enclaves of anorthosite.

Late-stage features within the Lake Melville terrane granitoid gneiss include fracturing, brecciation and shearing accompanied by epidote, chlorite and hematite alteration and the emplacement of associated quartz veins.

A total of 293 thin sections of Lake Melville terrane non-megacrystic granodioritic to granitic gneiss were examined. Of the felsic minerals, all contain plagioclase, 95% contain K-feldspar and 98% contain quartz. Plagioclase was interpreted to be metamorphic in 38% of thin section, igneous in 14% and a mixture of both in 48%. These values are very similar to those determined for Groswater Bay terrane granitoid gneiss. A small proportion of plagioclase grains show weak to moderate zoning and about 25% have albitic margins. K-feldspar is mostly microcline. Of the mafic minerals, biotite is the most common, being present in 90% of thin sections. In contrast to the Groswater Bay terrane granitoid gneiss, where biotite is mostly olive-green or green-buff, in the Lake Melville terrane about 80% is buff-orange, orange-brown or red-brown. Amphibole is present in 42% of thin sections, a moderate contrast to the 60% proportion in the Groswater Bay terrane granitoid gneiss. It is almost all green, blue-green, or green-brown hornblende. The grains are commonly ragged and relict. Clinopyroxene and orthopyroxene are both present in 7% of thin sections, and garnet is present in 20%, commonly having anhedral form and containing abundant quartz inclusions, and/or inclusions of opaque minerals, biotite, and plagioclase. Photomicrographs 10.2A, B illustrate examples of partially retrograded garnet (ghost garnet). About 95% of thin sections contain an opaque oxide and about 15% have some sulphide. Accessory minerals are muscovite, apatite, titanite, zircon, allanite, monazite, epidote (15% of thin sections, including instances where it is clearly late-stage), chlorite (mostly after biotite), scapolite (rare) and carbonate.

10.3.2.2 Megacrystic Gneissic Granitoid Rocks ($P_{3B}gp$)

Lake Melville terrane K-feldspar megacrystic gneissic granitoid rocks mostly have granodioritic to granitic compositions, but include minor quartz monzodiorite, quartz monzonite, and quartz syenite, the rock name being partly

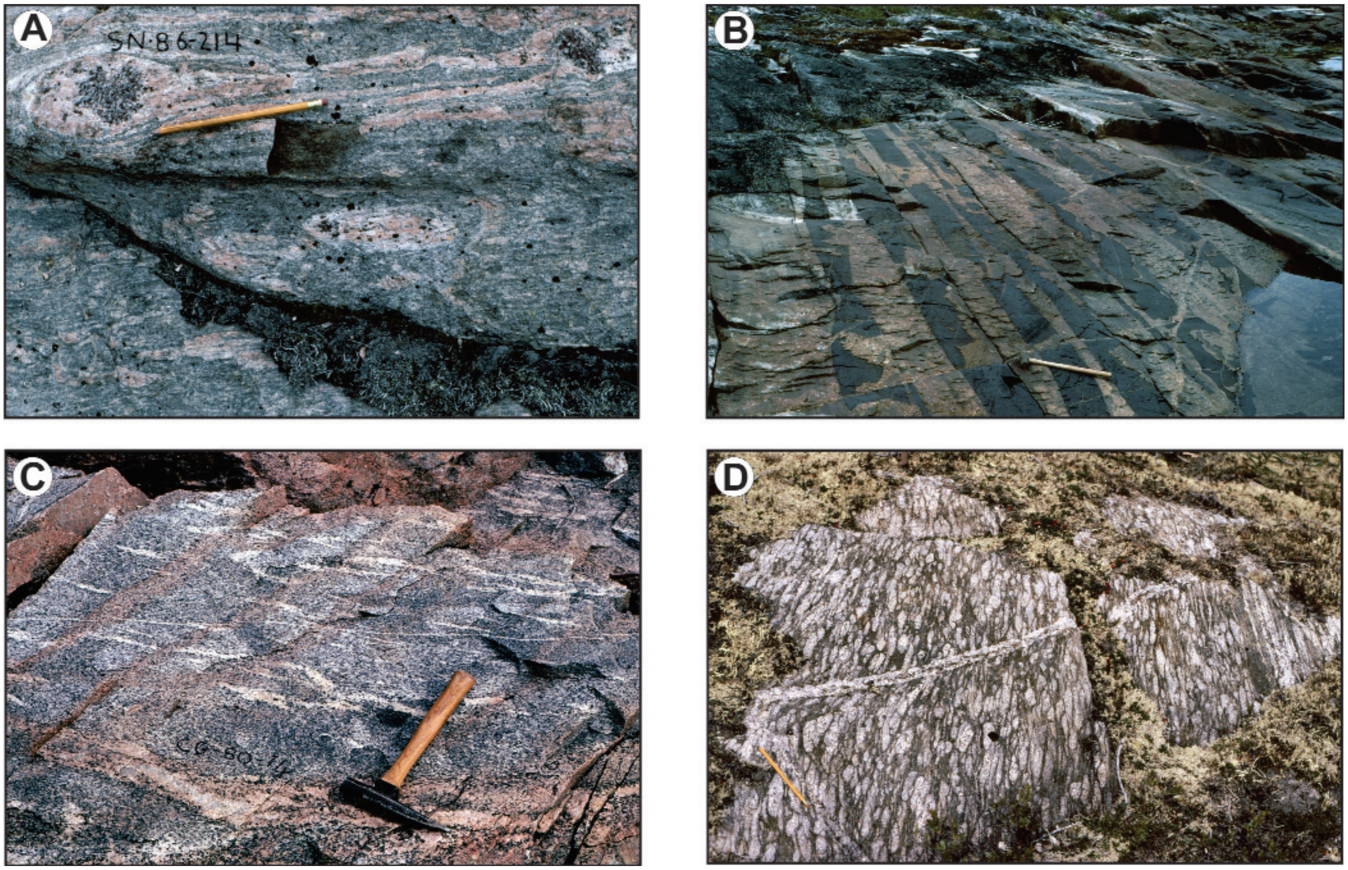
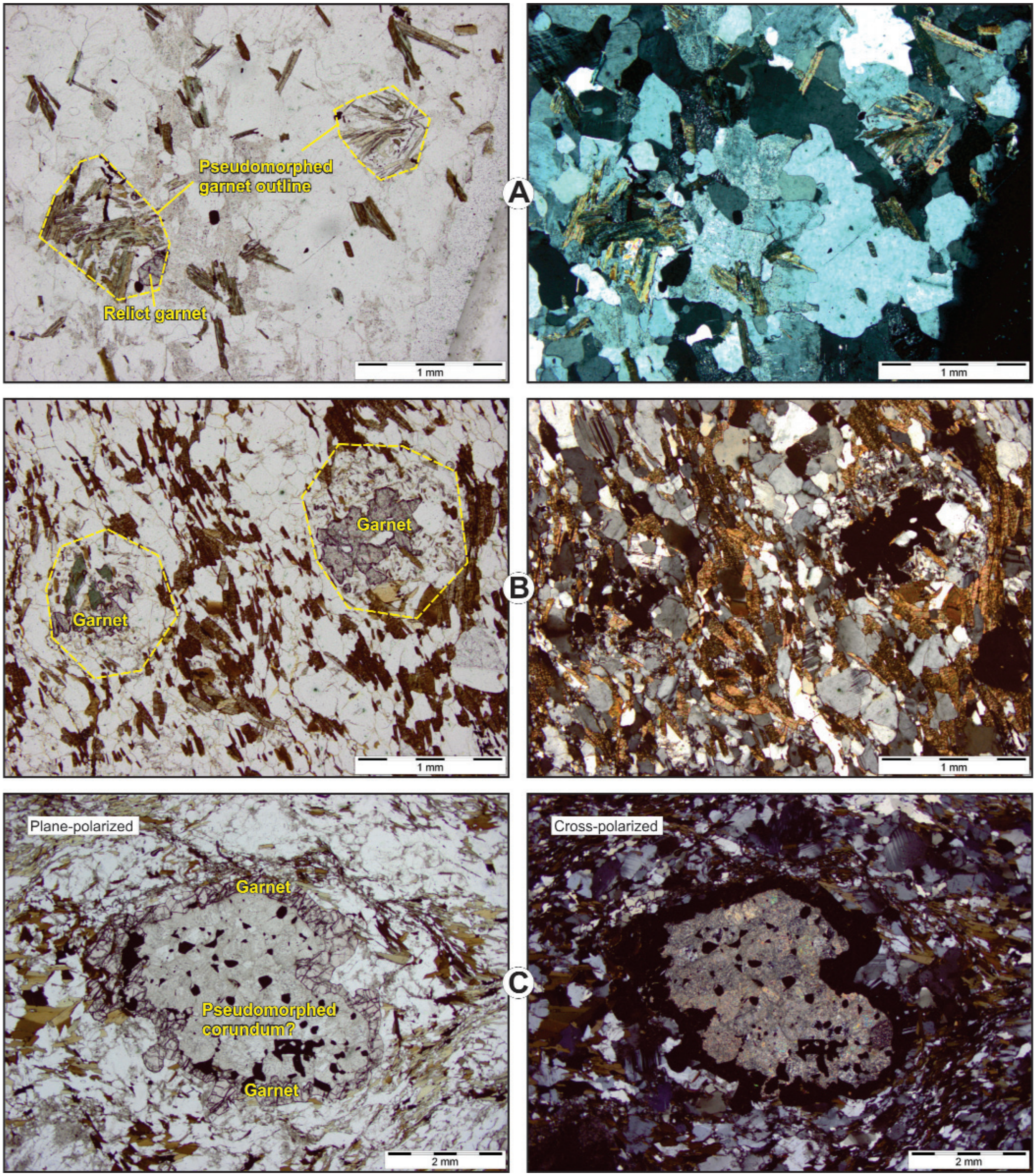


Plate 10.9. *Some specific features of Lake Melville terrane granitoid gneiss. A. Granodiorite to granite gneiss showing garnet–quartz (decompression?) symplectites in granitic leucosome (SN86-214), B. Granitoid rock intruded by parallel mafic dykes; 43 dykes counted on outcrop (CG86-746), C. Typical example of Rigolet quartz diorite (CG80-074), D. K-feldspar megacrystic granitoid rock, showing very large deformed megacrysts and discordant pegmatite vein (CG84-278).*

determined by the abundance of K-feldspar megacrysts. Much of the unit could, equally well, be termed granodioritic augen gneiss. The augen consist of partially to totally recrystallized K feldspar. In the augen gneiss, a pink quartzofeldspathic leucosome is normally present. Although most of the augen gneiss represents the deformed and migmatized equivalents of the K feldspar megacrystic units, some could be derived from porphyroblastic pelitic gneiss, with which the K-feldspar megacrystic rocks are spatially associated. Similar, but generally less-deformed rocks elsewhere, especially in the Hawke River terrane, have been assigned to Unit P_{3C}gp, but the time relationships between the two groups remain uncertain.

The rocks are white-, pink grey , or rusty buff weathering, and fine to coarse grained. Some are homogeneous, very weakly foliated and have an easily recognizable igneous plutonic protolith. Others have fabrics that can be variably described as well foliated, gneissic, nebulitic, well banded, finely laminated, or mylonitic. Marked planar fabrics may be matched by strong lineations, commonly subhorizontal (*e.g.*, CG80-188 where quartz grains are stretched to thin slivers 10 cm long). Intense recrystallization and grain size reduction is evident from a dark biotitic comminuted matrix.

The K-feldspar megacrysts vary (according to the degree of superimposed deformation) from euhedral, zoned, unrecrystallized crystals to smeared out, flattened, lensoid aggregates of recrystallized grains, not uncommonly having length:width ratios of 10:1 (*e.g.*, CG80-468, CG84-072, CG84-343). Commonly, they have pink or grey, intact, unrecrystallized cores and white recrystallized rims. Although the average size of the megacrysts is about 2 by 1 cm, they are locally as large as 5 by 4 cm (up to 8 cm at CG83-450), and may form 40 to 60% of the rock (CG86-370). The matrix of the megacrystic granitoid rock varies (again, according to extent of imposed deformation) from having a homogeneous, seriate or equigranular aspect to being dark-weathering, finely laminated and intensely comminuted, in which state the megacrysts remain as rounded porphyroclasts (CG84-033). Augen may be concentrated into zones.



Photomicrograph 10.2. *Some features of garnet in Lake Melville terrane granitoid rocks. A. Lake Melville terrane granitoid rock showing garnet partly to completely pseudomorphed by biotite and plagioclase (ghost garnet) (MN86-128), B. Another example of partial pseudomorphs of garnet (MN86-459), C. Lake Melville terrane granitoid rock showing garnet corona around white mica pseudomorph of unknown mineral (corundum?) (CG03-354G).*

In places, migmatization has imparted a banded appearance resulting from alternating white or pink, streaky to patchy, quartzofeldspathic leucosome and biotite rich palaeosome. In a few instances, at the southeast end of the terrane, the leucosome carries hornblende porphyroblasts (CG03-257, CG03-278, CG03-282, CG03-291). Garnet (up to 1 cm in diameter) is present in leucosome at a few localities (CG03-265, CG80-528, CG87-150). Magnetite is also commonly seen in leucosome, but orthopyroxene only rarely (CG86-185).

Irregular rafts of sillimanite–garnet pelitic gneiss are found in less-deformed K-feldspar megacrystic rocks, but, where deformation is more severe, pelitic gneiss forms narrow screens. In extreme cases, these are reduced to narrow, schistose, biotite-rich zones or streaky mafic veneers. Contacts with pelitic gneiss are invariably concordant and sharply defined. An apparent exception is locality CG86-741, where the contact was recorded as gradational.

Amphibolite is a near-ubiquitously associated rock, variously occurring as elongate enclaves, pods and boudinaged or folded layers, varying from a few centimetres to tens of metres in width and hosting white-weathering leucosome. It is clearly evident, from numerous examples, that the amphibolite represents the remnants of mafic dykes that either predate or postdate migmatization. Two periods of mafic dyking are demonstrated at CG86-156. Net-veined dykes are present in places (CG80-181, CG80-182, CG86-160). At CG86-746, 43 parallel-sided mafic layers were counted (Plate 10.9B). As there is no indication of isoclinal folding at this locality (unlike elsewhere, *e.g.*, CG83-552), they are interpreted to represent a swarm of parallel dykes. All the mafic intrusions are metamorphosed to amphibolite.

The K-feldspar megacrystic granitoid rocks are intruded by minor aplitic and pegmatitic intrusions or quartz veins. They range from concordant, isoclinally folded, recrystallized veins to discordant, planar, pristine dykes. Sporadic minerals of note include magnetite, garnet (4 cm in diameter at CG03-197), allanite, muscovite, fluorite and pyrite. Late-stage features include hematite-quartz veins and fault breccia.

K-feldspar megacrystic rocks were examined in 109 thin sections. Plagioclase is anhedral, polygonal, poorly to moderately twinned and lightly to moderately sericitized. K-feldspar is dominantly anhedral, well-twinned microcline, but some finely exsolved perthite is seen in a few thin sections. Quartz is anhedral and polygonal. Biotite occurs as aligned flakes that are typically orange-brown, but may be buff, bronzy or locally olive-green. Amphibole is locally present as ragged, relict leaf-green or blue-green crystals. Garnet typically occurs as anhedral, amoeboid grains, partly retrograded to biotite + plagioclase in several instances. Quartz, feldspar and opaque inclusions are commonly present in garnet. Sample CG03-354G is unusual. Although the rock is, macroscopically, a typical K-feldspar megacrystic rock (*cf.* Appendix 2 Slab images 10.3), in thin section garnet forms a corona around a mosaic patch of polygonal secondary white mica flakes (Photomicrograph 10.2A). The garnet corona indicates that the core material is out of equilibrium with the host rock and is likely a xenocryst (originally corundum?). Clinopyroxene occurs in only two thin sections (CG83-452, MN86-234), and orthopyroxene in six (CG84-340, CG84-041, MN86-051, MN86-234, NN84-325, NN84-415A). The opaque mineral is typically an oxide, but trace sulphide is present in some samples. Zircon exhibits rounded to subhedral cores and narrow euhedral rims in most samples. Other minerals are apatite, allanite (buff, yellow and orange), titanite (typically secondary and associated with the opaque oxide) and minor secondary epidote, muscovite, chlorite and rutile. Key characteristics of this group of rocks are the rather ragged form of garnet and the lack of titanite (other than that attributed to the retrograde breakdown of amphibole or biotite). These two features suggest mineral assemblage equilibration at high temperatures and pressures, followed by decompression and hydration to give 'ghost' garnet and amphibole breakdown to biotite ± an opaque oxide ± titanite. Most of the epidote-, muscovite-, chlorite- and rutile-bearing samples are situated close to known late-stage shear zones. Note the prevalence of garnet distinguishes these samples from K-feldspar megacrystic granitoid rocks assigned to Unit P3Cgp, in which garnet is lacking.

10.3.2.3 Dioritic Rocks (P_{3B}dr)

Dioritic gneissic rocks in the Lake Melville terrane are concentrated in the Rigolet district and have been grouped together under the name Rigolet quartz diorite (Plate 10.9C). Unassigned dioritic gneissic rocks are scattered throughout the Lake Melville terrane, however.

Rigolet quartz diorite. The Rigolet quartz diorite was first mapped by Gower *et al.* (1981). It was not separately distinguished on the map of Stevenson (1970). The first in-print usage of a name for the unit (Rigolet diorite) was by Corrigan *et al.* (1996). The term is refined to 'Rigolet quartz diorite' here, to improve descriptive accuracy.

A sample was investigated by U–Pb geochronological methods by Corrigan *et al.* (2000). Five zircon fractions were analyzed, four of which were discordant and yielded $^{207}Pb/^{206}Pb$ ages between 1986 and 1559 Ma. The other fraction, consisting of two tabular igneous grains, yielded a concordant result of 1489 +2/–8 Ma, which was taken as the time of emplacement. This date was challenged by Gower and Krogh (2002) who noted that the result relied on a single concordant fraction anchoring the lower intercept of a poorly correlated line that included two of the other four results and projected to an upper intercept of 2653 ± 37 Ma. Gower and Krogh's alternative explanation was that the scattered data points reflect pre-Labradorian inheritance, Labradorian emplacement and/or Labradorian, Pinwarian and Grenvillian Pb-loss. Corrigan *et al.* (2000) also argued that a lack of metamorphosed mafic dykes militated against a Labradorian age – an observation contradicted by Gower and Krogh (2002). Further mention of mafic dykes is given below. Given mutual similarity of rock type and tectonic setting, the Earl Island intrusive suite (1670 Ma – *see* earlier) and the Susan River quartz diorite (1672 +11/–10 Ma; Philippe *et al.*, 1993; west of the limit of map coverage in Figure 10.1) were advanced as potential correlatives.

The rocks consist of pale- to mid-grey, locally pinkish or creamy, medium-grained diorite, quartz diorite, tonalite and granodiorite. Diffuse, indistinct layering, possibly of primary igneous origin was noted at CG80-113. The rocks are recrystallized, commonly garnet bearing and migmatitic, but are, overall, fairly homogeneous. Fabric is mostly moderate and ranges from lacking to locally intense. A crude gneissic banding is typically present, defined by irregular, lensy, discontinuous or nebulitic leucosome, more-or-less parallel to the prevailing fabric. Leucosome, on average, makes up to 10% of the rock, and is generally in the 0 to 20% range, although, rarely is up to 60%. The leucosomes may be hornblende or garnet bearing. The gneissosity, such as it is, is emphasized by biotitic schlieren (garnetiferous in part), hornblende-rich screens and bands and garnet-bearing amphibolite enclaves, lenses and layers. Field notes record amphibolite as metamorphosed mafic dykes at CG80-104, CG80-194, NN80-020, NN80-093, RG80-232, RG80-234 and RG80-324.

The diorite, quartz diorite and granodiorite are intruded by concordant and discordant pegmatitic veins and dykes that are mostly fairly narrow (a few centimetres), but an exception is present at CG80-115 where the pegmatite contains K-feldspar crystals 50 cm across (total width of dyke was unrecorded). A few planar pegmatites have magnetite-rich central parts, forming up to 10% of the total width. Some pegmatites have hornblende- or epidote-rich margins. Discordant microgranite is found, but is rare. Brecciated zones with K-feldspar, hornblende, epidote, biotite, or fractures filled with secondary minerals (*e.g.*, epidote, quartz or hematite) were reported at CG80-124, CG80-519 and CG80-525.

Eleven samples were examined petrographically (CG80-042, CG80-074, CG80-101, CG80-110, CG80-464, CG80-518, CG80-525, NN80-021, NN80-564, SG68-069, SG68-197). They contain plagioclase, K-feldspar (microcline or untwinned), quartz, orange-brown biotite, leaf-green to blue-green hornblende, and opaque oxide and apatite. Other minerals sporadically recorded are zircon, titanite (mantling opaque minerals), epidote, allanite (multiple growth stages and cores to epidote), and chlorite (generally after biotite). The minerals are interpreted to be partly relict igneous and metamorphic. Corrigan *et al.* (2000) also noted clinopyroxene in the leucosome, on the basis of which, along with garnet, they suggested the uppermost-amphibolite facies reaction:

$$\textit{Hornblende} + \textit{Plagioclase1} = \textit{Garnet} + \textit{Clinopyroxene} + \textit{Plagioclase2} + \textit{Quartz} + H_2O$$

Neither garnet nor clinopyroxene are present in thin sections examined by the author, but garnet was commonly seen in outcrop in both the leucosome and its granitoid paleosome.

There is some plausibility that the Rigolet quartz diorite (Lake Melville terrane) correlates with the Earl Island intrusive suite (Hawke River terrane) given that a zone of predominantly dextral displacement is interpreted to separate the two terranes. The two units are morphologically very similar, the main difference being more garnet in the Rigolet quartz diorite.

Other dioritic rocks. Apart from the Rigolet quartz diorite, dioritic rocks are distributed throughout the terrane. Apart from being called diorite, they are described in field notes as: i) gradational into amphibolite, or ii) alternatively named as tonalite, or iii) speculated to have a metasedimentary (greywacke) protolith. Some localities, especially those along the south side of Henrietta Island, show well-preserved crosscutting mafic dykes and minor granitoid intrusions that provide insight into a multi-deformational geological history (*e.g.*, CG80-194, CG80-202, CG80-204). Many of the sites are found in the northern part of the Lake Melville terrane and may be dismembered remnants related to the Rigolet quartz diorite (Figure 10.1).

Of 28 thin sections examined in thin section, most have orange-buff-brown biotite and leaf-green to blue-green amphibole. One contains clinopyroxene (CG80-189) and four have garnet (CG80-163, CG80-201, MW82-078A, RG80-211).

10.3.2.4 Alkali-feldspar Granitoid Rocks and Syenite (P_{3B}ga, P_{3B}ya)

These rocks may well represent a distinct lithological entity from other Lake Melville terrane granitoid gneisses, and some, or all, may be unrelated to Labradorian events. Apart from a few sites, localities suggest a strike-parallel trend on the southwest side of the Alexis River anorthositic intrusion (Gower, 2010c; Figure 22). Occurrences show an apparent concentration of sites around St. Lewis, and west of Paradise River. This may be an artifact of more data stations in these areas as compared to the intervening region.

For the most part, the rocks are unremarkable in outcrop (at least at a reconnaissance-mapping observation level), so their separation also hinges on their stained-slab, thin-section or whole-rock geochemical character. The rocks tend to be pale-pink-weathering, coarse grained, and commonly not well foliated (although lensy banded, mylonitic or migmatitic apply in certain instances). Field notes for two localities provide minor enlightenment. At NN84-281, it was noted "[I] haven't seen anything like this [elsewhere]' (which petrographic study and a whole-rock analysis bear out; *e.g.*, high F and LREE) and, at VN91-449, the rock was recorded as massive pink granite containing biotite granodiorite gneiss enclaves (implying that is younger than the granitoid gneisses). Gower (2010c) noted that data station

MC77-151, at which fluorite, fayalite and hedenbergite were seen in thin section, is located 2 km along strike to the northwest of NN84-281. Even farther along strike to the northwest (27 km) site NN84-039 includes a rock anomalously enriched in Zr and LREE. The close proximity of NN84-281 and MC77-151 suggests that they might belong to a single body, but the extent to which the various other localities are related is unknown.

10.3.3 WESTERN LAKE MELVILLE TERRANE

Part of the western side of the Lake Melville terrane has somewhat distinct rock types, particularly a large body of K-feldspar megacrystic granitoid rocks and also some alkali-feldspar granite occurrences.

10.3.3.1 Megacrystic Granitoid Rocks (P_{3B}gp)

The K-feldspar megacrystic rocks are white-, pink-, creamy-, buff-, or grey-weathering and coarse to very coarse grained. They are most commonly described in field notes as homogeneous and strongly foliated, although a range of fabrics from massive to mylonitic are seen, related to local variation in strain. In rare instances, the rocks are referred to as gneissic, and, extremely rarely, as migmatitic.

It is the size and abundance of the K-feldspar megacrysts that make this unit distinctive. The megacrysts range up to about 10 cm in diameter and may constitute up to 50% of the rock (Plate 10.9D). In places, the texture is better described as seriate. Due to deformation, the K-feldspar megacrysts are now commonly seen as extremely flattened, pink, lensoid, recrystallized aggregates many centimetres long, wrapped around by groundmass minerals. The generally present mafic silicate is biotite, but subordinate hornblende was recorded in several places. Garnet is rare in the unit, but was noted sporadically (*e.g.*, MW84-059, where it is 1 cm in diameter). Clinopyroxene was seen in outcrop at CG84-306 and confirmed in thin section.

The megacrystic granitoid rocks are also found intermixed with other non-megacrystic gneissic rock types (either interleaved with them or having them as xenoliths) and amphibolite. Amphibolite occurs as distinct enclaves and less-distinct biotitic amphibolite schlieren. Locally, the amphibolite is heavily veined by concordant quartzofeldspathic material. In addition, it is clear that some of the amphibolite represents highly deformed metamorphosed mafic dykes (*e.g.*, CG84-200).

The megacrystic rocks are also intruded by concordant and discordant aplite and pegmatite, showing a range of deformational states. Some pegmatites were noted to have large biotite or magnetite (both up to 5 cm). The rocks are also transected by hematitic, epidote-filled, brittle fractures. Quartz-filled tension gashes were recorded at CG84-309. These features can be related to the Sandwich Bay graben.

Seventeen thin sections of the K-feldspar megacrystic granitoid rocks were examined. All contain relict igneous and metamorphic plagioclase, K-feldspar (mostly microcline), and quartz. All but two, contain biotite (olive-green to buff-orange). Over half contain leaf-green to blue-green hornblende, and one (CG84-306B) contains pale-green clinopyroxene. All but one contain an opaque oxide and about 25% have minor sulphide. Apatite, titanite (typically mantling opaque minerals) and allanite are present in most thin sections (three types of allanite in NN84-322). Secondary minerals are chlorite (after biotite), epidote and (in rare instances) carbonate.

10.3.3.2 Non-megacrystic Granitoid Rocks (P_{3B}gd, P_{3B}gr, P_{3B}ya)

The non-megacrystic granitoid can be subdivided into two groups, namely: i) granodioritic, dioritic, and amphibolitic gneiss with some monzonitic and granitic rocks, and ii) alkali-feldspar granitic, granitic, alkali-feldspar syenite and quartz syenitic rocks. Field evidence (albeit not as substantive as desirable) suggests that the alkali-feldspar granitic rocks are younger than granitoid gneiss of other compositions.

The granodioritic gneisses are grey-, dark-grey-, buff- or creamy-weathering, medium- to coarse-grained generally well-banded gneisses that grade into finely laminated mylonite. They locally display an inhomogeneous phlebitic fabric due to lensoid, flattened, quartzofeldspathic segregations. In a few instances, they have a K-feldspar seriate to sparsely megacrystic aspect. Common to abundant leucosome and biotitic schlieren are an integral part of the rocks, as is amphibolite, which occurs as both enclaves and concordant bands. Both the granodioritic gneiss and amphibolite commonly carry garnet. Concordant pegmatite showing diffuse margins and both deformed and planar pegmatites are associated. This description offers little to distinguish these granitoid gneisses from others elsewhere in the Lake Melville terrane, and there is no compelling reason to regard them as distinct.

The alkali-feldspar granitic are pink- or rusty-weathering, generously homogeneous, have weak to moderate foliations, and, although recrystallized, are not gneissic or migmatitic. Field notes for data station CG81-501 claim that they discordantly intrude the granodioritic gneiss, and, at CG81-502, the opinion is expressed that the granodioritic gneiss present there is a ‘complete contrast to the quartz syenite/granite seen earlier’. Granodioritic gneiss enclaves were seen at CG81-516 and large allanite crystals at CG81-525. The 1:100 000-scale geological maps for the area assign unit designators P_{3B}gr and P_{3B}ya (which refer to early Labradorian granite and syenite, respectively), but offer the possibility that some the alkali-feldspar granite might be younger *via* the alternate designator M_{3B}gr (syn-Grenvillian). Gower (2010c) discussed the possibility that these rocks might correlate with REE-enriched alkali rocks found farther to the southeast, in the St. Lewis area in the Lake Melville terrane.

10.3.4 LAKE MELVILLE TERRANE *VS.* GROSWATER BAY TERRANE GRANITOID GNEISS

Several differences between the Lake Melville terrane (LMT) and Groswater Bay terrane (GBT) gneisses have been mentioned in passing and are collected here. They are:

- i) LMT granitoid gneiss may have more granitic gneiss *vs.* that in GBT.
- ii) LMT has a much higher proportion of K-feldspar megacrystic granitoid rocks (35% *vs.* 20% for GBT).
- iii) LMT has a much higher proportion of discordant pegmatitic material, much of which is likely Grenvillian (by extrapolation from dated samples).
- iv) LMT has a much higher proportion of mylonitic rocks.
- v) GBT very commonly displays peritectic hornblende in neosome. In LMT, the closest analogue is a few pegmatites carrying large hornblende crystals, except, perhaps, for a few examples at its southeast end.
- vi) Epidote is ubiquitous throughout GBT granitoid gneiss, whereas in LMT it mainly occurs as a retrograde mineral in late-stage fractures and shears.

The author's interpretation is that the LMT and GBT granitoid gneisses both developed from similar Labradorian (and older?) protoliths, except that the contrast in abundance of K-feldspar megacrystic rocks is linked to the greater proportion of metasedimentary gneiss in the LMT (given the spatial association between the two rock types). The (possibly) higher proportion of granitic gneiss in the LMT granitoid gneiss is interpreted as due to the original protolith being augmented by minor granitoid intrusions – mainly emplaced during Grenvillian orogenesis. This was a period of more active tectonic activity in the LMT compared to the GBT, especially mylonitization and dextral transposition. The granite was introduced throughout Grenvillian deformation, hence the continuum from concordance in early minor intrusions to discordance in later additions.

10.4 MEALY MOUNTAINS TERRANE GRANITOID GNEISS

Granitoid gneiss in the Mealy Mountains terrane (Figure 10.1) is more-or-less restricted to a relatively narrow, dog-leg-shaped belt, which is confined by the Lake Melville terrane to the northeast, the Pinware terrane to the south and further restricted within the Mealy Mountains terrane by the Mealy Mountains and the Upper Paradise River intrusive (anorthositic–monzogranitic) suites, which intrude the granitoid gneisses. Coastal exposure of the Mealy Mountains granitoid gneiss is limited to a 5-km-wide zone (or less, depending on interpretation of terrane boundaries) in the St. Lewis area.

The dearth of coastal representation means that these rocks are not included in early geological investigations by Kranck (1939) or Christie (1951). The first recognition of gneisses in the region on a published geological map was by Eade (1962), who assigned most of the gneiss to his Unit 3 (granitic gneiss, banded gneiss, porphyroblastic in part). Current information on these rocks is based on various 1:100 000-scale mapping projects by Gower *et al.* (1985, 1986b, 1987, 1993), Gower and van Nostrand (1996), Gower (1998, 1999), and van Nostrand (1992). The name Mealy Mountains terrane granitoid gneiss is newly introduced, but is intended to be no more than an informal moniker pending more comprehensive understanding of the rocks' constituent nature.

The granitoid gneisses are here divided into: i) granodioritic to granitic gneiss, ii) K-feldspar megacrystic gneiss, iii) dioritic gneiss, and iv) monzonitic gneiss. Each of these lithological groupings contains elements of the other three, although less so in the case of the monzonitic gneiss. The monzonitic gneiss is spatially separate (in the western part of the region) and is part of a rock package that also includes monzonoritic rocks. It is suspected by the author to be not so closely related to the other three types.

10.4.1 ISOTOPIC DATA

10.4.1.1 U–Pb

The time of formation of early Labradorian granitoid gneiss in the Mealy Mountains terrane is constrained by U–Pb ages from three samples, namely CG98-128B, CG97-061 and CG98-243.

Data from granitic gneiss sample CG98-128B (Plate 10.10A) define an upper intercept age of 1670 ± 5 Ma, when regressed with results from a discordant, mildly deformed Grenvillian pegmatite at the same outcrop (Gower *et al.*, 2008b). If data solely from the gneiss are regressed, the granitic gneiss could be interpreted to be older (between 1687 ± 4 Ma and 1712 ± 27 Ma), but the regression that includes the pegmatite is preferred. It assumes that Labradorian zircon in the pegmatite was inherited from the granitic gneiss host and that Grenvillian titanite in the

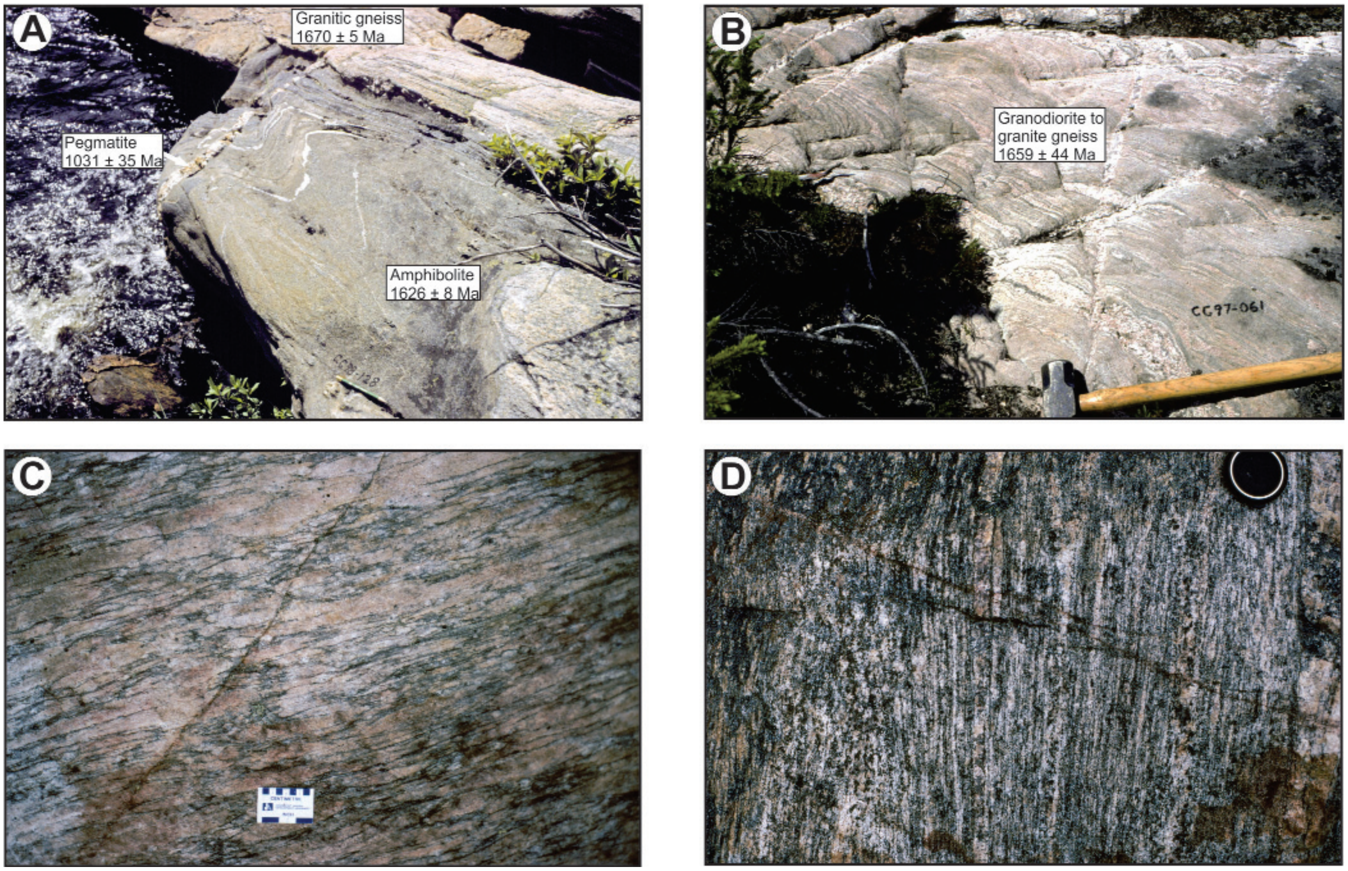


Plate 10.10. *Dated and undated gneissic granitoid rocks in the Mealy Mountains terrane. A. Key U–Pb geochronology locality displaying granitic gneiss, former mafic dyke(?) and discordant pegmatite (CG98-128), B. U–Pb dated granodiorite to granite gneiss (CG97-061), C. Undated, (formerly megacrystic?), strongly foliated to gneissic granite to granodiorite (VN91-118), D. Undated strongly foliated to gneissic diorite (VN91-126).*

granitic gneiss was formed at time of pegmatite emplacement. A sample of associated amphibolite was also analyzed (CG98-128A). Three, single zircons give collinear, concordant data having an upper intercept age of 1626 ± 8 Ma, if it is anchored at 1030 Ma, the age of the crosscutting pegmatite, and titanite in the host granitic gneiss. Given that the amphibolite is boudinaged and metamorphosed, the 1626 ± 8 Ma date is interpreted to be the time of metamorphism and associated ductile flow.

Locality CG97-061 (Plate 10.10B) comprises granodioritic to granitic orthogneiss, from which five zircon and two monazite grains/fractions were analyzed. The zircon data do not form a linear array, which suggests that the zircons represent more than one growth episode and/or they have experienced multiple episodes of Pb loss. A regression through two lower U zircon grains anchored at a lower intercept of 1030 Ma (the concordant age of the associated monazite) gives a date of 1659 ± 44 Ma. Choosing other zircon data points allows minimum and maximum ages of 1620 ± 2 Ma and 1739 ± 1 Ma, respectively. The 1659 ± 44 Ma result was argued to be the best result by Gower *et al.* (2008b), although it was acknowledged that an unequivocal interpretation of the data could not be made.

The third sample (CG98-243) is quartz monzonite. Three fractions of zircon give two concordant and one near-concordant data points. The weighted mean $^{207}Pb/^{206}Pb$ age of the two concordant single zircons is 1658 ± 3 Ma, which is judged to be the best estimate for the time of crystallization (Gower *et al.*, 2008b). The near-concordant point has a $^{207}Pb/^{206}Pb$ age of 1652 ± 3 Ma, which is interpreted to indicate minor Pb loss at the time of monazite crystallization at 1626 ± 10 Ma (based on two concordant data points).

10.4.1.2 Sm–Nd

Sm–Nd whole-rock isotopic data are available for the three U–Pb-dated samples. Two of them (CG97-061, CG98-128B) have analytically identical T_{DM} ages (1909 Ma and 1922 Ma) and εNd (1.66 Ga and 1.67 Ga, respectively) values (+0.95 and +0.85). The other dated sample (CG98-243) has lower T_{DM} (1805 Ma) and higher εNd (1.66 Ga) (+2.30), supporting the earlier comment that the rock is genetically distinct from the other two Mealy Mountains terrane granitoid gneisses. A fourth sample (CG86-344), which is a K-feldspar megacrystic dyke intruding pelitic metasedimentary gneiss, has not been dated. It also has distinct T_{DM} (2016 Ma) and εNd (1.67 Ga) (–0.37) values and is most readily interpreted as the result of contamination by metasedimentary gneiss. Bybee *et al.* (2014) concluded that the pre-Labradorian and Labradorian gneisses, into which the Mealy Mountains intrusive suite was emplaced, are juvenile, having $^{143}Nd/^{144}Nd$ at 1640 Ma = 0.51040–0.51051.

Note that there are no Rb–Sr, Ar–Ar or K–Ar data for Mealy Mountains terrane granitoid gneisses.

10.4.2 FIELD AND PETROGRAPHIC CHARACTERISTICS

10.4.2.1 Granodiorite to Granite Gneiss (P_{3B}gd, P_{3B}gr)

Although dominantly granodioritic to granitic, this group of gneisses also includes minor monzodiorite, monzonite, quartz monzonite, diorite, quartz syenite and syenite. The rocks weather white, creamy, buff, pink, and pale to dark-grey. Grain size varies from fine to coarse and is partly related to grain-size reduction during deformation. Fabric ranges from barely discernable to intensely mylonitic. Very commonly, field notes describe the rocks as ‘homogeneous’, ‘non-migmatitic’, ‘diffuse leucosome’, ‘not well banded’, or ‘gneissosity poorly developed’. That is not to say that mylonitic fabrics are scarce; mylonite is found in all areas, but is especially common in the attenuated southeastern zone adjacent to both the Lake Melville terrane and the Pinware terrane (*e.g.*, in roadside outcrops on the north side of St. Lewis River causeway). The rocks locally have small, sparse K-feldspar megacrysts. Biotite is the most common mafic mineral and amphibole is commonly associated, but clinopyroxene is rare. Leucosome varies from poorly developed, isolated patches, through discontinuous pods and lenses, to continuous and streaky, shredded quartzofeldspathic laminae, with which darker, biotite-rich bands and mafic schlieren are associated. Various types of amphibolite (leuco-, migmatized, inhomogeneous, plagioclase-phyric) show a range of shapes (narrow, concordant, pods, lenses, tightly folded), and evidence that it represents metamorphosed mafic dykes is present in a few instances. Both concordant and discordant microgranite and pegmatite dykes are found throughout, some muscovite bearing and displaying graphic textures.

A small area of granitoid gneiss found within the Mealy Mountains intrusive suite (MMIS) is also mentioned here. It was mapped and described by Gower (1999). It is informally termed here ‘Bird pendant’ on the basis of its inferred outcrop shape and interpreted status as a roof pendant within the MMIS (Figure 10.1). The rocks were only seen at two localities, where they were described as pink-, creamy-, buff- or grey-weathering, fine- to medium-grained, sugary, recrystallized, granitoid rocks having granular texture and showing diffuse but distinct compositional banding, enhanced by injection of quartz-rich pegmatitic veinlets. The rocks were noted to be different from the surrounding MMIS monzonite. Gower (1999) compared the rocks with fine-grained quartzofeldspathic enclaves seen in MMIS monzonite farther southeast, and considered them to represent country-rock material entrapped within the monzonite.

Fifty thin sections are available for Mealy Mountains terrane (non-megacrystic) granitoid gneiss. Half of the thin sections are granite, about 20% granodiorite, and the remainder monzodiorite, quartz monzonite and syenite. All except two contain relict igneous or metamorphic plagioclase. Plagioclase is lacking in an alkali-feldspar granite (CG97-107) and alkali-feldspar syenite (CG97-119), both of which may belong to the older Eagle River complex (Chapter 8). K-feldspar is present in all thin sections and is microcline with lesser perthite. Quartz is present in all but two thin sections (lacking in DE91-052, VN91-153; syenite and monzonite, respectively). Biotite was originally present is all thin sections, but, in two of them, has been totally pseudomorphed by chlorite. Biotite is dominantly orange-brown to buff-orange, although olive-green in about 20% of the sections. Hornblende is present in half of the sections, and includes green-brown, dark-green, leaf-green and blue-green varieties. Clinopyroxene and orthopyroxene are present in a few thin sections having overall monzonitic or syenitic compositions and garnet is seen is a few thin sections of granitic composition. Accessory minerals include an opaque oxide (in almost all thin sections), sulphide (uncommon), apatite, zircon (commonly with cores and rims), titanite (mantling the opaque oxide or secondary) and allanite. Secondary minerals are chlorite, epidote (uncommon) and rutile.

A thin section (CG98-030) from Bird pendant is alkali-feldspar granite, consisting of plagioclase, stringlet perthite, quartz, green hornblende, an opaque oxide, apatite, zircon and allanite.

10.4.2.2 Megacrystic Granitoid Gneiss (P_{3B}gp)

K-feldspar megacrystic granitoid gneiss in the Mealy Mountains terrane is concentrated in a 120-km-long by 20-km-wide zone flanking part of the boundary with the Lake Melville terrane. In addition, there are much smaller scattered areas of K-feldspar megacrystic rocks in the middle Eagle River area, 50 km to the west. The compositional range of the K-feldspar megacrystic rocks is not significantly different from the non-megacrystic granitoid gneiss in the Mealy Mountains terrane. They are similar in appearance to K-feldspar megacrystic rocks in the Lake Melville terrane, apart from being less deformed (excluding the more highly tectonized southeast end of the Mealy Mountains terrane). In the Mealy Mountains terrane, there are hints of bodies having ovoid form (possibly related to original pluton shape?), in contrast to the typically highly tectonized slivers of megacrystic rocks in the Lake Melville terrane.

The rocks weather white, pale cream, buff, pink or grey, are fine to coarse grained and range from homogeneous to migmatitic. They may be weakly to intensely foliated and/or lineated. Depending on deformational state, the K-feldspar megacrysts vary from euhedral, through ovoid, to lensoid recrystallized aggregates (Plate 10.10C), and the rock can, alternatively, be termed augen gneiss. The megacrysts are typically less than 2 cm in diameter and form 5 to 40% of the rock. In one instance, megacrysts reaching 11 cm across were seen (CG91-055). This example comes from an area close to the 'Western Lake Melville terrane' megacrystic granitoid rocks, where unusually large K-feldspar megacrysts are also found (*cf.* Plate 10.9D). It is quite possible that both areas originally belonged to a single pluton (despite the two areas now being assigned to different terranes). The dominant mafic mineral is biotite, although some hornblende may be associated. Leucosome is present, as are lenses and layers of amphibolite. As elsewhere, the amphibolite probably represents remnants of former mafic dykes, and convincing evidence that this was the case is displayed at localities DE91-101, VN91-040 and VN92-001. Enclaves of pelitic and psammitic gneiss were recorded at CG91-044 and CG91-046 and several instances of dioritic enclaves were noted. The rocks are concordantly and discordantly intruded by microgranitic and pegmatitic dykes.

The K-feldspar megacrystic rocks in the middle Eagle River area are less likely to be closely related to those flanking the Lake Melville terrane. They are distinct in having much more amphibole and also in having large quartz crystals (up to 1 cm across).

Fifty-one thin sections are available for Mealy Mountains (non-megacrystic) granitoid gneiss. Two-thirds of the thin sections are granite, about 20% granodiorite, and the remainder monzonite. All contain relict igneous or metamorphic plagioclase, K-feldspar (dominantly microcline), quartz and biotite (mostly orange-brown to buff orange). Hornblende is present in two-thirds of the sections and is comparable to that in the non-megacrystic granitoid rocks. Clinopyroxene is present in a few thin sections having overall monzonitic or granodiorite composition, and garnet is seen is a few thin sections of granitic composition. Details of accessory and secondary minerals are the same as for the non-megacrystic granitoid rocks.

10.4.2.3 Dioritic Gneiss (P_{3B}dr)

The nature of the dioritic gneiss unit in the Mealy Mountains terrane remains unclear to the author, in part because he has personally seen very little of it in outcrop (more in stained slabs, however). The rocks were first mapped and described by van Nostrand (1992), who comments that exposure is very poor in the area and that the extent of the rocks is partly inferred from positive aeromagnetic signatures.

Although most commonly identified as diorite or quartz diorite, it is described, in some instances, as gradational into more mafic rocks such as leucoamphibolite, amphibolite or metagabbro, and, conversely, as gradational into granodioritic gneiss. In some cases, it is a composite rock type, resulting from interlayering of granodioritic and amphibolitic rocks (or other combinations). Despite these indications of various types of heterogeneity, the conclusion can still be reached that dioritic gneiss is an entity in its own right (Plate 10.10D) and not just a mixture of other rock types. The dioritic rocks form a partial envelope around an ovoid mass of non-megacrystic and megacrystic gneissic granitoid rocks (collectively representing the extent of a former composite pluton?).

The rocks are pale creamy, grey, brown, or black-and-white, fine to coarse grained, homogeneous to heterogeneous, and crudely to well-banded. Fabrics range from weak to strong, but are rarely mylonitic. Sporadically, the rocks have a seriate aspect. Leucosome consists of irregular stringers and concordant veins of quartzofeldspathic material. Mafic minerals are mostly biotite and hornblende. Layers or lenticular pods of amphibolite are common, and, rarely, mafic-mineral-rich clots of biotite and hornblende are seen. The rocks are discordantly intruded by now-deformed microgranite and pegmatite. At VN87-356, K-feldspar megacrystic diorite was recorded as intrusive into diorite.

Eight thin sections of dioritic gneiss all contain plagioclase, minor K-feldspar (microcline) and quartz. Biotite (or its chloritized equivalent) is present in every section and is mostly orange-brown. Leaf-green hornblende is present in 75% of the sections; one contains clinopyroxene (VN87-047); and one contains orthopyroxene (CG91-041). Garnet is present in three thin sections. All contain an opaque oxide, 50% have sulphide, most contain apatite and zircon, and a few have titanite and allanite. Minor secondary epidote is present is half of the sections.

10.4.2.4 Monzonite Gneiss (P_{3B}mn, P_{3B}mq)

North of the No-Name Lake mafic intrusion (Section 14.1.1), a rather mixed assemblage of weakly to moderately deformed monzogabbronorite, monzonite, quartz monzonite and granite was mapped by Gower (1999) in an eastward-tapering area 20 km long and up to 10 km wide that is distinct from No-Name Lake mafic intrusion and orthogneisses situated on its southern flank and the Mealy Mountains intrusive suite located to the north (the area in the vicinity of CG98-243 in Figure 10.1). In spatial relationships, composition and in fabric, the rocks occupy an intermediate position between all three rock groups. The rocks differ from: i) the orthogneisses in lacking migmatization and having generally lower quartz contents, ii) the monzonitic rocks of the Mealy Mountains intrusive suite in being foliated and containing quartz, and iii) from the metamorphosed mafic rocks in having a lower colour index and more K-feldspar plus quartz (although some of the mafic rocks do have noteworthy K-feldspar). U–Pb data and Sm–Nd data for quartz monzonite sample CG98-243 were presented earlier (U–Pb age 1658 ± 3 Ma, and T_{DM} = 1805 Ma and εNd (1.66 Ga) = +2.30). Details of the various rock types present, also incorporating petrographic details, are given below.

Monzogabbronorite, leucogabbronorite, altered leucogabbro, two-pyroxene mafic granulite. The rocks are buff-grey-weathering, medium to coarse grained, mostly homogeneous and weakly to extensively recrystallized, and weakly to strongly foliated. Where recrystallization is extensive the term granulite would be equally appropriate.

Three two-pyroxene rocks were examined in thin section. Two monzogabbronorite samples contain appreciable K-feldspar (CG98-251, CG98-253) and one sample, lacking K-feldspar, is termed leucogabbronorite (CG98-237). All contain anhedral to subhedral, well-twinned plagioclase. In CG98-253, the plagioclase is primary and shows obvious zoning, whereas in CG98-251 it is thoroughly recrystallized. All contain anhedral pale-green clinopyroxene, anhedral, markedly pleochroic orthopyroxene, red-brown biotite, oxide and sulphide opaque minerals and apatite. The K-feldspar is perthite, partially inverted to microcline, in CG98-251 and well-twinned microcline in CG98-253.

Two other thin sections from the same area (CG98-242, CG98-245) are termed altered leucogabbro, although, plausibly, the mosaics of secondary amphibole, biotite, epidote, chlorite, biotite, titanite and opaque minerals could have been derived from orthopyroxene as well as clinopyroxene. Other minerals are plagioclase (mostly recrystallized), K-feldspar (very sparse in CG98-245) and apatite.

One anomalous outcrop (CG98-239) in the same area as the above described rocks, although compositionally most akin to the mafic intrusion farther south, is included here. In the field, from a poor exposure, the rocks were described as black weathering and fine to medium grained, but with sufficiently variable appearance (especially texture) that three samples were collected and thin sectioned. CG98-239A is a mafic granulite containing antiperthitic plagioclase, pale green clinopyroxene, pleochroic orthopyroxene, orange-brown biotite, apatite and an oxide opaque mineral. CG98-239B is its retrogressed equivalent, in which the plagioclase has developed clear albitic rims and contains epidote and blue-green amphibole. The third sample is a fresh diabase, which is probably a Mealy dyke.

Monzodiorite to quartz syenite. The rocks include monzodiorite, monzonite, quartz monzonite and quartz syenite, and are found intermixed with monzogabbronorite, leucogabbronorite and leucogabbro. The rocks are pink-, orange-, buff-, creamy- or grey-weathering, homogeneous, medium to coarse grained, moderately to extensively recrystallized and weakly to strongly foliated. K-feldspar megacrysts are present locally and reach 2 cm across, although are mostly less than 1 cm. Quartz, in outcrop, commonly shows a bluish hue and grains are up to 0.5 cm across. Elongate quartz and alignment of mafic mineral clusters assist in defining the foliation. A few pegmatite veins were seen.

Three thin sections of this rock group each represent a slightly different rock type, namely monzodiorite (CG98-250), monzonite (CG98-247) and quartz monzonite/syenite (CG98-243). The first two have the most in common, both containing partially recrystallized poor- to well-twinned plagioclase, well-twinned microcline, pale-green to pale-brown, partially retrogressed clinopyroxene, green-orange biotite, apatite, zircon, and secondary epidote and titanite. In addition, CG98-250 contains pseudomorphs of what might once have been orthopyroxene and CG98-247 contains common blue-green actinolitic hornblende pseudomorphing clinopyroxene. The thin section for dated sample CG98-243 differs in having common quartz, very little plagioclase and no clinopyroxene. Mosaics of secondary green biotite, chlorite, epidote, titanite, carbonate and opaque oxide probably represent its retrograded derivatives, but are not obvious pseudomorphs. Apatite, zircon (with cores and rims) and an opaque primary oxide are also present.