CHAPTER 9

EARLY LABRADORIAN ANORTHOSITIC, MAFIC AND ULTRAMAFIC ROCKS (P_{3B} 1710–1660 Ma)

Rocks of Labradorian age are overwhelming dominant in eastern Labrador, and the next four chapters are devoted exclusively to them. They are divided into 'Early' and 'Late' (P_{3B} and P_{3C}, respectively) based on geochronological and field criteria, and then subdivided into 'Anorthositic, mafic and ultramafic rocks' and 'Granitoid and related rocks', based on composition. Much uncertainty remains regarding to which category individual examples should be assigned – more so for 'Early' *vs.* 'Late', rather than their compositions. The approach adopted has been to identify groups of rocks that might reasonably be regarded as related, and to assign these as named units (with caveats regarding the reliability of so doing). Rocks not reasonably contained in named units are addressed as 'Unassigned'.

In this chapter, two units are recognized, namely the Alexis River anorthositic intrusion and the Upper Eagle River mafic intrusion. Representative stained slabs from both bodies are depicted in Appendix 2, Slab images 9.1).

9.1 ALEXIS RIVER ANORTHOSITIC INTRUSION

From a mapping perspective, the Alexis River anorthositic intrusion (ARAI) is a remarkable and critical unit (Figure 9.1). It is remarkable in that, despite being rather narrow (it rarely exceeds 10 km wide and is commonly less than 5 km wide), it has a strike length of about 225 km. It is critical in that, because it is distinctive, it provides an excellent marker unit within a belt of rocks (Lake Melville terrane) that has severe deformation as one defining characteristic. The ARAI is topographically recessive weathering and has a low-strength aeromagnetic signature (Figure 5.8), both of which assist in outlining its extent. In its central section, where rock exposure is generally poor, the ARAI was not found, being either absent or extremely attenuated. In the same area (NTS map area 13A/14), however, aeromagnetic patterns, particularly magnetic highs, suggest complications that ground mapping may have failed to identify. It seems most likely that the body originally had a sheet-like form. This is suggested, in particular, by a folded antiformal structure in the Cartwright Junction area, having its fold axis parallel to the trend of the intrusion. A three-dimensional interpretation of part of the body was offered by van Nostrand (1992).

The earliest 'indication' of the existence of the ARAI was probably a case of mistaken identity, in that the rock was reported as limestone (Geological Survey of Newfoundland and Labrador mineral occurrence 013A/09/Lst001). The original source of the information is obscure but the first reference found by the author was Beavan (1954, page 27) who wrote 'Port Hope Simpson area: amphibolite and crystalline limestone bands in micaceous gneisses'. The author knows of no limestone (or marble) in the area, and only trivial occurrences of calc-silicate rocks.

Rocks belonging to the ARAI were first recognized as such by Gower *et al.* (1985) in Paradise River 1:100 000-scale map region, but some tectonic slivers of anorthosite farther north that had been mapped earlier (Gower *et al.*, 1982b) were later correlated with it. Subsequent mapping traced the body southeastward to the Labrador coast north of St. Lewis (Gower *et al.*, 1987, 1988; van Nostrand, 1992; van Nostrand *et al.*, 1992). The northern end of the body seems to dissipate in a series of thrust-bound slivers. The unit was named 'Alexis River anorthosite' by Gower *et al.* (1987), but, despite the name's alliterative appeal, it is a slight misnomer as it is not all anorthosite, so the name is slightly modified here.

The age of the ARAI remains uncertain. No geochronological data are available, except a Sm–Nd analysis of a scapolitized amphibolite that may have affinity with the Alexis River intrusion. The data were obtained by Hewitson (2010) and gave values of T_{DM} = 1869 Ma and εNd (1.65 Ga) = +1.61. The ARAI was assigned as early Labradorian by Gower (2010a, b), but the author has wondered, from time to time, whether, alternatively, it might represent a deformation 'tail' from the mid- to late-Labradorian Mealy Mountains intrusive suite ; the tail having developed during Grenvillian thrusting in the dextral lateral ramp that the Lake Melville terrane represents. There is no obvious spatial linkage to the MMIS, however, and, unlike the MMIS, no associated monzonitic rocks. Its severely deformed state is no guide to its probable age, as much of the deformation is Grenvillian. An early, or a late, Labradorian emplacement age remains viable.

Oxygen isotopic data for the ARAI were reported by Peck *et al.* (2010). Seven samples were analyzed

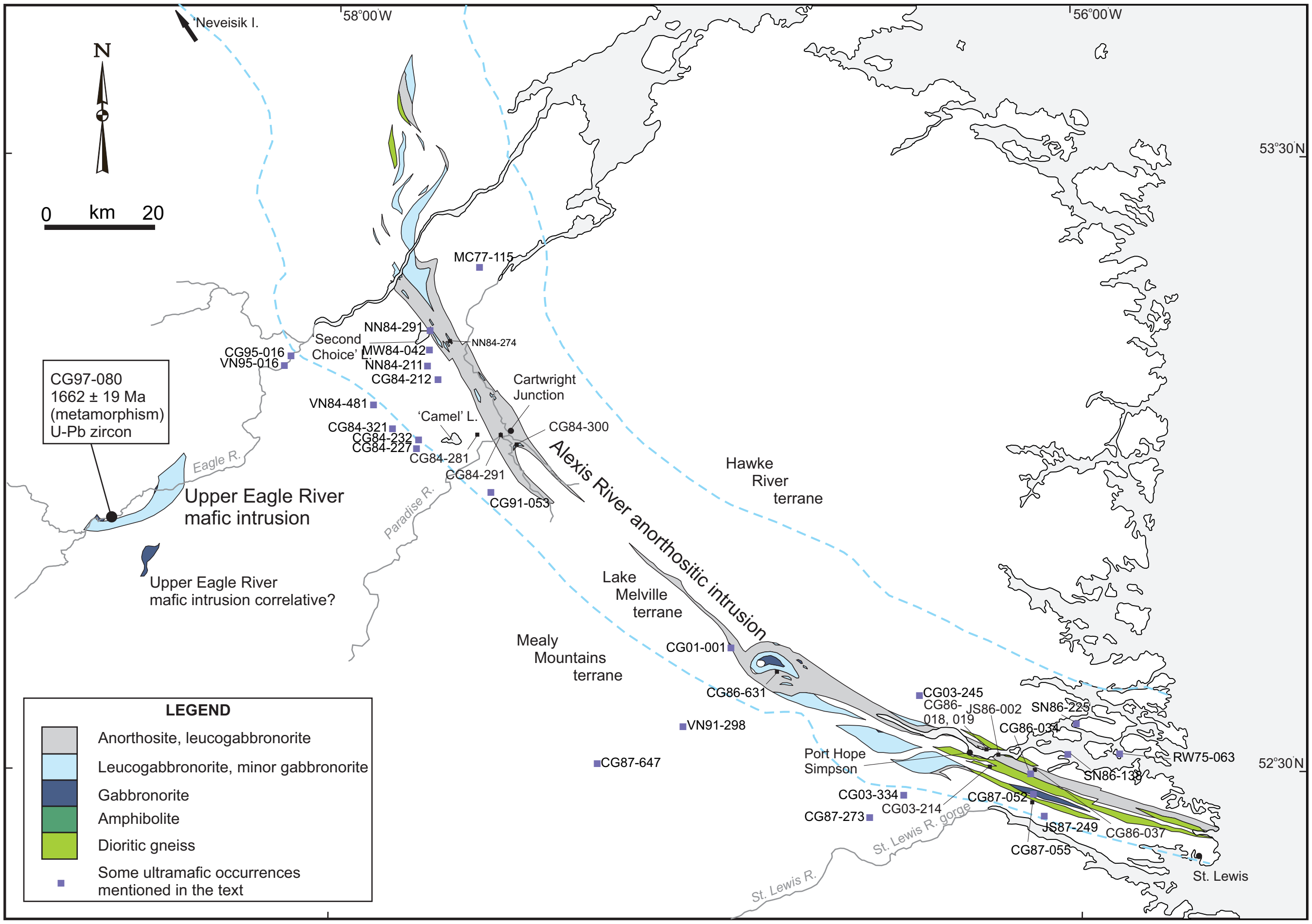


Figure 9.1. *Early Labradorian anorthositic, mafic and ultramafic intrusions (including Alexis River anorthositic intrusion and Upper Eagle River mafic intrusion).*

(O3LAB017, -018, equivalent to site CG04-236; O3LAB019, equivalent to site CG04-237; O3LAB020, -021, -022, and -023, equivalent to site CG03-224). The first three sites are close to Cartwright Junction and the remaining four near Port Hope Simpson. Values for δ^{18}O show a restricted range between 6.20 and 8.29 (‰ V_{SMOW} – Vienna standard mean ocean water), a little higher than mantle values of *ca.* 5.5 to 6.0 (‰ V_{SMOW}). The data were collected as part of a broader study of anorthositic rocks of various ages within the Grenville Province. All those from the 'Allochthonous Polycyclic Belt' (with which the Alexis River body was included) show similar δ^{18}O ranges, concluded to be consistent with mantle derivation or mantle-derived source materials and limited input from supracrustal sources.

Roughly two-thirds of the data stations within the ARAI have been designated as either anorthosite or leucogabbronorite. Other primary rocks include minor gabbronoritic and rare ultramafic rocks. These rocks mostly have recognizable igneous protoliths by virtue of either texture or composition, but associated with them are mafic granulite and amphibolite, and dioritic to quartz dioritic gneisses. These are termed metamorphic derivatives and interpreted to have gabbronoritic and leucogabbronoritic protoliths, respectively. Minor, spatially associated but not necessarily genetically related, granitoid gneissic rocks and mafic dykes are also present. These various rock types are addressed sequentially below. Within limitations imposed by scale, rock types are shown in Figure 9.1.

9.1.1 ANORTHOSITE AND LEUCOGABBRONORITE (P_{3B}an, P_{3B}ln)

As there is a complete gradation from anorthosite to leucogabbronorite, these two subdivisions are treated together, although a distinction was mapped (probably inconsistently) in the field based on colour index. The anorthosite–leucogabbronorite is typically brightly white-weathering, which correlates with plagioclase having been recrystallized to sugary aggregates. Where primary plagioclase remains, it is commonly grey or mauve. An attempt was made using X-ray diffraction (Gower, 2010c, Appendix

2, sample CG03-224C) to determine the reason for the mauve (or lilac) colour, but the identified minerals (illite, albite and sepiolite) did not provide an obvious answer. Minor sulphide content contributes to brown or rusty hues in some rocks. Primary orthopyroxene tends to be rusty-brown and primary clinopyroxene is grey green.

Original igneous grain size ranges from fine to extremely coarse, although, overall, the finer grained rocks are the product of severe deformation and recrystallization. The rocks collectively show a complete gradation from weakly to strongly foliated, and include finely laminated mylonite and banded gneiss. In low-strain areas, igneous textures, involving plagioclase, olivine and/or pyroxene (ortho- or clinopyroxene) may be preserved and igneous crystals up to 30 cm long were recorded in several places (Plate 9.1A). In an extreme case, Gower *et al.* (1985) noted poikilitic crystals over one metre in diameter on the Upper Paradise River (CG84-293). This site is in the vicinity of Cartwright Junction, in an area where such features are well displayed and are attributed to being in a fold-closure strain shadow (*e.g.*, CG84-287 to CG84-300; CG05-001 to CG05-004). The least deformed rocks commonly have a mottled black and white appearance due to patchy distribution of (partially to completely recrystallized) mafic and felsic silicates (Plate 9.1B). Farther southeast, van Nostrand (1992) reported orthopyroxene and clinopyroxene crystals up to 80 cm across in a matrix of recrystallized plagioclase.

In low-strain areas, primary layering is evident (*e.g.*, CG84-223, CG84-300 – Plate 9.1C, CG84-358, CG84-425, CG86-036, CG87-340, DD91-110, MN86-062, NN84-509). Individual layers vary from less than 1 cm to 10s of centimetres in thickness (expressed by concentrations of plagioclase, pyroxene or hornblende). Graded layering is present in places (Plate 9.1D). Layering is also a factor contributing to compositional heterogeneity in deformed units.

In strongly deformed rocks, the mafic silicates commonly appear as lensoid aggregates that vary from pods to

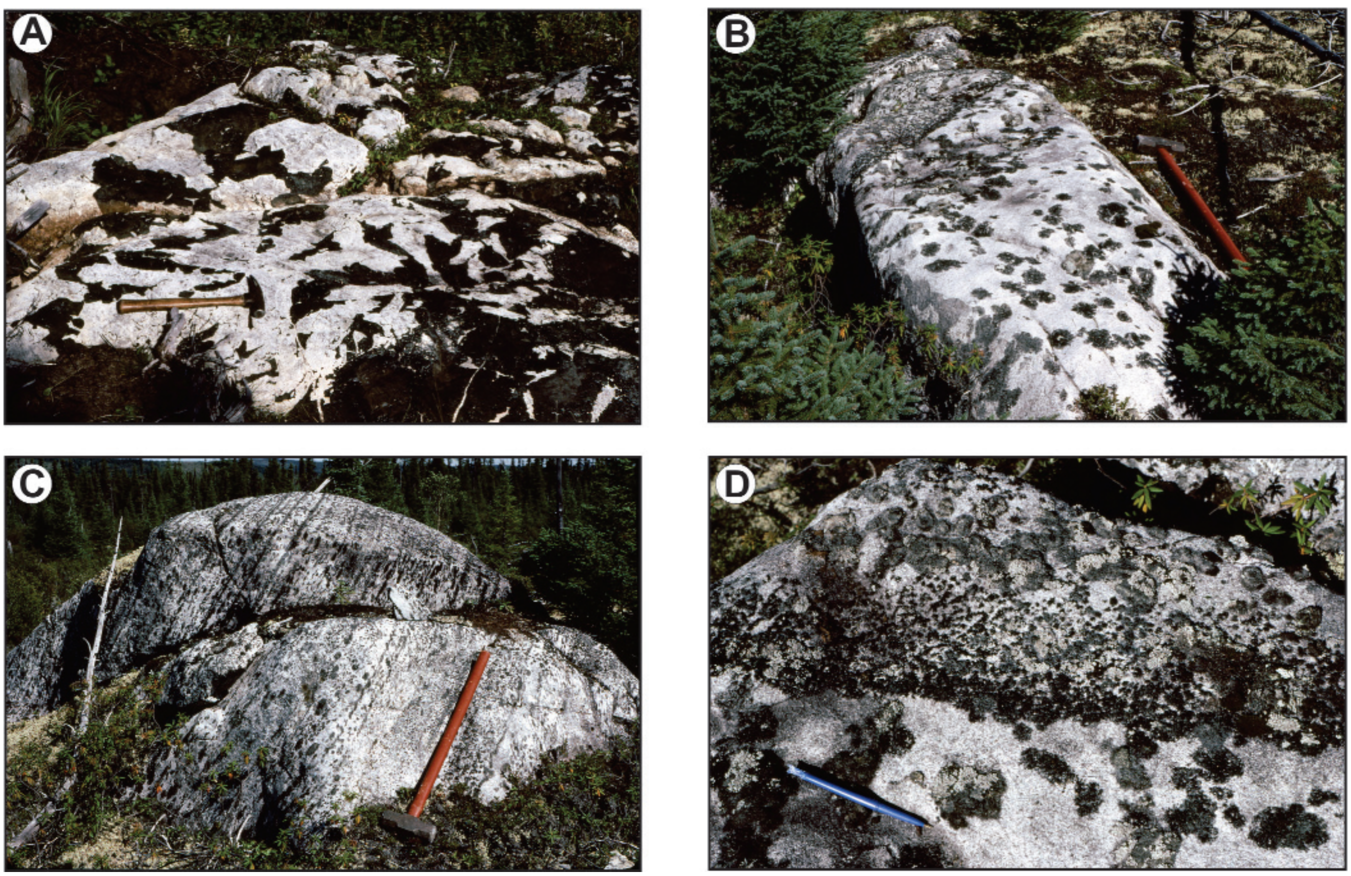


Plate 9.1. *Alexis River anorthositic intrusions showing examples of very coarse grain size, igneous layering and graded layering. A. Very coarse-grained leucogabbronorite. Brown cores of mafic clusters are orthopyroxene, with amphibole rims (CG84-291), B. Anorthosite/leucogabbronorite showing mottled texture due to recrystallization of pyroxene and plagioclase (CG84-300), C. Anorthosite/leucogabbronorite displaying well-preserved primary layering (CG84-300), D. Detail of B showing example of graded layering (CG84-300).*

extremely attenuated wisps, according to stretching severity (Plate 9.2A–C). Olivine and pyroxene are preserved in the cores of some clusters (*e.g.*, CG86-019 – Plate 9.2D, MC77-196). Relict primary mafic minerals may be enveloped in recrystallized aggregates of the same mineral, or show coronitic textures, such as crystals of olivine having double orthopyroxene–clinopyroxene/amphibole coronas, pyroxene being mantled by hornblende, and hornblende by biotite. Smaller mafic crystals are normally completely pseudomorphed by amphibole. Plate 9.2A displays two types of stretched mafic lenses; one black and the other mottled grey, presumed to reflect different igneous mafic minerals originally (ortho- and clinopyroxene?). Garnet (commonly up to 3 cm in diameter, and, rarely, up to 30 cm) is present as a prograde metamorphic phase, or retrograded to 'ghost' garnet pseudomorphs. Garnet also occurs as a coronal phase in some rocks. In places, it is clearly related to fluid introduction as it occurs in association with hornblende adjacent to quartzofeldspathic veins. The rocks are, locally, veined by secondary prehnite.

The anorthosite and leucogabbronorite are also intruded by minor granitoid intrusions. These include coarse-grained pink pegmatite and white-weathering quartzofeldspathic veins. Many instances of crosscutting relationships with respect to their host rocks were seen, although, equally, the felsic dykes themselves may be deformed. One pegmatite contains biotite sheets up to 15 cm across (CG84-289). A quarry near Port Hope Simpson (immediately north of the bridge/causeway crossing the Alexis River) has K-feldspar-rich pegmatites hosting unusually large allanite crystals, several centimetres across.

Thin sections of anorthosite available are CG04-237B, CG04-237C, CG84-173, CG84-294, CG84-297, CG86-017A, CG86-017B, CG86-018B, CG86-020C, CG86-029, CG86-322, CG87-055B, DD91-047, DD91-110D, DE91-020B, GF81-179, GF81-209, JS86-502, JS87-438, MC77-166A, MN86-041A, MN86-274, NN84-025, NN84-088A, NN84-231, NN84-247A, NN84-391A, NN84-509, SN86-059, SN86-063, SN86-067, SN86-237A, VN87-144, VN91-068A, VN91-068B, VN91-089, VN91-090B, VN91-180A and VN91-181 and those termed leucogabbronorite are CG84-287 (a single orthopyroxene crystal), CG84-300, CG86-316, CG86-631,

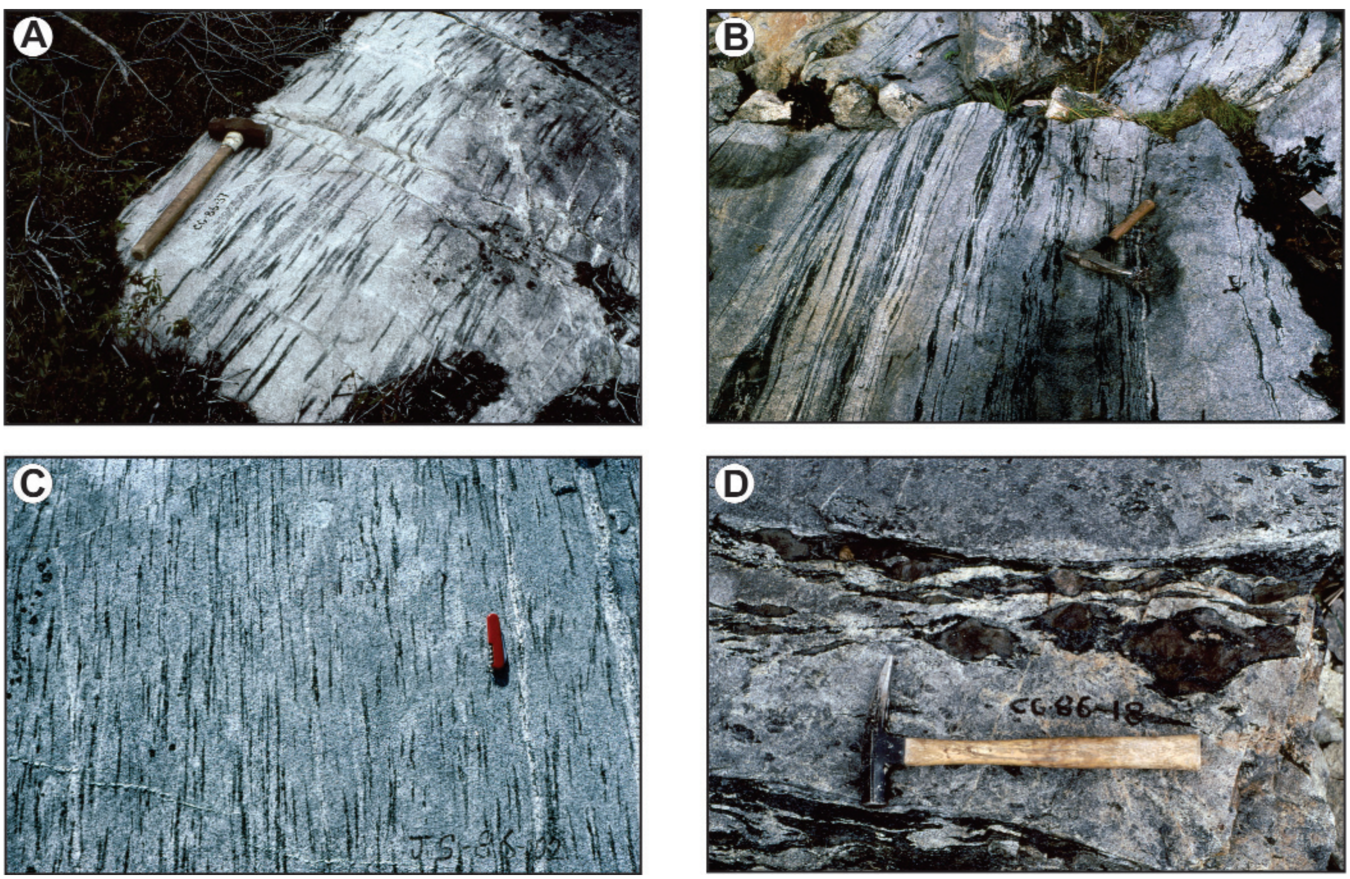


Plate 9.2. *Alexis River anorthositic intrusion in severely deformed state. A. Very deformed anorthosite. Note two types of mafic lenses (black and mottled grey (formerly orthopyroxene and clinopyroxene) (CG86-037), B. Very deformed anorthosite with some mafic layers (CG86-018), C. Very deformed, more uniform anorthosite (JS86-002), D. Anorthosite showing deformed, lensoid orthopyroxene and clinopyroxene, both with amphibole rims (CG86-019).*

GF81-208, GF81-212, JS86-003, JS87-231, MC77-163B, MC77-195A, MC77-196A and VN91-401. The mineral assemblage in the leucogabbronorite is much the same as that in the anorthosite, except having higher abundance of mafic minerals. Plagioclase mostly forms polygonal metamorphic grains having straight boundaries, although relict igneous plagioclase is present in about one third of samples examined. Weakly to strongly pleochroic orthopyroxene (in 6 thin sections), pale-green clinopyroxene (10 sections) and garnet (10 sections) are sporadically present. The pyroxenes are partly relict igneous and partly metamorphic and are locally mantled by amphibole. Garnet varies from large to small and euhedral to anhedral, and sporadically has abundant inclusions. In some thin sections (CG86-316, CG86-322, JS86-502), there is evidence for the reaction:

Garnet = Hornblende + Plagioclase + Opaque mineral ± Titanite

Evidence for the reaction:

Clinopyroxene + Plagioclase I = Garnet + Hornblende + Plagioclase II

can be seen in CG86-631 (Photomicrograph 9.1A). Of the hydrous mafic minerals, the most common is leaf-green to blue-green hornblende, typically anhedral and polygonal, but locally ragged. Biotite is mostly orange-brown, but locally red-brown or olive-green. An oxide opaque mineral and apatite are commonly present, and minor sulphide is seen in some samples. One grain of corundum was seen in CG84-297. A host of secondary minerals is present in trivial amounts, including titanite (commonly mantling an opaque mineral), hercynitic spinel, chlorite, white mica, epidote, prehnite, carbonate, rutile, quartz (in places as inclusions in amphibole from breakdown of clinopyroxene), K-feldspar, and a serpentinous mineral after amphibole. NN84-025 contains a small ultramafic xenolith consisting mostly of clinopyroxene and amphibole.

Southeast of Port Hope Simpson, anorthosite occurs in several narrow bodies south of the main body (too small to show on Figure 9.1), and may once have been part of it prior to the region being sheared and sliced by deformation. Some of the bodies are remarkably narrow and continuous along strike. One particularly noteworthy locality is CG87-055, mentioned earlier in Section 7.3.5.1. Sample CG87-055B comes from a very distinctive rock (Plate 7.9D) containing large lilac corundum porphyroblasts up to 2.5 cm across and several centimetres long. This occurrence was discovered during mapping in 1987 and first reported by Gower *et al.* (1988). The site was investigated by Rockhopper Corporation for sapphire (gem-quality blue corundum). Gower *et al.* (1988) interpreted the corundum bearing rock to be a metasomatized anorthosite, but there may be other possibilities (desilicified metasedimentary gneiss?).

Sample 87-055B contains polygonized plagioclase (An_{48}), red brown biotite, garnet, corundum, very minor opaque minerals, and secondary white mica and chlorite. Much of the white mica is retrograde, forming a wide ruff around cores of corundum (probably about 50% of the original corundum has been replaced by white mica) (Photomicrograph 9.1B).

9.1.2 GABBRONORITE (P_{3B}rg)

Gabbronorite and metagabbronorite form subsidiary rock types within the ARAI. The close spatial association with the anorthositic rocks clearly indicates that they were once part of the same layered intrusion. A few of the larger occurrences are shown in Figure 9.1. The rocks are grey-green, rusty or black and white-weathering, and medium to coarse grained. At some localities, tectonic enclaves of primary layered gabbronorite are enveloped in compositionally equivalent gneiss. The key distinction made between metagabbronorite and amphibolite is that, in metagabbronorite, igneous textures are preserved, whereas, in coarse-grained amphibolite, they are either vestigial or absent. A complete spectrum from igneous to metamorphic assemblages exists between the two rock types.

Six thin sections of (meta)gabbronorite from within the ARAI were examined (CG05-001B, CG86-018A, CG87-051, JS86-024, NN84-274, VN87-148). All contain anhedral, polygonal plagioclase, pale green, polygonal clinopyroxene, leaf-green amphibole and an opaque oxide. CG86-018A contains distinctly pleochroic orthopyroxene. Other phases are garnet (JS86-024), scapolite (JS86-024, VN87-148) and hercynitic spinel (CG86-018A). Garnet in JS86-024 forms discrete subhedral grains, and along with hornblende is indicative of a retrograde reaction between plagioclase and pyroxene. NN84-274 contains evidence for the reaction: (Photomicrograph 9.1C)

Clinopyroxene + Plagioclase1 = Orthopyroxene + Plagioclase2 + Amphibole + Opaque mineral

A 2-mm-wide prehnite-filled vein with K-feldspar flanking its borders is present in CG87-051. Relict igneous texture is preserved in VN87-148 indicating the original grain size was about 1 cm, although former igneous crystals have been recrystallized and flattened into ellipsoidal polygonal aggregates of plagioclase, scapolite and minor clinozoisite in felsic areas, and to pale-green clinopyroxene, leaf-green hornblende, and dark-orange-brown titanite in mafic areas.

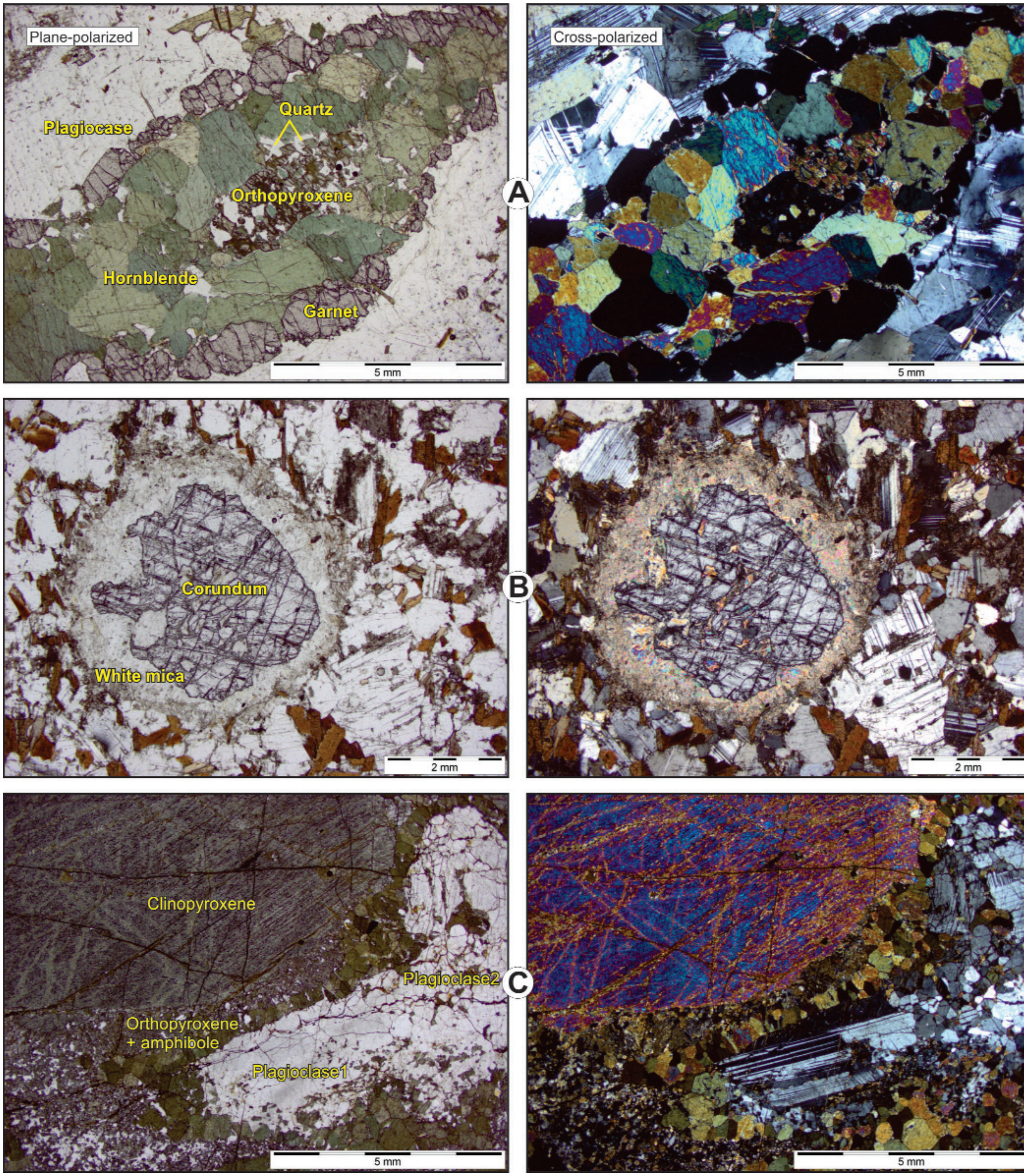
9.1.3 ULTRAMAFIC ROCKS (P_{3B}um)

Three types of ultramafic rocks are associated with the ARAI, namely olivine-, hornblende- and oxide-dominant types.

9.1.3.1 Olivine Dominant

Two occurrences of cumulate-textured, grey-green or ocherous ultramafic or near-ultramafic rocks were found 12 km east-southeast, and 14 km southeast of Port Hope Simpson (CG86-034 and CG87-052, respectively).

CG86-034 consists of partially serpentinized olivine, crisscrossed by opaque-oxide-filled fractures. The olivine is enveloped in broad, extremely polygonized double coronas, made up of an inner corona of orthopyroxene and an outer corona of clinopyroxene plus spinel. These are well-known products of reaction between olivine and plagioclase and, indeed, some residual primary plagioclase is present interstitially, heavily impregnated with small colourless inclusions. The other rock (CG87-052) is an olivine lherzolite to coronal olivine gabbro, containing relict primary olivine, plagioclase, clinopyroxene, opaque oxide and pale-orange-brown biotite. Clinopyroxene is heavily dusted with exsolved opaque inclusions. Plagioclase also contains abundant tiny dark inclusions in the cores of grains, but has recrystallized, clear outer parts. Broad double coronas separate olivine from plagioclase, consisting of an inner corona of fibrous or polygonal, granular orthopyroxene and an outer corona of colourless to pale-green flaky or polygonal amphibole. Coronal garnet forms discontinuous necklaces between coronal amphibole or orthopyroxene and plagioclase.



Photomicrograph 9.1. *Metamorphic reactions in Alexis River anorthositic intrusions. A. Alexis River anorthositic intrusion showing orthopyroxene + plagioclase reacting to garnet + hornblende + quartz (CG86-631), B. Corundum partially pseudomorphed to white mica in rock of uncertain protolith (metasomatized Alexis River anorthosite or pelitic gneiss?). Sapphire locality (CG87-055B), C. Alexis River anorthositic intrusion showing evidence for reaction clinopyroxene + plagioclase1 = orthopyroxene + plagioclase2 + amphibole + opaque mineral (NN84-274).*

One other site, only known from brief mention in field notes and already mentioned earlier (NN84-291), probably belongs to this group.

9.1.3.2 Hornblende Dominant

Another type of ultramafic rock associated with the ARAI is 'hornblendite', although the term is not intended to imply an igneous rock. It occurs as black-weathering, coarse-grained, typically elliptical pods (*e.g.*, CG86-023, CG86-316, CG86-317, CG87-173, JS86-499, MN86-063; NN84-291) of minor extent (usually only a few 10s of centimetres long). The ARAI is characterized by large pyroxenes that are commonly sheathed by amphibole, so it is suspected that the hornblendite pods are the end product of this process.

One such ultramafic pod within the ARAI examined in thin section (CG87-173) consists of two types of amphibole, with chlorite and very minor opaque oxide. The amphiboles are: i) a colourless flaky tremolite(?) and ii) a more equant variety, having blue, green and mauve pleochroism, leading one to suspect it is Na-rich. The mineral assemblage is interpreted to represent disequilibrium breakdown of orthopyroxene.

9.1.3.3 Oxide Dominant

This subgroup comprises oxide-rich ultramafic rocks. Metre-scale pods and boudinaged layers of an opaque mineral, thought to be ilmenite, were first reported by Gower *et al.* (1987; JS86-260).

The area was revisited by the author in 2001 and additional samples collected and investigated petrographically and chemically (CG01-001A, B, C, D, E). In addition to ilmenite, the rocks contain serpentinized olivine, hercynite, pale-green-brown amphibole and, in CG01-001E, weakly pleochroic orthopyroxene. The samples were determined to have TiO_2 between 8.24 to 22.16% and Fe_2O_3t between 51.09 and 66.50% (Gower, 2010c). Later mineral exploration in the same area resulted in the discovery of many additional occurrences, plus a locality having abundant apatite (Walsh, 2007), a common associate with ilmenite in anorthositic rocks. This is the only area within the Alexis River anorthositic intrusion where the author has seen oxide cumulates, but Greenshields Resources reported values for TiO_2 of 10.67% for a sample collected during mineral exploration near Port Hope Simpson (Jolliffe, 1997).

9.1.4 MAFIC GRANULITE (P_{3B}ag)

This unit has been assigned sparingly, and probably not in an entirely consistent manner. It refers to rocks having a noritic mineral assemblage, but a completely (or nearly so) metamorphic texture, such that their protolith is obscured. The rocks are suspected to be the end product of recrystallization of gabbro, norite, troctolite and their fine- and medium-grained equivalents.

Three samples examined in thin section (CG04-237D, MN86-239, SN86-218) comprise moderately to well-twinned plagioclase, strongly pleochroic orthopyroxene, pale- to mid-green clinopyroxene, equant garnet, dark-green amphibole, bronzy-brown biotite, an opaque oxide and common apatite. Grains are polygonal throughout. In MN86-239, garnet is a coronal phase surrounding polygonized mafic grains. Although olivine is no longer evident in this sample, the texture is typical of rocks in which it was formerly present.

9.1.5 AMPHIBOLITIC GNEISS (P_{3B}am)

Amphibolite within the ARAI is black, dark-grey-, brown- or greenish-weathering and medium to coarse grained. It ranges from melanocratic compositions verging on hornblendite to leucocratic rocks that resemble leucodioritic gneiss. The rocks vary from massive to intensely foliated, and commonly have a well-banded, gneissic appearance resulting from concordant layers of white to creamy quartzofeldspathic leucosome, concordant lenses and layers of texturally distinct amphibolite and minor granitic intrusions. Relict igneous pyroxene is locally present, but pyroxene also occurs in leucosome as a product of incongruent melting. Garnet is extremely abundant in some areas (*e.g.*, CG03-208).

Thin sections of amphibolite are CG03-208B, CG03-208E, CG84-178, CG86-019, CG87-342, DD91-110C, DD91-110E, GF81-181A, JS87-130A, JS87-136, MN86-001B, MN86-041B, MW84-013, MW84-026, MW84-030, NN84-104, NN84-234, SN86-047, SN86-259B, VN87-152 and VN87-388. The samples range from mela- to leucoamphibolite. The collective mineral assemblage is polygonal, well-twinned plagioclase, leaf-green to brown amphibole, orange-brown to buff-green biotite and an opaque oxide and/or sulphide. Garnet is present in many samples, where it forms subhedral grains as part of the stable mineral assemblage. 'Ghost' garnet (partially or totally retrograded and replaced by plagioclase) is present or, elsewhere, garnet is replaced by chlorite. Polygonal, pale-green clinopyroxene is also present in MN86-001B and NN84-104 and strongly pleochroic orthopyroxene in MW84-030. Minor secondary/accessory phases sporadically present include interstitial K-feldspar and/or quartz, apatite, carbonate, rutile and prehnite. Sample CG87-342 shows good evidence of retrogression to greenschist facies by the reaction:

Plagioclase + Hornblende = Actinolite +
Epidote + Albite + Quartz + Chlorite.

9.1.6 DIORITIC/QUARTZ DIORITIC GNEISS (P_{3B}dr)

Dioritic gneiss occurs mostly as a 6- to 7-km-wide envelop to the Alexis River anorthosite between Port Hope Simpson and the coast north of St. Lewis. The rocks are grey-, rusty-, or white weathering, and fine to coarse grained and have a discontinuous banding emphasized by layers of concordant amphibolite, leucosome and minor granitoid intrusions. It is compositionally heterogeneous and grades into amphibolite, leucoamphibolite and tonalite. The most repeated entry in field notes is 'amphibolitic to dioritic gneiss'. It is commonly garnet bearing and locally contains hornblende porphyroblasts. Despite being termed 'dioritic', a leucogabbronoritic protolith is most probable.

Three thin sections (CG86-005, GF81-186B, MN86-015) differ from the amphibolitic rocks in having more K-feldspar and quartz, absence of pyroxene and lower content of mafic minerals. GF81-186B differs from the other two, being leucodioritic, lacking amphibole and having garnet.

9.1.7 GRANITOID GNEISSIC ROCKS (P_{3B} MISCELLANEOUS)

Granitoid gneissic rocks are a minor but ubiquitous associated rock type in the ARAI. Rock types include granodiorite, K-feldspar megacrystic granodiorite, granite, and rare syenitic and monzonitic rocks. The rocks are pink-, white-, buff- and grey-weathering, fine to coarse grained, weakly to intensely foliated, and, generally, in concordant contact with more typical ARAI rock types. In some cases, similar rocks are seen to be discordant intrusions and it is possible that this was generally the case prior to close-to-layer-parallel transposition that typifies the Lake Melville terrane.

Thin sections have been grouped as follows: granite – MN86-241, NN84-099, NN84-247B, SN86-066A, SN86-262A, SN86-264; monzodiorite – EA61-043H, SN86-050; monzonite – MN86-170, MN86-279; tonalite – NN84-073, NN84-109; leucotonalite – GF81-184, GF81-186A. All have plagioclase, K-feldspar (not in leucotonalite) and quartz. All contain biotite, except monzonite MN86-279, which is also anomalous in having clinopyroxene. Leaf-green to blue-green amphibole is present in the monzonitic and tonalitic rocks, but lacking in leucotonalite and most of the granites. Both tonalites carry orthopyroxene (enderbites?). Garnet is sporadically present, but not confined to a particular rock type. Opaque minerals, apatite and zircon are generally present, as is allanite in the granitic rocks. Sporadically present are a sulphide opaque mineral and secondary white mica, chlorite and epidote.

9.1.8 MAFIC DYKES (P_{3B}d)

The anorthositic and leucogabbronoritic rocks are locally host to amphibolitized mafic dykes (*e.g.*, CG84-173, CG84-174, CG84-176, CG84-300, CG84-425, CG86-035, CG86-765, CG87-045, DD91-110, GF81-209, JS87-134, NN84-091, NN84-092). Most of the dykes are fairly small (<2 m wide), and consist of black-weathering, fine- to medium-grained, massive to strongly foliated amphibolite. Discordance to a host-rock fabric was recorded at CG87-045, although the dyke is, itself, deformed.

Two thin sections were examined (CG86-765, JS87-134). Neither sample has a strong deformational fabric, retaining a relict diabasic texture despite strong metamorphism. Both relict igneous plagioclase and clinopyroxene are present, along with metamorphic garnet, biotite (in CG86-765) and amphibole (orange-brown in JS87-134 – Ti-rich?). The garnet is coronal in both and is a product of reaction between plagioclase and clinopyroxene.

The lack of deformation and relict igneous texture might be taken as implying that these rocks escaped some of the deformation experienced by other units within the ARAI. It is possible that they are genetically unrelated to it, although must be pre-Grenvillian because of their metamorphosed state.

9.1.9 OBSERVATIONS REGARDING METAMORPHISM BASED ON PETROGRAPHIC STUDIES

Petrographic data for the ARAI were investigated to see if any systematic variations along the length of the body could be established from spatial distribution of minerals (*e.g.*, any longitudinal metamorphic gradient). A broad range of mineralogical parameters were examined, including distribution of phases, their shape, colour, alignment, and any indications of metamorphic reactions such as coronal textures. The author found no convincing evidence of any systematic spatial variations in any parameter examined. For example, high-grade minerals, such as garnet, or low-grade minerals, such as prehnite, are found along the entire length of the ARAI. Given that the ARAI is within a region of horizontal dextral transpression, lack of spatial differences is understandable as such a structural regime does not expose crust from different levels.

9.2 UPPER EAGLE RIVER MAFIC INTRUSION (P_{3B}rg, P_{3B}ag, P_{3B}ln)

A southwest-trending zone of extremely variable mafic to anorthositic rocks parallel to part of the Upper Eagle River in the Mealy Mountains terrane (Figure 9.1) is considered to represent the remnants of a disrupted layered mafic intrusion that has been metamorphosed to medium- and high-grade assemblages. Outside the confines of the Eagle River valley, the body is unexposed. The body was mapped by Gower (1998; 2010a; Eagle River map region). It was not suspected during mapping of the area to the north (Gower and van Nostrand, 1996; Gower 2010a; Southeast Mealy Mountains map region), if, indeed, it extends into it. Magnetic patterns in the vicinity of the intrusion and to the north do not assist greatly in delineating its boundaries. The name ‘Upper Eagle River mafic intrusion’ is introduced here, the unit having been previously unnamed when addressed by Gower (1998) and Gower *et al.* (2008b).

A sample (CG97-080) from the body was investigated by U–Pb geochronological methods by Gower *et al.* (2008b), having the intention to date the time of high-grade metamorphism to which the rock has been subjected. Three single zircons and one titanite fraction were analyzed. A regression line through the near-concordant zircon data alone gives an upper intercept of 1662 ± 58 Ma and a lower intercept of 1500 ± 340 Ma. Given the near concordance of the upper-most zircon analysis, however, a more realistic value is 1662 ± 19 Ma, if the lower intercept is anchored at 1500 Ma. The 1662 ± 19 Ma result is interpreted to be the time of metamorphism and the 1500 Ma lower intercept to reflect Pinwarian Pb loss. Grenvillian effects are not geochronologically evident at this site. The same sample yielded values of T_{DM} = 1894 Ma and εNd (1.66 Ga) = +1.76.

Rock names applied at various outcrops include ultramafite, melanorite, gabbronorite, leucogabbronorite, anorthosite, mafic granulite and amphibolite. This menu of names partly reflects the genuine lithological variation, but also the struggle to find appropriate rock labels. Gower (2010a; Eagle River map region) grouped the rocks into leucogabbronorite, mesogranulite/leucogabbronorite, and a more mafic unit that included gabbronorite and ultramafite.

The rocks are texturally as well as compositionally diverse. Parts are homogeneous, but diffuse or sharply defined primary layering (1–20-cm-thick layers) is also present in some outcrops (CG97-090). Grain size varies from fine to very coarse, embracing obvious ophitic textures as well as thoroughly recrystallized granular fabrics. The ubiquitous minerals are plagioclase, orthopyroxene, clinopyroxene and an opaque mineral, with biotite and hornblende also common. Pods, lenses, and 'sweats' of plagioclase-rich leucosome, some containing orthopyroxene, are pervasive in some outcrops, but absent elsewhere. Melanocratic pods and veneers, locally consisting solely of clinopyroxene, are also present. A sulphide-rich zone containing some chalcopyrite was found in association with an ultramafic layer. The history envisaged for these rocks is as follows: i) formation as a layered mafic intrusion, ii) metamorphism to granulite facies with local and irregular partial melting accompanied by deformation, iii) retrogression to amphibolite facies during subsequent tectonism, and iv) further disruption during late-stage brittle faulting.

Six rocks were examined in thin section (CG97-075B, CG97-076, CG97-080, CG97-081, CG97-090, CG97-092), although sample CG97-075B may be a separate xenolith from the body within a nearby granitoid unit. Samples CG97-090 and CG97-092 are readily grouped and can be considered representative of the leucogabbronorite. Plagioclase is well twinned, antiperthitic and thoroughly recrystallized. Both orthopyroxene and clinopyroxene are present as anhedral/polygonal, equant grains, also thoroughly recrystallized. Orthopyroxene tends to be in clusters surrounded by amphibole. Green spinel (hercynite) is common, preferentially associated with clinopyroxene (especially CG97-092, but also with an orange serpentine mineral in CG97-090). Opaque minerals in CG97-090 (mineral occurrence 13B/15/Pyr001) are judged to be pyrrhotite and pyrite based on thin-section, reflected-light observations. CG97-092 contains both sulphide and oxide, but only in very minor amounts. Other noteworthy minerals are very pale-orange biotite (phlogopitic?) and pale-green amphibole. It is suggested here that these rocks may have been olivine troctolite originally, but, as a result of coronitic reactions between olivine and plagioclase under moderate- to high-grade conditions, all the olivine has been consumed – the last vestiges being represented by orange serpentine and hercynite in the cores of mafic clusters. Annealing of the inner–outer double coronas characteristic of lower grades has produced the polygonal orthopyroxene and polygonal clinopyroxene + spinel, respectively. The resultant rock, both in texture and mineral assemblage, approaches that of a mafic granulite.

Samples CG97-076, CG97-080 and CG97-081 are all fine- to medium-grained, leucocratic rocks consisting mostly of recrystallized plagioclase, orthopyroxene and/or clinopyroxene, lesser green amphibole and orange-red-brown biotite, and minor opaque oxide (some sulphide in CG97-080), apatite, and, in CG97-080 and CG97-081, minor K-feldspar, quartz and zircon. A satisfactory name for these rocks remains elusive. Quartz-deficient enderbite might suffice, although perhaps implying connotations not envisaged here.

Thin section CG97-075B is from mineral occurrence 013B/15/Pyr001. It is completely recrystallized and consists of sericitized plagioclase, microcline, red-brown biotite, apatite and abundant sulphide (probably pyrite). The rock was considered by the author to be a hybrid in the field (between the mafic intrusion and its granitoid envelop), and microscopic examination has not altered that view.

9.2.1 UPPER EAGLE RIVER MAFIC INTRUSION CORRELATIVE? (P_{3B}rg, P_{3B}ag)

A small area of somewhat similar mafic rocks is depicted on the 1:100 000-scale map (Gower, 2010a; Eagle River map region) south of the Upper Eagle River mafic intrusion (Figure 9.1). The rocks here consist of metagabbro, amphibolite and leucoamphibolite. All are black-weathering and homogeneous within their respective outcrops, but are texturally disparate. The metagabbro is massive and shows obvious ophitic texture, in contrast to the other two rocks in which primary textures are poorly preserved. One of these is medium grained and has a well-developed fabric; the other is fine grained and only shows a weak fabric. The relationships between the three mafic rocks remain unknown. Their variability is no more than that in the Upper Eagle River mafic intrusion.

In thin section, the metagabbro (CG97-122), although preserving an igneous texture, is mostly recrystallized. The only primary silicate mineral is plagioclase, which still shows strong zoning in places, but grain boundaries are extensively recrystallized. Clinopyroxene has been replaced by felted mosaics of colourless to pale-green tremolite–actinolite, orange-brown biotite, secondary opaque oxides, and granular (?)titanite. An opaque oxide, recrystallized from its primary progenitor, and minor sulphide, also occur.

The simplest interpretation (but not the only one) is that these mafic rocks represent a dismembered part of the Upper Eagle River mafic intrusion. One alternative depiction, to the way the layered mafic intrusion has been represented on the 1:100 000-scale map, is that it is a half-ring-shaped body convex to the southeast, being coincident with an arcuate series of discontinuous magnetic highs.

9.3 UNASSIGNED ULTRAMAFIC ROCKS (P_{3B}um)

This section refers to ultramafic rocks that are not part of the Alexis River or Upper Eagle River intrusions, but for which an early Labradorian age is also favoured (although they may well have disparate protoliths and ages). Their rarity makes them of interest, and they could have tectonic and/or economic significance, but meaningful interpretation of them is hardly possible from present data. They occur in the Lake Melville and Mealy Mountains terranes. Possible correlatives in the Hawke River terrane are mentioned in Section 10.2.2.1.

9.3.1 LAKE MELVILLE TERRANE

Ultramafic rocks are rare in the Lake Melville terrane. Of the thousands of outcrops examined, only fourteen sites include rocks that might qualify.

Two localities of interest are MW84-042 and CG84-212, which are 5.5 km apart, more-or-less aligned along strike (Figure 9.1). Field notes offer few details except to record that the ultramafic rocks are intruded by quartz veins and pegmatites (which brings to mind the classic emerald deposit setting; *cf.* Groat *et al.*, 2008).

Samples from both sites were examined in thin section. MW84-042 has a totally mafic-mineral, igneous assemblage, consisting of olivine (*cf.* forsterite), weakly pleochroic orthopyroxene, pale-green amphibole (Mg-rich hornblende?), an opaque oxide, green spinel and serpentine. In contrast, CG84-212 has a metamorphic/metasomatic assemblage, consisting of tremolitic/actinolitic amphibole, red-brown biotite, apatite, trace plagioclase and K-feldspar, and clearly secondary opaque oxide(s), titanite, chlorite and serpentine.

Ultramafic rocks were also recorded in field notes at two other nearby sites, but no supporting petrographic data are available. One is 3.5 km north-northeast of MW84-042 (at NN84-291), where ‘numerous ultramafic lenses and bands’ were noted, and the other is 3.0 km south-southwest of MW84-042 (at NN84-211), where ‘garnetiferous ultramafic bands’ were recorded. As presently understood, the NN84-291 locality is within the Alexis River anorthositic intrusion, and the NN84-211 locality is within the metasedimentary gneiss. Neither is on strike with the first-mentioned localities, which reduces their potential to be related. One other site (CG91-053) in the area, but slightly farther afield (28 km south-southeast of MW84-042), is of relevance. The rock was noted in the field as being black-weathering and massive. A stained slab indicates a transitional mela-amphibolite to ultramafic composition.

A thin section contains a completely metamorphic assemblage of plagioclase, pale-olive-green biotite, pale-green (Mg-rich?) amphibole and scapolite.

Of the remaining localities (note that 1980 and 1982 sites are outside of the frame of Figure 9.1), most were recorded in the field as ultramafite/(mela)amphibolite, except NN80-074, which was recorded as an ultramafic dyke. One (MC77-115) was reported as interlayered with granitic gneiss, and others as occurring as blobs and layers in gneiss (NN80-015, NN80-081, PE82-018, RW75-063, SN86-138, SN86-225 – Plate 9.3A).

Thin sections were prepared from samples CG03-245B, CG91-053, JS87-249B, MC77-115A and MW82-114. All have different mineral assemblages. CG03-245 is strongly retrograded, containing relict igneous clinopyroxene, three types of metamorphic amphibole (hornblende, tremolite, riebeckitic?), with secondary chlorite, titanite, quartz and carbonate. CG91-053 contains pale-green amphibole (Mg-hornblende?), pale-green biotite, with minor plagioclase and scapolite. JS87-249 consists of tremolite/actinolite, chlorite, and an opaque oxide. MC77-115 contains clinopyroxene and amphibole (hornblende), with minor plagioclase and green-buff biotite. MW82-114 has green-brown hornblende, orange-brown biotite, minor plagioclase and quartz, and trace opaque oxide, apatite and titanite, and secondary chlorite. Of the five, it is closest in composition to amphibolite.

9.3.2 MEALY MOUNTAINS TERRANE

Ultramafic rocks are as scarce in the Mealy Mountains terrane as those in the Lake Melville terrane. Most of the localities are close the Mealy Mountains terrane–Lake Melville terrane boundary and, apart from two sites (CG87-647, VN91-298 – *see* end of section), they cluster in two areas, namely: i) west of ‘Camel’ Lake, and ii) southwest of Port Hope Simpson. Note that a few additional (and potentially similar in age) occurrences of ultramafic rocks in the Mealy Mountains terrane are found in the Eagle River complex and the Upper Eagle River mafic intrusion.

West of ‘Camel’ Lake (5 to 9 km), four localities include ultramafic rocks (CG84-227, CG84-232, CG84-321, VN84-481). All are closely associated with metasedimentary gneiss and both supracrustal and igneous intrusive protoliths are probably represented. At CG84-227, the rock was recorded as pale-grey-green-weathering and that it resembled a calc-silicate rock, except for its massive appearance. The ultramafite at CG84-232 is associated with well-banded, fine-grained amphibolite that could be of supracrustal origin; it was not examined in thin section. The other two are more likely igneous. The rock at CG84-321 was noted in the field to be part of a layered ultramafic–mafic intrusion.

In thin section, CG84-321 contains pale-green amphibole, weakly pleochroic orthopyroxene, relict olivine and secondary opaque oxides, spinel and serpentine (after olivine). The field context of VN84-481 is not specified in notes, but, in thin section, it is seen to have a relict igneous assemblage, consisting of plagioclase, orange-brown biotite, Mg-rich hornblende(?), colourless, non-pleochroic orthopyroxene and an opaque oxide.

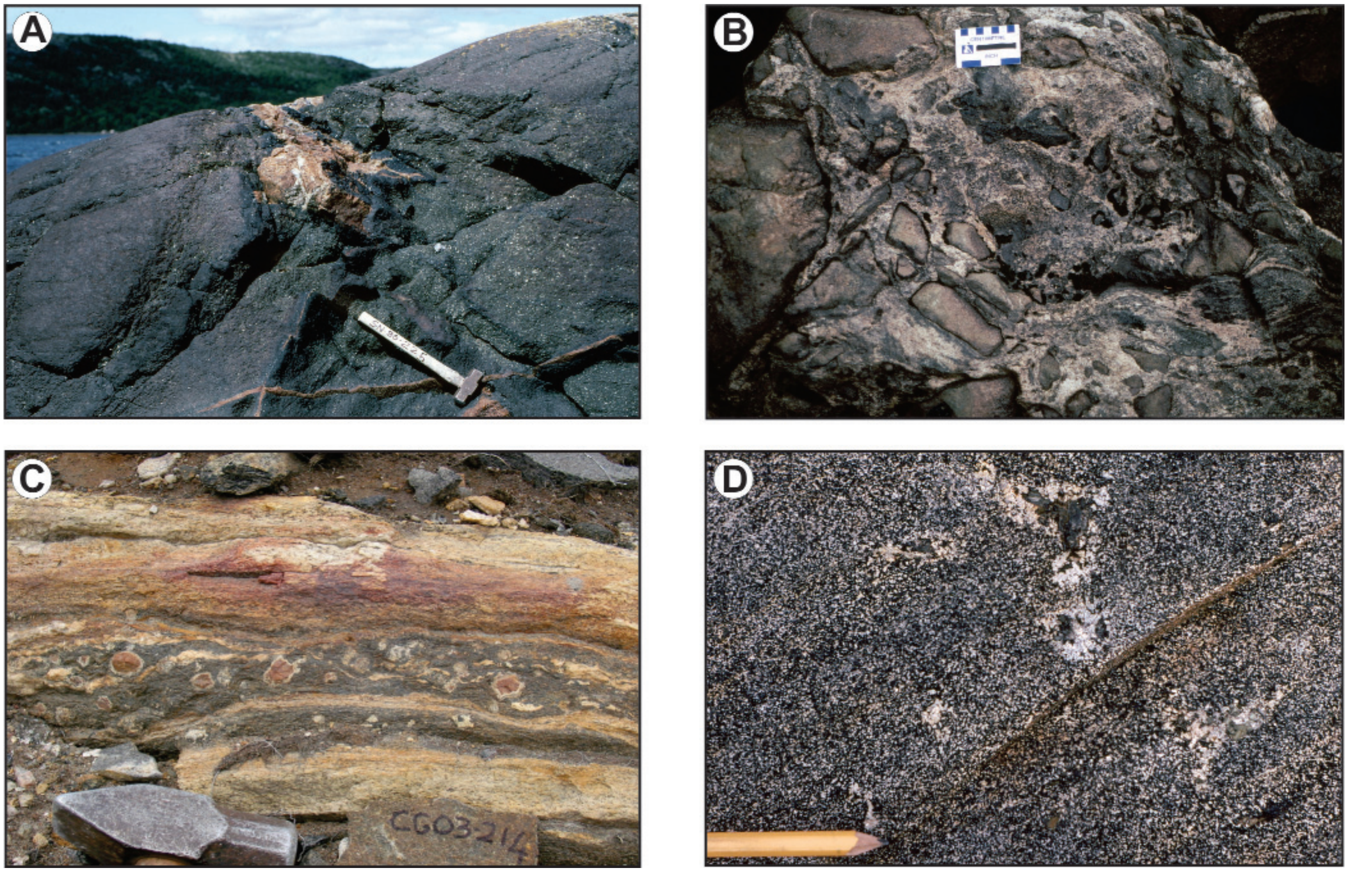


Plate 9.3. *Features of ultramafic and mafic rocks assigned to be early Labradorian. A. Ultramafite/mela-amphibolite intruded by granitic veins showing hydration of pyroxene to amphibole at their margins (SN86-225), B. Subrounded blocks of ultramafic material in migmatitic leucosome. Origin uncertain (VN95-016), C. Garnet in amphibolite layer in various stages of retrogression to plagioclase and biotite (CG03-214), D. Leucosome patches cored by orthopyroxene – indicating incongruent melting and onset of granulite-facies conditions (CG84-281).*

About 27 km farther north, on Eagle River, attention is drawn to two other sites about 2 km apart (CG95-016, VN95-016). The rock at CG95-016 was recorded as a pod of grey-green serpentinized dunite, whereas VN95-016 (Plate 9.3B) was described as pods of black to dark-green calc-silicate rock. On the 1:100 000-scale map for the area (Gower, 2010a; Southeast Mealy Mountains map region) VN95-016 is designated as an occurrence of calc-silicate supracrustal rock, but there is a possibility that both are derived from an ultramafic intrusive protolith.

Southwest of Port Hope Simpson (11 to 18 km), two ultramafic rock localities are known. On the basis of aerial photographic interpretation, the occurrence at CG87-273 is interpreted by Gower (2010a; St. Lewis River map region) to belong to a sinuous 5-km-long layered mafic body, associated with leuogabbronorite.

A thin section contains a primary igneous assemblage of olivine, orthopyroxene, clinopyroxene, plagioclase, pale-green amphibole and pale-orange (phologopitic) biotite. Opaque minerals are lacking. Coronitic textures are well developed between olivine and plagioclase, characterized by an inner corona of fibrous, colourless orthopyroxene normal to olivine grain boundaries and an outer corona of amphibole and green spinel. Green spinel also occurs as a myriad of tiny inclusions within plagioclase, giving it a dark-grey-green hue in places. The other locality (CG03-334) is only known from its field description as a dark-green- to black-weathering, ultramafic rock composed mostly of poikilitic amphibole and biotite.

One of the earlier excluded localities (CG87-647) is 67 km west of Port Hope Simpson. Field notes describe it as a khaki-weathering, massive, heavy, olivine–plagioclase–clinopyroxene ultramafic rock. A stained slab shows that it has a cumulate texture and that 5–10% intercumulus plagioclase is present. The other excluded locality is 50 km west of Port Hope Simpson (VN91-298) and is mapped as occurring within pelitic gneiss and described in field notes as a black-weathering, medium- to coarse-grained, garnet-bearing amphibolite.

In thin section, VN91-298 is recorded as having interstitial plagioclase, traces of quartz inclusions, green-brown hornblende, strongly pleochroic orthopyroxene, garnet, an opaque oxide, and apatite (a granulite-facies restite?).

9.4 UNASSIGNED MAFIC AND RELATED ROCKS (P_{3B} VARIOUS)

9.4.1 LAKE MELVILLE TERRANE

Rocks included under this heading are amphibolite, metagabbro/norite and mafic granulite (in all cases including leuco- and mela- varieties), and migmatized mafic dykes. Including them here assumes an early Labradorian age, but mafic rocks of several ages may be involved.

A relatively small proportion of outcrops have metamorphosed mafic rocks as the major rock type (roughly 300 mafic-rock data stations *vs.* over 3000 for granitoid rocks). However, of those outcrops at which granitoid rocks are deemed to be dominant, metamorphosed mafic rocks were also recorded at about 50% as a subsidiary rock type. Metamorphosed mafic rocks are therefore ubiquitous, albeit not volumetrically major, in the Lake Melville terrane.

Geochronological information dating their emplacement is lacking, but marginally useful constraints are available from two U–Pb, three Ar–Ar, and one K–Ar geochronological site(s). At the first U–Pb site, a metamorphosed mafic dyke intrudes K-feldspar megacrystic granitoid rocks dated to be 1678 ± 6 Ma (Schärer *et al.*, 1986; Neveisik Island; CG83-554; outside of Figure 9.1). The mafic dyke is unmigmatized, however, so it may be part of mid-to-late Labradorian mafic magmatism. At the second U–Pb site, banded migmatitic gneiss containing mafic enclaves was dated to be 1677 +16/–15 Ma (Schärer *et al.*, 1986; Second Choice Lake; CG84-495). The 1677 Ma date is defined by a long projection to an upper intercept from data points that are close to a Grenvillian lower intercept. The gneissic concordance of the amphibolite with its granitoid gneissic host and the severe Grenvillian overprint hamper meaningful interpretation of the early mafic-rock history at this site.

Geochronological data (for hornblende) from three Ar–Ar sites only provide evidence of Grenvillian history. At the above-mentioned Second Choice Lake site, R. Dallmeyer (personal communication, 2002, 2010; sample CG84-495B) obtained a total-gas age of 1018 ± 2 Ma from amphibolite associated with the banded migmatitic orthogneiss, and, 3.3 km to the south-southeast, van Nostrand (1988; sample VAN84-22B) obtained total-gas and plateau ages of 1020 ± 5 Ma and 1023 ± 1 Ma, respectively, from an amphibolite enclave in migmatitic orthogneiss. At a site 32 km northeast of Second Choice Lake, van Nostrand (1988; sample VAN84-23B) reported total-gas and plateau ages of 1116 ± 50 Ma and 1070 ± 50 Ma, respectively, from a concordant amphibolite dyke intruding migmatitic granodiorite orthogneiss. The K–Ar sample, from near the Lake Melville terrane – Mealy Mountains terrane boundary on the south shore of Lake Melville, gave a hornblende date of 951 ± 88 Ma from amphibolite gneiss (Emslie *et al.*, 1984).

Metamorphosed mafic rocks are generally given short shrift in field notes, rarely receiving more than mere mention of their presence. Amphibolite is overwhelmingly the most abundant. It is black-, grey-, green- or rusty-weathering, medium grained (rarely fine- or coarse grained), is massive to mylonitic, and commonly internally homogeneous (although may be part of an overall migmatitic or gneissic outcrop). Garnetiferous amphibolite is very common, having garnet up to several centimetres across. In places, the garnet is partially or completely pseudomorphed to plagioclase (‘ghost’ garnet; *e.g.*, CG84-064, JS86-505, MN86-171, MN86-461, NN80-074, CG03-214 – Plate 9.3C), or, elsewhere in retrograde, schistose rocks, to biotite or, more commonly, chlorite (*e.g.*, CG03-399). White-weathering, discontinuous to continuous, leucosome is normally present, forming 5–15% of the rock. The veins are either concordant and contribute to the gneissosity, or may be discordant, creating or augmenting an agmatitic aspect to the rock. Garnet, hornblende or pyroxene porphyroblasts are commonly present. Garnet locally forms a fringe around amphibolite enclaves in white-weathering leucosome. Amphibolite is intruded by a wide range of microgranite and pegmatitic intrusions, probably representing numerous separate injection events. In places, the rocks have also been subjected to late-stage, low-grade shearing and brecciation.

Relict igneous textures are sporadically preserved, in which case the rocks are termed metadiabase or metagabbro/norite, or their leucocratic or melanocratic equivalents, depending on grain size and composition. These are also commonly garnetiferous (garnet recorded as being 6 cm across at CG84-504).

Locally, the mafic rocks include two-pyroxene ± garnet assemblages that clearly achieved granulite facies. Superficially, they are similar to amphibolite, showing the same weathering, textural/fabric features, and associated leucosome characteristics. Locally irregular leucosome patches containing orthopyroxene are present, indicating incongruent melting and the onset of granulite-facies conditions (CG81-301, CG84-064, CG84-100, CG84-153, CG84-281 – Plate 9.3D, CG84-283, CG86-757) (*cf.* Timmerman *et al.*, 2002 for similar examples). Granulite-facies rocks include some of the mafic dykes (*e.g.*, CG86-746, MN86-217).

Recognizable metamorphosed mafic dykes make up about one third of all the Lake Melville terrane mafic rocks, and it is probable that many other metamorphosed mafic rocks were emplaced as mafic dykes, but are no longer identifiable as such. The recognizable examples are mostly referred to in field notes as amphibolite dykes, but, in some, relict igneous textures are preserved and the name metadiabase is more appropriate. They are generally fine to medium grained, and mostly homogeneous. Some are plagioclase-phyric. Fabric ranges from weak to strong and, commonly, the dykes have been boudinaged (*e.g.*, CG83-555), folded, or otherwise disrupted (*e.g.*, CG86-156). Generally, they are termed dykes because discordance to a fabric in their host rocks is preserved, but other features, such as relict chilled margins or diabasic texture provide guidance in rare cases. They are regarded as early Labradorian because they show signs of migmatization, but there is no proof that all the dykes are necessarily of this age.

One hundred thin sections are available of metamorphosed mafic rocks in the Lake Melville terrane. Following petrographic examination, they were given a variety of names, including amphibolite, metadiabase, diorite, metagabbro, metagabbronorite, norite and mafic granulite. The following minerals were identified (and the percentage of thin sections in which they occur given in parentheses): plagioclase (100%), K-feldspar (15%), quartz (48%), biotite (82%), amphibole (93%), clinopyroxene (41%), orthopyroxene (25%), garnet (27%), opaque oxide (90%), sulphide (41%), apatite (74%), titanite (25%), zircon (19%), allanite (12%), chlorite (25%), carbonate (11%), epidote (12%), rutile, scapolite, prehnite and serpentine (all less than 10%).

Most of the felsic minerals are deemed to be metamorphic, although some plagioclase retains an igneous euhedral to subhedral shape, especially in mafic rocks still recognizable as dykes. K-feldspar and quartz appear to be surprisingly abundant for mafic rocks, but they are most commonly present as interstitial phases or inclusions. The latter is especially true of quartz, which is retained as a product in breakdown reactions involving clinopyroxene. Biotite is overwhelmingly orange-brown, and much of the amphibole is green-brown. These colours are typical of higher grade metamorphism in mafic rocks. Green biotite and blue-green amphibole can be linked to retrogressive reactions. Both the clinopyroxene and orthopyroxene are represented by igneous and metamorphic types, although roughly three-quarters of each are interpreted to be metamorphic. Garnet is sporadically mantled by plagioclase retrograde products. The remaining phases are either accessory or secondary. Metamorphosed mafic rocks, specifically identified as dykes and examined in thin section are CG80-166B, CG86-048B, JS87-355, MN86-171B, NN80-091, NN80-252B, NN80-338, RG80-203B, SN86-233B and VN87-279.

The petrographic data were evaluated for a broad range of mineralogical parameters, including distribution of phases, their shape, colour, alignment, and any indications of metamorphic reactions. No systematic variations were found. This may be due to several genetically unrelated mafic rocks having been lumped together. On the other hand, it could be due to all the rocks being at a similar metamorphic grade. Such a conclusion was reached for the spatially associated Alexis River anorthositic intrusion (for which genetic disparity between samples is less likely). Generalized conclusions that can be reached are: i) granulite-facies conditions were experienced by the mafic rocks in all parts of the Lake Melville terrane, and ii) substantial late-stage retrogression also occurred. Granulite-facies conditions are suggested to have existed during the Labradorian orogeny, and the resultant rocks brought closer to the surface either then or during Grenvillian orogenesis (or both).

9.4.2 MEALY MOUNTAINS TERRANE

The mafic rocks included here are very similar to those in the Lake Melville terrane, namely amphibolite, diorite, metagabbro/norite, and mafic granulite (in all cases including leuco- and mela- varieties). The same caveat applies – including them here assumes an early Labradorian age, but that mafic rocks of several ages may be involved.

Also applicable is the comment that a relatively small proportion of outcrops have metamorphosed mafic rocks as the major rock type (roughly 70 mafic-rock data stations *vs.* 800 for metamorphosed granitoid rocks). Metamor-phosed mafic rocks were also recorded at less than 20% as a subsidiary rock type with granitoid rocks in the Mealy Mountains terrane (*vs.* 50% for the Lake Melville terrane). The metamorphosed mafic rocks in the Mealy Mountain terrane are mostly found close to the boundary with the Lake Melville terrane.

U–Pb geochronological constraints for the age of the metamorphosed mafic rocks in the Mealy Mountains terrane come from three sites (Gower *et al.*, 2008b). At CG95-096 (Figure 8.1), enderbitic granulite gneiss dated to be 1789 ± 29 Ma is discordantly intruded by a mela-amphibolite dyke that shows chilled margins against its granitoid host rock. The mafic dyke gave a near-concordant weighted average $^{207}Pb/^{206}Pb$ age of 1640 ± 2 Ma, interpreted to date time of metamorphism. At CG95-341, the age of a migmatized mafic dyke and a later, unmigmatized metamorphosed mafic dyke is bracketed between 1800 ± 40 Ma and 1496 ± 10 Ma (*cf.* Sections 7.3.6.1 and 8.1.1 for further details regarding these two localities). At CG98-128, amphibolite bands and boudins are interlayered with granitic gneiss. The two rock types are concordant. The preferred interpretation for the emplacement age of the host granitic gneiss is 1670 ± 5 Ma, based on five zircon analyses. The amphibolite gave an age of 1626 ± 8 Ma, based on three, near-concordant collinear zircon analyses, which is interpreted to date time of metamorphism. In none of the three cases is the emplacement age of the mafic rock established, but data from all sites are consistent with their assumed early to mid-Labradorian time slot.

The rocks are black-, grey-, green- or rusty-weathering, mostly medium grained (but may be fine or coarse grained).and vary in fabric from massive to mylonitic. They are commonly well-banded gneiss having gneissosity defined by quartzofeldspathic leucosome, and they also occur interlayered with granitoid (especially dioritic) gneiss. Over half of the outcrops were recorded as amphibolite or dioritic, and most of the remainder as gabbroic (leuco- and mela-types included). Some rocks were identified as mafic granulite in the field, but showing partial retrogression to amphibolite facies. Metamorphosed mafic dykes were recorded at a few sites (CG95-096, CG98-128, DE91-061, HP92-002, JS87-046).

Names for the 31 thin sections of mafic rocks from the Mealy Mountains terrane include amphibolite, diorite, gabbro, gabbronorite, norite and mafic granulite. The prefix 'meta' typically applies, as do 'leuco' or 'mela' in some instances. Minerals present are plagioclase (100% of thin sections), K-feldspar (10% – secondary or interstitial), quartz (40% – secondary, interstitial and(or) inclusions), orange-brown biotite (80%), amphibole (85% – half is green-brown hornblende), clinopyroxene (40%), orthopyroxene (45% – generally markedly pleochroic), garnet (30%), an opaque oxide (97%), an opaque sulphide (50%), apatite (80%), plus accessory/secondary titanite (23%), zircon (19%), allanite (16%), chlorite (23%), epidote (12%), carbonate, rutile, prehnite and serpentine (all less than 10%).

If comparison is made with the mineral percentages for metamorphosed mafic rocks in the Lake Melville terrane, it will be appreciated that the numbers are remarkably similar. Other features, such as proportions of metamorphic *vs.* igneous and mineral colours, are also very similar (one feature that might be different is dearth of garnet retrogression to plagioclase in the Mealy Mountains terrane). Still, any two batches of metamorphosed mafic rocks are likely to have similar petrographic characteristics regardless of their origin, so perhaps overmuch should not be made of the similarities. As for the Lake Melville terrane, the mafic rocks were evaluated spatially using the same mineralogical parameters, but, equally, no systematic variations were found. The same generalized conclusions regarding metamorphic history also apply. The author's opinion is that the metamorphosed mafic rocks in both terranes are sufficiently alike that genetic equivalence exists. Such a view could be tested using geochemical data (not done here, as available data are inadequate).