CHAPTER 13

LATE PALEOPROTEROZOIC AND EARLY MESOPROTEROZOIC (PM 1810–1350 Ma)

This chapter concerns late Paleoproterozoic and early Mesoproterozoic rocks in the Pinware terrane. These are mostly younger than those reviewed in Chapters 6–12, although some do have similar ages. On the 1:100 000-scale maps of Gower (2010a), the rocks are represented by the unit designator 'PM...', meaning either Paleoproterozoic or Mesoproterozoic in age.

Three major rock groups are recognized, namely: i) supracrustal rocks, ii) foliated and gneissic granitoid rocks, and iii) foliated and gneissic mafic rocks.

13.1 PINWARE TERRANE SUPRACRUSTAL ROCKS

Supracrustal rocks in the Pinware terrane, having a Pinwarian or earlier age, occur in two distinct regions, referred to here as the Upper St. Augustin River and Henley Harbour districts (Figure 13.1). Given that the two districts are geographically separate and that there are some rock-type differences between them (the most notable contrast between the two districts being that rocks of probable volcanic origin are only found in the Henley Harbour district), they are addressed separately here. Present information suggests that the supracrustal rocks in the St. Augustin River district might be older.

Identifying rocks having a probable supracrustal protolith in the Pinware terrane proved to be particularly troublesome so, prior to reviewing the rocks in these two districts, criteria are summarized that were used to distinguish them in the first place. Information is from Gower (2007), where further details are given.

13.1.1 CRITERIA FOR IDENTIFYING PROTOLITH OF MEDIUM- TO HIGH-GRADE SUPRACRUSTAL QUARTZOFELDSPATHIC GNEISSES

The identification of the protolith of metamorphosed supracrustal rocks that are the product of extreme differentiation in the sedimentary environment, such as pelite, quartzite, marble/calcareous rocks and iron formation from alumina-rich, silica-rich, carbonate-rich, and ferruginous sediments, respectively, or rocks that are texturally distinct, such as conglomerates, heterolithologic pyroclastic rocks and pillow lavas, is not a serious challenge for field geologists accustomed to working in high-grade terrains. On the other hand, distinguishing between medium- to high-grade quartzofeldspathic metasedimentary gneisses and those derived from igneous rocks of similar composition (*e.g.*, fine-grained felsic volcanic rocks) remains as lively a problem now as it was two hundred years ago. The object of the comments below is to summarize some of the criteria used to discriminate between psammitic gneiss and granitic/granodioritic gneiss in the Grenville Province in eastern Labrador, particularly the rocks addressed in this chapter.

i) Quartzofeldspathic gneiss associated with rocks of less equivocal sedimentary parentage, such as quartzite, calc-silicate rocks and pelites. If the quartzofeldspathic gneiss is interlayered in a regular, concordant manner with such rocks (or even regionally associated), then it is reasonable to suspect that both have the same origin, rather than the quartzofeldspathic rocks being later, injected granitic sheets. The more intimate the interlayering, the greater the probability of a sedimentary protolith.

ii) Even if the composition is not so extreme so as to exclude normal igneous rocks, abnormally high or low proportions of specific minerals (especially quartz) is a good indication of a sedimentary protolith. Igneous rocks with anomalous compositions may reflect their immediate host rocks or more distant precursors; muscovite-bearing pegmatite intruding pelitic gneisses is a good example.

iii) Quality of banding (layering) is a helpful, although far from diagnostic criterion. Banding may be formed in many secondary ways, among which deformation is one of the most common, but it seems reasonable to suppose that rocks having good banding initially are more likely to end up as those showing the best-developed banding in a high-grade metamorphic state. Banding/bedding reflects compositional heterogeneities between individual layers, some of which will have lower minimum melting temperatures than others, so par-

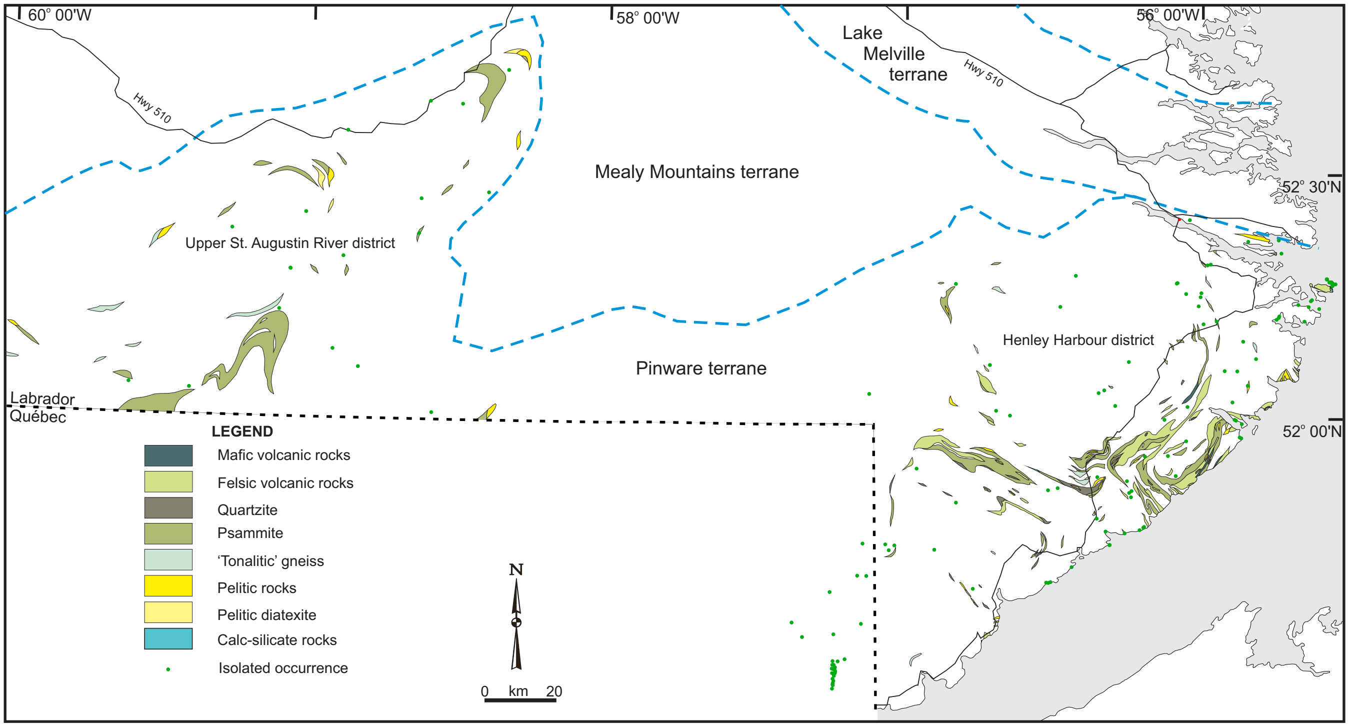


Figure 13.1. *Distribution and nature of supracrustal rocks in the Pinware terrane, also showing their subdivision into Upper St. Augustin River and Henley Harbour districts.*

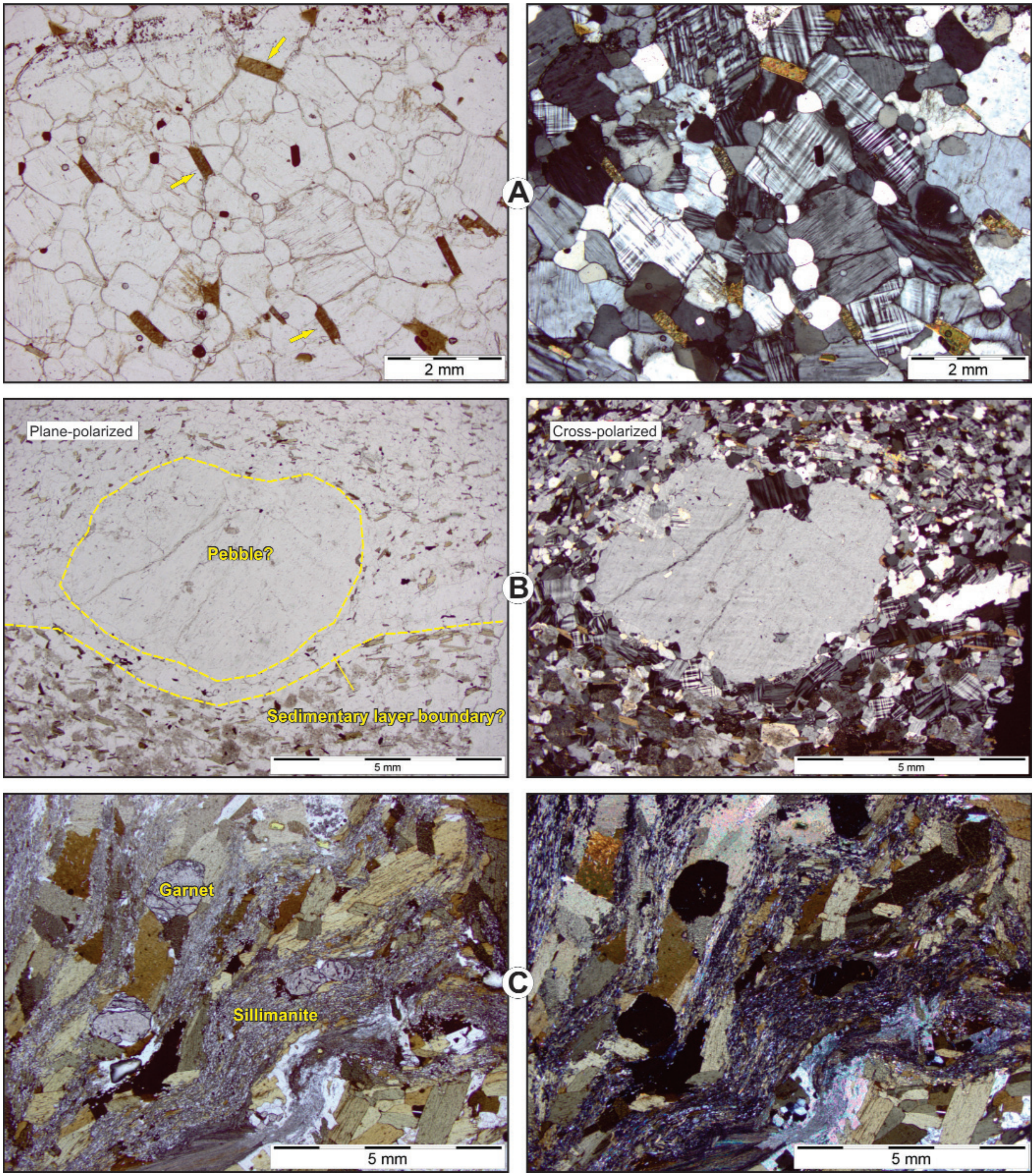
tial melting is more likely to emphasize, rather than obliterate, original structure. In more homogeneous rocks, such as granitoid intrusions, partial melting produces more irregular melt patches.

iv) In thin section, quartzofeldspathic rocks derived from clastic metasedimentary rocks commonly retain vestiges of rounded grains, the outlines of which may still be discerned despite fairly extensive recrystallization. Quartz grains in metasedimentary rocks tend to show less strain than in their igneous counterparts and feldspars sporadically show embayed grain boundaries. Plagioclase is typically more heavily sericitized and less well twinned, and K-feldspar is normally microcline. Grain-size contrasts commonly exist between individual layers.

v) Phyllosilicates, in thin section, include more muscovite and chlorite than in their igneous counterparts and tend to occur as interstitial material at grain boundaries between rounded quartz or feldspar grains (Photomicrograph 13.1A), and/or concentrated into particular layers. Interstitial material may also include amphibole and epidote, generally having rather ragged habit, and also tending to be concentrated into particular layers. Commonly, this material is too fine grained to identify individual minerals, simply having a 'grungy', non-descript appearance. These minerals simply reflect incomplete sedimentary differentiation to alumina-rich or calcareous products, perhaps being cementing material originally.

vi) A wide range of opaque minerals may be present and include magnetite, ilmenite, pyrite, hematite and leucoxene. Hematite commonly occurs as a coating to quartz grains and serves to emphasize clastic grain boundaries. Magnetite/ilmenite may be concentrated into heavy mineral layers, and, rarely, is associated with other durable minerals such as zircon. Garnet and more unusual minerals (*e.g.*, tourmaline) are more conclusive of a sedimentary protolith, but not often found.

vii) Accessory minerals, such as titanite, apatite and zircon, are more commonly dispersed single grains, rather than occurring in clumps associated with mafic silicate minerals as they do in granitoid rocks. Roundness of grains is not diagnostic, but is not to be ignored. Delicate, skeletal or amoeboid grains, or those with abundant inclusions, are less likely to withstand the rigours of fluvial transportation and, if seen, decrease the probability of a meta-



Photomicrograph 13.1. *Pinware terrane supracrustal rocks in the Henley Harbour district. A. Possible clastic texture, as indicated by 'roundish' felsic grains and interstitial biotite length-limited by flanking felsic grains (some examples arrowed) (JS87-286), B. Possible pebble deposited on biotite-rich sedimentary layer and later covered by less-biotite-rich sediment? (DL93-126A), C. Garnet–sillimanite–biotite pelitic gneiss (CG03-052A).*

sedimentary protolith. Nevertheless, one must be alert to branching secondary minerals in metasedimentary rocks that were formed during subsequent metamorphism. Titanite is a common culprit, and tends to be present in those rocks having most chlorite (both minerals being products of biotite breakdown).

viii) Anomalous features (for granitoid intrusive rocks) may be helpful. One example is a large, rounded quartz grain in a fine-grained matrix, located close to the compositional boundary between two layers in sample DL93-126 (Gower, 2007, his Plate 11a, b; Photomicrograph 13.1B). This may represent a small pebble resting on the sediment surface.

13.1.2 UPPER ST. AUGUSTIN RIVER DISTRICT

The supracrustal rocks in the Upper St. Augustin River district (Figure 13.2) were all discovered during 1:100 000-scale mapping (Gower, 1998, 1999, 2000, 2001). They mostly occur as small slivers that collectively have been folded around a regional reclined fold. The fold has a near-vertical axis, a northeast-trending axial trace, and closes to the northeast. It is a Grenvillian structure that formed between 1030 and 1015 Ma (Gower *et al.*, 2008b). The supracrustal rocks types present are grouped as: i) quartzite and psammitic gneiss, ii) anomalous 'tonalitic' gneiss, suspected to be of supracrustal origin, iii) pelitic gneiss, and iv) metasedimentary diatexite. Representative stained slabs are shown in Appendix 2, Slab 13.1.

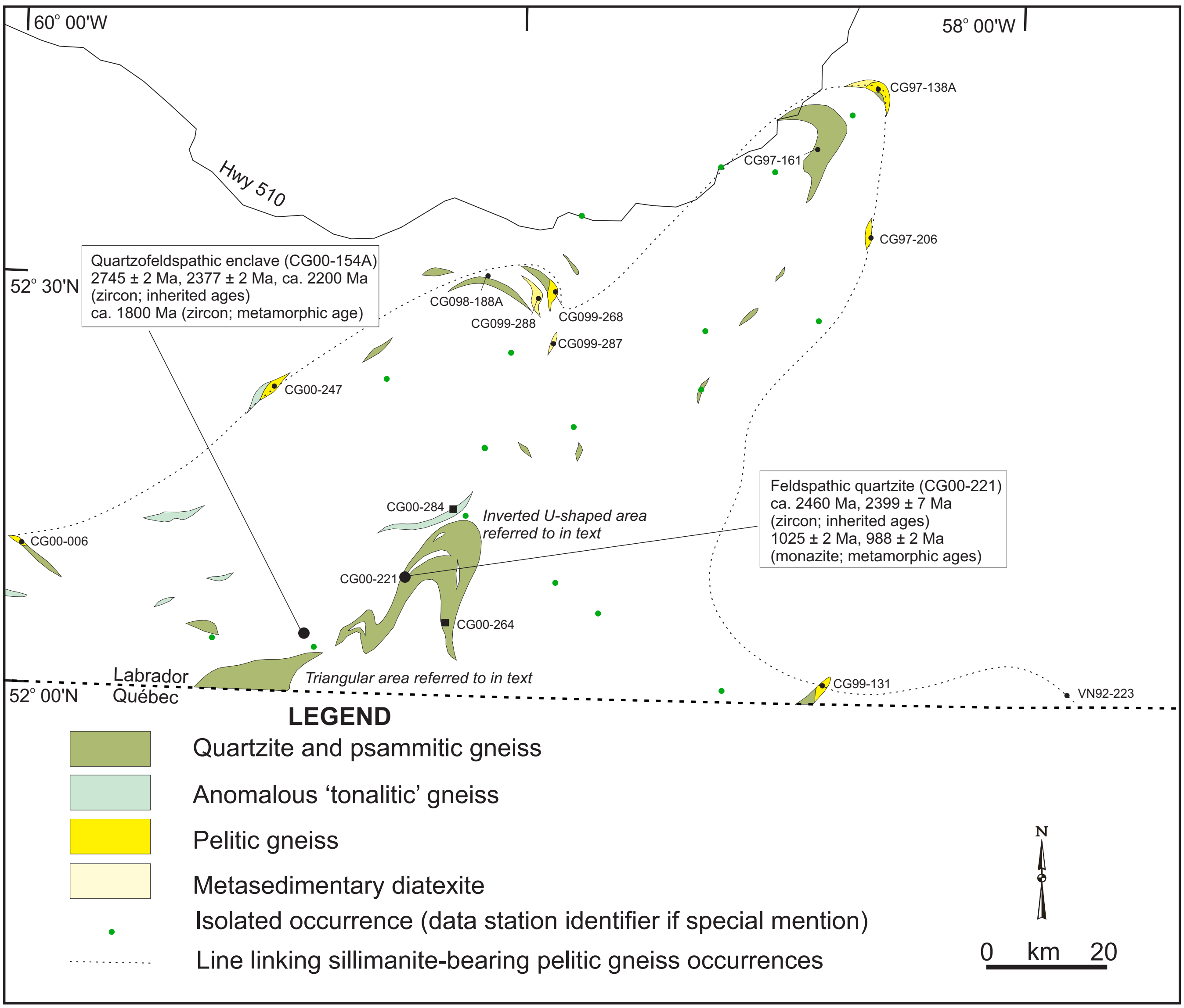


Figure 13.2. *Details of distribution and nature of supracrustal rocks in the Upper St. Augustin River district and U–Pb geochronological results.*

A point of interest, but of unknown significance, is that the sillimanite-bearing pelitic gneisses can be linked along a line that: i) conforms to the regional structure of the district and, ii) more-or-less defines the outer boundary of the supracrustal district (Figure 13.2).

13.1.2.1 Quartzite and Psammitic Gneiss (PMsq, PMss)

Quartzite and psammitic gneiss are best preserved in southern part of the district, in the core of the reclined fold, and similar rocks presumably continue south of the Québec–Labrador border, although none are indicated on geological maps for the relevant areas. Even where best preserved, the rocks are not easy to distinguish from foliated and gneissic granitoid rocks in their present metamorphic state, and outcrops are rare that do not show some associated granitic material. Later, discordant microgranite and pegmatite dykes are also present in some localities.

Age. The age of the quartzite and psammitic gneiss is addressed here in two ways; first, based on U–Pb geochronological data, and, second, by reviewing potential correlative rocks. U–Pb data are available for three samples, CG00-221, CG00-154A and CG97-161A. From CG00-221, a laminated feldspathic quartzite, zircon ages of *ca.* 2460 Ma and 2399 ± 7 Ma were interpreted to be detrital, and monazite ages of 1025 ± 2 Ma and 1015 ± 2 Ma to date Grenvillian metamorphism (Gower *et al.*, 2008b). The time of deposition for this sample is not otherwise constrained. The second sample (CG00-154A) is a quartzofeldspathic enclave, interpreted to be of clastic supracrustal origin, within a syn-Grenvillian (1043 Ma) K-feldspar megacrystic granodiorite. It yielded near-concordant Pb–Pb ages of 2745 ± 2 and 2377 ± 2 Ma, and a somewhat more discordant result implying an age of *ca.* 2200 Ma; all of these were interpreted to be detrital. On the basis of lower intercept projections from these arrays, plus information from other samples dated from the same outcrop, a metamorphic event at *ca.* 1800 Ma was inferred by Gower *et al.* (2008b). They opted for a pre-Labradorian depositional age (1805–1770 Ma) on the basis of these results and additional data from the adjacent Mealy Mountains terrane. Zircon from the third sample (CG97-161A) gave no indication of a detrital origin and yielded a concordant age of 1498 ± 8 Ma, which Gower *et al.* (2008b) interpreted to be time of igneous emplacement. Despite this conclusion, the protolith issue cannot be regarded as closed because of associated quartz-rich rocks at the same outcrop (*see* petrographic details following field description).

With respect to other supracrustal packages, three correlation options come to mind. The first is that these rocks are coeval with extensive areas of high-grade pelitic gneiss present farther north in the eastern Grenville Province, which are known to have a pre- *ca.* 1770 Ma depositional age. This option is favoured by U–Pb geochronological data, but the contrasting lithological nature and grade of metamorphism of the two packages of rocks casts some doubt (although it is acknowledged that such differences could be explained by sedimentary and metamorphic facies variations). The second possibility, based on lithological and metamorphic grounds, is correlation with the Wakeham Group situated about 200 km to the southwest and known to have a pre-1500 Ma age, at least in part. Although the large distance makes such a correlation tenuous, it must be remembered that metasedimentary gneiss exists between the Wakeham Group and eastern Labrador (albeit poorly mapped) that could contribute to geographic continuity. The third potential correlation is with supracrustal rocks in the Henley Harbour district. These are mostly quartzofeldspathic rocks suspected to be partly of felsic volcanic/volcaniclastic origin, but include other supracrustal rock types (*see* below). The age of those rocks is interpreted to be *ca.* 1640 Ma (Wasteneys *et al.*, 1997; Tucker and Gower, 1994).

Description. Within this arenaceous group of rocks, the most diagnostic type is banded quartzite (Plate 13.1A); any alternative protolith is unlikely. For example, one grey-weathering, medium-grained, recrystallized quartzite was confirmed in stained slab to comprise 90–95% quartz. Identifying psammitic gneiss (Plate 13.1B) is less straightforward. Some of the subtle distinguishing features are detailed below: i) in contrast to the pink-weathering granites, psammitic gneiss is normally pale-grey-weathering, but with creamy and white variants; only rarely does it take on hues of pink, ii) psammitic gneiss is generally finer grained than most of the granitoid rocks; the latter, even in a polygonized, recrystallized state, still commonly retain vestiges of their former coarser primary textures, iii) psammitic gneiss is also more continuously and evenly banded than the lensy fabric typical of the granitic orthogneiss, iv) in places, the psammitic gneiss is finely laminated and has narrow biotitic partings, although not containing aluminosilicate-mineral-bearing pelitic material. Very narrow black seams may be heavy mineral laminations and some of the layers are sufficiently uniform to accept them as primary bedding features, and v) stained slabs demonstrate either abnormally high quartz content (compared to a granitoid rock), or sharply defined, compositionally contrasting feldspar layers, or are unusually rich in biotite.

In addition to occurrences in the core of the reclined fold, several outcrops of similar rocks were mapped on the northwest flank of the reclined fold, continuing around the closure of the fold to link up with a few outcrops of quartz- and(or) feldspar-rich rock, interpreted to be psammitic gneiss, on the southeast flank of the fold. All were described as well-banded, granitic gneisses in the field, but a psammitic origin was speculated for some of them at the time.

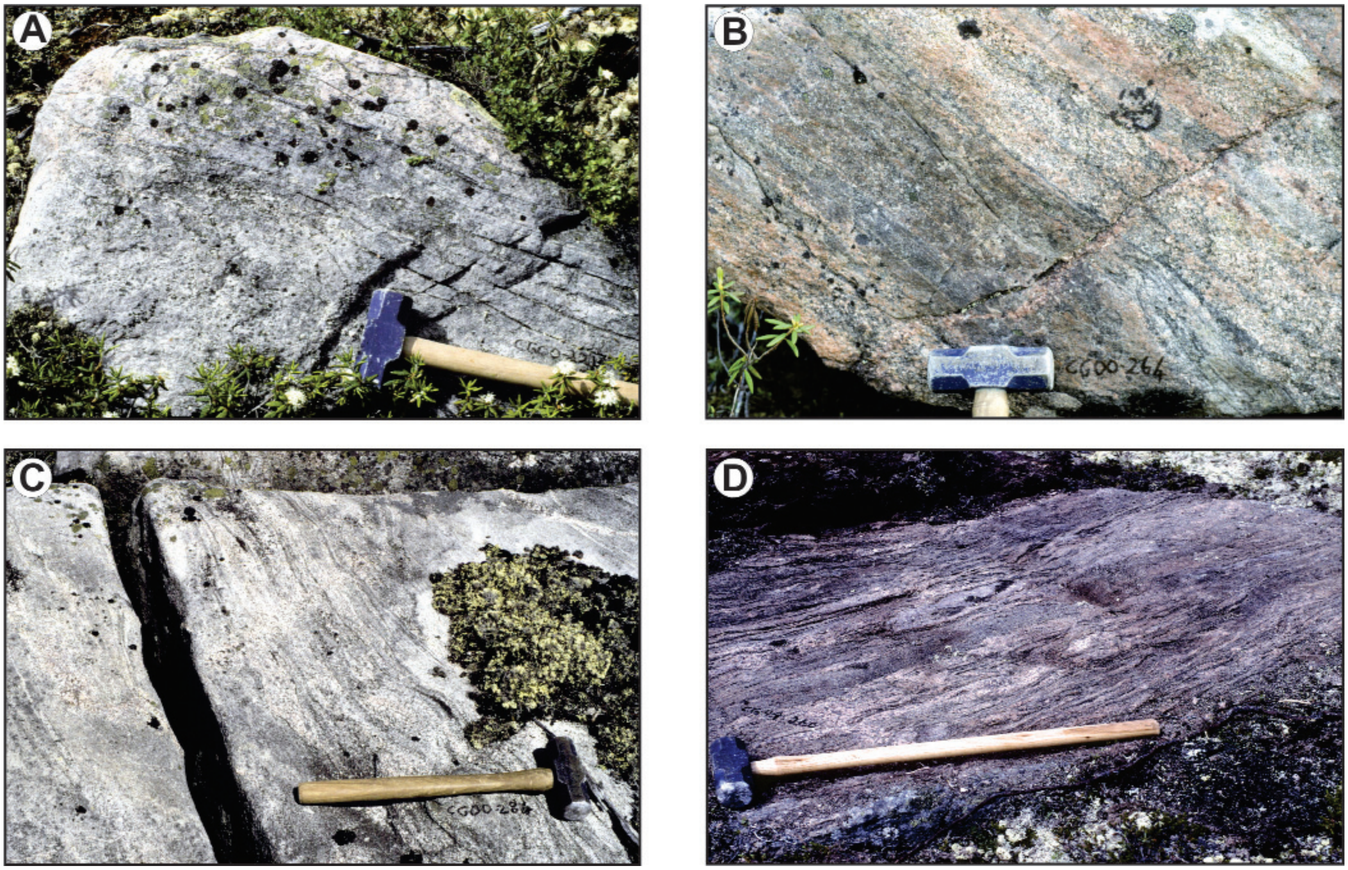


Plate 13.1. *Examples of rocks in the Upper St. Augustin River district having (or suspected to have) a sedimentary protolith. A. Quartzite showing dark partings that are probably biotite-rich. U–Pb geochronology site (CG00-221), B. Fine-grained sugary material is interpreted as psammitic gneiss and coarser grained layers to be granitic melt (CG00-264), C. Example of a 'tonalitic' gneiss, for which a metasedimentary protolith is considered an option (CG00-284), D. Sillimanite–garnet pelitic gneiss (CG99-268).*

Petrography. Because of protolith uncertainties, numerous samples were examined petrographically. Four psammitic gneisses from the triangular-shaped area adjacent to the Labrador–Québec border (CG00-070, CG00-071, CG00-129, CG00-130) are characterized by quartz content significantly higher than that seen in most igneous rocks. The plagioclase is commonly completely enveloped in quartz, which appears to have recrystallized and regrown around the feldspar. Twinning and alteration of plagioclase are somewhat variable. Sample CG00-070 is distinctive in that the cores of plagioclase grains are strongly hematized. Microcline tends to be interstitial and concentrated into particular zones. Biotite is the prevailing mafic silicate, occurring mostly as small, aligned buff-green flakes. Titanite is absent from most samples (CG00-070, CG00-129, CG00-130) and rare in CG00-071, where it appears to be secondary. Other accessory minerals are much less common than normally found in igneous rocks of similar composition. They include an oxide opaque mineral, apatite and zircon (in all samples, and characteristically small, euhedral and dispersed). Minor secondary white mica and chlorite are present in the two westernmost samples (CG00-070, CG00-071).

Seven samples were thin sectioned from the inverted U-shaped area of metasedimentary gneiss farther to the northeast (CG00-221, CG00-231, CG00-260, CG00-263, CG00-266, CG00-290B, CG00-292). Sample CG00-221 was targeted for U–Pb dating (*see* previous section). Overall, the rocks show less variation than those in the triangular-shaped area. Plagioclase is anhedral, recrystallized, generally poorly twinned and moderately to heavily sericitized. Grains tend to be rounded or embayed. K-feldspar is well-twinned microcline and is mostly interstitial to quartz (K-feldspar is almost absent in CG00-266). Quartz is the most abundant phase and in amounts exceeding normal granitoid rocks in all samples. Grains are mostly polygonal, but commonly have coalesced through recrystallization to form larger bulbous masses. Biotite is the sole hydrous mafic silicate, generally occurring as small, bronzy-green to orange-brown flakes. An oxide opaque mineral, rounded zircon (commonly showing cores and overgrowths), and apatite are typically dispersed as small, isolated grains throughout, although apatite is scarce or absent in some samples. Titanite is only present as a secondary mineral. White mica and chlorite are minor, but ubiquitous, secondary phases. Sample CG00-292 is distinctive in that the opaque oxide and zircon, as well as being dispersed grains, are also concentrated into a biotite-rich layer, which can be readily interpreted as a heavy mineral concentrate.

Fourteen samples were examined in thin section from other areas of the St. Augustin district (CG97-161A, CG97-161C, CG97-202, CG97-270, CG98-192, CG99-148, CG99-159, CG99-168, CG99-262, CG99-295, CG00-154A, CG00-328, CG00-333, CG00-343).

The first listed of these (CG97-161A) is of special interest in that it has been investigated geochronologically and interpreted to have an intrusive origin – *see* previous section. It is discontinuously banded, quartzofeldspathic gneiss containing common coarse-grained to pegmatitic zones and some wispy biotite-rich schlieren. It was equivocal in the field whether the rock should be interpreted as having a greywacke supracrustal or tonalitic igneous protolith. A thin section contains plagioclase, quartz, pale-orange-green biotite and zircon. It is lacking in K-feldspar, which is unusual for gneisses in the region. It is associated with a similar rock (CG97-161C) that differs in having interstitial K-feldspar, an opaque oxide, apatite and common rounded zircon. Interlayered concordantly with the gneisses is a broad layer (at least 40 m thick) of black-weathering, strongly schistose, thoroughly recrystallized, medium-grained, orthopyroxene-bearing amphibolite. An additional rock type present at the outcrop is a quartz-rich, well-layered, isoclinally folded rock for which (of all the rocks present at this outcrop) a psammitic protolith is most probable.

At locality CG97-202, the sample contains plagioclase, abundant quartz, dark-green-brown biotite, pale-green equant clinopyroxene (locally replaced by amphibole and an iddingsite-type product), an oxide opaque mineral, apatite, allanite, zircon and titanite (the latter three minerals are all very sparse). K-feldspar is confined to a concordant vein within the rock. High quartz content and lack of K-feldspar are the main features for retaining this sample on the metasedimentary-protolith suspect list.

Sample CG98-192 provided no diagnostic information as to protolith and could be an orthogneiss. The rock is thoroughly recrystallized and comprises quartz, plagioclase, very rare K-feldspar, brown biotite, zircon. Of the CG99- samples, only CG99-262 provides tangible evidence for a supracrustal protolith in that it is abnormally rich in quartz compared to a granitoid igneous rock and contains minor muscovite. Of the CG00- samples, CG00-154A is of particular interest in that it occurs as an enclave in K-feldspar megacrystic granodiorite, and was investigated geochronologically (*see* previous section). Plagioclase is poorly twinned, heavily sericitized and show albitic rims. Quartz is recrystallized and unevenly distributed, in one part forming a sea of bulbous polygonal grains surrounding islands of plagioclase. Biotite forms buff-green-brown flakes and, in CG00-154A, amphibole occurs as relict blue-green grains, which are confined to one part of the section. Accessory minerals are an oxide opaque phase, apatite and zircon. Titanite, allanite and epidote are also present in CG00-154A. The epidote shows distinct primrose pleochroism and is unusually common. Sample CG00-328 is unequivocally quartzite, in which both plagioclase and microcline are relegated to interstitial status. Olive-green biotite and titanite (rare), apatite, allanite (one grain) and zircon (rounded with overgrowths) are also present. Opaque minerals are absent. Sample CG00-343 is psammitic gneiss, containing recrystallized quartz, poorly twinned and moderately altered plagioclase, small flakes of dark-green biotite, an opaque oxide and very minor, somewhat rounded apatite and zircon. Inasmuch as it lacks K-feldspar, it also belongs to the tonalitic gneiss described below.

13.1.2.2 Anomalous ‘Tonalitic’ Gneiss (PMtn)

Description. A group of pale-pink, grey, white, or pale-buff, medium-grained, recrystallized, generally well-banded quartzofeldspathic gneisses (Plate 13.1C) has been classified separately, based on stained slabs and petrographic examination. The preference here is to regard them as having a clastic sedimentary protolith, although the balance of evidence favouring any specific rock-type origin is meagre. Their defining characteristic is that they all lack K-feldspar, except in rare concordant veins that can readily be interpreted as subsequently injected material. In the field, they were either assigned as K-poor members of the granodioritic gneiss unit, or K-poor psammitic gneiss. The banding, which is commonly unusually even and continuous (but not so much in Plate 13.1C), is due to grain-size contrasts, biotite-rich veneers, and plagioclase-rich leucogranite veins.

Petrography. Eleven samples examined petrographically fall into this group (CG00-008, CG00-049, CG00-053, CG00-064, CG00-103B, CG00-127A, CG00-128, CG00-190A, CG00-203, CG00-235, CG00-285). Plagioclase is poor to well twinned, lightly altered and recrystallized. Quartz is also thoroughly recrystallized, but has regrown to produce larger, irregular grains. K-feldspar is a trivial, interstitial mineral and entirely absent from CG00-064, CG00-103B, CG00127A, CG00-128 and CG00-285. The mafic and accessory phases include orthopyroxene, clinopyroxene, amphibole, biotite, epidote, an opaque oxide, sulphide, titanite, apatite, allanite, zircon, and secondary chlorite and white mica, but not all are consistently present. Specific minerals may provide clues to protolith. Orthopyroxene is present only in CG00-103B, where it occurs as poikilitic, anhedral, distinctly pleochroic grains in biotite-rich layers, in a rock that otherwise only contains quartz, plagioclase and accessory apatite and zircon. As the prevailing metamorphic grade is not granulite facies, its occurrence here may simply reflect anomalously high Fe, as might be found in ferruginous sediment. Clinopyroxene is also confined to one sample (CG00-008), where it occurs as pale-green grains in a rock containing plagioclase, quartz, interstitial microcline, dark-green amphibole, orange-brown titanite, allanite-cored epidote, zircon, apatite and an opaque oxide. The presence of clinopyroxene and epidote, as well as orange-hued titanite, hints at a calc-arenite protolith. A similar protolith might also apply to CG00-064, CG00-128 and CG00-203, all of which contain blue-green amphibole and have only rare pale-green biotite (clearly secondary in CG00-128). The amphibole in CG00-128 contains vermiform quartz inclusions and is associated with abundant high-relief, colourless epidote and dark-brown titanite, which collectively occur in clusters between quartz grains and may have been derived from calcareous cement. Epidote is also present in CG00-127A (in trivial amounts in microfractures), and also in CG00-190A. In the latter sample, it is concentrated in a specific layer along with opaque minerals (sulphide more abundant than oxide), titanite, apatite and zircon. As there is no indication that the layer is a xenolith, or due to precipitation along a secondary fracture, a depositional origin is favoured. It is perhaps noteworthy that the closest outcrop (2 km northeast, along strike) is sillimanite–biotite pelitic gneiss. Of the four remaining samples, three of them contain too much quartz to be normal igneous tonalitic rocks (CG00-053, CG00-235 and CG00-285) and the fourth (CG00-049) has an abnormal lensy fabric, possibly implying a conglomeratic/volcanoclastic protolith.

13.1.2.3 Pelitic Gneiss and Metasedimentary Diatexite (PMsp, PMsx)

Description. Pelitic gneiss in the St. Augustin district is white-, pink-, creamy-, rusty, and/or black-weathering, medium to coarse grained, heterogeneous, and schistose to well banded (Plate 13.1D). Typically, the melanosome contains abundant sillimanite associated with biotite and garnet and is interlayered with white- or pink-weathering, quartz-rich, diatexitic leucosome. Sillimanite occurs in the melanosome either as clusters or as white-weathering veneers and lenses, in which individual sillimanite needles may be up to 1 cm long. Rarely, sillimanite is concentrated in white layers, up to 3 cm thick, flanked by granitic leucosome or interspersed with feldspar biotite material. Psammitic rocks and quartzite are found interlayered with pelitic gneiss in places. The age of the pelitic gneiss is unknown, other than by indirect inference through the age constraints imposed by association with quartzite and psammite (perhaps pre-Labradorian; *see* earlier). One additional, isolated but potentially related, occurrence (VN92-223) of pelitic gneiss requires mention. It occurs as an enclave in a late- to post-Grenvillian Upper St. Paul River (west) granite. The enclave measures approximately 2 m wide by 3 m long, is rusty-weathering and medium grained, and has sharp contacts against the host granite.

Petrography. Nine thin sections of sillimanite-bearing pelitic gneiss are available (CG97-138A, CG97-206, CG98-188A, CG99-131, CG99-268, CG00-006, CG00-247, VN92-233B, VN92-223D). They contain plagioclase, microcline, quartz, biotite, sillimanite, and an opaque oxide. These minerals do not necessarily constitute an equilibrium assemblage as there is segregation between granitic and sillimanite-bearing portions. Garnet is seen in some samples and muscovite is also present in CG00-006 and CG00-247. Plagioclase is poor to moderately twinned, moderately altered and has albitic borders. Biotite is buff-green, tending to orange in CG00-247. Sample CG00-247 also contains corundum, which forms skeletal grains, discordant to the prevailing fabric and, therefore, presumably posttectonic. Sillimanite in this sample is fibrous and appears to be prograde from muscovite. Sample CG00-006 contains one grain of an anhedral, colourless, moderately high relief, low birefringent, uniaxial (or biaxial with a low 2V) positive mineral that is likely zoisite. Sample CG99-268 contains abundant garnet, but no sillimanite in thin section, although it was seen in outcrop. Sample CG99-131 contains sillimanite, but no garnet (which was not recorded in outcrop either). In sample CG98-188A, sillimanite occurs as small needles, closely associated with aligned orange-brown biotite. In the same sample, small sillimanite needles also occur in a colourless, polysynthetically twinned, six-sided equant grain that is possibly cordierite, but might be plagioclase. In thin sections of samples VN92-223B and VN92-223D, the mineral assemblage is sillimanite + garnet + biotite ± K-feldspar ± plagioclase ± quartz ± an opaque mineral ± zircon ± green spinel ± retrograde white mica and chlorite. The sillimanite needles and biotite define a strong fabric.

Metasedimentary diatexite in the Upper St. Augustin district is white-weathering, texturally heterogeneous and aplitic to pegmatitic. It is spatially regionally associated with pelitic gneiss, and commonly contains rafts of it, and was likely derived from pelitic gneiss by extensive partial melting. The metasedimentary diatexite at CG98-188B is noteworthy in that it contains abundant mauve garnet up to 2 cm in diameter, associated with restite containing common sillimanite. Also present is banded quartzite and grey-weathering, well-banded gneiss separated into garnet-bearing leucosome and sillimanite–biotite-rich melanosome.

Three samples were examined in thin section (CG98-188B, CG99-287, CG99-288). They contain abundant quartz, plagioclase, microcline, biotite and zircon. Sample CG99-287 also contains quartz–biotite–garnet clusters up to 2 cm across. The garnet is minor and residual, and it seems probable that the clusters outline former large garnet crystals, now almost entirely retrograded.

13.1.3 HENLEY HARBOUR DISTRICT

The name Pitts Harbour Group was introduced by Gower *et al.* (1994) for pre-Grenvillian (dominantly quartzofeldspathic) supracrustal rocks in the Henley Harbour district (Figure 13.3; Appendix 2, Slab 13.2). The name of the group is taken from the locality where the supracrustal rocks were originally discovered (Gower *et al.*, 1988). Since its introduction, however, the name has only been sporadically applied (including usage by the author), partly because of lingering doubts regarding its validity and, if it has any, which rocks should be included. Resolution of such issues is likely to take a long time and, in the meantime, all the pre-Grenvillian supracrustal rocks in the district are grouped here as if they belong to a single lithological package.

Gower *et al.* (1988, page 66), addressing the area north of latitude 52°N (St. Lewis map region), wrote that "metasedimentary gneiss is areally insignificant in the Pinware terrane, probably underlying less than 1 percent". Subsequent mapping south of latitude 52°N (Pinware map region), together with later petrographic studies in both areas, indicate that rocks of supracrustal origin are more extensive than first supposed, although still volumetrically minor (less than 10%). Reassessment hinges on interpreting more of the fine- to medium-grained quartzofeldspathic rocks as having a supracrustal, especially felsic volcanic, protolith. Note, however, that, even during mapping in 1987, the possibility of a volcaniclastic or sedimentary was suspected ("some granitic gneiss displays well-defined, regular layers, suggestive of a metasedimentary protolith..." Gower *et al.*, 1988, page 67). The field and petrographic criteria for identifying metamorphosed felsic volcanic rocks addressed at the start of this chapter have acute relevance here.

For completeness, supracrustal rock occurrences in easternmost Québec have also been included in Figure 13.3, using information from Bostock (1983), and also from his unpublished field notes. The author has also examined thin sections prepared by Bostock (which are listed in this author's petrographic database table), but has not completed detailed descriptions – merely listing minerals present and assigning a preliminary name.

The Pitts Harbour Group supracrustal rocks have been classified into seven units, for which descriptions are given in following sections. These are: i) banded amphibolite derived from a mafic volcanic protolith, ii) quartzofelds-

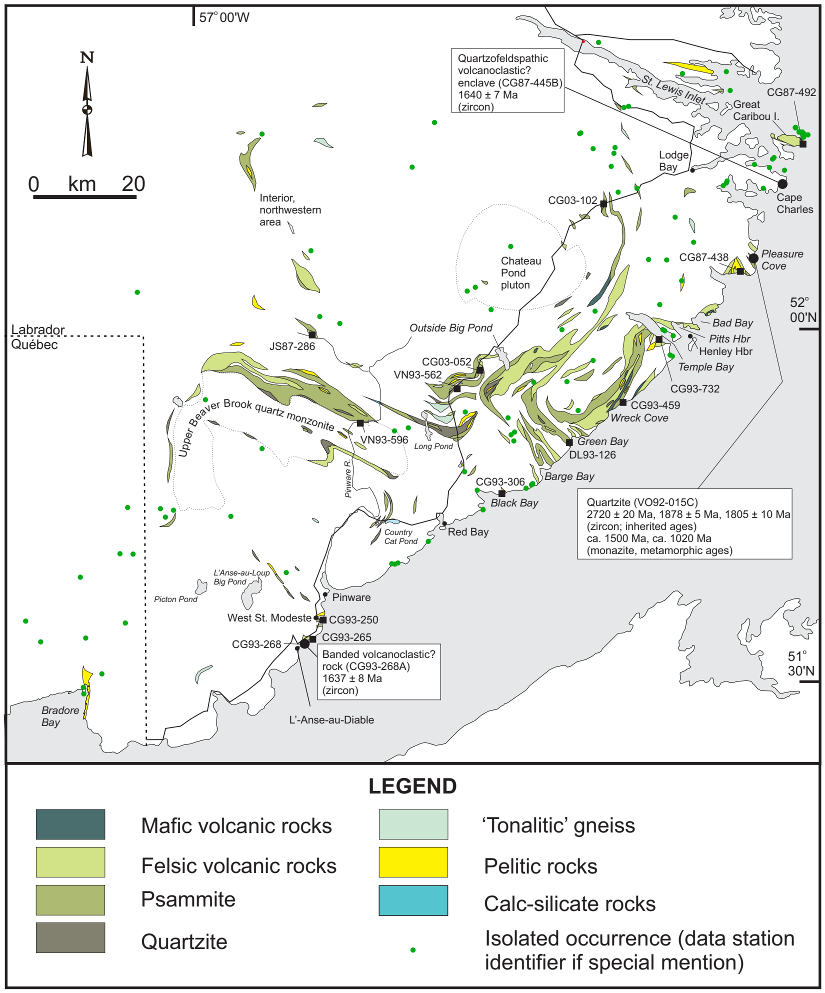


Figure 13.3. *Details of distribution and nature of supracrustal rocks in the Henley Harbour district and U–Pb geochronological results.*

pathic rocks having a felsic volcanic/volcaniclastic protolith, iii) quartzofeldspathic rocks derived from clastic metasediments, iv) quartzite and quartz-rich meta-arkose, v) 'tonalitic' gneiss, vi) pelitic rocks, and vii) calc-silicate rocks. Clearly, some of these units are somewhat similar to each other and even in an unmetamorphosed state would be expected to be intergradational (especially ii, iii, iv).

Age. Three U–Pb age determinations have been obtained on rocks assigned to the Pitts Harbour Group. Two samples were interpreted to have a felsic volcanic protolith and one is a quartzite (Figure 13.3). From the Cape Charles area, Tucker and Gower (1994) reported a near-concordant zircon age of 1640 ± 7 Ma for a quartzofeldspathic volcaniclastic(?) enclave (CG87-445B) within a Pinwarian quartz monzonite, which was also dated and yielded an age of 1490 ± 5 Ma. The enclave is a fine- to medium-grained, foliated and banded gneiss that was intruded by mafic dykes (now amphibolite remnants) prior to being incorporated into the quartz monzonite. A modal analysis from a thin section of the enclave sample comprises plagioclase (31%), K-feldspar (37%), quartz (26%), green biotite 4%, chlorite (after biotite), apatite, and opaque oxide, allanite, titanite and zircon (collectively 2%). The zircons were considered to be igneous.

From the L'Anse-au-Diable area, Wasteneys *et al.* (1997) reported an age of 1637 ± 8 Ma age, based on near-concordant and discordant zircon data, for a rock deemed to have a felsic volcaniclastic origin (CG93-268A). Wasteneys *et al.* (1997) commented that the zircon could be epiclastic, rather than strictly volcaniclastic, in which case the rock might be younger than 1637 Ma.

From Pleasure Cove, a quartzite, also investigated by Wasteneys *et al.* (1997; sample VO92-015C), yielded zircon ages of 2720 ± 20, 1878 ± 5 and 1805 ± 10 Ma, which were interpreted to be detrital. Monazite, from the same sample yielded Pinwarian and Grenvillian metamorphic ages of *ca.* 1500 and 1020 Ma, respectively. The time of deposition of the quartzite is thus bracketed between 1805 and *ca.* 1500 Ma. Despite uncertainties, the combined data for all three samples are consistent with a mid-Labradorian depositional age, which is the time slot adopted here.

13.1.3.1 Banded Amphibolite (PMvm)

Description. Banded amphibolite in the Henley Harbour district has an overall inhomogeneous aspect, is concordantly interlayered with other supracrustal rocks, and is interpreted to have been derived from a mafic volcanic protolith. The banding is mainly due to variation in hornblende–plagioclase ratios. It is commonly emphasized by epidote- or chlorite-rich laminations and by a later schistosity. Some rocks contain larger-than-groundmass, black, euhedral hornblende crystals, which are interpreted to be porphyroblasts. A very pronounced lineation is present in places, defined by acicular amphibole and/or aligned feldspar grains.

Occurrences of banded amphibolite are mostly found in the eastern part of the Henley Harbour district. Only the most extensive are shown on Figure 13.3. The main occurrences are: i) in the Temple Bay area, ii) on the shoreline and inland between Henley Harbour and Green Bay, iii) on the coast between Barge Bay and Green Bay, iv) east of Outside Big Pond (where it is epidote- and garnet-bearing and associated with quartzite), v) in the vicinity of Outside Big Pond (associated with quartzite and fine-grained chloritic schist), vi) on the shoreline about 3.5 km east of Black Bay, vii) within the Upper Beaver Brook quartz monzonite, viii) along the southwest flank of the Upper Beaver Brook quartz monzonite (where it is associated with a schistose, green-buff (chloritic?) rock containing black euhedral porphyroblasts of amphibole), and ix) in the West St. Modeste area.

In the Temple Bay area, on the bay's southwest shoreline, a 1-m-wide layer of rusty-weathering pyritic quartzite is interlayered with banded amphibolite. The banded amphibolite was subsequently intruded by a now-deformed and metamorphosed mafic dyke (Plate 13.2A). At a locality 5 km west of Temple Bay, tightly folded, fine-grained, schistose, laminated amphibolite (containing acicular amphibole, abundant epidote, and titanite) is associated with calc-silicate layers. Banded amphibolite on the north side of Bad Bay, 4 km east of Pitts Harbour, was interpreted as a possible mafic volcaniclastic rock.

Between Henley Harbour and Green Bay, schistose to massive amphibolite is found intercalated with banded quartzofeldspathic rocks. In addition to the extremely good layering/foliation, the amphibolite contains knots of quartzofeldspathic material that probably represent boudinaged remnants of deformed quartzofeldspathic intrusions. Locally, the amphibolite contains abundant porphyroblasts of a grey, euhedral plagioclase. Although the amphibolite is commonly schistose, it has some massive sections and it also has internal layering heterogeneities, which are emphasized by epidote-rich laminations. The quartzofeldspathic rock is fine to medium grained and shows textural contrasts between individual layers and groups of layers. Contacts with the schistose to massive amphibolites are concordant. Outcrops of schistose amphibolite, on strike northeast of Wreck Cove, are assumed to be correlative.

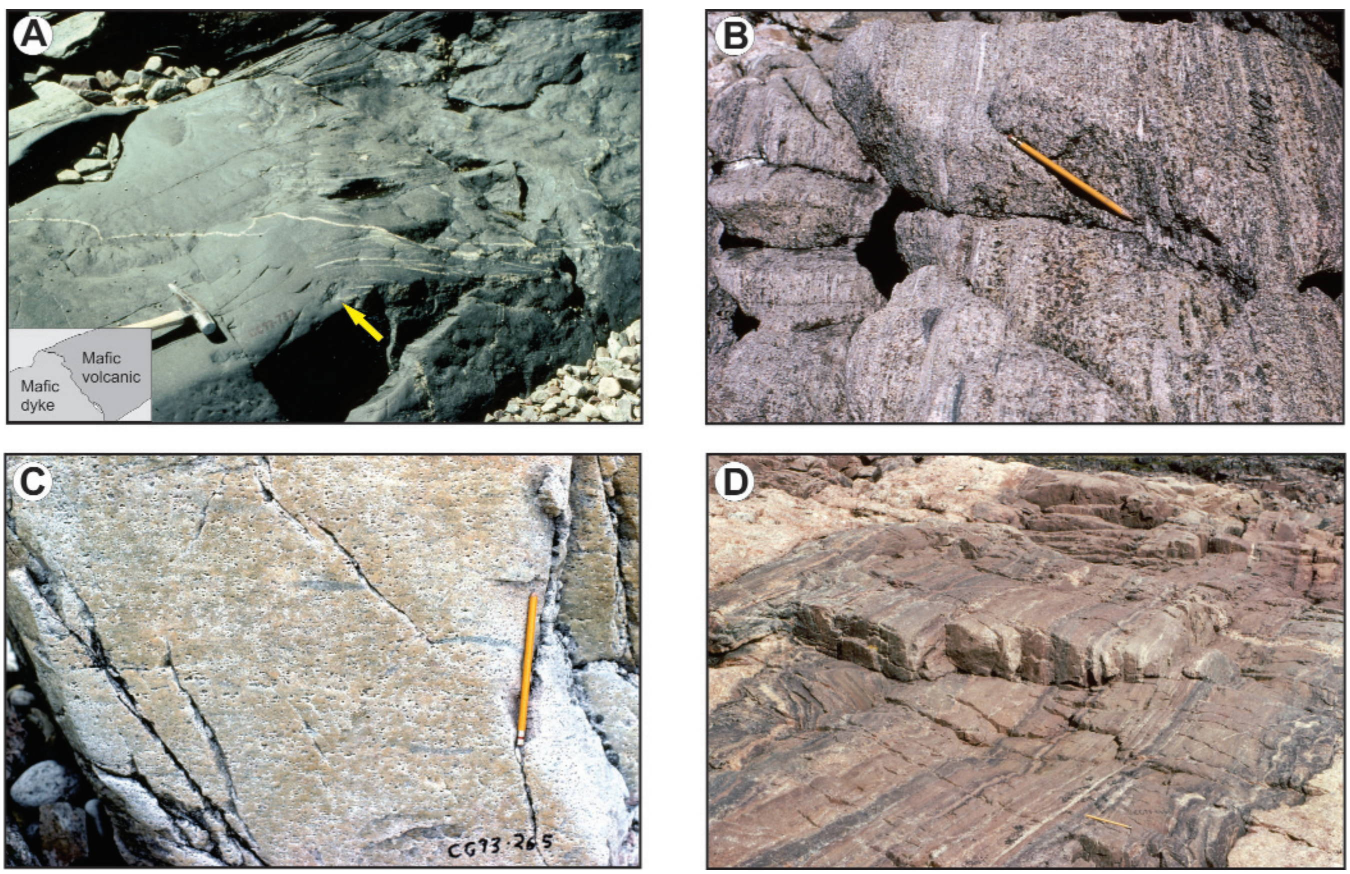


Plate 13.2. *Rocks in the Henley Harbour district interpreted to have volcanic protoliths. A. Banded amphibolite, interpreted to be mafic volcanic, intruded by mafic dyke. Arrow and inset show dyke margin location (CG93-732), B. Quartzofeldspathic rock containing ellipsoidal clasts. Rock is interpreted to be felsic agglomerate/conglomerate (CG87-492), C. Quartzofeldspathic rock containing lighter and darker lensy shapes, suggesting rock to be felsic volcanoclastic (CG93-265), D. Colour-banded quartzofeldspathic rocks, interpreted to have a felsic volcanoclastic protolith. Dated 1637 ± 8 Ma (CG93-268).*

South of Wreck Cove, thinly banded amphibolite is intercalated with biotite–muscovite–garnet psammitic rock and minor thinly bedded quartzite, with which rubiginous-weathering gossan zones are locally present.

East of Black Bay, banded amphibolite is of particular interest in that a 50-cm-wide band of extremely garnetiferous rock (80–90% garnet) of uncertain protolith is present at its margin. The amphibolite is associated with quartzitic and pelitic metasedimentary rocks and, collectively, the package is interpreted as a supracrustal septum between two contrasting granitoid rock types. A sample from this locality was used for garnet–biotite geothermometry by Owen and Greenough (1995).

Petrography. A sample from Bad Bay examined in thin section (VN87-332) comprises amphibole (emerald to leaf green), plagioclase, interstitial quartz, bronzy green biotite, opaque mineral (sulphide rimmed by oxide), titanite and apatite, the latter being unusually abundant. An amphibolite from northeast of Wreck Cove (CG93-819) contains polygonal plagioclase and quartz; aligned, bronzy-buff biotite; blue-green amphibole; minor sulphide; common titanite forming clusters with minor opaque oxide; and apatite. The amphibole grains are quite large (>0. 5 cm).They have cores sieved with abundant quartz inclusions, which, typically, denotes former clinopyroxene.

13.1.3.2 Felsic Volcanic/Volcaniclastic Protolith (PMvf)

Quartzofeldspathic rocks inferred to have a volcanic or volcaniclastic protolith are found throughout the Henley Harbour district (Figure 13.3). The greater petrographic detail provided for these rocks is, in effect, commentary regarding difficulties encountered in their recognition.

Description. Occurrences are reviewed by area, from north to south. The most northerly occurrences underlie the northeastern half of Great Caribou Island. The volcanic/volcaniclastic quartzofeldspathic rocks are associated with maroon, yellow and white weathering, medium grained, arkosic units and some layers of deformed conglomerate or felsic agglomerate, containing ellipsoidal clasts having a wide range of quartzofeldspathic compositions (Plate 13.2B). The conglomerate–agglomerate is interbedded with thinly laminated quartz rich metasediment and has abundant matrix carbonate. Rather than being part of this unit it could be related to the younger supracrustal rocks on Battle Island (Section 16.5).

Rocks in the interior northwestern part of the Henley Harbour district are the most uncertainly identified as felsic volcanic/volcaniclastic. For example, one sample from this area (JS87-286) was called 'granite, felsic volcanoclastite/ volcanic or psammite' in stained slab; and 'psammite or microgranite' in thin section. The outcrop lies on strike between unequivocal pelitic and psammitic gneiss at locality CG87-209 and another outcrop that is also equivocally designated as derived from a felsic volcanic/volcaniclastic protolith in the Pinware map region (CG93-665). Minor occurrences of similar rocks occur sporadically elsewhere in this north-northwest-trending zone, thus providing some indication that a belt of felsic volcanic rocks and clastic sediments may have existed in this district prior to granite emplacement. These rocks were initially mapped by Gower *et al.* (1988) as an elongate area of finer grained granite, and suggested to be a border and/or roof zone of the adjacent granitoid plutonic rocks. This alternative interpretation remains viable, at least in part.

The shoreline on the south side of Temple Bay offers the best-exposed, across-strike section, and encompasses most of the lithological variation within the map area. At the northwest end of the section, fine-grained, thinly laminated and compositionally heterogeneous quartzofeldspathic rocks are interpreted to have either a greywacke or a felsic volcaniclastic protolith. The banding is even and continuous, in part defined by biotite- and hornblende-rich layers. One rock type sampled has a mottled, heterogeneous appearance in hand sample and might be of volcaniclastic origin. Inland, between Green Bay and Henley Harbour, the supracrustal rocks form a 3-km-wide coast-parallel belt. The rocks are fine to medium grained, strongly foliated or schistose quartzofeldspathic rocks. Locally, they have an odd mottled appearance, suggestive of either porphyroclastic or pyroclastic origin. Some of the rocks are very micaceous and show well-defined layers. In places they are intensely lineated.

Between Green Bay and Barge Bay, and inland extrapolations, large areas are underlain by very fine-grained to fine-grained, locally schistose, quartzofeldspathic rocks. Many of the rocks have a 'sandy' feel to them – it is not known whether they weather this way because they were originally derived from clastic rocks, or because of some anomalous characteristic in recrystallized felsic plutonic rocks. Some of the rocks show narrow lensoid shapes, usually less than 1 cm long, that are generally composed of K-feldspar. Many rocks are rich in biotite, which is usually concentrated into particular bands, and a few are muscovite bearing. Locally, hornblende and epidote are also present. Although many of the rocks are completely structureless, in others a lamination, streakiness or wider banding parallel to the prevailing foliation, may imply a volcanic protolith. Rocks on the coast in this area are distinctly colour banded. The bands vary in thickness from a few millimetres to 20 cm. Broad bands show thinner internal laminations. The layers are continuous over long distances. Lensoid shapes are present and seem to be confined to specific layers. In places, an unusual, pseudo(?) brecciated appearance is apparent.

On the flanks of the Upper Beaver Brook quartz monzonite, especially to the north and west, rocks interpreted as having a volcaniclastic protolith are sparse, the supracrustal assemblage being dominated by psammite, although including quartzite, pelite and calc-silicate rocks. The best exposures of possible volcaniclastic rocks in this area are on the Pinware River south of the Upper Beaver Brook quartz monzonite and include a bouldery-looking rock that might be felsic agglomerate or a tectonically dismembered metasediment (CG93-695). East of the middle Pinware River, a hilltop outcrop of strongly foliated, streaky-textured quartzofeldspathic rock is interpreted to be derived from a felsic volcanic rock.

Inland, northwest of Pinware, most of the grey-, pink- and white-weathering, fine-to medium-grained, recrystallized, banded quartz-rich rocks are interpreted as quartzite and psammite, but a few examples of rocks containing plagioclase-rich lensoid shapes were found that might be primary clasts, hence suggesting a volcaniclastic protolith.

In the West St. Modeste area, the fine-grained felsic rocks commonly have a streaky or lensy appearance, which is interpreted by the author as indicating a volcaniclastic protolith. One rock containing macroscopic lensoid textures (CG93-265; Plate 13.2C) that was examined in thin section shows a wide variation in grain sizes that might indicate former clasts. Textures in the felsic rocks are not well-enough preserved to demonstrate the rocks are volcanic, but their association with other rock types (such as banded felsic rocks, quartzite, banded amphibolite and sillimanite- and/or garnet-bearing schist) at least makes a supracrustal protolith probable. The associated banded felsic rocks have a layering defined by colour, grain size, and mineral assemblage. Colour variations include red, cream, grey, dark-grey and green (Plate13.2D). A sample considered to be of volcaniclastic origin from this area was included in a U–Pb geochronological study by Wasteneys *et al.* (1997; sample CG93-268A) and yielded an age of 1637 ± 8 Ma. This date was interpreted as the time of magmatism, but the possibility was acknowledged that the rock could have an epiclastic origin, in which case the zircons could be detrital and the time of deposition younger.

Petrography–north of 52°N. The distribution of some key minerals in quartzofeldspathic rocks interpreted to be derived from both felsic volcanic and arenaceous protoliths is shown in Figure 13.4. Three samples were examined petrographically from the northern side of Great Caribou Island (VN87-470A, VN87-476, VN87-478). All have similar minerals, comprising plagioclase, microcline, quartz, bronzy-green biotite, blue-green amphibole, an opaque oxide, titanite, epidote, apatite, allanite and zircon.

A detailed petrographic study was made of felsic volcanic/volcaniclastic rocks on the coast between Cape Charles and Henley Harbour. The rocks can be divided into several lithological subgroups on the basis of amphibole ± clinopyroxene, fluorite, or muscovite, or none of the aforementioned. The samples thin sectioned that lack these minerals (CG87-243, CG87-418, CG87-444B, CG87-445B – dated sample, JS87-345, JS87-347, RH-101) contain plagioclase, microcline, quartz, green or orange-brown biotite, an opaque oxide, and titanite. Allanite, apatite, zircon and secondary chlorite are present in some samples. Although the samples containing amphibole (CG87-420, CG87-431, JS87-391, VN87-319, VN87-343) have a similar mineral assemblage, there are minor differences, such as minor carbonate in CG87-431, epidote in CG87-420 and VN87-319, and titanite in VN87-343. The amphibole in these rocks shows distinct blue-green ± mauve pleochroism and is likely Na-rich. Sample JS87-391 also contains bright green to yellow pleochroic clinopyroxene (*cf.* aegerine), further demonstrating the sodic nature of the rock. These rocks might be termed alkali-calcic, but it would be indulgent speculation to choose between primary igneous, metasomatic, or metasedimentary origins. One of the two fluorite-bearing samples (JS87-392) has a mineral assemblage like the amphibole-absent group above; the other (VN87-335B) is distinct in comprising almost entirely plagioclase and microcline with trivial amounts of an opaque oxide, zircon and fluorite. The fluorite is interstitial. These two samples were equivocally grouped as supracrustal rocks, with an alternative designator being granite/syenite intrusive rocks. Note that fluorite-bearing granitoid intrusive rocks have also been recognized in the area (JS87-405, VN87-334). Two petrographically investigated muscovite-bearing samples

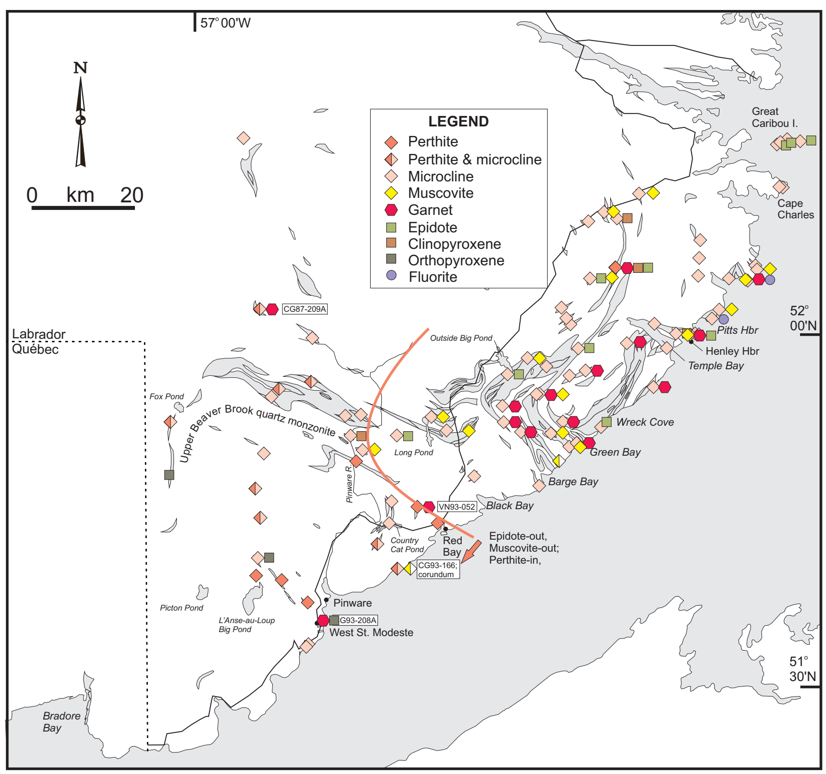


Figure 13.4. *Distribution of some key minerals in rocks interpreted to have either a felsic volcanic or arenaceous protolith in the Henley Harbour district.*

(JS87-396B, VN87-335A) could be reassigned to the pelitic gneiss unit (PMsp) as they have similar mineral assemblages to samples in that rock group. Sample JS87-396B is distinct in lacking quartz, and VN87-335A contains garnet.

Petrography–south of 52°N. Quartzofeldspathic rocks interpreted to have been derived from a volcaniclastic protolith in the Pinware map region (south of 52°N) were examined at a different time from that north of Henley Harbour and were subdivided slightly differently. Three mineralogical groups were identified on the basis of presence of garnet, amphibole, or absence of either. No sample contains both garnet and amphibole.

Garnet-bearing rocks are confined to the northeastern corner of the Pinware map region and include samples CG93-699, CG93-705, DL93-130, DL93-288, DL93-315A, DL93-335, DL93-339, VN93-582A, VN93-694. The feature in common to all samples is the dearth of mafic phases requiring Ca as a component. All the rocks contain poor to well-twinned plagioclase, microcline, quartz, green to bronzy biotite, garnet, an oxide opaque mineral (no sulphide seen in any thin section; some oxide is altered to hematite or leucoxene), zircon and apatite. The latter three phases are very sparse. Secondary minerals sporadically present are chlorite (after biotite), white mica, titanite (mostly as an alteration of the opaque oxide) and, rarely, epidote and allanite. The garnets are small, pinkish, most commonly subhedral and some contain vermiform quartz inclusions. Because of their shape and the quartz inclusions, it is unlikely that they are xenocrystic, and are hence considered a stable phase of these Ca-poor rocks.

The amphibole-bearing rocks are scattered throughout the map region, except in the garnet-bearing area. Samples examined in thin section include CG93-265, CG93-313, CG93-715, CG93-718, CG93-725, CG93-735A, DL93-115, DL93-190, DL93-236, DL93-383, VN93-289, VN93-667. Minerals common to all rocks are plagioclase (typically sodic), K-feldspar (microcline with some residual perthite in samples from western areas – Figure 13.4), quartz, green, orange, buff or bronzy biotite, amphibole, and an opaque oxide (no sulphide, but some secondary hematite). Almost all contain minor zircon and apatite, a few contain minor allanite, titanite and(or) monazite, and most have traces of one or more of secondary chlorite, white mica, carbonate, epidote and hematite. The amphibole is typically ragged, pale-green to blue-green and altered to an orange-brown phyllosilicate. The latter two features may be due to Na- and Fe-enriched compositions (*e.g.*, pargasitic hornblende), which would be in keeping with the sodic nature of the plagioclase and overall lack of Ca-rich minerals. The amphibole is porphyroblastic in some samples (DL93-236, DL93-383), perhaps the result of metamorphic growth from a calcareous intergranular cement. It should be noted that three northeastern samples (CG93-718, CG93-725, CG93-735A) are slightly different, in that K-feldspar is less abundant and the amphibole more typical of common hornblende.

The samples lacking amphibole or garnet show the same scatter as the amphibole-bearing samples. The samples examined petrographically are CG93-268A, CG93-363, CG93-526, CG93-585, CG93-663B, CG93-665, CG93-694B, DL93-111, part of DL93-126A, DL93- 287A, VN93-166A, VN93-335A and VN93-549A. All samples contain plagioclase, K-feldspar (perthite in the west, microcline in the east), quartz, biotite (buff, brown, orange, less commonly green), an oxide opaque mineral (CG93-663B has sulphide in a leucosome veinlet). Accessory minerals, which are not found in all samples, are titanite (mantling opaque grains in places), apatite, zircon and allanite (rare). Monazite was recorded in VN93-166A and VN93-335A and hercynite in CG93-663B. White mica and chlorite are sparse secondary minerals. Thin section DL93-126A is particularly interesting in that a large grain of K-feldspar is positioned on the boundary between pelitic and psammitic layers (Photomicrograph 13.1B). It was suggested earlier (Section 13.1.1) that this is a depositional feature, whereby the K-feldspar grain was deposited on top of the psammitic prior to being covered by the pelitic material. Some large lenses of recrystallized quartz-dominant material in CG93-585 may represent volcanic fragments, but textures are inconclusive.

Four other samples interpreted as having a probable volcaniclastic origin do not conform to the above groups. The samples are CG93-166, DL93-328, VN93-390, VN93-411. Sample CG93-166 has some mineralogical similarities to garnet- and amphibole-absent group, except that one layer contains relict cores of corundum, now largely pseudomorphed by a white mica, interpreted to be margarite. These identifications are consistent with absence of quartz in the thin section and the presence of hercynite at the corundum–opaque mineral interface. Noting that oxygen is a reactant in the first reaction and a product in the second, the two reactions implied are:

$$\textit{Anorthite (from plagioclase)} + \textit{Corundum} + H_2O + O_2 = \textit{Margarite}$$

$$\textit{Magnetite} + \textit{Corundum} = \textit{Hercynite} + O_2$$

The stability boundary between anorthite + corundum + H_2O and margarite is 470°C at 1 kb and 600°C at 6 kb (Deer *et al.*, 1992, page 315), thus providing a useful minimum estimate for temperature of metamorphism of (say) 550°C at pressures realistic for the area.

Sample DL93-328 comprises microcline, quartz, opaque oxide and fine-grained material interstitial to the felsic grains (determined to be white mica where grains are large enough to be identified). The rock clearly has a primary clastic texture, and, in this context, the intergranular material is considered to have originally been clay.

Samples VN93-390 and VN93-411 are anomalous in having an intermediate rather than felsic composition. Both contain plagioclase and quartz, but VN93-390 lacks K-feldspar, and, in VN93-411, it is minor and interstitial. The intermediate character is also reflected in VN93-390 by the former presence of amphibole (now pseudomorphed by chlorite and an opaque mineral), and, in VN93-411, by olive-green biotite (rather than the orange-brown variety characteristic of the more felsic rocks) and common epidote. Of additional interest is the presence of sulphide in both rocks, in contrast to its absence in all the other quartzofeldspathic volcaniclastic rocks described above.

13.1.3.3 Quartzofeldspathic Rocks Derived from Clastic Metasediment (PMss)

Description. Rocks thought to have been derived from a clastic arenaceous protolith occur in all parts of the Henley Harbour district (Figures 13.3, 13.4; Plate 13.3A, B). As their composition is very similar to many granitoid rocks and as they commonly also lack any obvious textural features that would characterize them as supracrustal, their protolith identification is challenging. The most difficult discrimination is between rocks having a felsic volcanic *vs.* a psammitic protolith. A starting criterion is that the felsic volcanic rocks tend to exhibit lensy or streaky textures and tend to be compositionally varied, whereas the psammitic rocks may be more regularly banded (bedded?). No hard-and-fast rules exist, however, and the author envisages both as having a common origin, albeit the psammitic rocks most likely occupying a more distal setting from centres of volcanic

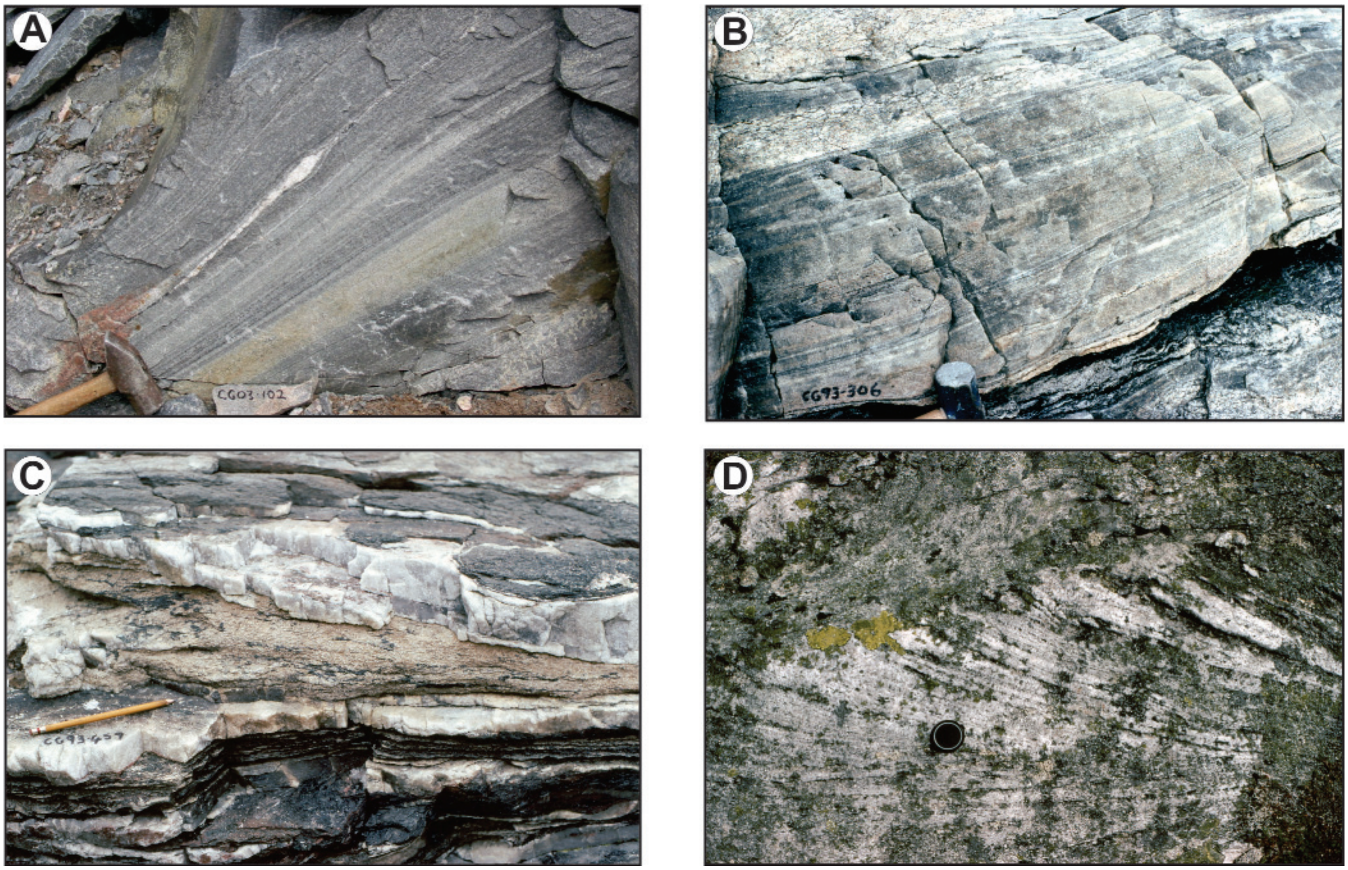


Plate 13.3. *Rocks in the Henley Harbour district interpreted to have an arenaceous protolith. A. Psammitic rock with calcareous zones, strongly deformed (CG03-102), B. Psammitic rock (CG93-306). Associated with pelitic gneiss (*cf. *Plate 13.4A), C. Quartzite interlayered with psammitic rock (CG93-459), D. Quartzite showing (rare) example of crossbedding (VN93-562).*

activity. The term 'psammitic', in any case, is a sort of shorthand for a somewhat varied package encompassing rocks from semi-pelite to feldspathic quartzite.

Postdating road construction, outcrops of psammitic rock were found in several places between 9 and 18 km southwest of Lodge Bay. Their recognition relies on high quartz content, regularity of banding and association with calc-silicate rocks. At data station CG03-113, the supracrustal rocks are discordantly intruded by fine-grained grey biotite granite (CG03-113F), which, if dated, would provide a minimum age constraint for the time of deformation at this site.

A large area of psammitic gneiss is present on the northeast side of the Upper Beaver Brook quartz monzonite and is a good example of equivocal protolith. The most common rock type is a generally pink-weathering, fine-grained, normally rather structureless, recrystallized K-feldspar-rich quartzofeldspathic rock. In addition to its interpretation as having either a psammite or felsic volcanic protolith, a felsic hypabyssal origin cannot be excluded. In this case, however, a supracrustal protolith is preferred because of the rock's association with quartzite and pelite.

Within the southeast part of the Upper Beaver Brook quartz monzonite, a large raft of supracrustal rocks is well exposed in the Pinware River bed and on a hilltop immediately to the west. The rocks are mostly fine-grained, very finely laminated quartzofeldspathic rocks, but include some slightly coarser grained felsic rocks, which might be of fragmental origin. A well-defined compositional layering and rounded quartz grains support a sedimentary protolith interpretation.

Petrography. On Great Caribou Island, sample VN87-479B, which comes from an outcrop that was described as gneissic granodiorite in the field, is spatially associated with rocks interpreted to have been derived from a felsic volcaniclastic protolith (Section 13.1.3.2). The sample has minerals (plagioclase, microcline, quartz, bronzy-buff biotite, an opaque oxide, titanite, apatite, zircon and allanite with epidote veneers) that are typically igneous in their proportions. It also contains blue-green amphibole poikiloblasts. Given its lithological associates, and the fact that amphibole poikiloblasts characterize crossbedded quartzite on Battle Island 4.5 km to the east, a psammitic protolith is now preferred.

From roadcuts southwest of Lodge Bay, four thin sections were examined from three outcrops (CG03-100, CG03-102, CG03-113A, CG03-113E). The samples contain quartz, plagioclase, microcline, biotite, an opaque mineral, apatite, and titanite, plus either amphibole or muscovite. The feldspars, in particular, are concentrated in specific layers that clearly reflect fluctuations in source and depositional conditions.

A sample from the Pitts Harbour area (CG87-415), in addition to having a typically igneous assemblage of plagioclase, well-twinned microcline, quartz, orange-brown biotite, an opaque oxide, apatite, allanite and zircon, also contains muscovite and garnet. A similar assemblage is present in Sample VN87-346 from near Pleasure Cove, except that garnet and allanite are not present, and it contains minor epidote. Despite recrystallization, VN87-346 also retains vestiges of a granular texture. Both psammitic rocks occur in association with muscovite ± garnet schist and minor calc-silicate and quartz-rich rocks. Sample VN87-346 is about 200 m from quartzite investigated by U–Pb geochronological methods by Wasteneys *et al.* (1997, sample VO92-015C; *see* end of introductory part of Section 13.1.3). A third sample (JS87-385), from Temple Bay, is equivocally added to this group on the basis of texture and higher than normal (for granite) quartz content. It contains minor muscovite, which may be secondary rather than part of the stable mineral assemblage.

Two samples were examined petrographically from west of the Chateau Pond granite (CG87-209A, JS87-107). One, CG87-209A, is from the same outcrop as sillimanite–garnet–cordierite pelitic gneiss (Figure 13.3). It contains plagioclase, stringlet perthite, bronzy-brown biotite, garnet, and opaque oxide, zircon and monazite. An alternative protolith candidate is alkali-feldspar granite, but the association with pelitic gneiss, and the presence of garnet and monazite (not otherwise present in granitoid rocks in this area), is taken as indication of its psammitic origin. Sample JS87-107 is 6.3 km north-northwest of the other sillimanite-bearing pelitic gneiss in the western part of the map region (CG87-087, *see* following). Sample JS87-107 comprises anhedral, fractured quartz (70%), with anhedral plagioclase and microcline, and lesser olivine-green biotite, and very minor zircon, apatite and allanite, plus trace secondary Fe oxide. The rock has been brecciated (Section 18.2.2).

Four quartz-rich samples from the north side of the Upper Beaver Brook quartz monzonite were described in thin section (CG93-662, CG93-664, DL93-378A, VN93-549C). All contain plagioclase, K-feldspar (microcline and/or perthite), quartz, biotite (all chloritized in DL93-378A), an opaque oxide, zircon (cores and rims), apatite and a secondary brown-black amorphous-looking material (secondary titanite?), plus sporadic secondary white mica and chlorite.
A thin section from a rock from within the southeast part of the Upper Beaver Brook quartz monzonite comprises plagioclase–K-feldspar–quartz–clinopyroxene–biotite–opaque mineral with minor apatite and secondary amphibole, titanite and chlorite (VN93-612).

13.1.3.4 Quartzite and Quartz-rich Meta-arkose (PMsq)

Description. The basis for interpreting rocks as having either a quartzite or quartz-rich meta-arkose protolith rests largely on the proportion of quartz in the rock being abnormally high compared to typical igneous rocks. Occurrences are reviewed on an area-by-area basis.

In the northern part of the Henley Harbour district, quartzite south of Outside Big Pond occurs as laminated, white or grey weathering, fine to medium-grained rocks, in association with psammitic rocks, minor calc-silicate rock and banded amphibolite. Most of the outcrops are small and isolated. Gower *et al.* (1988) depicted the then-known outcrops as a single sinuous layer. Subsequently, more outcrops of supracrustal rocks in the area have been recognized, partly as a result of later petrographic studies on samples collected during that mapping, and partly from examination of roadcuts created during construction of the highway between Red Bay and Lodge Bay. It now seems likely that a zone in which supracrustal rocks are present extends from Outside Big Pond northward to St. Lewis Inlet, and could be up to 10 km wide. Even within this zone, supracrustal rocks are still minor, however, being envisaged as remnants preserved after granitoid intrusive activity.

Quartzite occurs in lower grade rocks between Green Bay and Henley Harbour and inland to Outside Big Pond (Plate 13.3C). In these areas, minor thinly bedded quartzite is intercalated with biotite–muscovite–garnet psammitic rock, non-micaceous quartzofeldspathic rocks and schistose amphibolite. Rare examples of crossbedding were found (Plate 13.3D). The quartzofeldspathic rocks are fine to medium grained and show textural contrasts between individual layers and groups of layers. Contacts with the schistose to massive amphibolites are concordant. A 1-m-wide layer of rusty-weathering pyritic quartzite was found interlayered with banded amphibolite. In the vicinity of Long Pond, tightly folded quartzite and quartz-rich arenite are interlayered with amphibolite, calc-silicate layers and some thinner mica-rich layers. Some rocks contain appreciable amounts of biotite and magnetite.

Moving south to the coast, minor quartzite and psammite are associated with pelitic gneiss southwest of Black Bay. Between Black Bay and Barge Bay, garnetiferous quartzite is intercalated with well-banded to schistose, biotite–garnet–sillimanite pelitic gneiss and minor fine- to medium-grained quartzofeldspathic rocks.

Quartzite and quartz-rich psammitic rocks, rarely containing garnet, are also found sporadically along the southwest flank of the Upper Beaver Brook quartz monzonite. A rock having a calc-arenite protolith from this area is described subsequently (*cf.* CG93-495). At a locality within the Upper Beaver Brook quartz monzonite, thinly to thickly bedded quartzite forms about 90–95% of the outcrop and is interlayered with fine-grained sillimanite–muscovite–K-feldspar–quartz schist (CG93-586A; also previously visited by Bostock – BK71-469). Both rock types are intruded by muscovite- and opaque-mineral-rich pegmatitic veins.

In the Country Cat Pond area, quartzite is a minor component of psammite, which also contains narrow sillimanite-bearing pelitic layers. Psammitic rocks are best exposed in a quarry north of the road near the west end of the pond, but they are also present in small outcrops elsewhere in the vicinity. In the quarry, the rocks consist of interlayered quartz- and calc-silicate-mineral-rich rocks (CG93-014). Many of the rocks appear in the field to be almost pure quartzite, but stained slabs show that they contain substantial feldspar. These metasediments may link up with an isolated exposure of impure quartzite south of the Lower Pinware River alkali-feldspar quartz syenite and other remnants of supracrustal rocks to the north of Country Cat Pond.

Petrography. Six samples were examined in thin section from the northern part of the Henley Harbour district (CC87-075, CC87-101A, CC87-101B, EA61-717 (from M61-099a), JS87-349, VN87-275). From where the stations are plotted on aerial photographs, data station M61-099a (from Eade's (1962) mapping) and VN87-275 refer to the same outcrop, or two close together. The rocks also contain anhedral, generally heavily seriticitized plagioclase and well-twinned microcline (K-feldspar absent in VN87-275, EA61-717). A calcareous component is indicated in samples CC87-075 and CC87-101A by the presence of pale-green to colourless clinopyroxene (*cf.* diopside), and, more especially, in samples CC87-101A and CC87-101B, by grossularite, primrose-pleochroic epidote, carbonate (*cf.* calcite) and titanite. The presence of Ca-bearing silicates in quartzite is consistent with their close association with calc-silicate rocks. Other accessory minerals in these samples include apatite and allanite (CC87-075). The other two samples contain orange-brown biotite, an opaque oxide, apatite, allanite (JS87-349 only), amphibole partly altered to chlorite and epidote (VN87-275 and EA61-717), titanite (VN87-275, but not seen in EA61-717) and muscovite (after plagioclase, VN87-275, EA61-717). In field notes recorded during Eade's mapping by one of his assistants, foliated quartz-rich white 'granite' was reported at M61-099a that was suggested to be possibly of metasedimentary origin. Note that this outcrop is not to be confused with vein quartz at data station M61-099b, about 850 m to the south-southeast (Section 18.2.2). An additional sample examined petrographically (VN87-246B) from this region is very similar to VN87-275, but occurs as an enclave within the late- to post-Grenvillian Chateau Pond granite. It contains quartz, heavily sericitized plagioclase, well-twinned microcline, bright-green clinopyroxene (*cf.* aegerine), apatite, zircon, orange-brown grossularite, and secondary pale-blue-green amphibole hosting vermiform quartz inclusions (after clinopyroxene).

Quartzite examined petrographically from near Pleasure Cove (VN87-347C) is part of a sequence of thickly bedded quartzite, psammitic rocks (*e.g.*, VN87-346) and sulphide-bearing muscovite schist. The sample contains quartz, muscovite, olive-green biotite, rounded zircon and a secondary opaque oxide. Quartzite about 200 m from this site was investigated geochronologically by Wasteneys *et al.* (1997; sample VO92-015C).

In the Henley Harbour to Green Bay area, three samples were investigated in thin section; two on the coast between Green Bay and Wreck Cove (CG93-459A) and VN93-408B), and one inland (VN93-650A), east of Outside Big Pond. The two samples from the coast contain quartz, plagioclase, minor or zero K-feldspar, an opaque oxide, titanite and chlorite. Sample CG93-459A also contains pale-green biotite, apatite and a pseudomorph of an unknown mineral now comprising a mosaic of a serpentine-like mineral (orthopyroxene?). This rock also has a mylonitic fabric, in contrast to VN93-408B, which has grain boundaries reminiscent of primary clastic texture. Such a texture is even more evident in the third sample, which has a more varied mineral assemblage, including all of the above mentioned minerals, plus rare allanite, epidote and white mica. In a single sample examined petrographically from the Long Pond area (VN93-526B), it is only its high quartz content that obligates classification as quartzite. The remaining minerals are plagioclase, microcline, buff-orange biotite, apatite, zircon and secondary titanite, epidote, chlorite and muscovite.

Three samples were investigated petrographically from the Country Cat Pond area, in the north (VN93-010), at the quarry mentioned above (CG93-014C), and from the isolated quartzite in the south (CG93-142). The mineral assemblage comprises quartz, poorly twinned plagioclase, K-feldspar (mostly microcline but some stringlet perthite), buff-brown biotite, and opaque oxide, apatite and zircon. A concordant felsic veinlet in CG93-014C also contains amphibole, titanite and chlorite. One other sample from the same general area that was examined petrographically comes from a separate sliver of metasedimentary gneiss about 5 km farther east (VN93-052). It has the same mineral assemblage, except for having amoeboid garnet containing quartz inclusions.

Three samples farther southwest are grouped on the basis of all containing orthopyroxene (Figure 13.4). In the West St. Modeste area, a sample weathering to various shades of orange and brown and considered in the field to have a ferruginous quartzite protolith was seen in thin section (CG93-208A) to consist of plagioclase, quartz, orange-brown biotite, garnet and orthopyroxene, together with accessory apatite, allanite, zircon and a sulphide opaque mineral. The orthopyroxene is largely relict, having retrograded to hornblende and biotite, both hosting symplectic quartz inclusions. Farther to the northwest, along the zone of metasedimentary gneiss slivers northwest of Pinware, sample DL93-051 has a similar mineral assemblage, except having oxide rather than sulphide opaque minerals, and being characterized by secondary serpentine, chlorite and carbonate (mostly after the entirely pseudomorphed orthopyroxene) rather than amphibole. The apatite in this rock is anomalously large, which is also a feature of the third sample (CG93-486A), collected from the southern end of the zone of metasedimentary gneiss slivers on the west flank of the Upper Beaver Brook quartz monzonite. Orthopyroxene in this rock is fresh, forming equant to elongate, faintly pleochroic grains. Minor quartzite is present farther north in the same zone.

13.1.3.5 'Tonalitic' Gneiss (PMtn)

'Tonalitic' gneiss is depicted in two lensoid-shaped areas northeast of Long Pond. Even more so than was the case in the Upper St. Augustin River district, the protolith of these rocks is very uncertain. The rocks are white-weathering, fine to medium grained, recrystallized and strongly foliated. Stained slabs show that all samples lack K-feldspar.

A thin section (VN93-528) contains plagioclase, quartz, biotite, amphibole, opaque minerals (oxide and sulphide) and minor titanite and zircon.

13.1.3.6 Pelitic Rocks (Muscovite-bearing) (PMsp)

Description. Pelitic rocks can be subdivided into muscovite-bearing and sillimanite ± cordierite-bearing. The muscovite-bearing rocks are found in the east part of the region, east of a major north-northeast-trending fault, where, conversely, sillimanite-bearing rocks are absent. They can thus be considered lithologically equivalent, representing a lower grade equivalent of the sillimanite-bearing pelitic gneisses to the west and southwest (Figure 13.5). None of the muscovite-bearing assemblages show any indication of having been retrograded from former sillimanite-bearing assemblages.

The muscovite-bearing rocks are grey, white or creamy weathering, and fine to medium grained, consisting of quartz, K-feldspar, plagioclase, biotite, muscovite, garnet and accessory phases. Schistose zones containing abundant muscovite alternate with broader, more homogeneous layers. It seems likely that these rocks were derived from an argillaceous or fine-grained felsic pyroclastic protolith. The quartz- and muscovite-bearing schists from southwest of Henley Harbour to Wreck Cove are associated with schistose amphibolite and banded quartzofeldspathic rocks. South of Wreck Cove, biotite–muscovite–garnet psammitic rock is intercalated with thinly banded amphibolite and minor thinly bedded quartzite. Locally, rusty-weathering gossan zones are present. North of Wreck Cove, muscovite-rich schists are interlayered with quartzofeldspathic material, garnet-bearing biotite- or muscovite-rich quartzofeldspathic rocks and quartz-rich rocks. The belt of rocks can be extrapolated to the northeast toward Henley Harbour where muscovite-bearing schists are associated with banded amphibolite containing retrograded garnet and fine-grained quartzofeldspathic rocks. The proportion of mica-rich rocks decreases northeast. One distinctive rock, about 1 m thick, is made up almost entirely of biotite, and many of the rocks are extremely muscovite-rich. On the northwest tip of the large island west of Henley Harbour, schistose, well-banded and internally laminated, muscovite-rich quartzofeldspathic rocks are present, interlayered with less mica-rich, but otherwise similar quartzofeldspathic rocks. Inland, substantial widths of very schistose, muscovite-rich psammite to pelite are present, some containing white-weathering pegmatitic melt pods. Accepting a supracrustal origin for the rocks, the amphibolites are interpreted as mafic volcanic rocks, the laminated quartzofeldspathic rocks as greywacke, and the more micaceous rocks as siltstone, originally.

Petrography. In thin section, the muscovite-bearing rocks can be divided into two groups, based on the presence or absence of quartz. The quartz-bearing muscovite schists are seen to contain poor- to well- twinned plagioclase, well-twinned microcline (K-feldspar not seen in VN93-700), and accessory zircon. Green biotite is present in some samples. Accessory minerals include apatite, titanite, opaque minerals (oxide and/or sulphide), and secondary rutile and chlorite, although not all of these are present in every sample. Muscovite-quartz schists from the eastern area examined in thin section include six garnet-bearing samples (CG87-404, CG87-434, CG87-485A, DL93-315B, VN87-298, VN93-412A), and ten samples lacking garnet (CG03-033, CG87-406, CG87-437, CG93-733, CG93-756A, part of DL93-126A, VN87-347A, VN87-347B, VN93-666B, VN93-700). These two sub-groups do not show any systematic spatial pattern. The presence or absence of garnet reflects compositional differences, particularly Fe, as indicated by concomitant presence/absence of opaque oxides. The garnet-bearing samples also contain plagioclase, well-twinned microcline, quartz, green to orange biotite, opaque oxide (lacking in CG87-404), and zircon. Apatite, titanite, epidote, rutile, and chlorite are trivial accessory minerals (generally secondary). The garnet-absent samples are more heterogeneous. Samples CG87-437 and VN87-347B have assemblages similar to that of the garnet-bearing group, except for lacking garnet and opaque minerals. Two other samples (CG87-406, VN87-347A) have simpler mineral assemblages, namely plagioclase–quartz–muscovite–biotite–zircon and quartz–muscovite-trace sulphide, respectively. The muscovite in sample CG03-033 has a ‘fibrous’ form that looks like it is either reacting to, or from sillimanite. Four thin sections from samples collected by Bostock from the same area (BK71-065A, BK71-499, BK71-503, BK71-526) have similar assemblages and fill in gaps in coverage. The distribution of the muscovite ± garnet schist is attributed to lower grade rocks having been preserved in blocks down-faulted during Iapetan rifting.

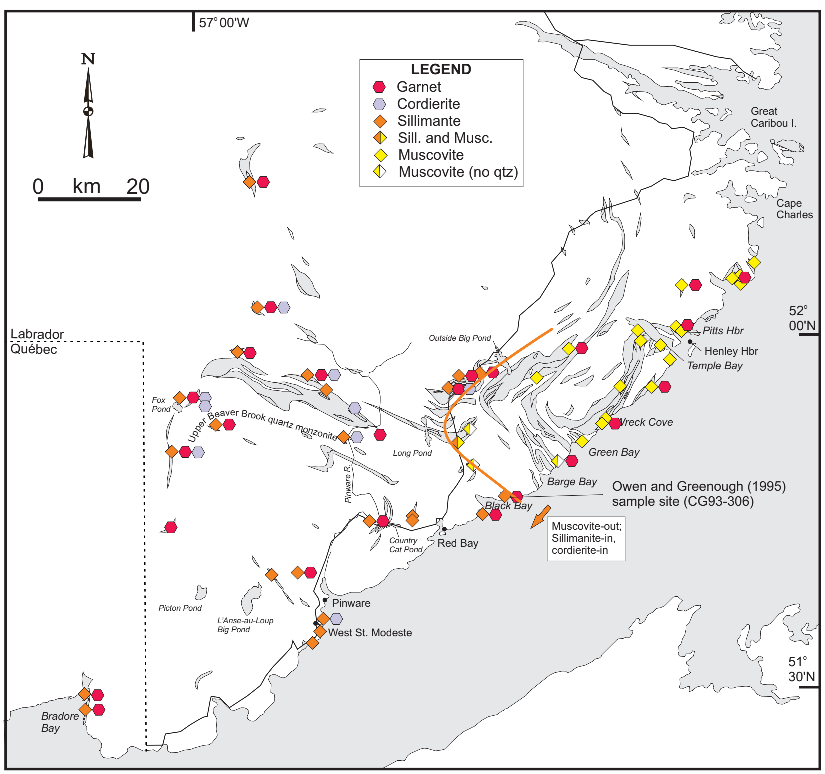


Figure 13.5. *Distribution of some key minerals in pelitic rocks in the Henley Harbour district.*

Muscovite-bearing schist lacking quartz is found in more westerly occurrences. This can be explained in terms of muscovite stability being extended westward in a zone where, if quartz had been present, the two minerals would have reacted according to the reaction:

Muscovite + Quartz = Sillimanite + K-feldspar + H_2O

At one of the localities is east of Long Pond, muscovite is concentrated in 10-cm-thick bands between psammitic layers. A sample examined petrographically (CG93-567) shows a stable assemblage of plagioclase, muscovite, green biotite and interstitial microcline. Secondary minerals are clinozoisite and chlorite. The other locality, on the coast between Barge Bay and Green Bay, is similar in that particular layers are very muscovite-rich. One such layer in thin section (CG93-412) consists of well-twinned unaltered plagioclase, muscovite, minor garnet, zircon and traces of opaque minerals. The opaque minerals comprise veneers of sulphide on muscovite cleavage traces, and leucoxene and hematite at muscovite grain boundaries. Pyrite was noted in hand specimens from this locality. Bostock termed his sample (BK71-608) a quartz-free mesogneiss; it consists of plagioclase, perthite, biotite, muscovite, chlorite, epidote, opaque mineral(s), zircon and apatite.

13.1.3.7 Pelitic Rocks (Sillimanite ± Cordierite-bearing) (PMsp)

Description. In the Pinware 1:100 000-scale map region, some of the sillimanite bearing pelitic gneiss localities were first discovered by Bostock (1983), but the presence of cordierite in the region was established from petrographic studies following mapping by Gower *et al.* (1994).

The most northerly sillimanite-bearing occurrences are 50 km west-northwest of Outside Big Pond. The rocks are white to pale-pink weathering, medium grained, have discontinuous to continuous banded fabrics, and are associated with psammitic gneiss.

In the Outside Big Pond area, sillimanite-bearing rocks are present 8 km to the southwest of the pond. Two sillimanite-bearing zones were mapped, about 0.5 km apart. Following road construction, an additional sillimanite–garnet-bearing locality was found 4 km southwest of Outside Big Pond (CG03-052A; Photomicrograph 13.1C), and is probably the northeastward continuation of the same zone. Gower *et al.* (1994) commented that they did not find a locality 3 km southeast of Outside Big Pond where they wrote that Bostock (1983) reported cordierite, sillimanite and fluorite. Gower *et al.* (*op. cit.*) were erroneous in their statement, having mistaken ‘cs’ on Bostock’s map to mean cordierite and sillimanite, whereas the abbreviation indicates calc-silicate minerals (which are certainly present in Bostock’s thin section from this locality; BK71-527).

A few kilometres farther southwest, in the vicinity of Long Pond, a small outcrop of fine-grained pelitic rock was found at the margin of Upper Beaver Brook quartz monzonite. It contains up to 20% porphyroblasts of a bluish mineral that Gower *et al.* (1994) suggested might be cordierite. A thin section prepared from a sample from this locality (CG93-552) provides no support for this identification, and the supposed cordierite is most likely plagioclase.

Supracrustal rocks are exposed on the shoreline about 3.5 km east of Black Bay. These separate coarse-grained granite on the south from K-feldspar megacrystic granitoid rocks to the north; therefore, the author considers them to be a septum between two different plutons. Supracrustal rock types present include sillimanite-garnet schist, quartzite, banded amphibolite, and various other more non-descript pale-grey-weathering rocks that may be psammitic or felsic volcaniclastic in origin. The pelitic schist is extensively migmatized and has abundant sillimanite and pale mauve garnet (Plate 13.4A). At the margin of the banded amphibolite, a 50-cm-wide band of extremely garnetiferous rock (80–90% garnet) of uncertain protolith is present.

South of Black Bay, a narrow zone of sillimanite-bearing metasedimentary gneiss is exposed along the shoreline. These rocks are bounded to the south by well-banded granodioritic gneiss and to the north by foliated granite. Minor quartzite and psammite are associated with the pelitic gneiss. The pelitic rocks exhibit a migmatitic banding, defined by biotite, sillimanite, garnet-bearing restitic layers and quartz–plagioclase–K-feldspar leucosome. Garnetiferous bands are common and range from 2 to 10 cm in thickness. Spectacular layers composed of fibrolitic and prismatic sillimanite are present up to 50 cm wide. Muscovite occurs locally as a retrograde product of sillimanite. Psammitic and quartzitic layers are composed of quartz, plagioclase, K-feldspar, biotite and minor garnet and sillimanite. Intercalated are fine-grained amphibolitic layers that are interpreted to be of supracrustal origin.

On the northeast flank of the Upper Beaver Brook quartz monzonite, Bostock (1983) shows three localities (more-or-less aligned on a southeast trend) where supracrustal, sillimanite-bearing rocks were identified (BK71-350, BK71-617, BK71-632). Gower *et al.* (1994) interpreted these as belonging to a regionally extensive supracrustal belt trending parallel to the margin of the quartz monzonite. Of these three localities, sillimanite was only seen during mapping at the central one (CG93-675, BK71-617). It is situated on a hilltop 5 km south-southeast of the confluence of Beaver Brook with Pinware River. The rock type has a distinctive ocherous-weathering, schistose appearance and contains abundant sillimanite and garnet. The garnets are dark-red and generally less than 0.2 cm in diameter. The southeastern locality indicated by Bostock (1983) as having sillimanite-bearing rocks, was visited, but sillimanite not seen. During mapping, only a very brief helicopter stop was made (CG93-676, BK71-632) and fine-grained quartzofeldspathic rocks noted. No thin sections are available from the locality from either survey, and Bostock does not mention sillimanite in his field notes. Nevertheless, there is no particular reason to question Bostock’s findings,

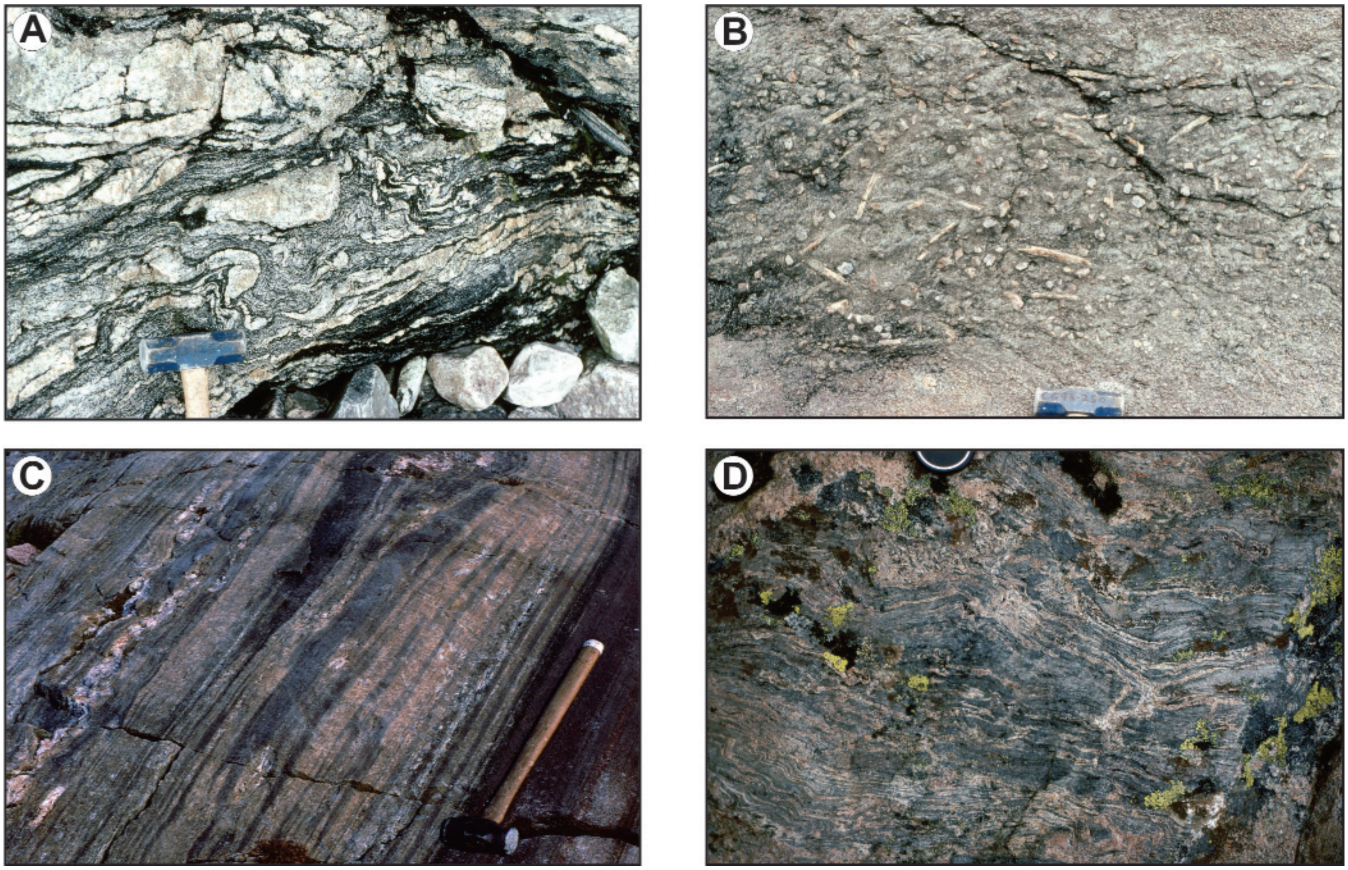


Plate 13.4. *Rocks in the Henley Harbour district interpreted to have pelitic and calc-silicate protoliths. A. Sillimanite-bearing pelitic gneiss. Same outcrop as Plate 13.3B (CG93-306), B. Sillimanite bundles up to 10 cm long (pseudomorphs from staurolite?) in pelitic rock (CG93-250), C. Calc-silicate rock, regularly banded (CG87-438), D. Calc-silicate rock showing layering disrupted by deformation and minor migmatization (VN93-596).*

so sillimanite-bearing rocks are indicated on the Pinware 1:100 000-scale map at this site. The northwestern locality was not visited during mapping.

West of Upper Beaver Brook quartz monzonite, definite/probable supracrustal rocks occur in a zone as narrow bands, generally less than 200–300 m wide. Rock types include garnet–sillimanite–biotite schist, associated with a rather variable dark grey, micaceous, schistose material that was probably derived from a fine-grained clastic rock. At the north end of the zone, Bostock (1983) reported sillimanite-bearing rocks near the north shore of Fox Pond, at a site not visited by Gower *et al.* (1988) during 1:100 000-scale mapping. The locality is very valuable from a regional perspective in that it provides a spatial link between the slivers of metasedimentary gneiss on the west flank of the Upper Beaver Brook quartz monzonite with those on the northeast flank. Bostock's thin section (BK71-584A) contains quartz, mesoperthite, sillimanite, garnet, cordierite, hercynite, zircon and opaque mineral and secondary chlorite.

At the south end of the same zone of supracrustal rocks west of the Upper Beaver Brook quartz monzonite, a narrow band of schistose, rusty-weathering garnet-rich rock is interpreted as supracrustal (CG93-449). Most of the garnet is blood-red, but some is mauve. No sillimanite was seen was seen in outcrop and no thin section is available, but it is likely that sillimanite would be found if searched for more thoroughly. It should be noted that extrapolation southward around the west side of the Picton Pond quartz monzonite, leads to linkage with sillimanite-bearing pelitic gneisses in the Bradore Bay area in easternmost Québec, about 25 km to the south (Figure 13.5). These rocks have been described by Bostock (1983).

A hilltop west of the middle Pinware River (close to the southwest flank of Upper Beaver Brook pluton) was previously visited by Bostock (BK71-469) and the rocks identified by him as supracrustal. Fine-grained sillimanite–muscovite schist is interlayered with quartzite. Both rock types are intruded by muscovite- and opaque-mineral-rich pegmatitic veins.

Northeast of Country Cat Pond, pelitic gneisses form a minor proportion of the supracrustal rocks present (*e.g.*, locality VN93-052). Those present contain biotite, garnet, sillimanite, magnetite in restite layers and quartz, plagioclase and K-feldspar in the leucosome, but were not examined in thin section.

In the West St. Modeste area, three sillimanite-bearing-rock localities were found. On the north side of the West St. Modeste granite, sillimanite- and garnet-bearing schists are intercalated with ferruginous quartzite, calc-silicate-rich layers and a banded amphibole-bearing rock (CG93-208, CG93-209). The orange weathering indicates high sulphide content. On the south side of the West St. Modeste granite, not far from West St. Modeste (CG93-250), spectacular bundles of sillimanite, up to 10 cm long and over 1 cm wide, occur in extremely biotite-rich schist (Plate 13.4B). Nearby, other similar schists exist that are almost as biotite-rich, containing retrograded sillimanite and garnet scattered throughout. Farther south, sillimanite occurs in narrow biotite-rich veneers associated with white-weathering inhomogeneous pegmatite (CG93-261). This rock is interpreted to be an extensively melted pelite.

Northwest of Pinware, narrow zones of metasedimentary gneiss were found, and it seems probable that these are the northward strike continuation of those in the West St. Modeste area. At one locality, the supracrustal rock consists of quartzite interlayered with ocherous-weathering quartz-rich psammite and thin veneers of sillimanite- and garnet-rich rocks.

Petrography. Samples examined in thin section from the interior northwestern area (CG87-087, CG87-209B) contain anhedral, well-twinned plagioclase, poorly twinned microcline, quartz, bronzy to red-brown biotite, amoeboid-shaped garnet with quartz ± biotite ± opaque mineral inclusions, prismatic sillimanite, zircon and an opaque oxide. In addition, sample CG87-209B contains pinitized cordierite and one grain of hercynite. This is the only occurrence of cordierite known in the St. Lewis River 1:100 000-scale map region, but can be readily explained as a northward extension of a zone of pelitic gneisses having cordierite-bearing sillimanite–garnet assemblages that are known in the northwest part of the Pinware map region to the south.

A thin section prepared from a sample taken from the Outside Big Pond area (VN93-566) contains poorly twinned plagioclase, microcline, quartz, red-brown biotite, poikilitic garnet (feldspar and opaque mineral inclusions), small prismatic sillimanite, an opaque oxide, zircon and possibly cordierite.

Both the sillimanite-bearing pelitic gneiss and the garnet-rich rock east of Black Bay mentioned earlier in this section were examined in thin section (CG93-306B, CG93-306A, respectively). The sillimanite-bearing pelitic schist has large grains of plagioclase and quartz, but K-feldspar is only found as a minor interstitial mineral in quartzofeldspathic leucosome. Biotite is orange-brown. Sillimanite forms small, prismatic needles and is pseudomorphed to a low-birefringent, colourless mineral thought to be cordierite. Other minerals are large, irregular garnet grains, zircon inclusions in biotite, and large flakes of late-stage muscovite. The texture suggests the breakdown of sillimanite + biotite to give cordierite + garnet. The garnet-rich rock comprises about 60% garnet, associated with orange biotite, quartz, apatite, an opaque oxide and traces of hercynite. Samples from this outcrop were investigated by Owen and Greenough (1995) in a study addressing how the mode and distribution of garnet and biotite influence garnet-biotite geothermometric results. For their study, they selected rocks types containing various proportions of garnet + biotite and demonstrated that the distribution coefficients varied according to the absolute amount of garnet and biotite and the distance separating the two minerals. In turn, this implies a spread of calculated metamorphic temperatures, which ranged from 560 to 700°C.

A thin section of pelitic gneiss from south of Black Bay (VN93-218C) contains poorly twinned plagioclase, K-feldspar in the form of both fine-stringlet perthite and microcline, quartz, prismatic and fibrolitic sillimanite, garnet with quartz inclusions, red-brown biotite, an opaque oxide and fairly common zircon. Cordierite is suspected, but was not confidently identified.

A sample from the central locality on the northeast flank of the Upper Beaver Brook quartz monzonite mentioned above contains, in thin section (CG93-675), anhedral finely twinned plagioclase, poorly twinned K-feldspar and quartz. These are associated with orange-brown biotite, anhedral garnet containing quartz inclusions, cordierite, prismatic sillimanite and opaque oxide, very minor sulphide, apatite and zircon inclusions in biotite. Bostock also reported vesuvianite in his sample, but it was not identified by the author during re-examination. Bostock prepared a thin section from the northwestern locality (BK71-350A), which contains microcline perthite, sillimanite, garnet, quartz, biotite and hercynite.

An example from west of the Upper Beaver Brook quartz monzonite examined in thin section is sample DL93-173, which is dominated by quartz, with subsidiary finely perthitic K-feldspar and anhedral sericitized plagioclase. Other minerals are prismatic sillimanite, red-brown biotite, polygonized cordierite, graphite, zircon inclusions in biotite, and secondary chlorite and muscovite. One other rock from this area examined in thin section occurs as an enclave in the marginal part of the Upper Beaver Brook quartz monzonite in this area (VN93-473). It consists of plagioclase, K-feldspar, quartz, biotite, an opaque mineral and an equant mineral showing hexagonal outline and pseudomorphed to a phyllosilicate aggregate (probably cordierite). The outcrop was described as 'heaved' in this area, so there is a small possibility that it might not be exactly *in situ*.

Sillimanite-bearing pelitic schists were also discovered on the southwest flank of the Upper Beaver Brook quartz monzonite, and two thin sections prepared (VN93-463C; quartz-rich and VN93-463D; garnet-rich). Both contain quartz, plagioclase, K-feldspar (microcline in one and finely exsolved perthite in the other), garnet, orange-brown to red-brown biotite, an opaque oxide, zircon inclusions in biotite, hercynite and secondary muscovite and chlorite. In addition, VN93-463C contains a colourless, high-relief mineral forming cores to garnet and thought by the author to be corundum.
From the hilltop west of the middle Pinware River, a thin section of sillimanite schist (CG93-586A) also contains interstitial microcline, recrystallized quartz concentrated into specific layers, and an oxide opaque mineral (no plagioclase seen). In addition, small equant grains of a mineral pseudomorphed to a colourless to green phyllosilicate are present, and thought by the author to have originally been cordierite. It also contains some muscovite, much of which is clearly secondary, but, in most cases, the status of muscovite in the sample is ambiguous. From the distribution of muscovite elsewhere in the map region, it seems likely that it is all secondary. Hand sam-

ples are reddish-brown due to hematite staining; this is borne out in thin section where hematite and leucoxene are seen in fractures and at fringes of oxide grains.

A thin section of a pelitic rock (CG93-238A) from northwest of Pinware contains plagioclase, a mixture of very fine stringlet perthite and well-twinned microcline, red-brown biotite, prismatic sillimanite, anhedral garnet containing hercynite and quartz inclusions, an oxide opaque mineral (rare traces of sulphide are also present), zircon inclusions in biotite, and an uncertainly identified amorphous-looking dark-brown to black mineral that is white in reflected light (probably a Ti-bearing mineral, possibly leucoxene or altered titanite). Bostock (1971, field notes, data station BK71-360) records a 6 ft (2 m)-wide layer of quartzite within leucogneiss on strike with this locality, providing justification for extending the belt more than as shown by Gower *et al.* (1994).

In the West St. Modeste area, three samples from data station CG93-208 were examined in thin section, two of which are sillimanite bearing (CG93-208B, CG93-208C; *see* earlier for CG93-208A). They are mutually similar, containing plagioclase, quartz, perthitic K-feldspar, red-brown biotite, sillimanite, common zircon and abundant sulphide. Altered mosaics of fibrous phyllosilicate aggregates may indicate former cordierite in CG93-208C. Secondary flakes of white mica are present in CG93-208B.

13.1.3.8 Calc-silicate Rocks (PMsc)

Description. In the area south of Outside Big Pond, calc-silicate rocks are associated with quartzite, psammitic gneiss and some banded amphibolite. Farther south, calc-silicate rocks occur along the northeast flank of the Upper Beaver Brook quartz monzonite southeast toward the Long Pond area (with a few occurrences within or south of the quartz monzonite), then having a more scattered distribution in the northeast. The rocks are typically light-grey to greenish-weathering, fine to medium grained, well banded, displaying layers ranging in thickness from a few millimetres to 20 cm, and the wider bands including less-pronounced thinner internal layers (Plate 13.4C, D). The rocks are typically associated with quartzite, quartzofeldspathic rocks of probable volcaniclastic origin, and, less commonly, muscovite schist or amphibolite. Most of the calc-silicate rocks were probably derived from a calcareous psammitic or volcaniclastic protolith. Calc-silicate minerals present include diopside, grossularite, scapolite, amphibole, and epidote (Figure 13.6). The rocks can be grouped according to mineral assemblage present, which, although blurred by compositional differences between samples, reflect an increase in metamorphic grade from east to west, inasmuch as, in the east, carbonate, epidote and amphibole dominate and clinopyroxene is lacking (or is a minor non-equilibrium phase), and *vice versa* in the west. Garnet (*cf.* grossularite) and scapolite occupy a transient middle area. Calc-silicate rocks are also known in the Country Cat Pond area, but no petrographic information is available. Grey-green-weathering diopside was identified in one hand sample (CG93-014).

Petrography. A thin section from the area south of Outside Big Pond (CG87-386) comprises plagioclase, quartz, clinopyroxene, carbonate, scapolite and titanite. An epidote-rich layer (CG87-242) contains blue-green hornblende, polygonal plagioclase, primrose-pleochroic epidote, an opaque oxide, titanite and apatite. Following road construction, calc-silicate rocks were discovered at additional localities and some examined in thin section (CG03-089, CG03-113B, CG03-153A, CG03-154C). Sample CG03-089 is somewhat distinctive in having a hornfelsic texture, in keeping with its location marginal to the Chateau Pond granite.

Calc-silicate rocks from the Wreck Cove area, examined in thin section (CG93-459B, DL93-352), are mutually similar, being dominated by polygonized plagioclase, quartz and carbonate, which are associated with pale-olive-green biotite and ragged, inclusion-filled, blue-green amphibole. Accessory minerals include an opaque oxide (minor sulphide in a narrow quartz vein in DL93-352), apatite, titanite, allanite and secondary chlorite. In addition, DL93-352 contains large, ragged garnet, hosting abundant inclusions of carbonate, quartz, opaque mineral and epidote. The garnet is rotated and therefore predates final deformation.

From the Barge Bay area, two samples were examined petrographically (CG93-407B and VN93-335B). Both contain plagioclase, microcline, quartz, pale olive-green biotite, amphibole, epidote and

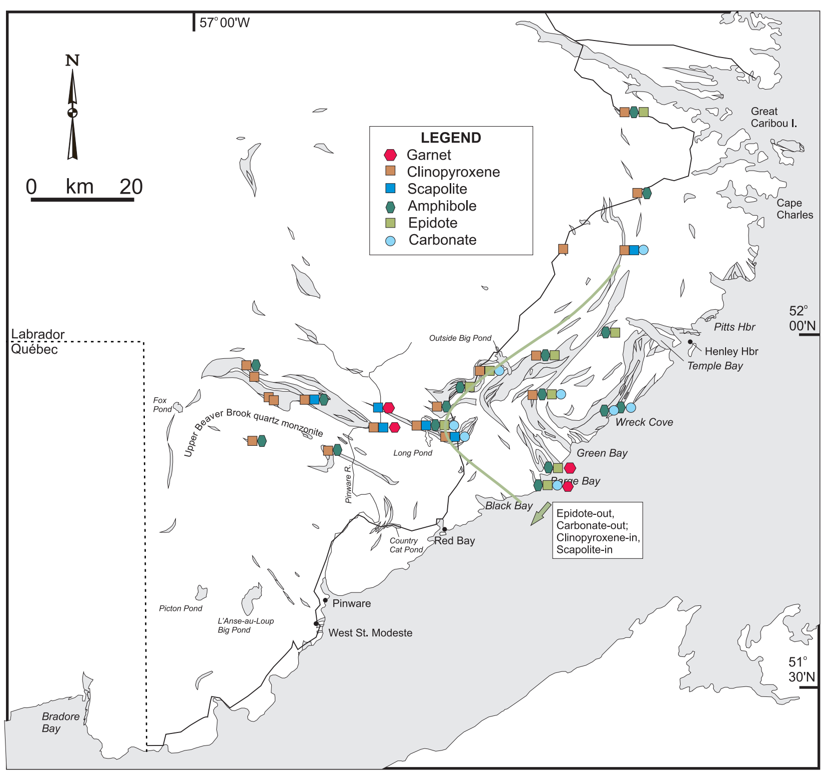


Figure 13.6. *Distribution of some key minerals in calc-silicate rocks in the Henley Harbour district.*

garnet with accessory titanite, opaque minerals (oxide in one, sulphide in the other), allanite, apatite, zircon and secondary chlorite. Most of the amphibole is a ragged blue-green hornblende, but colourless, acicular tremolite–actinolite is also present in VN93-335B. The garnet has an amoeboid shape. Sample VN93-335B also contains secondary prehnite.

Farther north, east of Outside Big Pond, sample DL93-295 contains plagioclase, minor quartz, abundant epidote, ragged, blue-green amphibole, relict clinopyroxene(?), and accessory opaque oxide, titanite and apatite. Bostock's sample BK71-527, from 5 km to the south, is similar in that it contains clinopyroxene, amphibole and epidote, but differs in having some carbonate. Farther west (6 km southwest of Outside Big Pond), a rock that was described as ultramafic in the field (VN93-564) probably has a calc-silicate protolith. It contains perhaps as much as 20% plagioclase (thoroughly sericitized), which is associated with hornblende, green slightly chloritized biotite and common dark-brown titanite. This interpretation is indirectly supported by the presence of calc-silicate rocks in a roadcut 3 km southwest of Outside Big Pond, along strike from VN93-564. A sample was examined in thin section (CG03-055). Another sample (VN93-537) that belongs to this group is from an outcrop much farther west, in the Long Pond area, but, rather than truly being a calc-silicate rock, it may have a calcareous quartz arenite protolith. It contains the same mineral assemblage as DL93-295, except for having K-feldspar, minor red-brown biotite, zircon and minor epidote.

Moving west, to the Long Pond area and then west to the Pinware River, five samples form a group in that they all contain scapolite; although otherwise they have differing mineral assemblages. They reflect a transition to higher grade rocks. All contain quartz and titanite. Carbonate is abundant in the two southeastern samples (CG93-546B, VN93-524), less common in VN93-543, rare in VN93-606B, and absent from VN93-627. There is, therefore, a decrease in carbonate from east to west, except for VN93-543, which is much more quartz-rich, and the only one to lack plagioclase (hence allowing carbonate to remain stable). Amphibole and epidote are present in one of the two southeastern samples (CG93-546B), but neither mineral is present in the three northwestern samples, two of which contain garnet (*cf.* grossularite). Clinopyroxene is present in four samples. Its absence from VN93-627 (where its presence might be anticipated from a metamorphic grade standpoint), can be attributed to low Mg and Fe, as no other phases requiring these components are present, with the exception of sparse, small grains of a yellow mineral thought to be allanite. Formation of scapolite at the expense of carbonate can be accomplished by the reaction:

Anorthite + Calcite = Meionite (scapolite Ca end-member)

but textural relationships in VN93-606B suggest a more complex reaction involving grossularite, scapolite, carbonate and quartz as reactants and diopside and plagioclase as products.

The most westerly group of samples (CG93-495, DL93-377, DL93-378B, VN93-494, VN93-516, VN93-612) all contain plagioclase, quartz, clinopyroxene (equant, pale-green diopside), and opaque oxide, apatite, zircon and secondary chlorite. Microcline is present in all sections, except DL93-378B and CG93-495. The former sample is devoid of K-bearing phases, except white mica, which is a secondary mineral found in fracture fillings along with carbonate, chlorite and epidote. The latter sample differs in containing minor orange-buff biotite and being more quartz-rich. Titanite is present in DL93-378B and VN93-612. The two samples from the southwest flank of the Upper Beaver Brook quartz monzonite (VN93-612, CG93-495) and the most westerly from the northeast flank (VN93-494) also contain amphibole. In all three cases, amphibole is considered to be a retrograde product of clinopyroxene (it contains vermiform inclusions of quartz, for example); hence amphibole is not indicated at these localities in Figure 13.6. A thin section from a calc-silicate rock collected by Bostock (BK71-620) from the same area has a similar mineral assemblage (plagioclase, microcline, quartz, clinopyroxene, apatite, zircon opaque mineral). The essential feature of these rocks is the stable mineral assemblage comprises volatile-absent phases (except for minor biotite), demonstrating higher metamorphic grade of this region.

13.2 PINWARE TERRANE FOLIATED AND GNEISSIC GRANITOID ROCKS

13.2.1 OVERVIEW OF ROCK TYPES PRESENT

Much of the Pinware terrane is underlain by deformed, K-rich granitoid rocks (Figure 13.7) that, collectively, contrast compositionally with granitoid rocks in terranes farther north in eastern Labrador. Granitoid rocks in the Pinware terrane are grouped here as: i) syenitic rocks and alkali-feldspar granite, ii) granite, iii) quartz monzonite and monzonite, iv) granodiorite, v) quartz monzodiorite and diorite, vi) K-feldspar megacrystic granitoid rocks. For all groups, gneiss equivalents are implied, as are quartz-prefixed variants of the rock types, where not specifically listed. The groups are gradational into each other and each includes lesser amounts of other groups. Note that, because of these overlaps, rock names applied to thin sections do not always conform to the compositional group into which the outcrop has been placed. Assigning unit designators also incorporates information from stained slabs, field descriptions, and (rarely) the exigencies of geological map making. Detailed descriptions of individual units address the unit-defining rock type. Subsidiary rock-type descriptions are included in the appropriate namesake unit. Generalized field and petrographic description of each unit are given below, followed by additional details of specific localities for which further information is pertinent. Places names referenced in Section 13.2 are shown on Figure 13.8. Representative slabs of Pinware terrane granitoid rocks are given in Appendix 2, Slab 13.3.

Table 13.1 summarizes the number of thin sections for each rock type within a particular Unit PM granitoid rock type. Although it relies on a somewhat subjective process of assigning rock names, the author believes it provides useful information. For the most part, the correspondence between rock unit and namesake rock type is very high – as it should be. Where this is not so much the case, the second-most abundant rock type is the most compositionally similar type. The unit having the lowest proportion of its namesake rock type is PMmq. This is largely an artefact of it having a compositionally 'in-between' status, thus providing more options for alternative names. A key point to be gleaned from the table is that over 2/3 of the rocks are very potassic (granite or syenite). As the megacrystic granitoid unit is

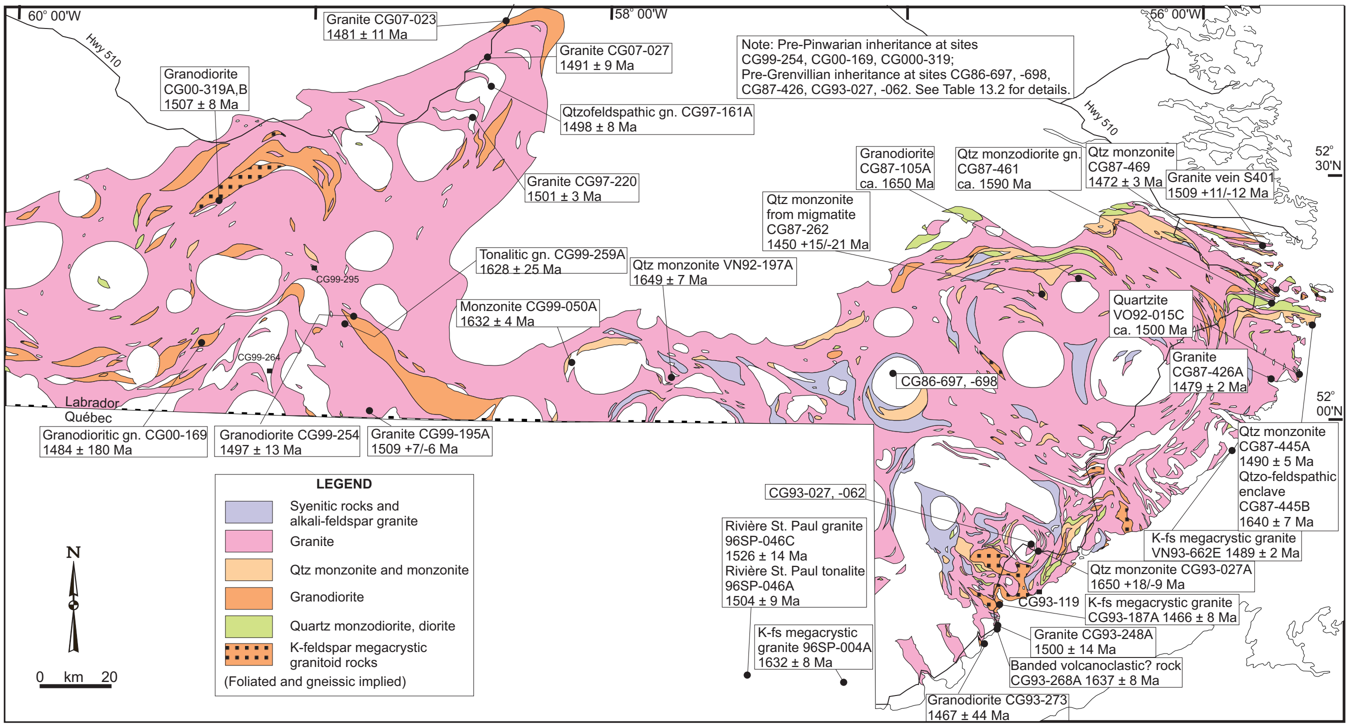


Figure 13.7. *Distribution of granitoid rocks in the Pinware terrane. Both late Paleoproterozoic and Mesoproterozoic granitoid rocks are included (Unit PM).*

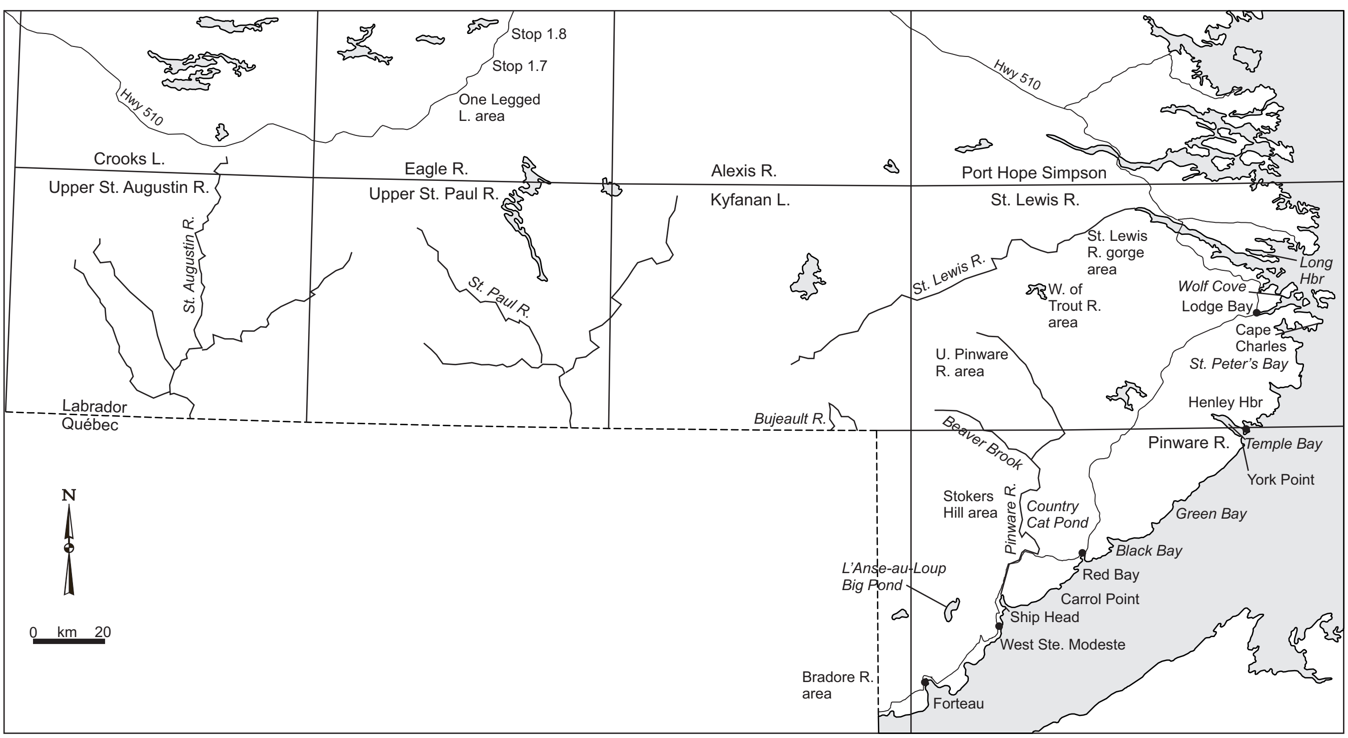


Figure 13.8. *Locations mentioned in section on Pinware terrane foliated and gneissic granitoid rocks.*

Table 13.1. Field/slab names *vs.* names based on this section examination

Assigned unit (from field & slab) \ *Thin section name*	Syenite, quartz syenite, alkali-feldspar granite (PMyq)	Granite (PMgr)	Quartz monzonite, monzonite (PMmq)	Granodiorite (PMgd)	Quartz monzodiorite, diorite (PMmd, PMdr)	K-feldspar megacrystic granitoid rocks (PMgp)	Others	Thin section totals
Syenite, quartz syenite, alkali-feldspar granite (PMyq)	25 **(83%)**	4	0	0	0	0	1	30
Granite (PMgr)	3	222 **(91%)**	8	2	1	0	7	243
Quartz monzonite, monzonite (PMmq)	2	21	52 **(56%)**	9	7	0	1	92
Granodiorite (PMgd)	0	5	1	31 **(79%)**	1	0	1	39
Quartz monzodiorite, diorite (PMmd, PMdr)	0	1	1	0	15 **(88%)**	0	0	17
K-feldspar megacrystic granitoid rocks (PMgp)	0	13	1	6	0		0	20
Rock type as a percentage of all Unit PM granitoid rocks	*7%*	*60%*	*14%*	*9%*	*6%*	*2%*	*2%*	

Note: Of 243 outcrops that were termed granite in the field and from which thin sections were prepared: 222 were considered to be granite based on the thin section examinations; 8 were considered 'monzonite'; 3 'syenite'; 2 'granodiorite' and 1 'diorite'.

defined texturally rather than compositionally and because megacrysts are not necessarily evident in thin section, this unit must be treated separately. Compositionally it is most commonly granite, followed by granodiorite.

13.2.2 AGE OF PINWARE TERRANE GRANITOID ROCKS

U–Pb dating has established that, collectively, granitoid rocks in the Pinware terrane have pre-Labradorian (1810–1770 Ma), Labradorian, Pinwarian or Grenvillian ages (Tucker and Gower, 1994; Wasteneys *et al.*, 1997; Heaman *et al.*, 2004; Gower *et al.*, 2008b; Kamo and Hamilton, 2007; S. Kamo, unpublished internal report to the GSNL, 2012). Information pertaining to pre-Labradorian and Grenvillian rocks in the Pinware terrane is discussed in earlier and later parts of this report, respectively, so this section addresses rocks believed to have Labradorian or Pinwarian ages.

No criteria, other than geochronological, have been identified that reliably discriminate between Labradorian and Pinwarian granitoid rocks, hence there is little choice but to treat them collectively. With more detailed mapping, and structural and geochemical studies in well-exposed locations, it will likely be possible to distinguish between the various age groups, but such a mission remains to be attempted seriously. A compilation of Labradorian and Pinwarian U–Pb ages in the Pinware terrane is given in Table 13.2.

Because of the uncertainty between Labradorian and Pinwarian rocks in the Pinware terrane, unit designator usage is less straightforward than for most other rock groups. On the 1:100 000-scale maps of Gower (2010a), all rocks addressed as 'Pinware terrane foliated and gneissic granitoid rocks' are included as units PMgr, PMgd, *etc.*, where 'PM' is intended to imply either a Paleoproterozoic or Mesoproterozoic age. The 1:100 000-scale maps also have units M_1gr, M_1gd, *etc.* The latter rocks were distinguished separately where their early Mesoproterozoic age had been established. Thus, chronologically, any M_1 unit could be part of a PM unit, but not necessarily *vice versa*. During writing, it became impractical and repetitive to maintain this separation, with the exception of the 'Pinware–Mealy Mountains

Table 13.2. Labradorian and Pinwarian U–Pb ages of foliated to gneissic granitoid rocks from the Pinware terrane

SampleNo	RockType	Intercept Age	Mineral	Intercept	Interpretation	Reference	Notes
Labradorian – *Supracrustal*							
CG87-445B	Quartzofeldspathic enclave	1640 ± 7	Zircon	Concordant, nearly	Emplacement	Tucker and Gower (1994)	Two fractions are 0.8 and 2% discordant. L.I. is anchored by 964 Ma Pb-loss in host rock
CG93-268A	Banded volcanoclastic? rock	1637 ± 8	Zircon	Upper	Emplacement	Wasteneys *et al.* (1997)	Regression includes data for crosscutting pegmatite CG92-268B
Labradorian – *Plutonic intrusive*							
CG87-105A	Foliated granodiorite	*ca.* 1650 Ma?	Zircon	Upper	Emplacement?	Tucker and Gower (1994); Wasteneys *et al.* (1997)	Re-interpretation of original 1145 Ma upper intercept
CG93-027A	Country Cat Pond quartz monzonite	1650 +18/-9 Ma	Zircon	Upper	Emplacement?	Wasteneys *et al.* (1997)	
VN92-197A	Quartz monzonite	1649 ± 7	Zircon	Upper	Emplacement	Wasteneys *et al.*. (1997)	Precise mixing line between 1649 and 1009 Ma
96SP-004A	Brador River K-feldspar megacrystic granite	1632 ± 8	Zircon	Upper	Emplacement	Heaman *et al.* (2004)	
CG99-050A	Monzonite, recrystallized	1632 ± 4	Zircon	Upper	Emplacement	Gower *et al.* (2008b)	L.I. anchored by zircon data from CG99-050B, otherwise zircon/titanite data give 1632 +10/-6 Ma and 960 +154/-169 Ma
CG99-259A	Tonalitic gneiss	1628 ± 25	Zircon	Upper	Emplacement	Gower *et al.* (2008b)	
CG87-461	Quartz monzodiorite gneiss	*ca.* 1590	Zircon	Upper	Emplacement	Wasteneys *et al.* (1997)	Oldest fraction is near concordant
Pinwarian – *Plutonic intrusive*							
97SP-046C	Rivière St-Paul granite	1526 ± 14	Zircon	Upper	Emplacement	Heaman *et al.* (2004)	
CG99-195A	Granite, foliated	1509 +7/-6	Zircon	Upper	Emplacement	Gower *et al.* (2008b)	L.I. anchored by zircon data from CG99-195B
CG00-319A, -319B	Granodiorite, recrystallized (K-feldspar megacrystic?)	1507 ± 8	Zircon	Upper	Emplacement	Gower *et al.* (2008b)	Combined regression of zircon data from CG00-319A and B. U.I. is 1505 ± 13 Ma if anchored by 990 Ma titanite
97SP-046A	Rivière St-Paul tonalite	1504 ± 9	Zircon	Upper	Emplacement	Heaman *et al.* (2004)	L.I. anchored at 985 Ma
CG97-220	Lost Leg Lake granite	1501 ± 3	Zircon	Upper	Emplacement	Gower *et al.* (2008b)	Monazite anchors L.I.; one (of 6) zircon analysis excluded from regression
CG93-248A	West St. Modeste granite	1500 ± 14	Zircon	Upper	Emplacement	Heaman *et al.* (2004)	Figure 4c of Heaman *et al.* (2004) labelled as 97SP-046A; erroneous - should be CG93-248A
CG97-161A	Quartzofeldspathic gneiss	1498 ± 8	Zircon	Upper	Emplacement	Gower *et al.* (2008b)	Monazite anchors L.I.; one (of 5) zircon analysis excluded from regression
CG99-254	Granodiorite, recrystallized	1497 ± 13	Zircon	Upper	Emplacement	Gower *et al.* (2008b)	
CG07-027	Pinware-Mealy Mountain terrane border granite	1491 +/-9	Zircon	Upper	Emplacement	Kamo (2012, unpublished)	
CG87-445A	Cape Charles quartz monzonite	1490 ± 5	Zircon	Upper	Emplacement	Tucker and Gower (1994)	L.I. is controlled by four titanite fractions (discordant, above L.I.)
VN93-662E	York Point K-feldspar megacrystic granite	1489 ± 2	Zircon	Concordant, nearly	Emplacement	Kamo and Hamilton (2007)	Weighted mean of two concordant points
CG00-169	Granodioritic gneiss	1484 ± 180	Zircon	Upper	Emplacement	Gower *et al.* (2008b)	L.I. anchored at 1.9% discordant, 1022 Ma Pb/Pb date
CG07-023	Pinware terrane granite	1481± 11	Zircon	Upper	Emplacement	Kamo (2012, unpublished)	
CG87-426A	St. Peter Bay granite	1479 ± 2	Zircon	Concordant	Emplacement	Tucker and Gower (1994)	Minor Pb loss in some fractions
CG87-469	Wolf Cove quartz monzonite	1472 ± 3	Zircon	Concordant	Emplacement	Tucker and Gower (1994)	
CG93-273	Diable Bay K-feldspar megacrystic granodiorite	1467 ± 44	Zircon	Upper	Emplacement	Heaman *et al.* (2004)	L.I. anchored at 985 Ma
CG93-187A	Pinware megacrystic granite	1466 ± 8	Zircon	Upper	Emplacement	Heaman *et al.* (2004)	
Pinwarian –*Metamorphic*							
VO92-015C	Quartzite	*ca.* 1500	Monazite	Upper	Metamorphism	Wasteneys *et al.* (1997)	Points in middle of chord between 1500 and 1020 Ma
CG87-262	Quartz monzonite from migmatite	1450 +15/-21	Zircon	Lower, Concordant, nearly	Metamorphism	Wasteneys*et al.* (1997)	Short projection to L.I.
Labradorian and Pinwarian Inheritance – *Pre-Pinwarian inheritance in Pinwarian rocks*							
CG00-319C	Pegmatitic infill	1645 ± 60	Zircon	Upper	Inheritance	Gower *et al.* (2008b)	Inheritance dates use 1017 Ma anchor
CG00-169	Granodioritic gneiss	1637 ± 7	Zircon	Upper	Inheritance	Gower *et al.* (2008b)	L.I. anchored at 1.9% discordant, 1022 Ma Pb/Pb date
CG00-319C	Pegmatitic infill	1575 ± 8	Zircon	Upper	Inheritance	Gower *et al.* (2008b)	Inheritance dates use 1017 Ma anchor
CG99-254	Granodiorite, recrystallized	1549 ± 8	Zircon	Upper	Inheritance	Gower *et al.* (2008b)	1549 Ma inheritance based on two colinear data, for which the L.I. is 1032 ± 30 Ma
Labradorian and Pinwarian Inheritance – *Pre-Grenvillian inheritance in Grenvillian granitoid rocks*							
CG86-697B, -698	Rivière Bujeault headwaters quartz syenite	1530 ± 30	Zircon	Upper	Inheritance	Gower *et al.* (1991)	U.I. projection from lower half of chord; tentatively taken as age of zircon cores
CG87-426C	St. Peter Bay aplite	1478 - 1463	Zircon	Concordant	Inheritance	Tucker and Gower (1994)	If regressed with 974 titanite, U.I. is 1511 ± 6 Ma
CG93-027C, -062	Lower Pinware R. alkali-feldspar syenite	1413 ± 27	Zircon	Upper	Inheritance	Heaman *et al.* (2004)	Middle part of mixing line between 1359 and 962 Ma

terrane boundary' mafic and felsic units. These are spatially distinct and are deemed worthy of separate treatment in the text (Chapter 14), although probably are also Pinwarian.

Labradorian ages in Table 13.2 are subdivided according to supracrustal or plutonic intrusive protolith. The 1640 ± 7 and 1637 ± 8 Ma ages for supracrustal rocks in the Pinware terrane were reviewed in Section 13.1.3. Five reliable Labradorian plutonic intrusive ages (1650–1628 Ma) have been obtained. A Labradorian age is also suggested for two other samples for which only equivocal data are available. One is a foliated granodiorite, for which Tucker and Gower reported a preliminary age of 1145 +35/–47 Ma, but was re-interpreted by Wasteneys *et al.* (1997; CG87-105A), in the context of their own data, as having a *ca.* 1650 Ma age. The other is quartz monzodiorite gneiss have an age of *ca.* 1590 Ma. This is also considered to be Labradorian, but with a minor Pinwarian component (Wasteneys *et al.*, 1997; CG87-061).

Four, additional, post-1650 Ma – pre-Pinwarian dates are available. These have been obtained from rocks having Pinwarian emplacement ages, thus the dates are interpreted to be inherited. Two are Labradorian (1645 ± 60 and 1637 ± 7 Ma; CG00-319C, CG00-169, respectively), whereas the other two are nominally post-Labradorian–pre-Pinwarian (1575 ± 8 and 1549 ± 8 Ma; CG00-319C, CG99-254, respectively). Given the limited data on which they are based, the latter two may well be Labradorian also. Regarding the Labradorian dates, two generalizations can be made, namely: i) they are found in all parts of the Pinware terrane (but *cf.* Section 13.2.9), and ii) they are all mid- to late-Labradorian – no early Labradorian rocks are known.

Pinwarian granitoid activity in the Pinware terrane is defined by 17 emplacement ages between 1526 ± 14 and 1466 ± 8 Ma. Heaman *et al.* (2004) expressed reservations with respect to the older age limit of 1526 Ma, suspecting the data to indicate an age that is slightly 'too old', as the rock (granite) intrudes tonalite, for which an age of 1504 ± 9 Ma was obtained. For completeness, Table 13.2 includes two Pinwarian metamorphic ages, and three inherited ages that may have Pinwarian significance. One metamorphic age is from a migmatitic quartz monzonite (1450 +15/–21 Ma); the other is a *ca.* 1500 Ma monazite age from a quartzite. The three inherited ages (1530 ± 30, 1478–1463, 1413 ± 27 Ma) all come from late- to post-Grenvillian granitoid rocks, none of which, for various reasons (*see* Chapter 17), proved straightforward to date. From the granitoid emplacement ages, the duration of Pinwarian orogenesis was taken to be 1520–1460 Ma by Gower *et al.* (2008b). The additional metamorphic and inherited dates assist in demonstrating the ubiquity of this event throughout the Pinware terrane.

The reader is reminded that Pinwarian activity was not confined to the Pinware terrane. It is also found in: i) the Pinware – Mealy Mountains terrane border region and, ii) sporadically, in all other Grenvillian terranes in eastern Labrador. These two situations are reviewed separately in subsequent sections of this report. Anticipating this information, however, a key implication is that Pinwarian rocks in the Pinware terrane were not accreted to the rest of eastern Labrador during the Pinwarian but, rather, formed at the margin of, or within, already assembled pre-Pinwarian crust.

13.2.3 SYENITE, QUARTZ SYENITE AND ALKALI-FELDSPAR GRANITE (PMyq)

Very K-feldspar-rich granitoid rocks are restricted entirely to the eastern part of the Pinware terrane in eastern Labrador and have a similar distribution to foliated and gneissic quartz monzonite described in Section 13.2.5.

Syenite and quartz syenitic rocks are white-, pink-, creamy- grey-, orange-, buff-, brown- or red-weathering, fine to coarse grained, recrystallized, generally homogeneous and foliated. Most of the rocks are moderately to strongly foliated, but a gneissic appearance is attained locally. The subtle gneissic banding is defined by grain size, mineralogical variations, flattened quartz grains, or stringers of mafic minerals, especially hornblende. The rocks show streaky textures, have concordant amphibolite lenses, folded fabrics, and have been injected by minor granitoid intrusions. A curious 'crazy paving texture' is fairly common in the syenitic rocks, although rarely seen unless the rock is stained. Irregular branching seams (about 1 mm wide) of sugary, recrystallized felsic minerals (determined to be albite in thin section, locally with minor quartz), separate patches of K-feldspar. It is suggested that the crazy paving is an exsolution and recrystallization texture that developed during metamorphism. The texture is particularly common in a 10-km-wide belt of rocks in the narrow central part of the Pinware terrane. The samples showing the texture best are CG92-140, HP92-138B, JA92-126A and VN92-190B.

Some rocks that were called syenite in the field proved to be alkali-feldspar quartz syenite and alkali-feldspar granite following staining and petrographic study. In consequence of inadequate and inconsistent discrimination in the field, a common designator has been applied to all very K-feldspar-rich granitoid rocks. The rocks are pink-, buff-, creamy- or white-weathering, medium to coarse grained, generally homogeneous, and massive to moderately foliated. Significant examples are addressed below.

Of the samples examined petrographically (47 thin sections), all, except one (VN92-247) have some sodic plagioclase, which is lightly altered and well twinned. Perthitic K-feldspar is seen in 90% of thin sections, and is anhedral, finely to coarsely exsolved patch or string textured, and locally inverted to microcline. Albite, apart from occurring as exsolution lamellae in perthitic alkali feldspar, also occurs as larger separate grains in some rocks, especially at grain margins. Quartz (absent in 10% of the samples) occurs as: i) an interstitial anhedral mineral, ii) as uncommon spherical grains that resemble amygdales (HP92-138B), iii) euhedral grains that resemble phenocrysts, and iv) flattened slivers. Mafic minerals are biotite, amphibole, and pyroxene. Biotite (87% of thin sections) is buff-green, buff-orange, or orange-brown and generally only defines a weak foliation. Hornblende (75%) varies from leaf-green to dark-green. Both biotite and hornblende commonly have vermiform quartz inclusions. In many samples, biotite and hornblende are clearly emplacement/retrograde products of pyroxene breakdown and are not part of the stable igneous assemblage. Clinopyroxene (35%) is generally pale-green but noted to be emerald in VN87-069 and apple green in JS87-427. The clinopyroxene is extensively retrograded to an orange-brown phyllosilicate in many thin sections. Exsolution character suggests that at least some of it is inverted pigeonite (especially CG93-154, CG93-647, CG93-653). Orthopyroxene (markedly pleochroic) was only definitely identified in one thin section (VN93-461), where it was deemed to be relict igneous. Accessory minerals include an opaque oxide (sulphide in 6% of thin sections), apatite (all but 2 thin sections), zircon (80%; commonly large and euhedral), allanite and titanite (the latter both about 50%). Secondary chlorite is sporadically present and, very rarely, white mica, epidote and a serpentinous mineral after hornblende and pyroxene.

13.2.3.1 Specific Details of Unit PMyq Granitoid Rocks

Southwest corner of St. Lewis River map region. An area of alkali-feldspar granite straddles the southern part of the boundary between the Kyfanan Lake and St. Lewis map regions, and continues to the southeast in the Pinware map region.

Samples examined petrographically (CG87-163, CG87-204, CG87-208, CG87-217, CG87-324, CG87-328, JS87-259, JS87-284, VN87-182) form a fairly cohesive group in both texture and mineralogy. All are coarse-grained rocks with weak fabrics and no evidence of strong recrystallization. Particular features are sodic plagioclase, string perthite, orange-green 'oxidized' biotite, and ragged, relict and partly pseudomorphed amphibole (a sodic hornblende?).

Northeast of St. Lewis River gorge. Alkali-feldspar granite to granite was mapped at the northeast end of St. Lewis River gorge.

Samples examined petrographically (JS87-227, JS87-427, JS87-430, JS87-432, VN87-069) contain sodic plagioclase, flame perthite, quartz, sodic amphibole, clinopyroxene (not in JS87-227, JS87-432), rare orange-green biotite, and accessory minerals.

Temple Bay area. Two samples from the Temple Bay area (JS87-381, JS87-388) are both coarse-grained rocks exhibiting relict igneous texture, although substantially modified by metamorphism; one locality is 2.5 km from the other, along strike, and may belong to a single body. Granular garnet forms a coronal symplectite with quartz, around biotite-opaque mineral cores. Amphibole occurs as a coronal fringe replacing clinopyroxene, and in more ragged form elsewhere.

Upper Pinware River area. The syenitic rocks from the Upper Pinware River district have a crescent-shaped distribution that follows the regional strike, and wrapping around the late- to post-Grenvillian Upper Pinware River pluton.

Upper Beaver Brook. The syenitic rocks northeast of the eastern end of Upper Beaver Brook quartz monzonite are extremely rich in K-feldspar. Other minerals, making up less than 5% of the rock, include minor quartz, albite, and a green mafic mineral thought to be aegerine (hand-specimen identification). The rocks weather salmon-pink to yellow-buff. They have been recrystallized from a coarse-grained rock, but remain medium to coarse grained, and are moderately to strongly foliated. Bostock's (1983) correlation of these rocks with the large late-stage quartz monzonite intrusions occupying much of the southwest part of the area has not been validated.

Stokers Hill area. Syenitic rocks underlie a sizable area around the Stokers Hill granite, extending south toward L'Anse-au-Loup Big Pond, and include a wide range of textural types. Among the more noteworthy rocks is a massive to weakly foliated, coarse-grained syenite that is distinct enough to doubt its classification as part of this unit.

Carrol Point. At Carrol Point, the syenite is mylonitic, showing layering strongly accentuated by alternations of colour (red, pink or creamy) and fine- to coarse-grain size (Plate 13.5A). Amphibolite is associated with the syenite. Some amphibolite is present as tectonic fish, but it also forms more continuous parallel-sided layers that are folded into reclined or recumbent structures, verging to the east. The syenitic rocks resemble arkosic sediments, but their overall homogeneity argues against such a protolith.

13.2.4 GRANITE (PMgr)

Although foliated granite and granitic gneiss is the most voluminous granitoid rock type is this group, it may not be as dominant as map patterns suggest, because the tendency during map compilation was to use it as the 'default' rock type in areas of poor exposure. The rocks weather shades of pink, pale-pink, pale-grey, orange, buff, white, creamy or, locally, rusty, purple or red, but most commonly have a streaky pink and grey/white appearance (Plate 13.5B, C). They are typically medium to coarse grained, but locally fine grained, seriate-textured, or, rarely, pegmatitic. The seriate textures are uncommon and poorly developed and may have been produced by a porphyroclastic process, by which the larger original feldspars resisted polygonization and deformation. Generally, the rocks are sugary-textured and have been extensively to completely recrystallized. Both texturally homogeneous, equigranular and texturally heterogeneous, inequigranular types are present and show evidence of having been polygonized from coarser grained, primary, igneous plutonic protoliths. Foliated granite enclaves within less-foliated host granite were also recorded, which implies that not all the granitoid rocks have the same age. There is sufficient textural variation to indicate that many different granitoid bodies are present, but the scarcity of outcrop and the scale of mapping precluded subdivision. Foliations are typically moderate to strong, but include weakly foliated (in places, even massive), gneissic and mylonitic fabrics. Tightly folded fabrics were seen sporadically.

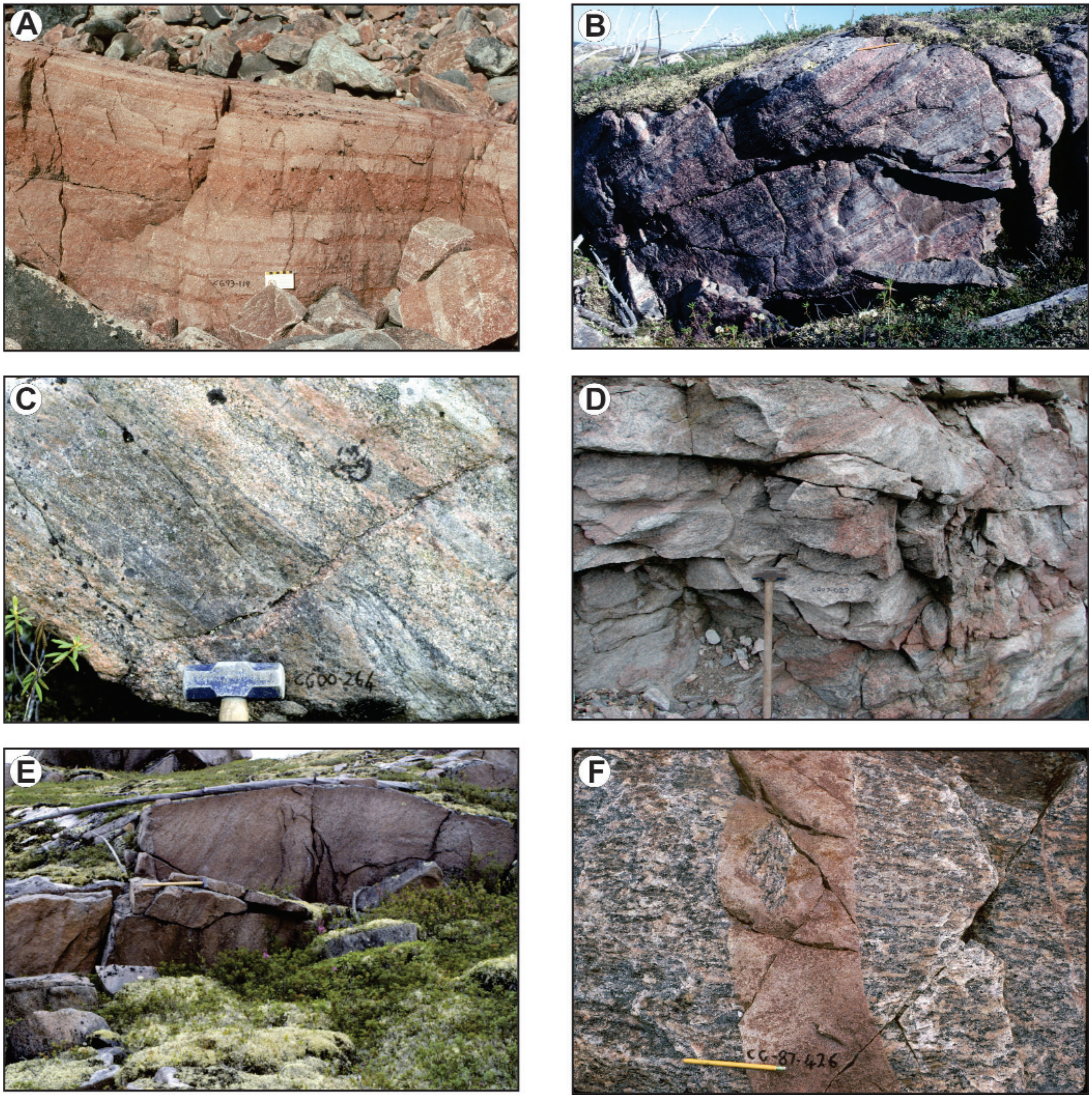


Plate 13.5. *Pinware terrane foliated and gneissic syenite and granite. A. Well-banded K-feldspar-rich rock, interpreted to be mylonitized syenite (or meta-arkose?) (CG93-119), B. Granitic gneiss for which an igneous parentage is preferred, but could have a psammitic protolith (CG99-295), C. Another example of a granitic gneiss that could have a psammitic component (CG00-264), D. Gneissic granite rock dated to be 1491 +11/–9 Ma (CG07-027), E. Foliated to gneissic granitoid rock dated to be 1509 +7/–6 Ma (CG99-195), F. Homogeneous granite dated to be 1479 ± 2 Ma. Intruded by Grenvillian microgranite (CG87-426).*

In the gneissic variants, the banding is defined more by grain-size variation than by marked compositional heterogeneity. Compositional banding varies from poor, diffuse, wispy or lensy, to obvious and continuous. It is also expressed by biotitic schlieren and veneers, diffuse biotite or hornblende-rich layers, quartzofeldspathic leucosome lenses, segregations and pods; dioritic or amphibolite boudins and/or enclaves, xenoliths of granodioritic, psammitic or quartz-rich gneiss, and streaked-out concordant or anastomosing K-feldspar-rich zones, pegmatite and microgranite layers. Despite all these features, it cannot be overemphasized that original compositional layering and migmatization are not major factors in causing any gneissic fabric that might be present. Large enclaves are rare, but were seen at a few localities and consist of black-weathering, medium-grained, amphibolite invaded by quartz-feldspar veins. One typical example measured 30 by 15 cm.

Minor granitoid intrusions are most commonly concordant to foliation and an integral part of the foliated granite unit. Diffuse and irregular contacts with the prevailing granitic host are typical. The rocks are also intruded discordantly by sporadic microgranite and pegmatite dykes. Biotite books up to 6 cm in diameter were seen in one discordant pegmatite. Quartz veins and segregations, usually only a few centimetres wide and tens of centimetres long, are also a feature of this unit.

Foliated granite and granitic gneiss in the Pinware terrane are represented by a large collection of thin sections (243, Table 13.1). It may seem puzzling that so many thin sections were prepared from rocks that do not show very much petrographic variation, but it must be kept in mind that, apart from being a major unit, the suspicion was also held during mapping, that some of the quartzofeldspathic rocks might have a psammitic protolith, thus possibly could contain detrital minerals only likely to be detected in thin section (*e.g.*, tourmaline). This was found not to be the case and an igneous plutonic protolith is preferred.

Every thin section contains plagioclase, K-feldspar and quartz, which are partly igneous and partly metamorphic. Almost all thin sections contain biotite and about 40% also contain amphibole. A few contain clinopyroxene, garnet, or orthopyroxene. All, except three, contain an opaque oxide mineral, and roughly 15% also contain an opaque sulphide mineral. Plagioclase is poorly to moderately twinned, lightly to heavily sericitized, very commonly shows albitic borders against K-feldspar, lacks zoning, and has anhedral form that is polygonal in part. K-feldspar is well-twinned microcline in all thin sections in which it is seen, although vestiges of residual perthite are present in about 30% of the sections. Quartz shows variable grain size and some wavy, sutured grain boundaries. Recrystallization of quartz is more-or-less ubiquitous, but variable, and much of the quartz is interpreted to be relict igneous. Biotite ranges from olive-green to orange-brown and locally contains vermiform quartz inclusions. Hornblende is subhedral to anhedral-relict, and colour variations include dark-green, leaf-green or blue-green. In 25% of the thin sections, it was judged to be a sodic hornblende. Locally, in the field, it was interpreted to be porphyroblastic. Clinopyroxene is relict igneous, anhedral and pale-green (CG92-238, CG93-188, HP92-172A, VN93-268). Garnet is deemed to be metamorphic (CC87-025, CG87-582, CG93-270, CG93-746, CG93-768, CG97-225, CG99-134, VN87-441A). For three of the garnet-bearing samples (CC87-025, CG87-582, VN87-441A), the granite is adjacent in the field to psammite, or psammite was considered to be an alternative protolith. Garnet was noted sporadically at other outcrops in the field, but is rather uncommon and nowhere large. Most grains are less than 0.2 cm across and the largest seen is 0.4 cm in diameter. Both hornblende and garnet have vermiform quartz inclusions. Orthopyroxene was recorded in thin sections VN93-190 and VN93-205 (in the latter as pseudomorphed grains). The opaque minerals are unspecified oxide or sulphide. In outcrop, an opaque mineral forming porphyroblasts in places consistently proved to be magnetite where tested. Rarely, the sulphide was noted to be pyrite in outcrop. Of the other accessory minerals, apatite, zircon and allanite are all common, but none is universally present. Zircon is locally zoned, and may show cores and rims. Colourless and/or purple fluorite was recorded from three samples (DL93-298, JS87-405, VN87-334). Titanite is most common as a secondary phase, characteristically occurring as a fringe around an opaque mineral. Chlorite (mostly after biotite), a serpentine group mineral (after amphibole), white mica, epidote, rutile and carbonate are found sporadically as secondary minerals.

One feature in many granitoid rocks of the Pinware terrane is the presence of biotite depleted haloes around magnetite grains, where the width of the halo is proportional to the size of the magnetite grain at its centre. This can be explained as due to the oxidation of biotite according to the reaction:

$$\textit{Biotite} + O_2 = \textit{K feldspar} + \textit{Magnetite} + H_2O.$$

The haloes do not appear to be especially enriched in K feldspar, as one might anticipate from the above reaction, so appeal is made to dispersal of the K feldspar forming components in a fluid phase. Various stages of this process were observed, the end result is pegmatite produced by coalescing several fluid enriched patches along pre existing fractures.

13.2.4.1 Specific Details of Unit PMgr Granitoid Rocks

This section addresses particular examples of Unit PMgr, namely those having noteworthy features or those investigated geochronologically. The order is broadly northwest to southeast.

One Legged Lake granite. The name for this granite is newly introduced here. The granite was shown as a separate body from the surrounding granitoid gneiss by Gower (1998), depicted as a folded lensoid body, and described as a pink- or grey-weathering, medium- to coarse-grained, recrystallized, fairly homogeneous, two-feldspar, biotite granite. The distinction was retained by giving it a separate unit designator on the map for the Eagle River map region (Gower, 2010a; Unit M_1gr), because, unlike its enveloping rocks, its age is known to be Mesoproterozoic (Pinwarian).

Additional dating in the district has demonstrated, however, that the surrounding foliated to gneissic granite is also Pinwarian, so the separation between Unit PMgr and M_1gr is artificial in this instance. A sample of the granite (CG97-220) yielded a near-concordant age of 1501 ± 3 Ma, based on five single-zircon analyses (Gower *et al.*, 2008b).

Granite 145 km east of Kenamu River. This is Stop 1.7 in the field trip guidebook of Gower (2012). The rock at the site is grey- to pink-weathering, fine- to medium-grained, recrystallized biotite granite (Plate 13.5D). It contains concentrations of lensy K-feldspar-rich material and grades into gneiss in places, but, for the most part, is fairly homogeneous. It contains xenoliths rich in clinopyroxene, and amphibolite enclaves. A sample of the granite (CG07-027) has yielded a near-concordant age of 1491 +11/–9 Ma, based on two single zircons and a third analysis of two small crystals (S. Kamo, unpublished internal report to the GSNL, 2012).

Granite 155 km east of Kenamu River. This is Stop 1.8 in the field guide of Gower (2012). The rocks at this locality are judged to have a granodioritic composition overall, but mention of the locality is included here because of its relationship to the previous locality. The rocks are pink-, creamy- and grey-weathering gneiss, containing abundant pink and white leucosome and common biotitic veneers and amphibolite layers. Unlike localities immediately to the north and south, the outcrop is characterized by strong, pervasive mylonitic fabrics. These are taken as defining the Pinware terrane–Mealy Mountains terrane boundary in this area. A sample of granite to granodiorite was collected at the site (CG07-023; complementing that from locality CG07-027 above) to test whether a Labradorian–Pinwarian boundary, as defined by regional geochronological data (Gower *et al.*, 2008b), exists in the area. Prior to dating, the rock was guessed to have a Labradorian age, but, based on three of four single zircons, a near-concordant age of 1481 ± 11 Ma was obtained (S. Kamo, unpublished internal report to the GSNL, 2012), so a geochronological boundary between the two localities was not demonstrated. The concept of a Labradorian–Pinwarian boundary is not negated, however, as a granodioritic to granite gneiss, from a locality 14 km farther to the northeast (CG97-061) previously yielded an age of 1659 ± 44 Ma (Gower *et al.*, 2008b), implying that the boundary must now be positioned north of CG07-023. Note that, lacking any evidence for post-Pinwarian–pre-Grenvillian severe deformation in the region, combined with a lower intercept of 985 ± 37 Ma, the mylonitization is taken to be Grenvillian.

Southern St. Paul River map region. This locality is mentioned because biotite granite from it was dated by Gower *et al.* (2008b). The granite is homogeneous, strongly foliated, and streaky textured (Plate 13.5E). From sample CG99-195A, it yielded a near-concordant age of 1509 +7/–6 Ma based on two (of three) least-discordant single zircons, using a lower intercept anchor of 1025 ± 11 Ma from a pegmatite that intrudes the granite.

Eastern Kyfanan Lake map region. A distinct granitic type occurs in the Kyfanan Lake map region, north of St. Lewis River and south of the Kyfanan Lake layered mafic intrusion, near the eastern margin of the map region (*e.g.*, CG92-018). The rock is a pale-pink to grey-weathering, strongly foliated, recrystallized but was originally coarse-grained hornblende biotite granite. The rock lacks enclaves, but is commonly intruded by massive microgranite and pegmatite dykes that clearly truncate the foliation in the host granite.

Long Harbour granitic vein. This locality is at the northern fringe of the Pinware terrane in easternmost Labrador (Figure 13.7). A pink-weathering aplitic vein discordantly intrudes granoblastic, granitic straight gneiss but, as it is traced across strike, the vein becomes transposed and merges into parallelism with the straight gneiss. This relationship was taken by Scott *et al.* (1993) as indicating intrusion after some deformation, but prior to its termination. Four multigrain fractions, plotting close to the lower end of a discordia line, defined an upper intercept of 2067 ± 28 Ma and a lower intercept of 1509 +11/–12 Ma (sample S401). The 1509 Ma age was interpreted to be the minimum time of emplacement of the vein into an actively deforming shear zone.

St. Peter Bay granite. The St. Peter Bay granite (Plate 13.5F) was named, described and dated by Tucker and Gower (1994). Strictly, the name only applies to the dated locality, as the extent of the body of granite has never been mapped out. The granite was intruded by mafic dykes, then microgranite and pegmatite and subsequently deformed twice. During the second deformation, axial planar segregations developed and were then crosscut by pegmatite. The late stage history includes local shearing, further pegmatite injection, and hematite alteration and brecciation along late stage fractures. The dated granite (CG87-426A) is a pink-weathering, strongly foliated, homogeneous granite consisting of plagioclase, K-feldspar (both perthite and microcline), quartz, titanite, zircon and Fe(Ti) oxide. Chlorite and white mica are secondary minerals, but not much of either is present. Four zircon fractions define a near-concordant age (maximum discordance 0.83%) of 1479 ± 2 Ma, which was interpreted as the time of emplacement of the granite. Thin sections in the area surrounding the dated locality at St. Peter Bay have been examined to establish potential correlatives. The samples most similar are JS87-312, JS87-319, JS87-401, JS87-409 and VN87-314, all of which are to the north of St. Peter Bay, except JS87-401, which is at the southeast extremity of St. Peter Bay (and also less similar). The St. Peter Bay granite was originally included by Gower *et al.* (1988) as part of a package of strongly foliated and gneissic granitoid rocks, termed Group I granitoid rocks at the time, but that classification is now regarded by the author as obsolete.

Southwest of Green Bay. On the shoreline southwest of Green Bay, Bostock (1983) isolated an area of granitoid rocks as belonging to his Unit Hgdn (foliated granodiorite, quartz monzonite, some granite). The rock is a pink-weathering, medium- to coarse-grained, strongly foliated, homogeneous, biotite-bearing granite to alkali-feldspar granite. It contains common enclaves of the fine-grained foliated quartzofeldspathic rocks that are typical of the surrounding area. The central part of the granite is the most homogeneous, even lacking enclaves, and only intruded by a few flat-lying pegmatitic dykes. To the author, the area of granite has no unique features that distinguish it from the surrounding rocks, hence it has been included as part of this unit.

Granitic rocks exposed on the shores of the Pinware River about 15 km northwest of Red Bay. The rocks in this area are shown as a separate granitoid body by Bostock (1983) and included in his Unit Hqm-h. The rocks weather to shades of pink, cream and buff. They are medium grained, thoroughly recrystallized, and moderately to strongly foliated. The rocks are characterized by common screens of concordant fine-grained amphibolite, which vary in width from a few millimetres to several centimetres. These are commonly boudinaged. The compositions grade from granite to alkali-feldspar granite to locally syenite. Some minor granitoid intrusions are present and the rocks are discordantly intruded by metamorphosed mafic dykes.

West St. Modeste granite. A pluton mapped by Bostock (1983) south of West St. Modeste is included as part of Unit PMgr. At the margin of the body (*e.g.*, data station CG93-249), elongate bands (usually several tens of centimetre wide) of fine-grained, banded quartzofeldspathic rock and some amphibolite, alternate with zones of coarse-grained, homogeneous granite (Gower *et al.*, 1994; Stop 1.3 in the field guide of Gower *et al.*, 2001). Most of the bands are long, narrow and extend across the width of the outcrop and it is difficult to distinguish whether they are rafts or minor granitoid intrusions.

A thin section of the fine-grained, banded quartzofeldspathic rock (thin-section CG93-249A) lacks obvious interpretive clues. It consists of plagioclase, microcline, quartz, chlorite, titanite and oxide opaque mineral and zircon. The host granite has the same mineral assemblage (thin-section CG93-249B), with the addition of ragged, chloritized biotite and apatite. The two rock types are interpreted to be closely related; the fine-grained granite perhaps being cognate xenoliths, or enclaves resulting from injection of the granite parallel to pre-existing planes of weakness.

A sample (CG93-248A) from an adjacent outcrop was dated by Heaman *et al.* (2004) and yielded a discordant age of 1500 ± 14 Ma, based on two single-zircon grains and two multigrain fractions. Note that in Figure 4c of Heaman *et al.* (*op. cit.*) the sample label is erroneously given as 97-SP-046A, which correctly applies to Figure 4a.

Forteau area. Outcrops on the shoreline in the Forteau area show vestiges of a seriate or K-feldspar megacrystic texture, although not regarded as distinctive enough to group the rock as a megacrystic granitoid rock. The rocks are granitic, pink-weathering, medium grained, recrystallized and strongly deformed. The 'megacrysts' now have the form of elliptical polygonal aggregates. Both biotite and hornblende are present and show alteration to greenschist-facies minerals. One feature of these rocks is the high proportion of pegmatite and microgranite minor intrusions. Some of the pegmatites contain abundant magnetite.

Rivière St. Paul granite. Being in Québec (50 km west of Forteau), this granite is, strictly, outside the area of this report, but is it clearly part of the same package of rocks and was also dated by Heaman *et al.* (2004). Excluding one of six zircon fractions, a discordant age of 1526 ± 14 Ma was obtained, but with the caution that the nominal age might be slightly too old as the rock discordantly intrudes a tonalite from which an age of 1504 ± 9 Ma was obtained.

13.2.5 QUARTZ MONZONITE AND MONZONITE (PMmq)

Foliated or gneissic quartz monzonite and monzonite are, with trivial exceptions, restricted to the eastern half of the Pinware terrane in eastern Labrador and have a distribution that is essentially identical with the syenitic rocks described in Section 13.2.3. Most of both rock types are concentrated into a 20-km-wide swath along the northern fringe of the eastern Pinware terrane. A subsidiary cluster is located in the central part of the Pinware map region. Of key importance is that, of the six dated examples, five show either Labradorian emplacement ages, or evidence of involvement of Labradorian crust through either zircon inheritance or hosting enclaves of Labradorian age (the sixth sample also contains enclaves, but the age of these is not known).

In addition to quartz monzonite and monzonite, the unit commonly includes granite or granodiorite, and, less commonly, also monzodiorite or syenite. The rocks weather pale-pink, grey, white or creamy, or, where affected by hematitic alteration (due to brittle faulting, *e.g.*, southern branch of the Upper St. Lewis River), to various shades of red or brown. The rocks are texturally more heterogeneous than earlier described Pinware-terrane foliated granitoid rocks, being fine to coarse grained, partly to completely recrystallized, moderately to strongly foliated, or gneissic. Leucosome partings occur in the monzonitic swath close to the northern boundary of the Pinware terrane. Interlayered foliated monzonitic rocks with amphibolite or amphibolitic gneiss were recorded locally and amphibolite enclaves seen sporadically. The rocks are discordantly intruded by minor granitoid intrusions. One noteworthy outcrop is situated 10 km northwest of the centre of the Rivière Bujeault headwaters quartz syenite. This is the only distinctly megacrystic monzonitic rock seen. As a result of strong deformation, the K-feldspar megacrysts are completely recrystallized and drawn out to lenticular aggregates 4-5 times their width.

Foliated monzonitic rocks and their gneissic equivalents are represented by a large collection of thin sections (92), second only to their granite associates. The typical mineral assemblage is plagioclase, K-feldspar, quartz (90% of samples), biotite, hornblende (85%) and an opaque oxide mineral. The feldspars retain relict igneous textures, except in about 20% of the samples. Plagioclase is mostly light to moderately altered, anhedral, moderately to well twinned, lacks zoning, and has narrow albitic margins (50% of the thin sections). K-feldspar is mostly microcline, but about 30% of the thin sections have some perthite. Biotite is present in all, but one, thin sections, and is typically buff-orange or orange-brown – in only 14% of cases is it olive-green. Hornblende is green, blue-green or dark-green, and, in 20% of thin sections, judged to be ‘sodic’. Clinopyroxene is colourless, brown or pale-green and considered relict igneous. Weakly pleochroic, relict orthopyroxene (inferred to be igneous) was seen in two thin sections (JA92-147A, CG93-385) and garnet in three (JS87-464, VN87- 399A, VN92-298A). In addition to an oxide opaque mineral, sulphide is present in 30% of thin sections. Typical accessory minerals are apatite and zircon (83%), with lesser titanite (70% – primary and secondary?) and allanite (66%). Secondary minerals are chlorite (common), together with white mica, epidote, carbonate and a serpentinous mineral after hornblende and clinopyroxene (all rare).

13.2.5.1 Specific Details of Unit PMmq Granitoid Rocks

Southeast St. Paul River map region recrystallized monzonite. This monzonite is part of a complex package of granodioritic, monzonitic and amphibolitic/gabbroic rocks. The monzonite is pale-pink-weathering, homogeneous, strongly foliated to mylonitic, and has a porphyroclastic texture. The mafic rocks at the locality show a wide range in composition and texture and could include both enclaves and dykes. The rocks were suggested to be the shredded contact between a layered mafic body and a granitoid intrusion by Gower *et al.* (2008b). They reported an age of 1632 ± 4 Ma for a sample of monzonite from the locality (CG99-050A), based on three abraded, single, near-concordant zircons.

Tributary of St. Paul River quartz monzonite. A quartz monzonite (VN92-197A) was collected for dating from a site at the confluence of a tributary with the St. Paul River in the southwest part of the Kyfanan Lake map region. The rock is a pink-weathering, fine to medium grained, strongly foliated, and associated with coarser granitic layers and amphibolite (Plate 13.6A). As the layers of amphibolite and granite are quite narrow and delicate in places, Wasteneys *et al.* (1997) acknowledged the possibility that the rock may have a supracrustal origin. On the basis of five zircon fractions (two single and three multigrain), Wasteneys *et al.* (1997) defined a mixing line between 1649 ± 7 and 1009 ± 10 Ma.

West of Trout River quartz monzonite from migmatite. A sample of a fairly homogeneous layer of quartz monzonite (CG87-262) was collected for geochronological analysis. The migmatite contains abundant mafic enclaves, diffuse hornblende-rich patches and abundant leucosome (possibly of several generations), as well as some discordant buckled pegmatite and planar pegmatite. A lower intercept date of 1450 +15/–21 Ma, based on five zircon fractions (three single grains and two multigrain fractions) was obtained by Wasteneys *et al.* (1997). The date was interpreted by them to be the time of a metamorphic event in the area. The five analyses define an imprecise upper intercept at 2089 ± 140 Ma, considered to represent inheritance from an unknown source.

A survey of petrographically described rocks from the surrounding area revealed only one sample (CG87-265) that is comparable to the geochronologically dated rock at CG87-262. Somewhat similar rocks are present in a sigmoidal-shaped monzodiorite to monzonite body flanking the south side of St. Lewis Inlet and the St. Lewis River gorge.

Wolf Cove quartz monzonite. The Wolf Cove quartz monzonite (Figure 13.9) is a coarse-grained, strongly foliated rock containing hornblende-rich schlieren and amphibolite enclaves, the latter several metres long. It was dated by Tucker and Gower (1994) and an age of emplacement of 1472 ± 3 Ma determined, based on two multigrain zircon fractions (one concordant and the other less than 1.2% discordant).

Granitoid rock samples from the surrounding area for which thin sections had been prepared were examined collectively and compared with the dated sample. Texturally, the rocks fall into two groups, namely: i) a coarse-grained, generally amphibole-bearing group that closely resembles the Wolf Cove quartz monzonite and, overall, is fairly similar to the Cape Charles quartz monzonite, and ii) a finer grained, generally amphibole-absent group that is somewhat like the St. Peter Bay granite. Samples classified with the amphibole-bearing, ‘Wolf Cove analogue’ group are CG87-450, CG87-455A, CG87-463, CG87-468, CG87-469, CG87-473, JS87-494, JS87-535, JS87-539 and VN87-409.

Cape Charles quartz monzonite. The Cape Charles quartz monzonite (Figure 13.9) is a pink- to creamy-weath-

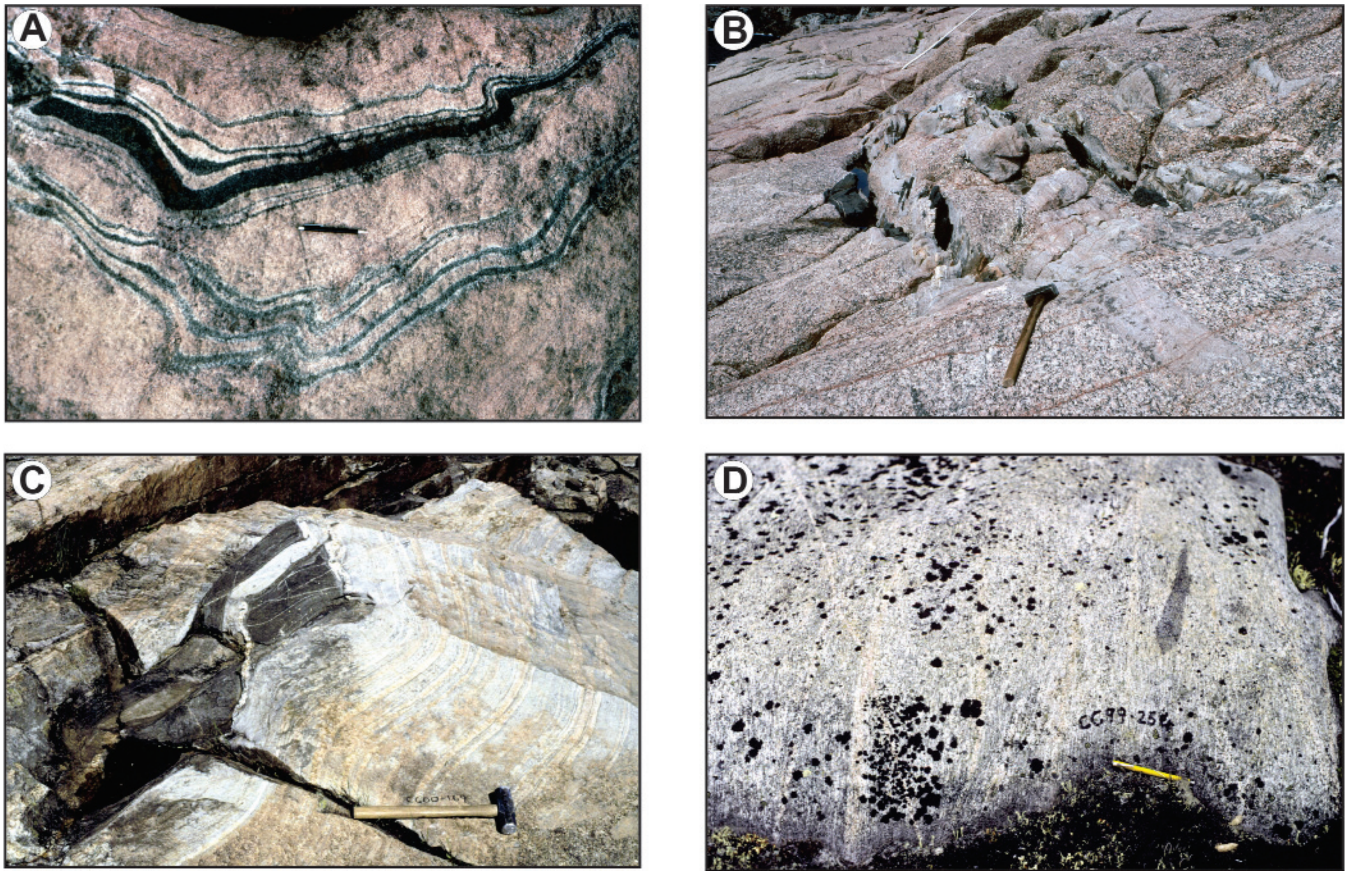


Plate 13.6. *Pinware terrane foliated and gneissic quartz monzonite and granodiorite. A. Tributary of St. Paul's River quartz monzonite dated to be 1649 ± 7 Ma (VN92-197), B. Cape Charles quartz monzonite dated to be 1490 ± 5 Ma, hosting volcanoclastic? enclaves dated to be 1640 ± 7 Ma (CG87-445), C. Granodiorite gneiss dated to be* ca. *1484 Ma, but having Labradorian inheritance (CG00-169), D. Foliated granodiorite, dated to be 1497 ± 13 Ma, hosting mafic enclave (CG99-254).*

ering, coarse-grained, homogeneous rock having a poorly developed seriate to megacrystic texture (Plate 13.6B). The outcrop is of key interest because of relationships to its enclaves. These comprise banded quartzofeldspathic rock, interpreted to have a volcaniclastic protolith (*cf.* Unit PMvf). This material was deformed and migmatized prior to intrusion by mafic dykes and their subsequent inclusion in the granite. Deformation of the granite was followed by pegmatite injection, intrusion of distinctive buff coloured microgranite, and finally brittle faulting.

A sample of the host quartz monzonite (CG87-445A) selected for dating consists of well-twinned plagioclase with albitic rims (45%), well-twinned microcline (31%), quartz (14%), biotite (8%) and accessory amphibole, apatite, titanite, zircon, opaque oxide(s), and secondary chlorite. On the basis of two fractions of prismatic zircon tips, two fractions of clear whole prisms, and four fractions of titanite, Tucker and Gower (1994) defined an 8-point discordia line having an upper intercept emplacement age of 1490 ± 5 Ma and a Grenvillian lower intercept. A sample of the banded quartzofeldspathic enclave material was also dated (CG87-445B) and, as earlier noted, yielded an age of 1640 ± 7 Ma.

An attempt was made to establish the extent of the body, utilizing thin sections available for samples collected in the vicinity. Comparable rocks occur at data stations CG87-444A, CG87-567, CG87-573, JS87-412, JS87-449, JS87-482, JS87-483, JS87-490, JS87-493, VN87-407, VN87-426, VN87-430 and VN87-512. Note that rock names awarded to individual thin sections stray from quartz monzonite (mostly to granite), but this is believed to reflect genuine mineralogical variation. Present data suggest that the Cape Charles quartz monzonite does not extend far to the south. Similar rocks to those at Cape Charles are exposed along the highway in roadcuts between 1.5 and 3.5 km west-southwest of Lodge Bay.

Country Cat Pond quartz monzonite. This locality is of interest because it exposes a contact between gneissic quartz monzonite and a much younger fayalite-bearing alkali-feldspar syenite (Lower Pinware River pluton, for which an

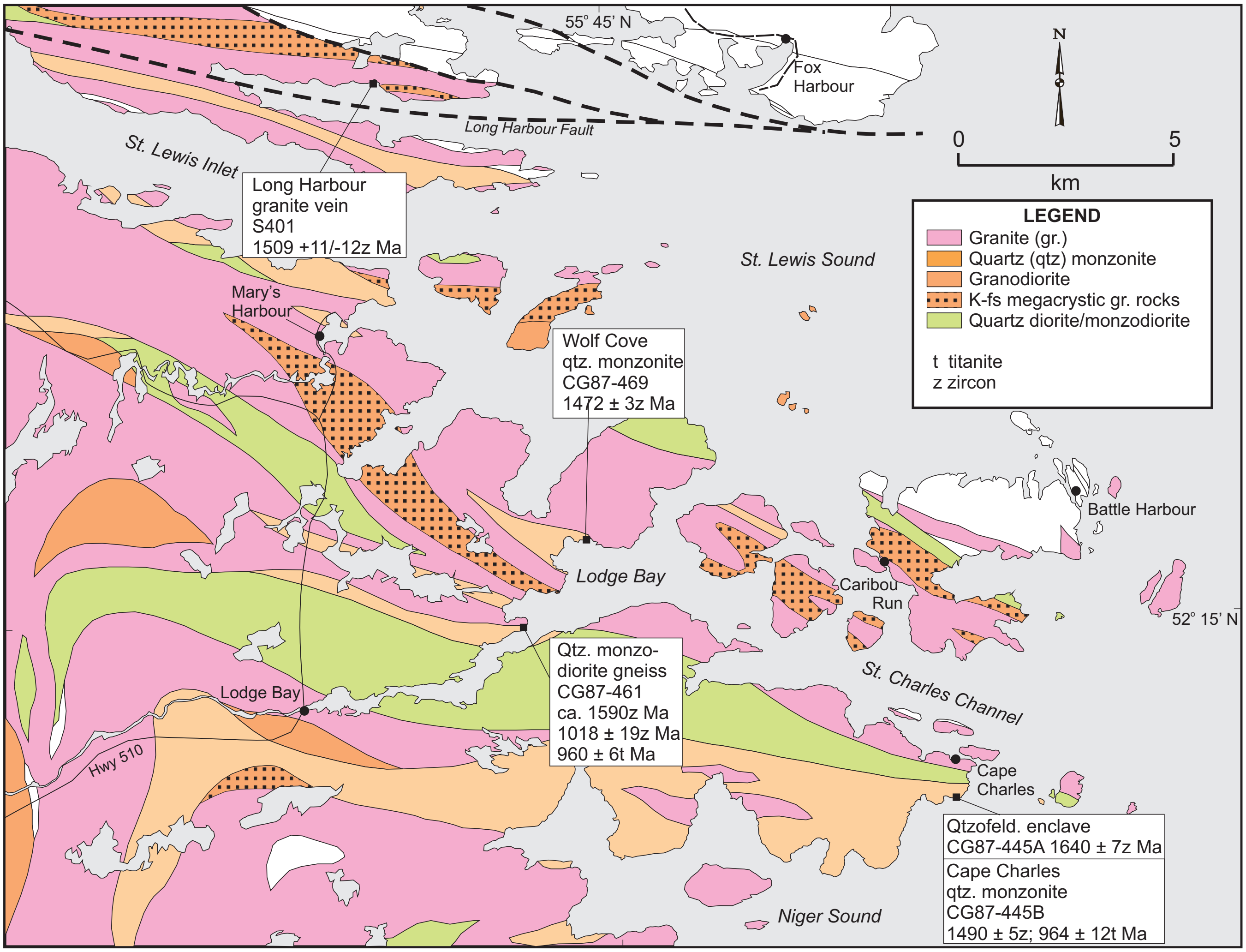


Figure 13.9. *Map enlargement of Lodge Bay area.*

age of 973 ± 7 Ma has been determined; Wasteneys *et al.*, 1997; Heaman *et al.* 2004; Stop 4.7 in the field guide of Gower, 2012). The gneissic quartz monzonite is a creamy-weathering, medium- to coarse-grained, indistinctly banded rock having a fabric that is parallel to the contact of the younger alkali-feldspar syenite. A sample of the gneissic quartz monzonite (CG93-027A) was interpreted to have an age of 1650 +18/–9 Ma from 4 zircon fractions collinearly aligned in the middle fifth of a mixing line extending to a lower intercept of 1030 ± 15 Ma (Wasteneys *et al.*, 1997).

13.2.6 GRANODIORITE AND MINOR TONALITE (PMgd, PMtn)

Rocks included in this unit are dominantly granodioritic, but include some minor tonalite, quartz monzodiorite, quartz monzonite and granite. Although Unit PMtn is distinguished as a separate rock type on the 1:100 000-scale maps of Gower (2010a), it is very minor and is grouped here with granodiorite.

The rocks show most of the characteristics of the granite, and are separated from it mainly on the basis of visual estimates of K-feldspar:plagioclase ratios from both outcrop and stained slab. Granodioritic rocks are most common in the western segment of that part of the Pinware terrane in Figure 13.7, with a secondary concentration close to the northern margin of the eastern part of the Pinware terrane.

Dominant weathering colours are pink and grey, but white, creamy, buff, rusty, orange or red are also seen. The granodioritic foliated and gneissic rocks are dominantly grey-weathering whereas the granites are more typically pink (reflecting higher K-feldspar content – confirmed by staining). Banding is generally better in granodioritic rocks than their granitic counterparts. Grain size varies from medium to coarse and the rocks are thoroughly recrystallized. Fabric ranges from weakly foliated or diffusely banded to well-banded gneiss. Seriate or nebulitic textures are seen in places. A separate leucosome component is normally absent, but some rocks do show diffuse patches or layers enriched in K feldspar. Where the rocks grade into well-banded gneiss, then pink or white leucosome layers are present. Banding is also defined by feldspar-rich layers, biotite- or amphibole-rich schlieren, or more obvious amphibolite lenses and layers. Granitic material (*sensu stricto*) occurs as concordant microgranite and pegmatitic layers, segregations and lenses, and as discordant irregular microgranitic or pegmatitic veins.

In contrast to the foliated and gneissic granite, the number of thin sections assigned to this unit is small (35), but in keeping with the low proportion of granodiorite in 'Unit PM' granitoid rocks in the Pinware terrane. No petrographic characteristic consistently discriminates the foliated granodiorite and granodiorite gneiss in the western part of the Pinware terrane from the east, hence a composite description follows. All samples have plagioclase, K-feldspar and quartz, which are roughly equally divided between relict igneous and metamorphic origins. All have biotite, except for three where it has been replaced by chlorite. Amphibole is present in 43% of thin sections. All lack clinopyroxene, orthopyroxene and garnet. An opaque oxide mineral is universally present and 17% of the samples have a sulphide mineral. Plagioclase is poorly to moderately twinned, lightly to extensively sericitized, shows albitic borders against K-feldspar in 33% of the samples, has weak zoning, and has anhedral irregular form. K-feldspar is well-twinned microcline, but relict perthite is present in about 10% of sections. Quartz shows undulose grain boundaries, or is polygonal. Biotite is green-buff to olive-green (only rarely orange-brown). Amphibole is typically hornblende, but recorded as sodic hornblende in two thin sections. Apart from the opaque minerals noted above, accessory phases are apatite, zircon (with cores and rims in 30% of the samples) and allanite. Titanite typically mantles an opaque oxide and is interpreted as mostly secondary, as is white mica, chlorite, and rare epidote, leucoxene, carbonate and rutile. Note that these characteristics are remarkably similar to those of the granite in the previous section. In fact, the petrographic data do not lend much credence to any significant distinction between these two units, but it should be kept in mind that the map unit representation also utilizes field and rock slab information.

13.2.6.1 Specific Details of Units PMgd and PMtn Granitoid Rocks

Review of specific PMgd units follows the same pattern as for Unit PMgr earlier.

Southern St. Augustin River map region. Granodioritic gneiss (CG00-169) in this area was selected for dating by Gower *et al.* (2008b). It is a grey to pink, heterogeneous, well-banded, medium- to coarse-grained gneiss containing distinct leucosome and melanosome layers and abundant anastomosing granitoid veins (Plate 13.6C). The sample (CG00-169) came from a homogeneous 50-cm-wide zone within the gneiss, which is the same rock type as that occurring within narrower layers elsewhere in the outcrop. From the five single zircons analyzed, it was concluded that the rock was emplaced at *ca.* 1484 Ma, had Labradorian inheritance (1637 ± 7 Ma) and Grenvillian metamorphism at 1022 ± 5 Ma. Gower *et al.* (2008b) commented that the rock could be either regarded as Labradorian with Pinwarian metamorphism, or Pinwarian with Labradorian inheritance.

Southwestern St. Paul River map region # 1. A sample of tonalitic gneiss (CG99-259A) was collected from this site. The gneiss is associated in outcrop with granite to alkali-feldspar granite. The bedrock was mapped as granitic gneiss overall, but granodioritic gneiss is close by (*ca.* 300 m) and granodioritic gneiss was sampled 1.5 km to the northeast (CG99-254 – *see* next locality description). On the basis of eight zircon and two titanite analyses, an age of 1628 ± 25 Ma was obtained for the tonalitic gneiss. One analysis yielded a minimum age of 1661 ± 9 Ma, which could imply that emplacement was earlier if unrecognized Pinwarian Pb loss occurred (Gower *et al.*, 2008b).

Southwestern St. Paul River map region # 2. The rock at this site is a grey-weathering, strongly foliated, medium- to coarse-grained, recrystallized granodiorite (CG99-254) that is homogeneous apart from containing common irregular mafic enclaves and numerous microgranite and pegmatite dykes (Plate 13.6D). It was investigated geochronologically by Gower *et al.* (2008b), who interpreted the rock to have an emplacement age of 1497 ± 13 Ma based on four zircon fractions, and inheritance of 1549 ± 8 Ma, based on two zircon fractions. Gower *et al.* (2008b) noted that the post-Labradorian–pre-Pinwarian age of 1549 Ma is anomalous for the local area. This sample and the previous one provide a good example of the problems in discriminating between Pinwarian and older crust (particularly Labradorian) in the Pinware terrane. Gower *et al.* (2008b) also noted that the two samples are structurally equivalent, being on opposite sides of a regional fold structure.

Eastern margin of the Kyfanan Lake map region. Granodiorite is scarce in the Pinware terrane in the Kyfanan Lake map region, the only significant outcrops being at the eastern margin of the map region. A miscellany of rock types is present, including K-feldspar megacrystic granodiorite, equigranular granodiorite, monzodiorite, various textural varieties of amphibolite and some late-stage minor granitic intrusions. The rocks have been modified by both ductile and brittle deformation, so determination of protolith composition is equivocal.

Three thin sections examined are all granodiorite, consisting of heavily sericitized plagioclase, microcline, quartz, biotite or chlorite, an opaque mineral, and traces of apatite, titanite, zircon and allanite.

Upper Trout River, St. Lewis River map region. Foliated granodiorite in this area was originally included by Gower *et al.* (1988) as part of a package of strongly foliated and gneissic granitoid rocks, termed Group I granitoid rocks at the time. The granodiorite was separately named, described and dated by Tucker and Gower (1994). The sample they investigated (CG87-105A) is a fine- to medium-grained, strongly foliated granodiorite. No satisfactory date was obtained, however, because of inheritance and secondary Pb-loss problems. A mid-chord cluster of four of five fractions analyzed gave an upper intercept of 1145 +35/–47 Ma, whereas the other fraction gave an older ^{207}Pb/^{206}Pb age of *ca.* 1209 Ma. The age was tentatively interpreted by Tucker and Gower (1994) as the time of emplacement. Wasteneys *et al.* (1997) re-examined the data in the context of their additional geochronological information from the Pinware terrane. Noting that Tucker and Gower's (1994) results also plotted on a Labradorian–Grenvillian chord they reinterpreted the data to mean that sample CG87-105A was derived from a Labradorian protolith.

Rivière St. Paul tonalite. Although not a granodiorite, this is the most convenient place to mention this example. The tonalite forms part of a sequence of rocks at the outcrop that progresses from gabbro in the east, through diorite, tonalite, granodiorite and, finally, K-feldspar megacrystic granite in the west. A sample (97SP-046A) dated by Heaman *et al.* (2004) gave an age of 1504 ± 9 Ma, based on three moderately discordant multigrain abraded zircon fractions. Note that the tonalite is intruded by granitic veins, one of which was dated (97SP-046C) to be 1526 ± 14 Ma; the nominal ages are thus inconsistent with field relationships (*see* previous section).

13.2.6.2 Comment on Protolith of Granodioritic and Tonalitic Gneiss

A dilemma arising from mapping of the Upper Eagle River map region (Gower, 1998) was that some of the rocks mapped as granodioritic gneisses had indications of derivation from a metasedimentary protolith (*e.g.*, slightly anomalously quartz-rich, unusually well banded, some features of metasedimentary diatexite), but that they lacked characteristics generally taken as diagnostic of supracrustal origin, such as primary sedimentary structures or association with rocks generally regarded as being of unequivocal sedimentary parentage (*e.g.*, quartzite, calc-silicate rocks or aluminosilicate-bearing pelites). This problem was encountered again during mapping of the Crooks Lake, St. Paul River and St. Augustin map regions (Gower, 1999, 2000, 2001). Mapping in the Upper St. Augustin River map region, perhaps more than in any of the previous three, strengthened the notion of a spatial relationship between granodioritic gneiss and metasedimentary gneiss, especially psammitic gneiss, and also with K-feldspar megacrystic granitoid rocks described in Section 13.2.8. From a field standpoint, the problem reduces to deciding what is a granodioritic (ortho)gneiss and what is a psammitic (para)gneiss – pragmatically from which one does not escape by demanding non-genetic mapping. The approach adopted here is to indicate alternative unit designators for those localities considered to be most equivocal, hence offering the reader the conceptual flexibility to recode the map as desired. Note that this protolith problem was only encountered as an issue in the western part of the Pinware terrane in eastern Labrador, which is the same region as that having supracrustal rocks suggested to be different to (and possibly older than) those farther east (*i.e.*, St. Augustin *vs.* Henley Harbour districts – *cf.* Section 13.1). A possible conclusion is that the granodioritic gneisses result from having a metasedimentary component, but more detailed work is required to determine if this is so.

The association between K-feldspar megacrystic granitoid rocks and metasedimentary gneiss is a slightly different issue in that it does not so much involve naming rocks, but rather why any spatial association should exist at all. The only response offered here is that, in the author's experience, it is fairly common, and might be related to potassium mobilization from any K-rich supracrustal rocks in the vicinity, such as pelite, semipelite or meta-arkose.

13.2.7 QUARTZ MONZODIORITE AND DIORITE (PMmd, PMdr)

Two units, namely monzodiorite (PMmd) and diorite (PMdr) are combined in this section because of their similarity. Neither is very abundant nor especially remarkable. They are found mostly in the eastern part of the Pinware terrane in eastern Labrador, but a few occurrences were mapped in the St. Augustin district. The rocks in the east show spatial association with quartz monzonite and syenitic rocks.

Both the monzodioritic and dioritic rocks are generally darker weathering than the granitic or granodioritic gneiss, being creamy, brown, rusty or grey. They are medium to coarse grained, fairly homogeneous, recrystallized, and weakly to strongly foliated. Rarely, they have a seriate texture. They may have irregular quartzofeldspathic leucosome segregations, in which large hornblende crystals are sporadically present. The rocks include well-banded gneiss and migmatite, and have interdigitating, gradational contacts with syenitic, granitic, monzonitic, and amphibolitic units. Overall, there is very little that is distinctive or cohesive about this unit. The rocks show appreciable variation in colour index, grain size and texture and it seems unlikely that they belong to a single genetic package. Possibly, they are hybrid rocks (*cf.* sample CG97-461.2 following) or are derivatives of other rocks by metamorphic processes – such as metasomatism of amphibolite, or leucosome-depletion of granodiorite. They have been injected concordantly and discordantly by pegmatite and microgranite.

In thin section, felsic minerals are seen to be partly primary and partly metamorphic. Plagioclase is anhedral, poorly to moderately twinned, weakly zoned and light to moderately sericitized. A few grains have narrow albitic margins. K-feldspar is well-twinned microcline, tending to be interstitial; perthite is rare. Biotite is mostly orange-buff to orange-brown. Hornblende (80% of thin sections) is blue-green to leaf-green and sporadically has quartz inclusions. In one thin section (DL93-263), secondary amphibole is a strongly pleochroic blue to pale-mauve variety that must be sodic, perhaps approaching riebeckite. Pale-green to colourless clinopyroxene is present in 30% of thin sections (in part as cores to hornblende), and orthopyroxene in one case (VN93-270). An oxide opaque mineral is present in all thin sections and sulphide in half of them. Two sulphide minerals (probably pyrrhotite and pyrite) are present in CG00-184, which is also characterized by unusually abundant sulphide overall. All sections contain apatite, and most contain zircon and allanite. Sample CG00-184 is unusual in having an abnormally large allanite. Titanite commonly occurs as mantles around the opaque oxide, but is also found as isolated grains. Secondary chlorite, carbonate, white mica, and epidote are all rare.

13.2.7.1 Specific Details of Units PMmd and PMdr Granitoid Rocks

Lodge Bay quartz monzodiorite gneiss. Quartz monzodiorite gneiss at Lodge Bay (Figure 13.9) is very representative of the rocks included in this section. The gneiss forms part of a septum between, and distinct from, the more homogeneous Wolf Cove (1472 ± 3 Ma) and Cape Charles (1490 ± 5 Ma) quartz monzonites to the north and south, respectively. A sample (CG87-461.2) was collected for dating from a relatively homogeneous layer of leucocratic biotite-bearing quartz monzodiorite, within a sequence of intermixed creamy weathering granodioritic, dioritic and amphibolitic gneisses (Plate 13.7A). The rock contains plagioclase (60%), well-twinned microcline (26%), quartz (9%), buff-green biotite (4.5%), opaque oxide, apatite, titanite, allanite, zircon and secondary chlorite (collectively 0.5%).

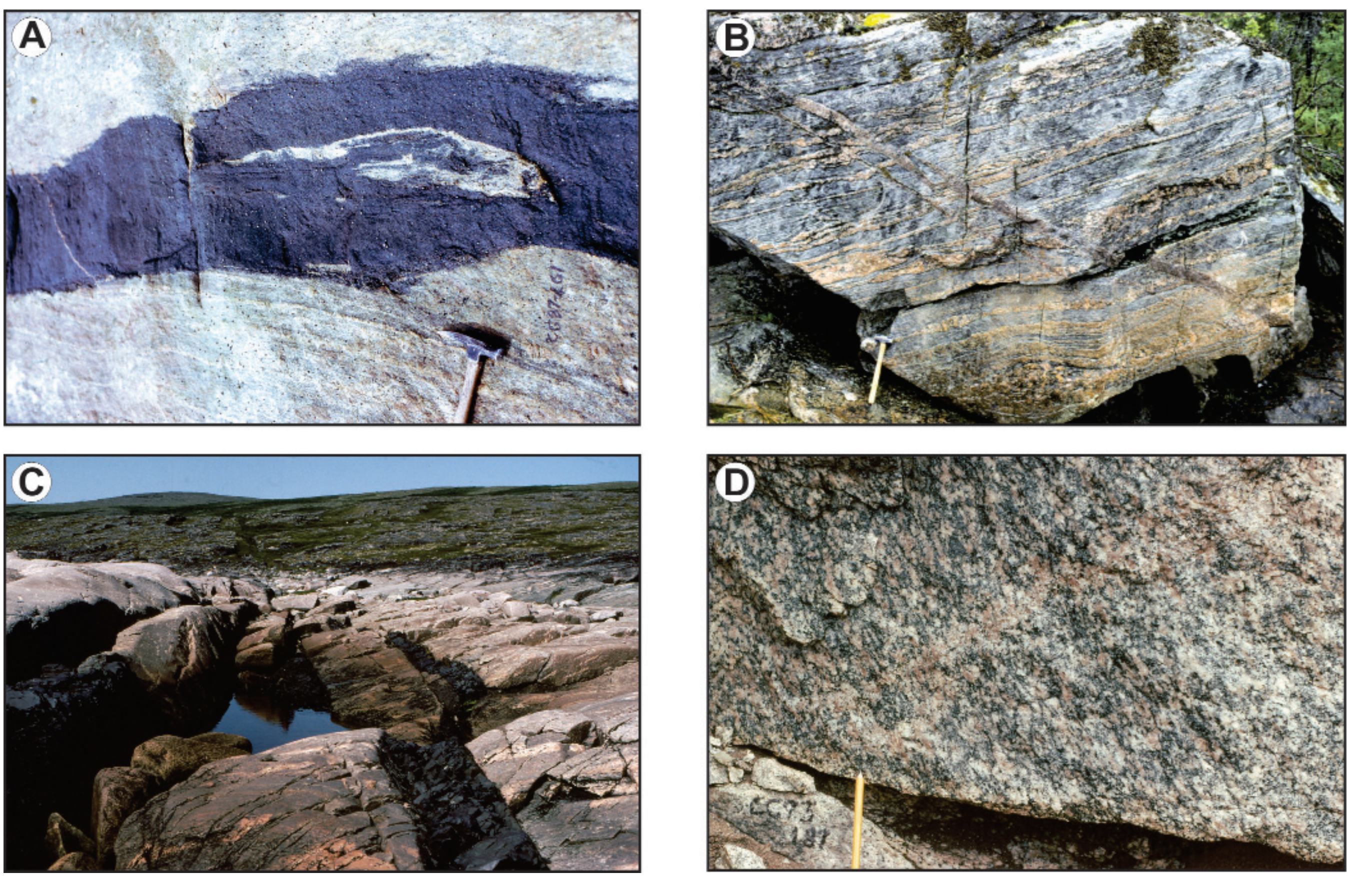


Plate 13.7. *Pinware terrane foliated and gneissic quartz monzodiorite and K-feldspar megacrystic granitoid rocks. A. Lodge Bay quartz monzodiorite dated to be* ca. *1590 Ma, discordantly intruded by metamorphosed mafic dyke (CG87-461), B. St. Augustin River megacrystic granitoid gneiss dated to be 1507 ± 8 Ma (CG00-319), C. York Point megacrystic granitoid rock dated to be 1489 ± 2 Ma, intruded by York Point mafic dykes (VN93-662), D. Pinware megacrystic granite 1466 ± 8 Ma (CG93-187).*

For geochronological study, eight zircon and two titanite analyses were completed by Wasteneys *et al.* (1997). They wrote (page 112) "although, in isolation, an unequivocal interpretation of the complex zircon systematics of this sample would appear impossible, data from nearby and related, but less complex, localities suggests a reasonable interpretation." The least equivocal data indicate high-grade Grenvillian metamorphism at 1019 ± 14 Ma, based on four single zircons, followed by post-metamorphic closure at 960 ± 6 Ma, based on two titanite fractions. The four older, and discordant, zircons plot on a non-linear array near the upper intercepts of Pinwarian and/or Labradorian mixing lines (the oldest upper intercept is *ca.* 1590 Ma, anchored at 1019 Ma). Wasteneys *et al.* (1997) suggested that the quartz monzonite formed in a high-strain zone at the interface between the Pinwarian Wolf Cove and Cape Charles plutons containing a concentration of Labradorian quartzofeldspathic enclaves (such enclaves are not evident at the locality). The Pinwarian zircon component is only weakly represented and therefore probably occurs in the form of overgrowths on Labradorian zircons from digested quartzofeldspathic enclaves.

From a follow-up survey of thin sections from the surrounding area, four samples are deemed to be petrographically similar to the dated rock. The samples had been named granite (JS87-451), granite/psammite (VN87-429), psammite or granite (VN87-441A) and granodiorite or psammite (VN87-108). Evidently, if these samples had a supracrustal protolith, they are now borderline igneous rocks and the author could not tell the difference. In the context of the U–Pb interpretation above, which invoked the existence of digested quartzofeldspathic enclaves, there is convergence of petrographic and geochronological interpretation. Note that the original descriptions of the thin sections and rock names applied were completed without reference to their location or geological context, and before geochronological investigation.

Northwest of Forteau. A distinctive rock type is present northwest of Forteau, where a hook-shaped body is depicted on the Pinware map region of Gower (2010a). It is too small to show on Figure 13.7. It is a white- to grey-weathering, leucocratic rock showing bands averaging 10 cm in thickness, being defined by compositional and grain-size variations.

Two thin sections (CG93-287, VN93-311E) from separate localities within the body are fairly leucocratic quartz diorite to tonalitic rocks, comprising plagioclase, quartz, K-feldspar (only in CG93-287, where it is rare, and interstitial), pale-green to buff-brown biotite, ragged, relict amphibole with vermiform inclusions, and opaque oxide, apatite, zircon and rare allanite. The protolith of the rock is uncertain; it could be a remnant of a layered anorthositic to leucogabbronorite intrusion.

13.2.8 K-FELDSPAR MEGACRYSTIC GRANITOID ROCKS (PMgp)

The K-feldspar megacrystic granitoid Unit PMgp is a classification disparity with respect to other Pinware terrane granitoid rocks, as it is defined on textural rather than compositional grounds. Compositionally, two-thirds of the petrographically examined samples are granite and the remainder granodiorite. The occurrences tend to form discrete, mappable entities and, for this reason, it is possible to address field characteristics of the bodies on an individual basis (*see* below). Almost all the bodies are found close to the coast in eastern Labrador, except for one large occurrence (and a few other trivial instances) in the St. Augustin map region.

In thin section, no features that might consistently characterize an individual megacrystic body were identified, hence a summary description is given here. All thin sections contain plagioclase, K-feldspar, quartz, biotite and an oxide opaque mineral. Hornblende is present in 40% of the samples, and clinopyroxene in 10%. Relict igneous plagioclase and K-feldspar are present in almost all samples, with about 50% also having metamorphic derivatives. Plagioclase is generally anhedral, and light to moderately altered. Zoning is either lacking or weakly developed and narrow albitic rims present in about two-thirds of the samples. Microcline is the prevalent K-feldspar, but some perthite is present in about 50% of the samples. Biotite ranges from olive-green to orange-brown. The hornblende is dark-green to blue-green and, typically, has ragged outline; it was not inferred to be 'sodic'. The two samples containing clinopyroxene (CG93-077A, VN93-209) are both from the Black Bay district. Clinopyroxene is pale-green and considered to be relict igneous. Sulphide is present in 50% of the samples. One possible intrusion-specific feature is that all examples of the Pinware megacrystic granite are sulphide bearing (although sulphide is sporadically found in a few of the other megacrystic bodies). Other accessory minerals are apatite, zircon and allanite (the latter in 55% of samples). Secondary minerals are titanite (mantling opaque minerals in part), chlorite (after biotite) and epidote (25%), and, more rarely, white mica, rutile and carbonate. No orthopyroxene, garnet or monazite was noted. The discerning reader will have recognized that this description closely compares to that of the previous two units.

13.2.8.1 Specific Details of Unit PMgp Granitoid Rocks

Review of specific PMgp units follows the same pattern as for Unit PMgr earlier.

St. Augustin River megacrystic granitoid rocks. Grey- to pink-weathering, medium- to coarse-grained, recrystallized, mostly homogeneous, K-feldspar megacrystic granodiorite extends from the northeast corner of the St. Augustin map region. Small occurrences of K-feldspar megacrystic granite to the north (Crooks Lake map region) and southwest may be related. The K-feldspar megacrysts are rather sparse and poorly developed, being little more than streaked-out aggregates of polygonized K-feldspar grains in places. The megacrysts are most obvious in sample CG00-323, where they form elliptical, slightly recrystallized grains up to 1 cm long and comprising about 15% of the rock.

The unit is best exposed on the St. Augustin River (CG00-319), where the rock forms broadly banded gneiss, due to alternation of the granodiorite with concordant amphibolite and pegmatite (Plate 13.7B). The amphibolite is black-weathering, medium grained, and assumed to be derived from mafic dykes emplaced into the host megacrystic granitoid rock. The pegmatites are generally less than 20 centimetres wide and have biotite-rich borders suggesting local derivation from the enveloping host granodiorite. Based on four single, near-concordant, abraded-zircon analyses from megacrystic granodiorite sample CG00-319A, in conjunction with supporting data from other samples also investigated at the same outcrop, the age of emplacement of the granodiorite was interpreted to be 1507 ± 8 Ma (Gower *et al.*, 2008b).

Kyfanan Lake map region megacrystic granitoid rocks. Megacrystic granitoid rocks were not observed in this region except for a single outcrop of sparsely megacrystic quartz monzonite that has been given the unit designator PMmq/gp in the southeast part of the map region.

York Point K-feldspar megacrystic granitoid rock. A distinctive K-feldspar megacrystic granitoid rock was first mapped on the coast southwest of Henley Harbour by Bostock (1983, his Unit Hgdn; termed schistose, augen granodiorite). It is pink- to grey-weathering, coarse grained and homogeneous (Plate 13.7C). The unit contains enclaves of fine-grained granodiorite, and amphibolite and garnet–biotite schlieren and is intruded by pegmatite, quartz veins and mafic dykes. In addition to a generally well-developed penetrative fabric, some rocks have a strong lineation and show a folded fabric. The K-feldspar megacrysts are subhedral, commonly unrecrystallized, up to 5 cm long, and comprise as much as 40% of the rock. In shear zones, the megacrysts are attenuated to veneers of polygonized grains, but elsewhere less-deformed K-feldspar aggregates, mantled by albite rims, are evident. A sample (VN93-662E) from the body was dated by Kamo and Hamilton (2007) and, based on four abraded single zircon grains, gave a concordant age of 1489 ± 2 Ma, which was interpreted to date the time of emplacement of the body.

East of Black Bay K-feldspar megacrystic granodiorite. K-feldspar megacrystic granitoid rock extends inland from the coast between Black Bay and Barge Bay. It was not separately distinguished by Bostock (1983). Concordant amphibolite layers, possibly the remnants of former dykes, and minor granitoid intrusions are present. K-feldspar megacrysts make up to 20% of the rock, are up to 2 cm long, anhedral and form recrystallized to polygonal aggregates. Commonly they are severely attenuated to elongate ellipsoids.

Between Red Bay and Black Bay K-feldspar megacrystic granitoid rock. Megacrystic granodiorite in this area has a well-banded gneissic appearance due to interbanded, black- and pink-weathering, amphibolitic and quartzofeldspathic material. The amphibolitic material clearly represents various dyking events. Early dykes are thoroughly shredded and migmatized, in contrast to later dykes, which, although metamorphosed, are clearly discordant to earlier fabrics. The granodiorite is intruded by buff-coloured microgranite, pegmatite and other minor granitoid dykes, veins and stringers. The K-feldspar megacrysts occur as recrystallized aggregates up to 3 cm long, in which relict kernels of primary K-feldspar are sporadically preserved.

Pinware megacrystic granite. An irregular-shaped body of seriate to megacrystic two-feldspar granodiorite to granite was mapped north of Pinware. It is one of the more coherent foliated to gneissic granitoid units in the Pinware terrane. The shape of the body is interpreted to result from fold interference. The rocks are white-, grey-, creamy- or pink-weathering, medium to coarse grained, generally strongly foliated and recrystallized (Plate 13.7D). Some rocks have irregular pink segregations and, although fairly homogeneous overall, are, locally, full of elongate, lensoid, hornblende-rich (diorite to amphibolite) enclaves (CG93-183, CG93-199). The body is intruded by mafic dykes and minor granitoid dykes. Anhedral, partially to completely recrystallized K-feldspar aggregates up to 3 cm long are interpreted as former megacrysts. They make up to 20% of some rocks, but are almost absent from others. The megacrysts commonly show albitic rims.

The granitoid rocks that form Ship Head (at Pinware) and the area immediately to the south are included as part of this body. This classification is at variance with Bostock (1983), who distinguished those rocks as part of a separate, younger unit, which he referred to as "foliated granodiorite, quartz monzonite, some granite" (his Unit Hgdn). The rocks are more distinctly megacrystic than much of the remainder of the unit, but the megacrysts are equally polygonized and are similarly mantled by albitic rims.

Seriate to megacrystic granitoid rocks are also well exposed along the shoreline east of the mouth of the Pinware River and mentioned by Bostock (1983), who termed them augen granodiorite. The K-feldspar megacrysts are up to 2 cm long and form about 20% of the rock. In some areas, there are hornblende-rich segregations forming discontinuous layers, and migmatized zones enriched in granitic melt material. Bostock (1983) described the megacrystic granodiorite as being interlayered with gneiss and discussed the possibility of more than one age of granitoid rock being present. His suggestion remains to be evaluated, but the geochronological data outlined in the next paragraph offers credence to this viewpoint.

The unit has been dated by Heaman *et al.* (2004) at a small quarry 0.5 km north of Pinware (Stop 4.7 in the field guide of Gower, 2012). The rock is fairly uniform, coarse-grained, strongly foliated hornblende biotite granite (CG93-187A). It is discordantly truncated by buff-coloured micro-granite dykes (*e.g.*, CG93-187B). Seven multigrain fractions, plus 5 single zircons, and an allanite fraction were analyzed from the sample, of which 8 zircon fractions were abraded. On the basis of a line constructed through 6 of the (discordant) analyses, a best-estimate time of emplacement was concluded to be 1466 ± 8 Ma. Note that one of the fractions gave a $^{207}Pb/^{206}Pb$ age of 1635 Ma, suggesting involvement of Labradorian crust. Although accepting a Pinwarian time of emplacement, the age cannot be regarded as definitive, given the rather complex U–Pb systematics demonstrated by the sample.

Diable Bay megacrystic granodiorite. The granodiorite is creamy-, grey- or pink-weathering, medium grained (recrystallized from an originally coarse-grained rock) and relatively uniform. It is strongly foliated to locally mylonitic and contains diffuse, narrow, hornblende-rich schlieren and several generations of minor granitic dykes. It is seriate textured to megacrystic, showing K-feldspar as lensoid aggregates of polygonized grains up to 10 cm long that are interpreted as stretched former megacrysts. The rock is intruded by deformed pegmatites and transected by shear zones showing apparent dextral displacement. On its north side, it has a fairly sharp contact against fine-grained banded quartzofeldspathic rocks that are interpreted as supracrustal. The contact is intruded by pegmatite.

A sample (CG93-273) from a central location in the body was dated by Heaman *et al.* (2004). Of the six multigrain fractions analyzed, three were abraded and gave near-concordant age of 1467 ± 44 Ma age when anchored at 985 Ma. A second sample from the body (CG93-270) was collected close to its contact with the supracrustal rocks. Notwithstanding the generalized petrographic description given earlier, this sample also contains garnet, unusually common zircon, common monazite and interstitial white mica. The somewhat anomalous accessory minerals and white mica might imply that the rock could have been derived from an arkosic metasediment, interpreting the garnet, zircon and monazite as detrital and the white mica as having been derived from matrix clay minerals. Alternatively, the garnet, zircon and monazite could be xenocrystic from arenaceous country rocks.

Bradore River megacrystic granitoid unit. The Bradore River granitoid unit is anomalous with respect to other K-feldspar megacrystic units addressed here, in that the granitoid rock is Labradorian, rather than Pinwarian. The site is in eastern Québec, 20 km west of Forteau. The rock is pink- and grey-weathering, coarse grained, recrystallized and fairly homogeneous. It contains diffuse veins of quartz syenite to granite, together with amphibole-rich schlieren, boudinaged amphibolite lenses and enclaves of metasedimentary gneiss. A sample from the locality (96SP-004A) was dated by Heaman *et al.* (2004), and gave an age of 1632 ± 8 Ma, based on three very discordant multigrain zircon fractions. It is the southernmost dated Labradorian rock in the eastern Grenville Province.

13.2.9 COMMENTS ON WHOLE-ROCK GEOCHEMISTRY OF UNIT PM GRANITOID ROCKS

Whole-rock geochemical data are available for 89 Pinware terrane granitoid rocks that have been assigned to Unit PM. U–Pb geochronological data are available for 24 of these. The data were briefly examined with two objectives in mind. The first was to determine if granitoid rocks dated to be Labradorian could be distinguished from those of Pinwarian age. The second was to characterize both groups of rocks in terms of their likely tectonic setting.

With respect to Labradorian–Pinwarian discrimination, a large selection of geochemical variation diagrams was examined. The plots mostly show near-complete overlap between the compositions of dated Labradorian *vs.* dated Pinwarian samples (Figure 13.10), but there are useable exceptions. In Figure 13.10A, dated Labradorian dated samples tend to have both lower Y + Nb and lower Rb; in Figure 13.10B, the dated Labradorian rocks are slightly less alkalic, and, in Figure 13.10C, the Labradorian dated samples tend to have higher Nb/Y. Available REE data for dated Labradorian and Pinwarian samples are shown in Figure 13.10D. Clearly both Labradorian and Pinwarian samples show similar patterns, namely enriched LREE, small or non-existent negative Eu anomalies, flat HREE and lack of significant fractionation.

Excluding REEs, the data suggest some geochemical differences between Labradorian and Pinwarian dated samples. Utilizing both dated and undated analyzed samples, the data were then interrogated to determine whether any geographical biases existed. A simple means of doing this is by plotting the sum of Rb + Y + Nb *vs.* location. In histogram form, the Rb + Y + Nb data shows a crude bimodal distribution with a trough at Rb + Y + Nb at 140 ppm, so this was taken as a practical dividing value within the data. The results are plotted in Figure 13.11. It appears that lower Rb + Y + Nb values are concentrated along the northern boundary of the Pinware terrane, with an additional area of low

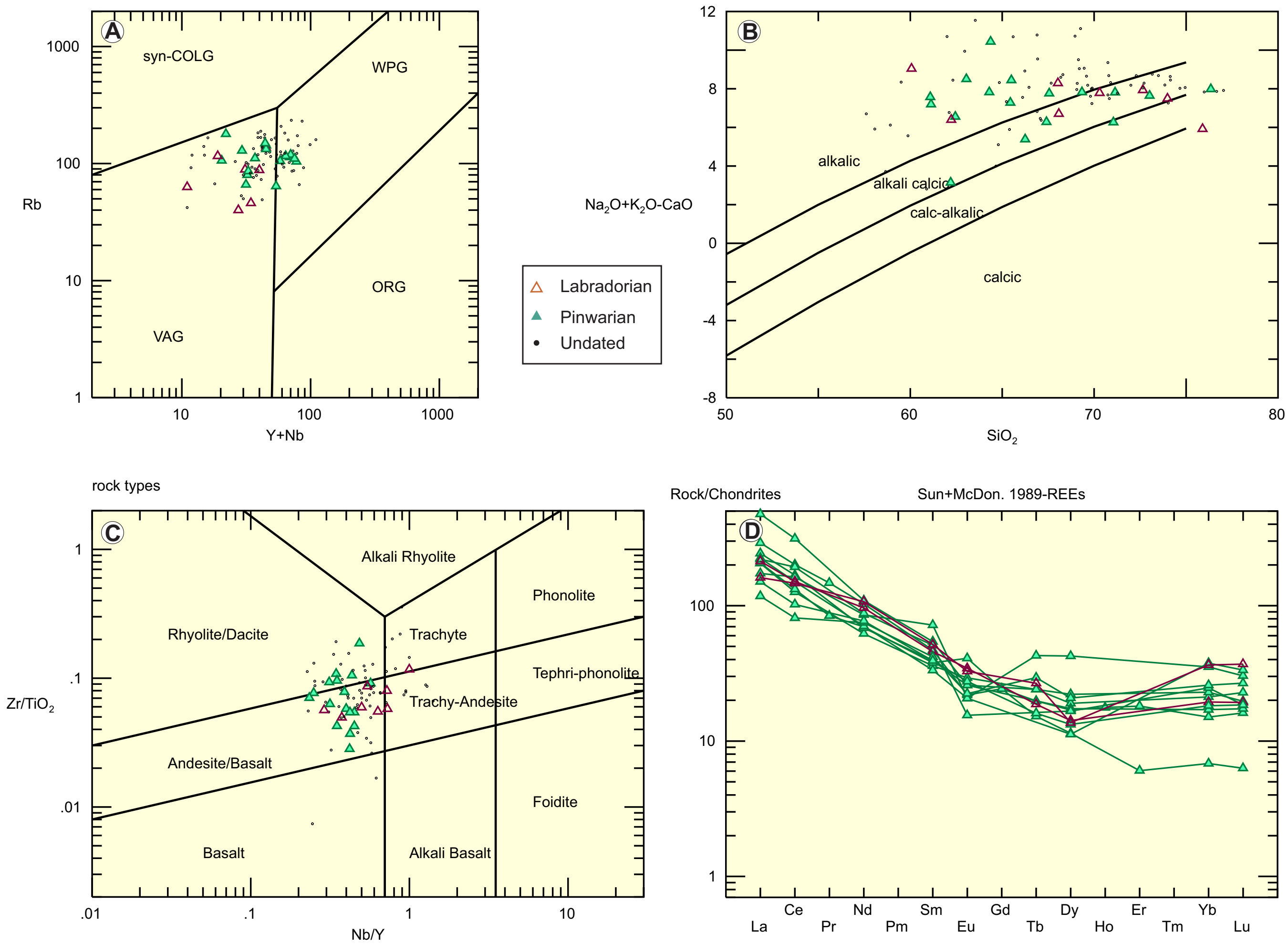


Figure 13.10. *Selected whole-rock geochemical variation diagrams attempting to discriminate between Labradorian and Pinwarian granitoid rocks in the Pinware terrane.*

values in the Forteau to Red Bay region. As the undated samples having lower Rb + Y + Nd appear to be in the same areas as the Labradorian-dated samples, the author presents the possibility that a whole-rock geochemical approach may provide an additional clue as to where to expect Labradorian crust in the Pinware terrane. At the same time, he acknowledges that the patterns are inconclusive and could be an artefact of inadequate data.

In regard to tectonic setting, Gower and Krogh (2003) interpreted Labradorian rocks as having formed in an outboard arc on a substrate of pre-Labradorian crust, and to have subsequently collided with pre-Labradorian Laurentia between 1665 and 1655 Ma. The collision triggered the 1655–1645 Ma Trans-Labrador batholith and shortly after, the 1650–1625 Ma Mealy Mountains AMCG suite and related, similar-aged, rocks. Tucker and Gower (1994) were the first to propose that the Pinwarian granitoid rocks formed in a later continental margin arc, a position endorsed by Gower and Krogh (2002). The whole-rock geochemical data shown in Figure 13.10 is consistent with such settings, albeit not significantly advancing interpretation.

13.3 PINWARE TERRANE FOLIATED AND GNEISSIC MAFIC ROCKS

Mafic rocks reviewed in this section are foliated to gneissic amphibolite, gabbro and leucogabbro that are spatially closely related to Pinware terrane foliated and gneissic granitoid rocks. There is no certitude that any genetic affiliation exists with the granitoid rocks however, except where indicated by geochronological data. One striking feature is their scarcity, making up less than 5% of the total area.

13.3.1 AMPHIBOLITE (PMam)

Amphibolite, and its light- and dark-coloured variants and (locally) granulite-facies equivalents, occur in all parts

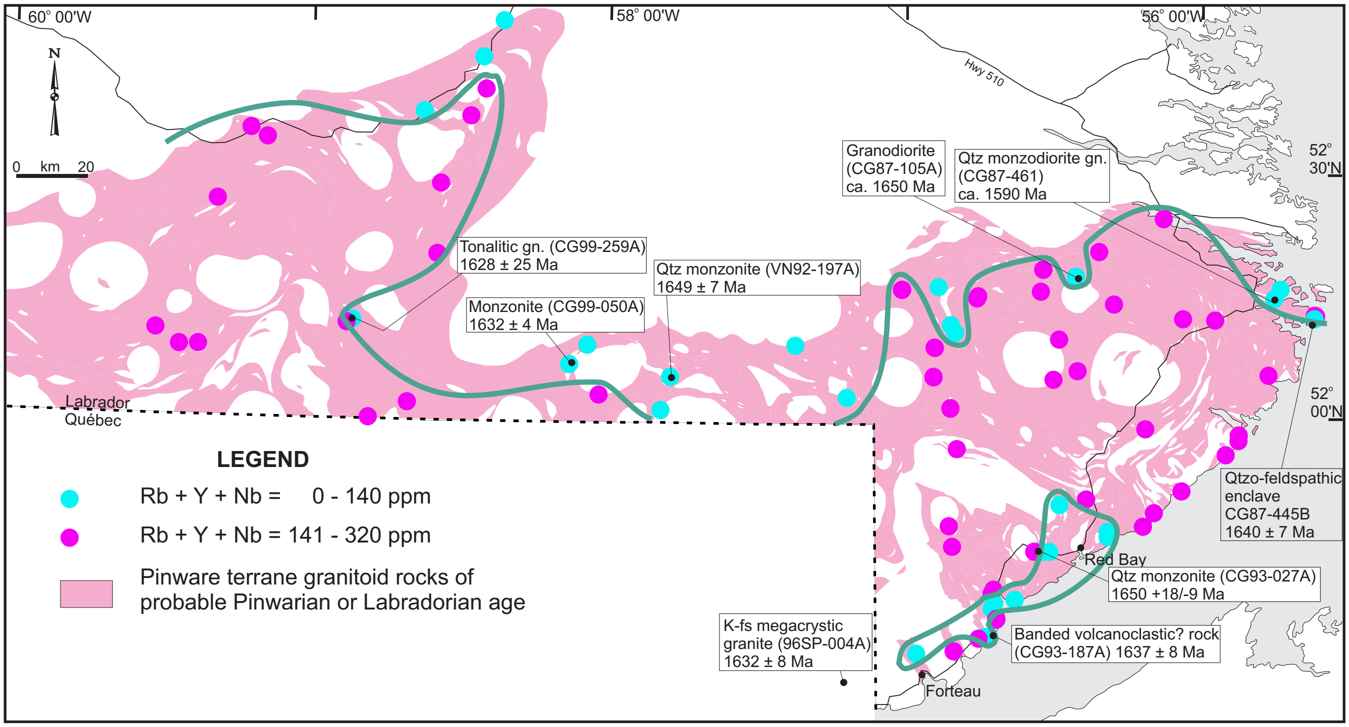


Figure 13.11. *Variations in Rb + Y + Nb in Pinware terrane foliated and gneissic granitoid rocks, carrying the implication that the low and high Rb + Y + Nb categories correlate with Labradorian and Pinwarian granitoid rocks, respectively.*

of the Pinware terrane (Figure 13.12). It is less commonly seen in lichen- or moss-covered outcrops away from riverside or coastal exposures, but there seems little doubt that it is a ubiquitous minor rock type associated with the granitoid rocks throughout the region. Some lighter weathering types were mapped as diorite during field work, but were likely derived from a plagioclase-rich basic protolith. The various mafic rocks probably belong to a wide range of mafic intrusions and it would be unwise to consider them to be a coherent group.

Amphibolite is grey-, brown-, rusty-, dark green-, grey- or black-weathering, fine to coarse grained, weakly to strongly foliated, recrystallized, and texturally variable. Many occurrences are quite small, merely forming a minor part of an outcrop that mostly comprises granitoid rocks. Amphibolite is found as veneers, layers, lenses, boudins and hornblende-rich pods. In places, the lenses grade into wispy or irregular schlieren. Their width ranges mostly between 1 cm and 10 m, concordant to the foliation in the enveloping host rocks. At a few large outcrops, amphibolite can be traced across the outcrops as semi-continuous bands. It may be intercalated with other rock types to give an overall banded rock. Relict primary diabasic texture is locally present, or the rock may be thoroughly deformed to a schist or gneiss. Where deformation is most severe, amphibolite forms elongate, schistose bands of highly foliated material. The fabric in the amphibolite is almost everywhere parallel to that in the granitoid host rocks, and rarely are earlier structures truncated. Mostly, the amphibolites are equigranular, but some examples contain larger polygonal aggregates of plagioclase that could represent former phenocrysts. Concordant, commonly irregular, locally folded, white quartz-feldspar veins and melt patches (sporadically containing pyroxene) are found in places and assist in defining banding. Discordant quartz-feldspar veins and pegmatites are also seen.

Much of the amphibolite probably represents dismembered remnants of pre-deformation mafic dykes, but, as the amphibolite layers are generally concordant to the foliation in the adjacent granitoid rocks, this interpretation cannot be verified in the field. In any case, occurrences are sufficiently varied to assert that any single origin is unlikely.

The typical mineral assemblage seen in thin section (47 sections) is plagioclase, amphibole, biotite, and opaque minerals. Plagioclase is mostly metamorphic and has anhedral polygonal form (but judged to be relict igneous in about 20% of samples). It is lightly to severely altered, poor to well twinned and, in a few instances, is weakly to strongly zoned. Amphibole is characteristically hornblende (Ti-rich or sodic in a few cases), polygonal, and blue-green, dark-green, leaf-green, or green-brown. Biotite is present in 90% of thin sections and is mostly buff, orange or brown (only rarely green). An opaque oxide mineral is seen in over 90% of thin sections and sulphide in roughly 45%. Clinopyroxene and orthopyroxene occur in 10% of thin sec-

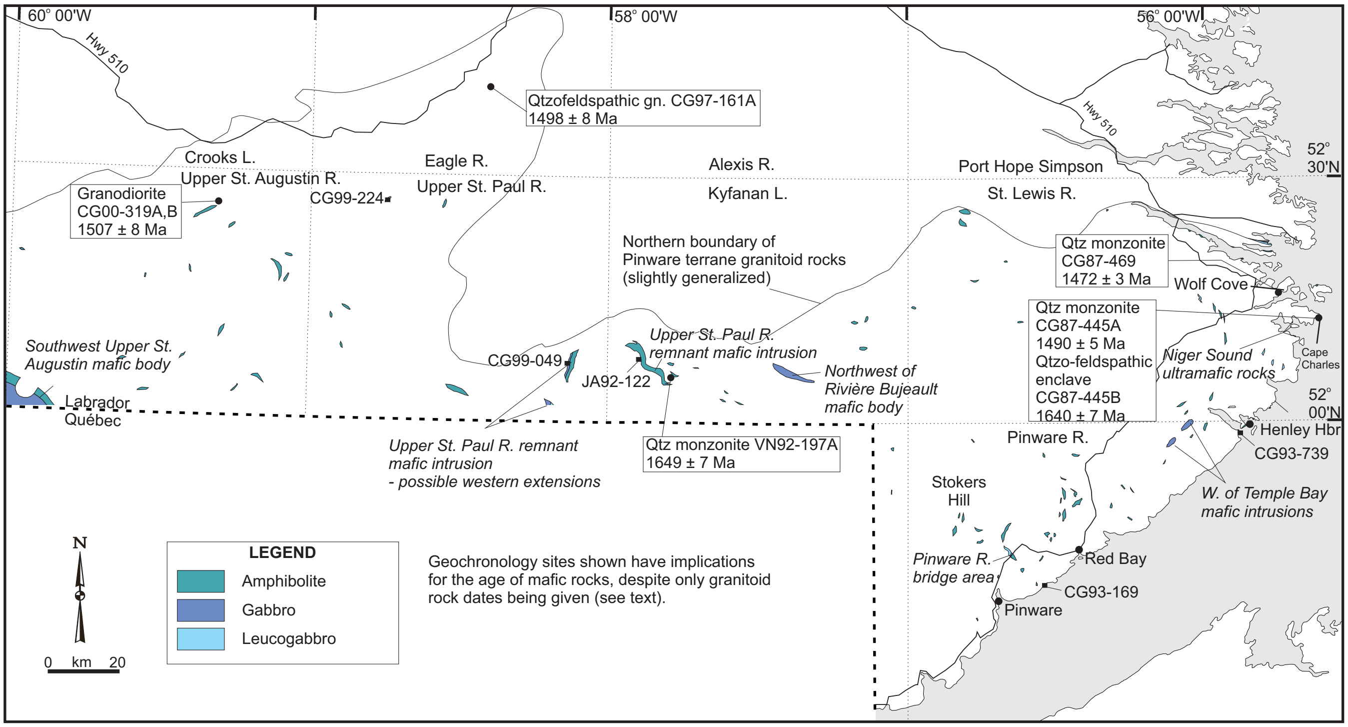


Figure 13.12. *Distribution of Unit PM mafic rocks in the Pinware terrane. Both late Paleoproterozoic and Mesoproterozoic rocks are included.*

tions, although are not found together. Clinopyroxene is pale-green or, rarely, brown, and orthopyroxene is typically strongly pleochroic. Garnet, locally with clino- or orthopyroxene, was recorded in 15% of thin sections. Other minerals, and their percentage occurrence in thin sections, are K-feldspar (10%), quartz (15%), apatite (>90%), zircon (20%), titanite (40%), allanite (15%), chlorite (20%), epidote (15%), carbonate (5%) and scapolite (5%). Zircon grains are small and, being located in mafic minerals, presumed metamorphic. The titanite, chlorite, epidote and carbonate are late-metamorphic or secondary.

13.3.1.1 Specific Details of Unit PMam Amphibolite

Upper St. Augustin River map region, southwest. Plagioclase-porphyritic recrystallized amphibolite is present having a medium-grained, weakly foliated matrix that retains relict diabasic texture (CG00-026). Plagioclase phenocrysts are euhedral to subhedral and up to 1 cm across. The contact of the amphibolite with foliated K-feldspar megacrystic granodiorite is exposed, but is faulted, so uncertainty remains whether the amphibolite is a xenolith or mafic dyke.

Upper St. Augustin River map region, northeast 1. A melanocratic amphibolite (CG00-329) contains abundant scapolite and is the only rock in the district to do so. It lacks biotite, except for a few trivial red-brown flakes. Two other distinct features of the amphibolite are that sulphide is common, comprising about 20% of the total opaque grains, and the opaque oxide forms overgrowths on sulphide. Titanite is also unusually plentiful compared to the other amphibolite in the Pinware terrane. These mineralogical contrasts suggest an origin or subsequent history that differs from other amphibolites in the map region.

Upper St. Augustin River map region, northeast 2. Amphibolite occurs as an irregular band concordant to the prevailing foliation in a sparsely K-feldspar megacrystic granitoid rock. The granitoid rock and amphibolite were both investigated by U–Pb isotopic methods (CG00-319A, CG00-319B). Four near-concordant zircon analyses from the amphibolite (when regressed with four 20–30% discordant zircons from the host granodiorite) yielded at upper intercept age of 1507 ± 8 Ma (Gower *et al.*, 2008b, *see* earlier), which was inferred to date metamorphism, when the amphibolite was incorporated into the host granodiorite. The data provide one of the few indications that at least some amphibolite must be Pinwarian or older. For completeness, mention is made here of a third sample investigated geochronologically from this locality (CG00-319C). It is a plagioclase–quartz pegmatitic rock that forms anastomosing veins within amphibolite. Three zircon analyses indicated pre-Pinwarian inheritance (1575 ± 8 Ma), and the fourth a minimum age of 1017 ± 3 Ma, interpreted to reflect time of Grenvillian metamorphism.

Eagle River map region. Amphibolite is rather uncommon in the Eagle River map region, but an exception occurs in the central part of the map region where a band of amphibolite about 50 m wide was recorded. Apart from pegmatite layers that are parallel to a strong, schistose foliation, the amphibolite is homogeneous. It seems likely that it is a metamorphosed intrusion, but, as contacts with the adjacent gneisses are concordant, field proof is lacking. The amphibolite is associated in outcrop with tonalitic quartzofeldspathic gneiss. During mapping, it was judged uncertain whether the gneiss protolith was igneous or greywacke supracrustal (Section 13.1.2.1). Both tonalite and amphibolite were investigated by U–Pb geochronological methods (Gower *et al.*, 2008b). The tonalitic rock (CG97-161A) gave a zircon age of 1498 ± 8 Ma and a monazite age of 1023 ± 9 Ma. The amphibolite (CG97-161B) yielded a 4% discordant $^{207}Pb/^{206}Pb$ age of 987 ± 7 Ma.

Kyfanan Lake region 1. A segmented mafic layer occurs within granite near the eastern margin of the area (VN92-072; 30 km northeast of the 'Northwest of Rivière Bujeault mafic body'). The granitic material infilling the area between the mafic segments is the same as that in the surrounding area, which may indicate that the dyke was synplutonic. On the other hand, a zone of recrystallization at the borders of the dyke appears to be truncated by the material between the segments, perhaps indicating that mobilization of granitic material into the dyke was later, following a period of metamorphism. The example suggests to the author that the amphibolite is Pinwarian.

Kyfanan Lake region 2. An outcrop (VN92-179) near the central part of the eastern border of the map region contains plagioclase, clinopyroxene and relict corona textures consisting of amphibole + spinel symplectite surrounding orthopyroxene aggregates or single crystals. It seems likely that olivine was originally present in the rock and that it has been completely replaced by orthopyroxene.

St. Lewis River region, Wolf Cove. Amphibolite, not examined petrographically, occurs where the Wolf Cove quartz monzonite has been dated to be 1472 ± 3 Ma (CG87-469; *cf.* Section 13.2.5.1). The amphibolite was interpreted by Tucker and Gower (1994) to be an enclave. Geoscientist visitors who have accompanied the author to the site have disputed whether the amphibolite is a mafic enclave or metamorphosed mafic dyke. The field evidence is inconclusive; but the enclave interpretation has generally been favoured. Recognizing the possibility of later remobilization, both interpretations could have validity.

St. Lewis River region, Cape Charles. Fine- to medium-grained, quartzofeldspathic gneiss dated to be 1640 ± 7 Ma, and thought to be of volcaniclastic origin, was intruded by mafic dykes (now amphibolite remnants) prior to being incorporated as enclaves within the 1490 ± 5 Ma Cape Charles quartz monzonite (Tucker and Gower, 1994) (*cf.* Section 13.2.5.1). The amphibolite has not been examined petrographically. The locality (CG87-445) is yet another example indicating pre- or syn-Pinwarian mafic magmatism in the Pinware terrane.

Pinware region, Henley Harbour area. In the Henley Harbour area and the adjacent mainland to the southwest, the mafic rocks are all thoroughly metamorphosed. Mafic rocks west of Henley Harbour consist of a black-weathering, homogeneous, strongly foliated, medium- to coarse-grained amphibolite containing abundant garnet (up to about 15%). The garnets are up to about 0.5 cm in diameter and are partially retrograded. The garnetiferous amphibolite is itself intruded by amphibolitized mafic dykes. The contact between the amphibolite and its host alkali-feldspar granite is transposed and complex due to interdigitating mafic and granitoid rocks, combined with injection and deformation of leucosome material. At Henley Harbour, many of the islands are made up largely of mafic rocks retaining some primary igneous layering. The rocks are garnetiferous leuco- and meso-amphibolite and are strongly deformed and injected by pegmatite veins.

Four representative samples were examined petrographically (CG93-735B, CG93-771, VN93-692, VN93-707). All are strongly foliated amphibolite containing plagioclase, amphibole, buff-brown biotite, oxide and sulphide opaque minerals, garnet, and secondary/trace minerals. The garnet is relict, having been partly pseudomorphed to a multi-mineral aggregate that includes plagioclase, an opaque mineral, biotite, and amphibole.

Some exotic-looking mafic dykes containing large (several centimetres long) plagioclase phenocrysts are associated with these mafic rocks. At one locality (CG93-739; Plate 13.8A), the large plagioclase crystals are concentrated in the western 80% of the intrusion (where they comprise about 25% of the rock) and are very sparse in the eastern 20%. These have been attenuated to pencil-like form exceeding 3 cm long (Plate 13.8B). A curious feature of the large plagioclase crystals is that they have black centres (Plate 13.8C).

In thin section (CG93-739B), the large plagioclases are seen to have euhedral outlines but to comprise polygonal mosaics of randomly oriented clinozoisite and scapolite in their cores, which is not a good match for the black material seen macroscopically. Other minerals are bronzy-brown biotite, dark-blue-green amphibole, oxide and sulphide opaque minerals, titanite and apatite.

Pinware region, Red Bay area. Amphibolite containing large, recrystallized plagioclase clusters up to several centimetres long was mapped between Red Bay and Pinware (*e.g.*, CG93-083, CG93-136, CG93-169). The plagioclase clusters are considered to be former phenocrysts. The rocks are similar to those in the Henley Harbour area and may be

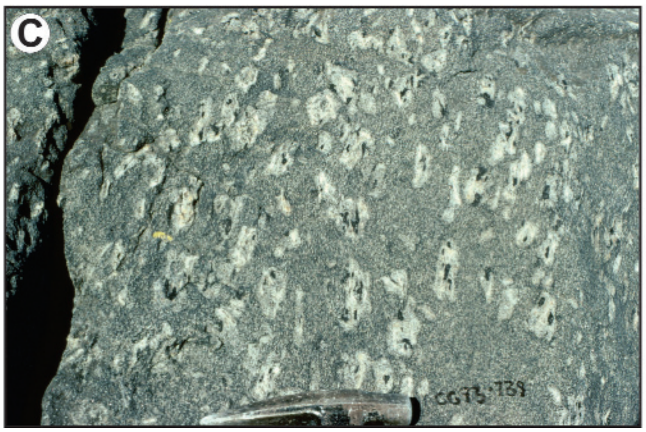


Plate 13.8. *Example of an unusual Pinware terrane amphibolite. Based on stained slabs and thin sections, the white areas are interpreted as recrystallized plagioclase phenocrysts. A. Note sparsity of plagioclase phenocrysts in eastern (right) part of body, B. View showing strong horizontal extension, C. Detail showing black cores to plagioclase envelopes. Mineral forming black core has not been identified (CG93-739).*

genetically linked. One such body in which the feldspathic lenses are confined to one side of the body was illustrated by Bostock (1983, his Figure 11; CG93-169; Plate 13.9A). Could this be an example of plagioclase floating/sinking in an originally near-horizontally emplaced intrusion?

A sample from an outcrop on strike with this locality, 4.7 km to the northeast, which might be part of the same intrusion, was examined petrographically (CG93-083B). It is granoblastic and contains plagioclase, hornblende, minor orange-brown biotite, opaque oxide and apatite. Former plagioclase phenocrysts are represented by ovoid aggregates of polygonized grains.

Amphibolite without plagioclase phenocrysts is also present in the area. Two were thin sectioned (CG93-034B, DL93-030) and have the same mineral assemblage, with the exception that CG93-034B contains secondary titanite and chlorite, explicable by its proximity to the Red Bay fault.

Pinware region, west of Pinware. West of the Pinware alkali-feldspar syenite, grey-weathering, medium-grained, recrystallized plagioclase-rich (plus biotite and hornblende) rocks are exposed. These show some layer-to-layer variability, including melanocratic layers up to 15 cm thick. Farther west still, on Lost River and outcrops to the north, grey-, buff- or creamy-weathering, medium-grained, recrystallized, and banded/boudinaged leucogabbronoritic rocks are present. One possibility is that these outcrops represent remnants of a single body folded into a south-plunging synform.

A sample from this area (CG93-350) does not compare closely with the rocks exposed northeast of the Pinware River bridge, being a two-pyroxene granulite (other minerals are plagioclase, amphibole, red-brown biotite, and opaque oxide, apatite, and interstitial K-feldspar).

Pinware region, southeast of Stokers Hill. Small areas of medium- to coarse-grained, clinopyroxene-bearing amphibolite to leucoamphibolite southeast of Stokers Hill could be related to the rocks described above.

Samples VN93-368 and VN93-372 were examined petrographically. Their essential minerals are mutually similar, comprising plagioclase, pale-green clinopyroxene and hornblende, but accessory phases differ. Buff-coloured biotite, apatite and traces of an oxide opaque mineral are present in VN93-368, whereas oxide and sulphide opaque minerals, apatite, titanite and scapolite characterize VN93-372.

Pinware region, mafic rocks west of Upper Beaver Brook intrusion. A few small and apparently discontinuous bodies of mafic rock were mapped west of the Upper Beaver Brook intrusion (which is indicated in Figure 13.3). They are black- to grey-weathering, medium to coarse grained,

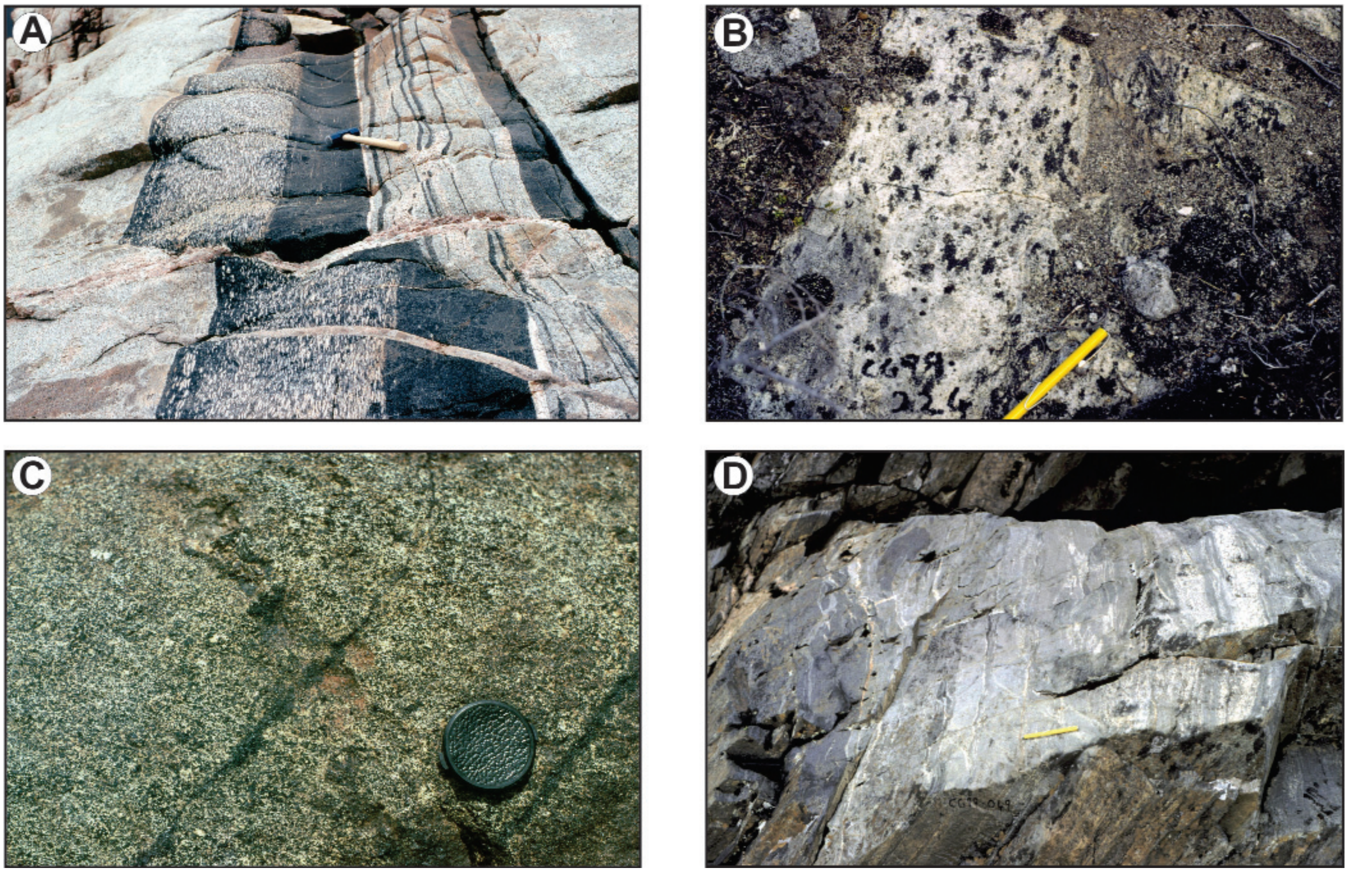


Plate 13.9. *Pinware terrane foliated and gneissic mafic rocks. A. Amphibolite layer showing plagioclase lensoid shapes (recrystallized phenocrysts?) on one side of body (CG93-169), B. Meta-leucogabbronorite, which could also be termed a leucocratic two-pyroxene granulite (CG99-224), C. Amphibolite/metagabbro from Upper St. Paul River remnant mafic intrusion (JA92-122), D. Possible western extension of Upper St. Paul River mafic body. Associated granitoid rocks nearby dated to be 1632 ± 4 Ma (CG99-049).*

recrystallized, commonly foliated, and very variable in texture. The only one for which dimensions are known is at CG93-518B, which is a 4-m-wide band within a recrystallized granite.

A sample examined petrographically from this outcrop is sufficiently similar to another rock investigated 10 km to the south (VN93-450) for a common origin to be entertained. The mineral assemblage comprises polygonal plagioclase, distinctly pleochroic orthopyroxene, minor clinopyroxene, dull-green amphibole, buff-brown biotite, apatite and an oxide opaque mineral. A mafic enclave within the Upper Beaver Brook intrusion but close to its western contact (VN93-443B) is also somewhat similar.

Pinware region, Outside Big Pond district. In the Outside Big Pond area (for location *see* Figure 13.3), mafic rocks are not common.

Only one sample was investigated in thin section (VN93-646). It is typical of amphibolite derived from a mafic intrusive rock, retaining evidence of a coarse-grained subophitic texture and plagioclase that is largely primary, albeit showing very irregular, recrystallized grain boundaries. The major mafic mineral was originally clinopyroxene, but is now represented by pale-blue-green amphibole containing abundant quartz inclusions. The opaque mineral is mostly oxide (rare sulphide also present), mantled by titanite and both enveloped in buff-green biotite. Apatite is a common accessory phase, forming fairly large grains.

13.3.2 LEUCO-AMPHIBOLITE AND LEUCOGABBRONORITE (PMln)

Rocks termed leuco-amphibolite or leucogabbronorite form an insignificant component of foliated to gneissic rocks in the Pinware terrane, although some occurrences are of interest simply because they are anomalous with respect to their surroundings. It is most straightforward to review the more significant examples on an individual basis.

One such occurrence occurs in the north-central part of the Upper St. Paul River map region and is the only example of its type known from this region (Figure 13.12 data station CG99-224). The rock is pale-grey-weathering, medium grained, and recrystallized (Plate 13.9B).

A thin section (CG99-224A) shows that it consists of plagioclase, pale-green clinopyroxene, strongly pleochroic orthopyroxene, dark-orange-brown biotite, and oxide opaque mineral, apatite and possibly some interstitial quartz. Lack of any amphibole makes this rock distinctive. The pyroxenes occur in polygonal clusters suggestive of former primary grains. The term leucogabbronorite, and concomitantly implied igneous origin, is preferred over the two-pyroxene basic granulite alternative.

Three occurrences are found in fairly close proximity in the eastern St. Lewis River map region, although there is no particular reason to consider them related (EA61-395 from locality R61-1002a, VN87-311, VN87-518A). The rocks are medium grained, show a marked fabric and are intruded by granitic veins in outcrop. The mineral assemblage comprises heavily sericitized plagioclase, pale-green to blue-green amphibole, pale-green biotite, apatite and zircon. The pale coloured amphibole and biotite suggest very low Fe content. The occurrence closest to the northern margin of the Pinware terrane is mylonitic.

The final occurrence addressed here is a 300-m-long section in a roadcut between the road bridge over Pinware River and the Lower Pinware River alkali-feldspar syenite. A wide range of rock types includes meta-anorthosite, leuco-, meso- and melanocratic amphibolite, as well as abundant leucosome and hornblendite pods (Stop 1.6 in the field guide of Gower *et al.*, 2001). The rocks in this case are considered to be remnants of a layered mafic intrusion. Compositional banding is well developed in places although locally severely boudinaged and disrupted by leucosome and hornblendite pods. The leucosome pods commonly contain large euhedral clinopyroxene and/or hornblende crystals several centimetres long. Deformed and metamorphosed pegmatite dykes add further complications to an already complex association of rocks.

Four thin sections (from two samples) examined from this body (CG93-064A1, A2, CG93-064B1, B2) have the same mineral assemblage, consisting of plagioclase, clinopyroxene, amphibole, biotite, apatite and an oxide opaque mineral. Both can be termed amphibole-bearing clinopyroxene granulites. The proportions of minerals differ between the two rocks, one having only about 10% plagioclase, the other over 60%.

13.3.3 GABBRO, NORITE, TROCTOLITE (PMrg)

Gabbroic and closely related, coarse-grained mafic intrusive rocks retaining elements of igneous character in the Pinware terrane were assigned Unit PMrg on the maps of Gower (2010a). The rocks are black-weathering, medium to coarse grained, foliated, and partially to extensively recrystallized. They comprise mostly plagioclase, clinopyroxene and hornblende, but some contain orthopyroxene and garnet as significant minerals, plus accessory oxide opaque mineral, apatite, hercynite and biotite.

13.3.4 LARGER REMNANT ULTRAMAFIC TO MONZONORITIC BODIES IN THE PINWARE TERRANE

Larger bodies of mafic rock than those included in Units PMam, PMln and PMrg in the previous sections are addressed here. They are more compositionally variable than the previously described rocks in that they range from ultramafic to monzonoritic, and they are interpreted as having originally been layered. Gower (2010a) assigned these bodies as part of his Unit M_1 (Chapter 14) in the absence of geochronological or adequate geochemical data. Such a grouping is not an entirely satisfactory grouping, however, as all other 'M_1' units belong to a package of mafic and AMCG-type rocks defining a zone between the Mealy Mountains and Pinware terranes. Describing them at this stage of the report serves as a compromise that emphasizes their uncertain status. The bodies are reviewed from west to east and are identified on Figure 13.12.

13.3.4.1 Specific Details of Larger Remnant Mafic Bodies

Southwest Upper St. Augustin River map region mafic body. Three outcrops of mafic rock are grouped as part of a mafic intrusive body. One outcrop, very close to the western boundary of the St Augustin River map region, was previously visited by Eade (1962; EA61-018), who mapped the rock as gabbro (his Unit 7). No extension of the unit to the west is indicated on the map of James and Nadeau (2000), who broadly refer to rocks in the area as granitoid orthogneiss with amphibolite boudins. To the south, rocks affiliated with the undated Petit Mecatina AMCG suite are depicted on the maps of Avramtchev (1983a, b). Although not directly correlative with any of the rocks belonging to the AMCG suite purported to exist immediately south of the border (monzonite, anorthosite or anorthositic gabbro), it is nevertheless possible that the mafic rocks described here could be genetically associated.

All three outcrops comprise grey- or black weathering, medium to coarse grained, recrystallized mafic rocks. Two are foliated amphibolite, whereas one, in the extreme southwest corner of the map region, retains vestiges of an igneous fabric and is termed melanocratic metagabbro. In this sample (CG00-011), relict pyroxene remains in the cores of mafic grains and is surrounded by amphibole. Traces of pyrite were seen on a fracture surface in the easternmost mafic rock exposure.

Upper St Paul River remnant mafic intrusion. Mafic rocks mapped by Gower *et al.* (1993) in the vicinity of the Upper St. Paul River were interpreted to represent the remnants of a single mafic intrusion, which, as depicted, is northwest-trending, somewhat sinusoidal, and about 15 km long by 1–2 km wide. In the field, the impression is gained that the original body is only preserved as deformed and metamorphosed slivers.

The rocks are white-, grey-, brown- or black-weathering, medium to coarse grained and massive to strongly foliated (Plate 13.9C). Compositions include ultramafic rocks, gabbro and/or norite (and their leucocratic variants) and monzogabbro. Some of the leucogabbronorite and monzogabbro retain primary minerals and textures, such as layering, cumulate textures, and associations of rock types like those found in magma-mingling environments. More commonly, these rocks have been thoroughly recrystallized to inhomogeneous leucocratic to melanocratic amphibolite. Metamorphic grade is sufficient for minor leucosome to have developed locally. Garnet is found in amphibolite in outcrops north of St. Paul River and, along strike, on a southwest-flowing major tributary. The garnets are partially retrograded and are generally less than 3 mm in diameter. In ultramafic units, primary features are rarely preserved. Instead, the rocks are typically completely recrystallized and composed almost entirely of hornblende with some biotite. Further complexities result from interleaving with granitoid rocks and injection by younger granitic veins.

In thin section, the rocks can be classified into three types. These are: i) ultramafic to melanocratic igneous-textured rocks, ii) two-pyroxene granulites, and iii) amphibolites.

The ultramafic/melanocratic group (JA92-115, JA92-139B) contains olivine, zoned clinopyroxene, orthopyroxene and plagioclase as primary minerals, together with brown amphibole and red-brown biotite as either late primary or secondary minerals. In addition, sample JA92-115 contains K-feldspar, hercynite and minor apatite. The K-feldspar occurs as large late-stage crystals that appear to be infilling interstitial cavities. Both samples contain coronal orthopyroxene mantling olivine and sample JA92-139B also has an outer corona of either clinopyroxene or amphibole.

The two-pyroxene granulites (JA92-123, JA92-152) contain plagioclase, orthopyroxene, clinopyroxene, amphibole, biotite, apatite and an opaque mineral, but differ considerably in colour index, one being mafelsic and the other mafic.

The amphibolites (JA92-135, JA92-137B, JA92-138, VN92-158A) contain plagioclase, hornblende, biotite, apatite, an opaque mineral, some titanite and traces of chlorite. In addition, one sample (JA92-135) contains relict clinopyroxene, partially pseudomorphed to amphibole.

Four other ultramafic–mafic rocks and one anorthositic rock in the vicinity are included here (although not necessarily related to the St. Paul River remnant mafic intrusion). A dunite exposed on the east bank of St. Paul River (CG92-150), in addition to olivine, also contains very pale-brown euhedral amphibole and pale-brown biotite, both interpreted as hydration products (this rock is fairly similar to JA92-139B). Three garnet- and orthopyroxene-bearing amphibolitic rocks (CG92-141, VN92-189B, VN92-195) are exposed in separate outcrops north of St. Paul River. In view of the fact that garnet is uncommon in the area, and the combination of garnet + orthopyroxene is elsewhere unknown, it seems probable that the three outcrops are genetically related. The garnet occurs as prograde amoeboid grains. In one rock it is associated with a plagioclase(?)-clinopyroxene symplectite that is probably also prograde. The anorthosite north of the garnet- and orthopyroxene-bearing rocks is a strongly deformed rock that is regionally on strike with a leucoamphibolite farther east on the southwest-flowing tributary of the St. Paul River (VN92-158A), perhaps indicating more continuity of rock types that present outcrop allows to be depicted.

Two samples that were thin sectioned from areas shown on the 1:100 000-scale map as monzonite to the west and north of the west end of the mafic intrusion (JA92-147B, JA92-132B) are pyroxene-bearing leucogabbro and leucoamphibolite, respectively (monzonite is dominant at these localities, hence the polygon designation on the map). The relationship of these rocks to the mafic intrusion on St. Paul River is unknown.

A clinopyroxene-, amphibole-, and biotite-bearing monzogabbro near the western border of the map region, 2 km north of St. Paul River (CG92-120A) predates granite at the same locality. That the granite intrudes the monzogabbro is unambiguous, because enclaves of monzogabbro occur in the granite and granitoid dykes intrude the monzogabbro.

Upper St Paul River remnant mafic intrusion – possible western extensions. Mafic rocks of diverse composition and fabric occur in two areas in the southeast part of the Upper St. Paul River map region. The rocks may represent the remnants of a small layered mafic intrusion that has been extensively disrupted by deformation and invaded by granitoid material during a high-grade metamorphic event that included partial melting. They compare with ultramafic to monzogabbroic rocks in the Upper St Paul River remnant mafic intrusion (*see* previous paragraphs) and may well be the (discontinuous?) extension of them to the west, wrapping around the late- to post-Grenvillian Upper St. Paul River (northwest) monzonite. Such an interpretation is consistent with foliation trends in the district and a zone of foliated monzonitic rocks (in an area otherwise characterized mostly by foliated granitoid rocks), that are spatially associated with the mafic rocks.

The mafic rocks are black- to grey-weathering, fine to coarse grained, leucocratic to melanocratic and weakly to strongly foliated, or form well-banded amphibolitic gneisses. Compositions range from ‘leucodiorite’ (probably metamorphosed leucogabbronorite) to melagabbro (over 80% mafic minerals in one example). The rocks are mostly amphibolite-facies metamorphic rocks and contain irregular hornblende- and biotite-rich pegmatitic pods and layers, quartz-feldspar stringers, irregular hornblende-rich veneers and lenses, and show common evidence of shearing or grain-size comminution. The quartz-feldspar veins have either gradational or discordant contacts against the rocks in which they occur. Also present are enclaves and/or boudins of fine-grained amphibolite within coarser grained material. The rocks have a close spatial relationship with their enveloping granitoid rocks, interlayered with them as composite gneisses or having been injected by them in an irregular, anastomosing manner (Plate 13.9D).

Thin sections from two samples exemplify the diversity of mafic rocks from this area. One is a gneissic to mylonitic amphibolite, and the other is an igneous-textured orthopyroxenite. The amphibolite (CG99-049) contains plagioclase, amphibole, biotite and accessory mineral. The plagioclase forms thoroughly recrystallized, polygonal grains that are poorly twinned and lightly sericitized. A wide range in grain size suggests heterogeneous recrystallization. Amphibole is also polygonal and is darker green than typical for common hornblende, so it may be an Fe-rich variety. Biotite form small, aligned, green-brown flakes showing strong preferred alignment. Both oxide (dominant) and sulphide are present and tend to be species-specific in particular bands. Other accessory minerals are apatite, zircon (unusually common for this type of rock), titanite (associated with the opaque oxide), late-stage chlorite and minor K-feldspar. The orthopyroxenite (CG99-072), from farther south, consists of interlocked grains of pale-brown, high-relief orthopyroxene (Fe-rich?), with which minor interstitial plagioclase, poikilitic clinopyroxene, secondary amphibole and biotite and opaque minerals (oxide and sulphide) are associated.

Northwest of Rivière Bujeault mafic body. The existence of a 10-km-long lenticular mafic intrusion 30 km east of the Upper St. Paul River remnant mafic intrusion was first interpreted by Gower *et al.* (1993). The status of the intrusion remains somewhat conjectural, being inferred from a distinct positive aeromagnetic anomaly in the area and a single outcrop of metamorphosed leucogabbro, associated in the outcrop with biotite-bearing monzonite to syenite.

The leucogabbro is dark-honey-brown-weathering, coarse grained and partly recrystallized. Relict primary clinopyroxene and plagioclase are present, but much of the rock has been recrystallized to polygonal aggregates of secondary plagioclase and amphibole. Biotite, apatite and an opaque phase constitute the remaining minerals (JA92-168A, JA92-168B).

West of Temple Bay mafic intrusions. Olivine metagabbro occurs in two elliptically shaped bodies of mafic rock west of Temple Bay. They were mapped by Bostock (1983), and remapped by Gower *et al.* (1994). The rocks are black-weathering, medium to coarse grained, and massive. Primary layering, accentuated by olivine-rich layers, is evident, and partially recrystallized, igneous textures and minerals are well preserved in places. Both olivine and primary pyroxene are present, and coronitic textures mantling olivine are easily seen in outcrop. A few quartzofeldspathic stringers are present, but minor granitoid intrusions are largely lacking. Two smaller bodies of mafic intrusive rock (CG93-830, VN93-646) are present 7 km south-southwest and 8 km west, respectively of the southernmost elliptical body. Data station CG93-830 is regionally on (arcuate) strike with the two elliptical intrusions so it is the more likely of the two to be correlative. The age of these rocks is unknown and including them in this section of the report is tenuous.

Only the southernmost elliptical body was examined petrographically (DL93-336) following 1:100 000-scale mapping. The rock contains primary olivine, plagioclase, clinopyroxene, and an oxide opaque mineral. Red-brown biotite, generally mantling the opaque mineral, is probably also primary. Double coronas are ubiquitous at olivine-plagioclase interfaces. The inner corona comprises orthopyroxene and the outer corona is amphibole + green spinel. Small garnets are present locally at the boundary between the inner and outer coronas. The above description probably also applies to parts of the northern body, as double coronas around olivine were recorded in field notes (CG93-743). Despite the above comments, it is not certain that all of either of these two bodies is entirely coronitic metagabbro. Bostock (1983) described colourless amphibole identified as anthophyllite in clots surrounded by hornblende in samples that he examined petrographically from both bodies (BK71-501 and BK71-509) and included a photomicrograph from one of them in his report (Bostock, 1983, his Figure 14). The texture depicted is that of a retrograded coronite, in which the olivine core has been completely replaced by amphibole; similar textures were described by Gower (1986) from the Double Mer area, for example.

The smaller bodies at CG93-830 and VN93-646 were also examined petrographically. Sample CG93-830 contains relict primary plagioclase and clinopyroxene, whereas VN93-646 only retains some relict plagioclase. Both rocks have been extensively recrystallized. Former coronitic texture in CG93-830 is indicated by radiating aggregates of amphibole enclosing pale green or brown phyllosilicates (mainly a mixture of amphibole, mica and serpentine) that were originally olivine.

A string of isolated mafic rock occurrences appears to define a corridor between the West of Temple Bay intrusions and the Northwest of Rivière Bujeault mafic body. One outcrop in this corridor (VN87-258B) is a garnetiferous amphibolite in an area dominated by strongly foliated granite of uncertain age. The amphibolite comprises green hornblende, symplectic-textured garnet, strongly zoned plagioclase, orange-brown biotite, an opaque oxide, large red-brown rutile, and hercynite–orthopyroxene intergrowths. The garnet texture is characteristic of a decompression symplectite. No other rocks like it were found anywhere in the region, and its genetic context cannot be related to any other feature in its surroundings. In the absence of a better explanation, the rock is suggested to be an enclave carried up rapidly during emplacement of the enveloping granitoid rocks.

Niger Sound area. During 1987 mapping, three small occurrences of ultramafic rock (JS87-586, VN87-400, VN87-433) were found close together in the Niger Sound area, 10 km southeast of Lodge Bay. These localities were not separately mentioned by Gower *et al.* (1988), and were grouped with amphibolite/metagabbro on the preliminary 1:100 000-scale map for the area. The rocks may have economic significance as the central outcrop is rusty-weathering and sulphide-rich (Gower, 2010a; St. Lewis River map region). The locality is listed in the Mineral Occurrence Database for Newfoundland and Labrador (03D/04/ Pyr001).

The three outcrops are aligned a north-northwest direction, which is at a high angle to the area's prevailing east to east-southeast structural trend. This might lead to speculation they are related to a discordant ultramafic dyke, but, if so, any such dyke must have been emplaced prior to Grenvillian orogenesis (at latest), as the rocks have largely metamorphic assemblages. No evidence of discordance was seen in outcrop.

The most abundant mineral in all three samples examined petrographically (JS87-586, VN87-400, VN87-433) is amphibole, which shows bright bottle-green pleochroism in VN87-400, but a paler leaf-green in the other two samples. Anhedral, pale-green pleochroic clinopyroxene is present VN87-400 and VN87-433. It is partly replaced by amphibole, a reaction that is assumed to have proceeded to completion in JS87-586, which lacks clinopyroxene and contains minor quartz. All three samples contain minor, interstitial, moderately altered plagioclase. Sample VN87-400 also contains interstitial microcline. Both oxide and sulphide opaque minerals are present. These are very minor in two of the samples but abundant in JS87-586 (*ca.* 15%), which has sulphide and oxide in roughly equal proportions. Apatite is present in all three samples. Secondary chlorite (abundant in JS87-586), tremolite/actinolite, titanite, rutile and carbonate are present sporadically. The rocks had a clinopyroxenite, or clinopyroxene-rich, melagabbro protolith.