CHAPTER 17

LATE MESOPROTEROZOIC (M_3 1200–900 Ma)

Late Mesoproterozoic units are subdivided into five age-defined groups, namely: i) pre-Grenvillian intrusions (M_{3A} 1200–1090 Ma), ii) early syn-Grenvillian intrusions (M_{3B} *ca.* 1090–1045 Ma), iii) late syn-Grenvillian intrusions (M_{3B} *ca.* 1045–985 Ma), iv) early post-Grenvillian intrusions (M_{3C} *ca.* 985–975 Ma), and v) late- to post-Grenvillian intrusions (M_{3D} 975–955 Ma). Representative stained slabs of most of these units are included in Appendix 2, Slabs 17.1 to 17.11).

17.1 PRE-GRENVILLIAN INTRUSIONS (M_{3A} 1200–1090 Ma)

17.1.1 GILBERT BAY GRANITE (M_{3A}gr)

The Gilbert Bay granite was first recognized, mapped and named by Wardle (1976, 1977). It was re-examined by Gower *et al.* (1987) and has been revisited by the author on several subsequent occasions. The pluton is located on the northern border of the Gilbert River belt, which forms the attenuated southeast part of the Lake Melville terrane. Gower *et al.* (1987) suggested that the pluton might be crossed by an east-southeast-trending fault that dextrally offsets the two halves of the pluton by about 2.5 km (Figure 17.1). In a pre-fault restoration, the pluton has an elliptical map pattern and measures roughly 4 by 3 km, having its long axis in an east-southeast direction, parallel to the regional trend. If not faulted (and there is no proof that it was), then the pluton would measure 7 by 2.5 km, elongate in an easterly direction.

The granite intrudes sillimanite-bearing metasedimentary gneiss, K-feldspar megacrystic granitoid rocks (typically deformed to augen gneisses having mylonitic fabrics), and net-veined amphibolite, which represents the remnants of migmatized mafic dykes. These rocks have not been dated in the vicinity of the pluton, but from regional considerations are known to be Labradorian. Similar rocks occur as abundant, subrounded to angular xenoliths within the Gilbert Bay granite (Plate 17.1A), from which it is clear that the deformation (including mylonitization) and migmatiza-

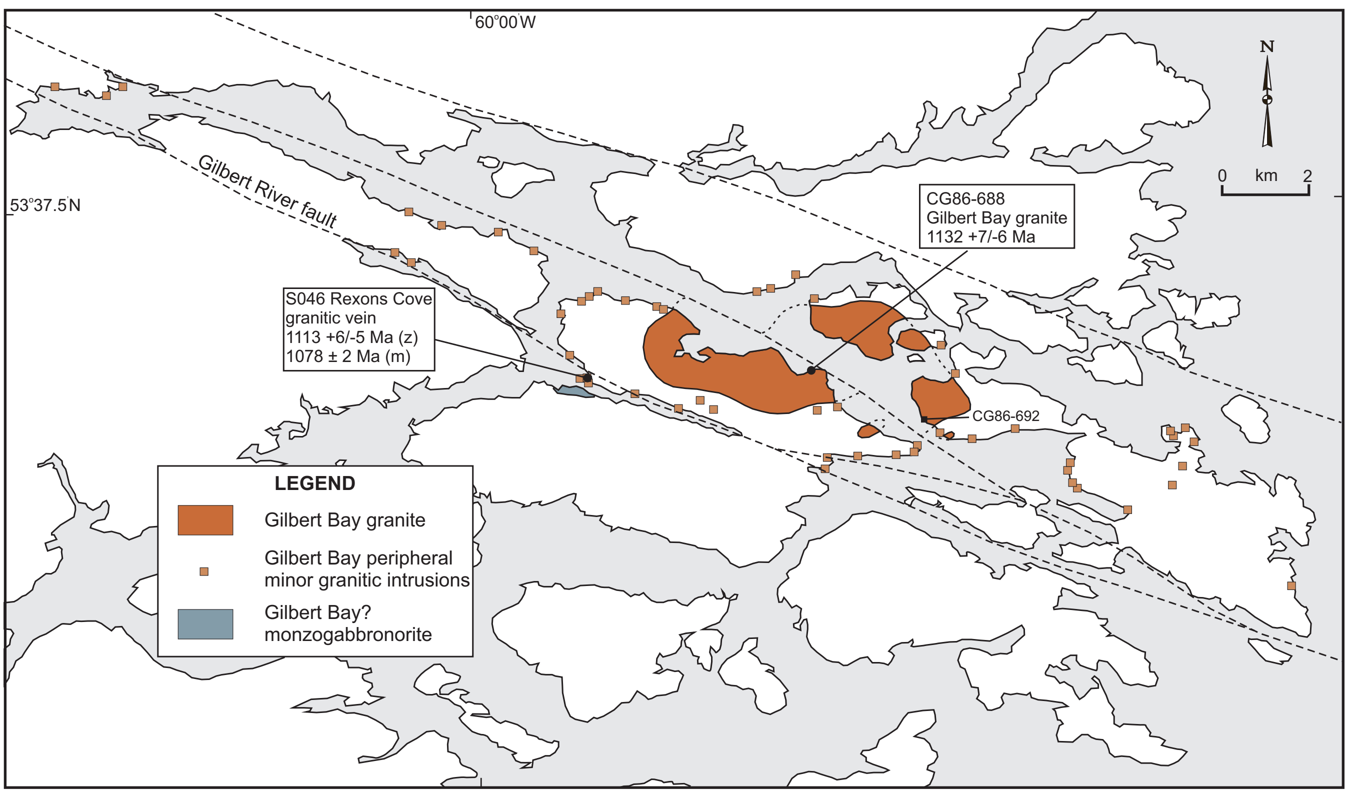


Figure 17.1. *Gilbert Bay granite, peripheral minor granitic intrusions, and Gilbert Bay(?) monzogabbronorite.*

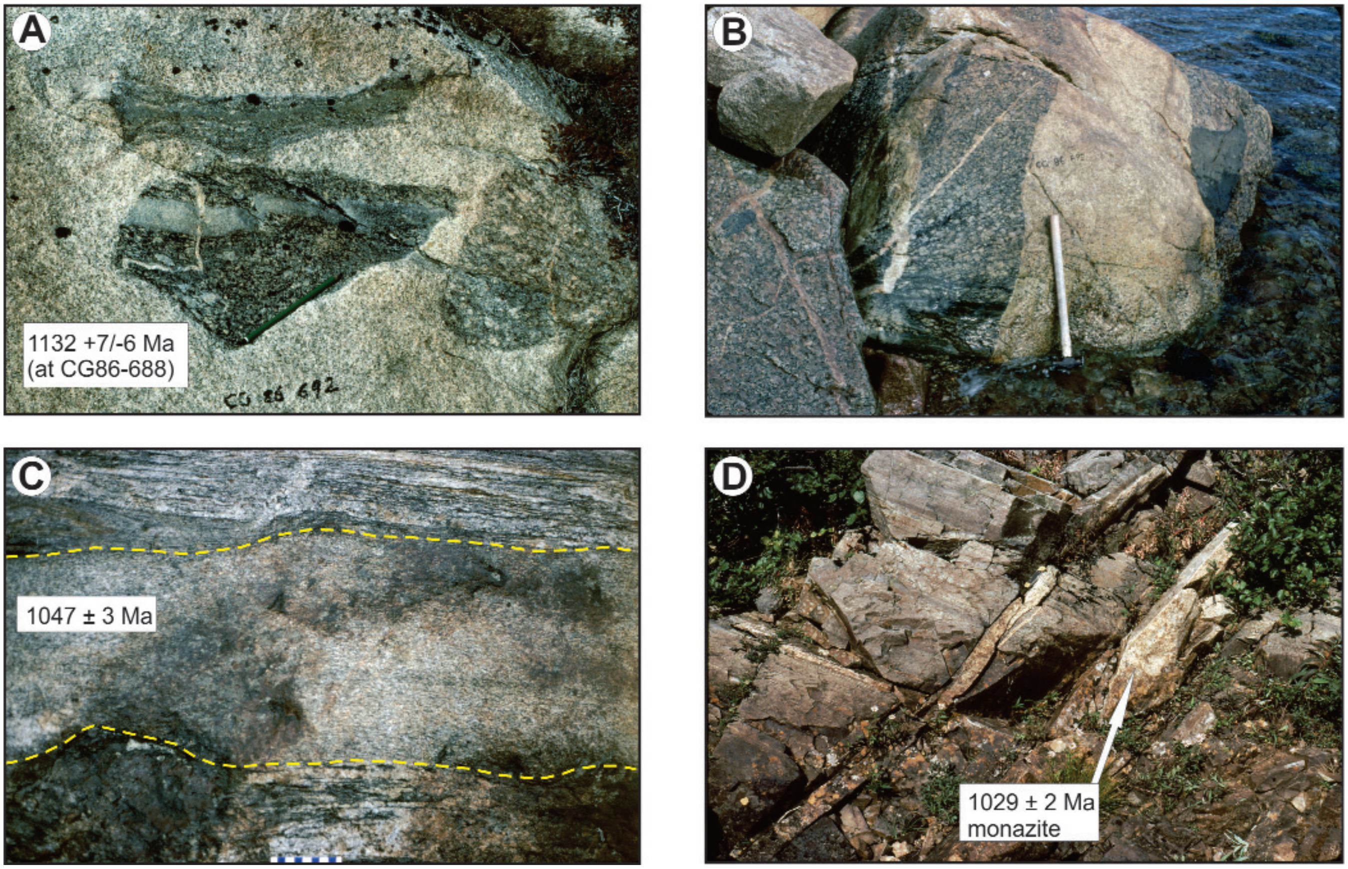


Plate 17.1. *Pre-Grenvillian Gilbert Bay granite and examples of dated syn-Grenvillian minor granitoid intrusions (WBAC– White Bear Arm complex). Zircon ages, where not specified otherwise. A. Gilbert Bay granite hosting enclaves of earlier, strongly foliated K-feldspar megacrystic granitoid rock, intruded by grey microgranite (CG86-692), B. Gilbert Bay granite dyke intruding foliated to mylonitic K-feldspar megacrystic granitoid rock containing amphibolite enclaves (CG86-692), C. Paradise River granodiorite dyke discordantly intruding isoclinally folded gneiss (VN91-264), D. Beaver Brook microgranite dyke discordantly intruding mylonitic, granulite-facies WBAC gabbronoritic rocks (VN84-431/CG84-494).*

tion that affects the host rocks predated emplacement of the pluton (hence was pre-Grenvillian). Rather than being a simple contact with the country rock, the margins of the pluton are marked by increased abundance of enclaves, passing outward into an agmatite.

The pluton is well exposed on the shores of Gilbert Bay, where it consists of light-pink- to buff-weathering, medium- to coarse-grained, homogeneous, massive to weakly foliated, muscovite-bearing, biotite leucocratic granite. Wardle (1976, 1977) reported cavities, possibly of miarolitic origin, at RW75-117. These are elongate in the plane of cleavage and locally contain acicular quartz, biotite books, and epidote. The weak fabric seen in some outcrops was interpreted to be related to pluton emplacement by Gower *et al.* (1987), but the observations of Wardle (1976, 1977) and Hanmer and Scott (1990), plus a re-examination of the field data of Gower *et al.* are now accepted as more persuasive that there was a superimposed regional deformation (Grenvillian), variously imparting a weak foliation, schistosity, jointing or cleavage parallel to the regional trend (*i.e.*, 110°). Closely spaced 020° joints, parallel to and possibly coeval with fractures elsewhere occupied by the 615 Ma Long Range dykes, were recorded at CG86-690.

The Gilbert Bay granite was investigated geochronologically by Gower *et al.* (1991; sample CG86-688). Four zircon fractions were analyzed, three of which were seemingly collinear but slightly discordant. The three fractions yielded an upper intercept of 1132 +7/–6 Ma, interpreted as the time of emplacement of the granite. A fourth fraction plotted to the left of the discordia line and was excluded from the regression. Because of the unexplained and excluded fraction, Gower *et al.* (1991) did not consider the date obtained rigorous, but further dating in the vicinity, by Scott *et al.* (1993), suggests that it is valid (*see* Gilbert Bay peripheral intrusions, next section). The Gilbert Bay granite is intruded by Gilbert Bay alkalic mafic dykes (CG86-693, MN86-188, MN86-190), one of which (MN86-188) has been dated to be 974 ± 6 Ma (Wasteneys *et al.*, 1997).

In retrospect, the sample used for dating the granite was not ideal (CG86-688), as it contained two lithological phases, a slightly foliated dark-grey phase and a massive lighter phase. The site was chosen, however, because of unequivocal field relationships with large gneiss xenoliths within the granite, derived from both igneous and metasedimentary protoliths. The gneisses were intruded by microgranite, then folded and mylonitized. Subsequent mafic dykes were metamorphosed to amphibolite prior to being incorporated as enclaves in the Gilbert Bay granite. The granite, in turn, is intruded by pegmatite.

The granite comprises plagioclase, quartz, microcline, biotite, muscovite, and accessory apatite, allanite, zircon, fluorite, and magnetite (thin sections CG86-688, CG86-690, JS86-197, JS86-201, JS86-204, JS86-206, JS86-207, MN86-189, MN86-190, MN86-193, SN86-197A). Secondary minerals are chlorite, white mica, rutile, hematite, and very rare epidote and carbonate. The absence of titanite and the sporadic presence of fluorite characterize the granite. Plagioclase is anhedral to subhedral, generally well twinned (except where masked by extensive sericitization), shows weak oscillatory zoning, and has clear albitic rims. Microcline is well twinned, and locally accompanied by relict stringlet perthite. Myrmekite is present in many samples. Biotite is anhedral and olive-green. Muscovite occurs as large clear flakes that are interpreted to be primary, and as smaller ragged grains, more likely to be secondary. Allanite forms orange-brown, subhedral to euhedral, locally zoned grains, but is not present in all samples. Zircon typically forms elongate to needle-like grains, is euhedral and colourless. The secondary chlorite, rutile and fluorite are derived from biotite breakdown.

17.1.1.1 Gilbert Bay Granite Peripheral Minor Granitic Intrusions (M_{3A}gr)

The granite is intruded and surrounded by muscovite-bearing granite, microgranite and pegmatite dykes (Plate 17.1B). All investigators in the Gilbert Bay area (Wardle, 1976, 1977; Gower *et al.*, 1987; Hanmer and Scott, 1989) concur that the similarity in appearance between weakly or undeformed minor granitoid intrusions surrounding the pluton and the Gilbert Bay granite indicates genetic linkage. The minor intrusions are typically parallel-sided dykes, ranging in width from a few centimetres up to about 5 m. They are white-, creamy-, light-grey- or pink-weathering, fine to medium grained, or pegmatitic, and characteristically muscovite-bearing. Magnetite was noted to be common at locality RW75-085. The dykes are locally weakly foliated, cleaved or jointed parallel to 100–110°. The fabric is accentuated as the Gilbert River fault is approached. It is noteworthy that the southern limit of the minor intrusions appears to be the Gilbert River fault (Figure 17.1). Gower *et al.* (1991) reported that the minor intrusions occur within an elliptical envelope up to 15 km west-northwest and east-southeast of the pluton but only up to about 3 km across the regional trend. Incorporating information subsequently extracted from the field notes of Wardle, Hanmer and Gower, these figures are revised here to 30 km northwest of the body, 12 km southeast of the body (to the coast), and 4 km wide (Figure 17.1). This pattern clearly indicates that the pre-existing structure has influenced the distribution of the satellite minor granitoid dykes related to the pluton. Intrusive relationships demonstrate that the pluton and its peripheral minor intrusions were emplaced by exploiting fractures and stoping into relatively cool, brittle rocks (in contrast to the late- to posttectonic Grenvillian plutons farther southwest, which had a hotter, ductile emplacement environment).

Three minor intrusions interpreted as satellites to the Gilbert Bay granite were examined in thin section (JS86-212, MN86-209B, SN86-201A). The mineral assemblage is comparable to that described for the granite in the pluton, but showing some minor differences. In the minor intrusions, biotite is less abundant and extensively altered to chlorite, white mica appears to be mostly secondary, accessory minerals are less abundant (allanite is absent), no fluorite was detected, and most of the opaque oxide appear to be secondary.

Scott *et al.* (1993) sampled a granite vein (data station SH89-046; sample S046) from a locality in Rexon's Cove, less than 2 km from the southwest border of the Gilbert Bay granite. The granite vein was interpreted to have been emplaced syntectonically with greenschist-facies mylonitization along the Gilbert River fault. The vein yielded a slightly discordant zircon age of 1113 +6/–5 Ma. A single monazite fraction gave a concordant age of 1078 ± 2 Ma. Scott *et al.*'s preferred interpretation was that the 1113 Ma date represented the time of emplacement of the vein, although they offered an alternative scenario whereby the 1078 Ma monazite age might date emplacement, meaning that the 1113 Ma zircon was inherited. Scott *et al.* (1993) interpreted the Rexon's Cove granite vein as genetically related to the Gilbert Bay pluton. It is probably significant that the imprecise lower zircon intercepts for both ages are similar (*ca.* 482 Ma for the Gilbert Bay granite *vs. ca.* 440 Ma for the Rexon's Cove granite vein), implying that Grenvillian orogenic effects were not severe in these two samples. A pooled regression of the six data points gives an upper intercept of 1117 ± 18 Ma and a lower intercept of 420 ± 150 Ma.

17.1.2 GILBERT BAY? MONZOGABBRONORITE (M_{3A}mn)

Three localities (SN86-206, SN86-207, SN86-219) include an anomalous rock type for the area that cannot be readily accommodated within any of the previously described units. It is a massive, medium-grained, rather fresh-looking monzogabbronorite. It was initially assigned as a Long Range dyke, but it is not in alignment with any known Long Range dyke and, based on the rather meagre knowledge of the rock's distribution, an unusually wide dyke would be implied, if that were the case. The other two likely possibilities for its genetic association are that it is either Labradorian, or of similar age to the Gilbert Bay granite. If it is Labradorian, then it somehow entirely escaped the deformational and metamorphic effects of its associates. The thought (and choice) that it might be similar in age to the Gilbert Bay granite is partly based on close proximity. Regardless of its age, a key point to be captured here is that it is sufficiently different to require attention.

In thin section (SN86-207), plagioclase forms euhedral, primary, well-twinned laths that are weakly zoned and lightly sericitized. K-feldspar has a distinctive habit in that it is an interstitial, late-crystallizing perthite in symplectic intergrowth with quartz. Both clino- and orthopyroxene form subhedral primary grains, albeit slightly corroded at grain margins and replaced by amphibole. Biotite and the opaque minerals are also primary. Biotite forms orange-brown flakes. The opaque mineral is mainly an oxide, but some sulphide is present. Apatite is abundant. The only mineral not obviously primary is a dark-green amphibole that mantles pyroxene and the opaque oxide.

17.1.3 AILLIK MAFIC DYKE CORRELATIVE? (on map as M_{3B}d)

During 1:100 000-scale mapping in 1979, Doherty (field notes, AD79-213, AD79-214) recorded a gabbroic dyke at two locations on the southeast side of the entrance to Abliuk Bight, noting the intrusion to have a width of 15 m and a 095° trend (Figure 17.2). The location is within the area of the preliminary 1:100 000-scale geological map of Gower (1981) for the Byron Bay area, but the dyke is not depicted on that map.

Owen (1985) carried out detailed mapping in the area as part of his Ph.D. thesis. In addition to locating the dyke described by Doherty, he also mapped an on-strike, similarly trending, 20-m-wide dyke to the east, passing through Marks Island and Cut Throat Island. This dyke was correlated with the Abliuk Bight locality to give a total strike length of about 12 km. Owen describes the dyke as brown-weathering, massive, undeformed olivine gabbro having well-defined chilled margins. On the basis of lacking coronitic textures, the dyke is explicitly distinguished from the Michael gabbro, which occurs in the same area. Owen interpreted the dyke to be younger, possibly correlating with the similarly trending Aillik dykes in the Makkovik area (Figure 17.2, inset), for which *ca.* 1000–900 Ma K–Ar ages are available (Gandhi *et al.*, 1969; Wanless *et al.*, 1973).

A thin section of the dyke from Owen's collection (V519-2) has been examined by the author. It has a mostly primary igneous mineral assemblage consisting of subhedral elongate, well-twinned, moderately to strongly twinned plagioclase; pale-brown subhedral to anhedral clinopyroxene; subsidiary olivine; and orange-brown biotite mantling opaque oxide in part. Secondary ragged, colourless to green amphibole and green biotite area also present.

The lack of a significant metamorphic overprint supports a late- or post-Grenvillian emplacement age. Owen (1985) also reported microprobe end-member compositional parameters for olivine (Fo – 39.4) and clinopyroxene (Wo:En:Fs – 38.2:45.8:16.0) for the sample and a whole-rock chemical analysis (duplicated).

17.2 EARLY SYN-GRENVILLIAN INTRUSIONS (M_{3B} *ca.* 1090–1045 Ma) (p, f)

A contrast exists between early and late syn-Grenvillian intrusive activity in eastern Labrador, in that early syn-Grenvillian intrusive activity occurred in the Lake Melville terrane, whereas late syn-Grenvillian intrusive activity (from *ca.* 1045 Ma onward) was in the Pinware terrane, and, to a lesser extent, in the Mealy Mountains terrane (Grenvillian activity in the Hawke River and Groswater Bay terranes was minor). Furthermore, early syn-Grenvillian intrusive activity is confined to miner granitic pegmatite intrusions, whereas later syn-Grenvillian intrusive activity included both minor granitic intrusions and pluton-size granitoid and syenitic bodies. The distribution of early and late syn-Grenvillian intrusions is shown in Figure 17.3. The emplacement ages of four early syn-Grenvillian minor granitic intrusions from the Lake Melville terrane, plus more equivocal age data for a fifth sample (the Beaver Brook microgranite), have been obtained. Details for all five samples are given below.

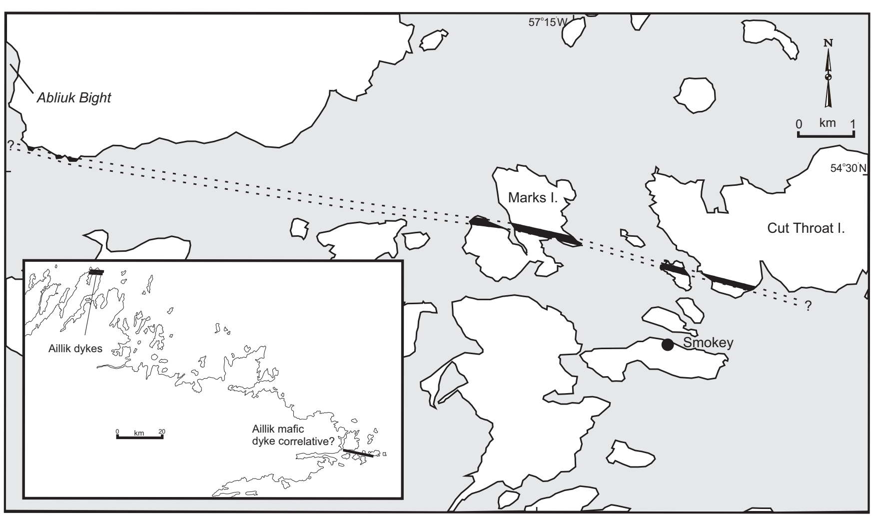


Figure 17.2. *Aillik mafic dyke correlative(?). Inset shows location of Aillik dykes.*

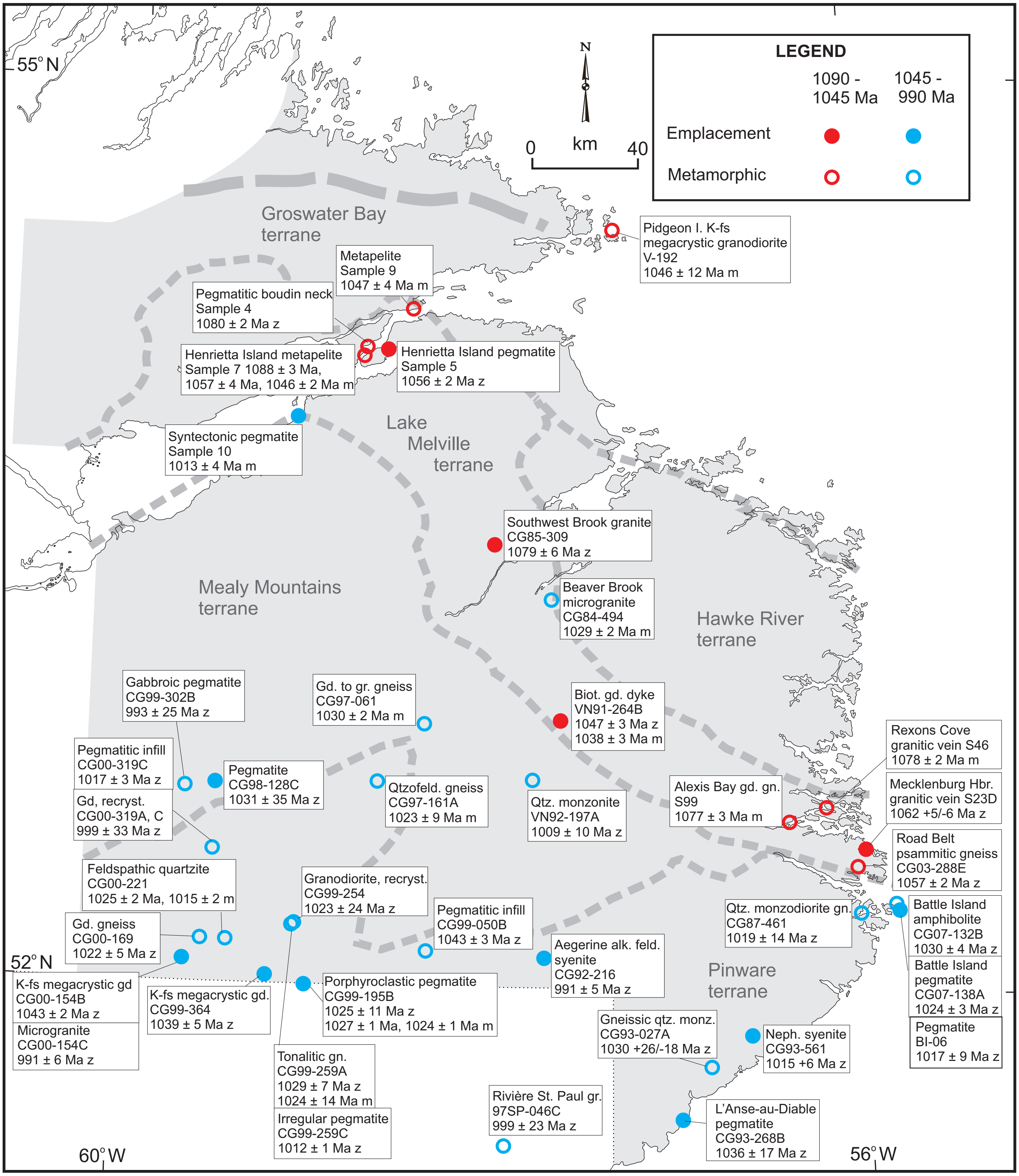


Figure 17.3 *Early and late syn-Grenvillian intrusive and metamorphic zircon and monazite ages.*

17.2.1 HENRIETTA ISLAND PEGMATITE

A pegmatite was selected for dating from the north shore of Henrietta Island by Corrigan *et al.* (2000; sample 5) on the basis of its late syntectonic status inferred from field relationships. The authors wrote that the pegmatite crosscuts leucosome and foliation in its host rock (Rigolet quartz diorite), but itself shows a weak foliation parallel to that in the quartz diorite. It also shows an apophysis intruded along a foliation plane in the quartz diorite and infolded with it. Four fractions of zircon were analyzed, of which three are co-linear (one above discordia line, however) and give an upper intercept of 1056 ± 2 Ma. The age was interpreted as the approximate time that penetrative deformation ceased in the Lake Melville terrane. This conclusion is more-or-less consistent with regionally extensive information dating both emplacement and metamorphic activity elsewhere in the Lake Melville terrane, except that the best-estimate time of termination of deformation and metamorphism is between 1045 and 1040 Ma (*cf.* Gower and Krogh, 2002).

17.2.2 SOUTHWEST BROOK GRANITE

The Southwest Brook granite was originally mapped by Gower *et al.* (1985) and described as pink-weathering, coarse-grained, alkali-feldspar granite containing biotite schlieren and amphibolite enclaves. They noted that it is characterized by a distinct radio-element signature commonly 3 times background, but one outcrop registering up to 20 times background (total counts). It was dated by Schärer and Gower (1988, page 413), who referred to it as "… massive to weakly foliated, K-feldspar rich granite at Southwest Brook (sample CG[85]-309), containing abundant enclaves of earlier gneiss..." (digits '85' were omitted by Schärer and Gower). Three multigrain zircon fractions defined a discordant upper intercept at 1079 ± 6 Ma, with one fraction close to concordia.

Schärer (1991) reported Sm–Nd and Rb–Sr isotopic data for the same sample, these being T_{DM} = 1692 Ma and εNd (1.09 Ga) = –4.92 and, and I_{Sr}(1.09 Ga) = 0.70558 and interpreted the results as indicating that the granite was generated from Labradorian crust.

Following a revisit to the area and further examination of field photographs, Gower *et al.* (1991) concluded that, in areas where exposure was good, the enclaves were the dominant rock rather than the granite. They suggested that it was more likely that the so-called 14-km-wide pluton was, in reality, a stockwork of Grenvillian vein material. This view was repeated by Gower and Krogh (2002), who acknowledged that the dated sample came from one-such vein.

The dated sample consists of well-twinned, weakly zoned, moderately altered plagioclase, microcline, weakly recrystallized quartz, dark-orange-brown biotite, opaque oxide and sulphide minerals, apatite, zircon (with rims) and allanite. Myrmekite is common.

17.2.3 BIOTITE GRANODIORITE DYKE ON PARADISE RIVER

A biotite granodiorite dyke (Plate 17.1C) on Paradise River, recorded by van Nostrand during mapping in 1991 (van Nostrand, 1992), was subsequently revisited and sampled for dating because of excellent kinematic relationships displayed at the outcrop. The locality is very close to the Lake Melville–Mealy Mountains terrane boundary. The biotite granodiorite dyke was dated by Wasteneys *et al.* (1997), who described it as a 1–2-m-wide, medium-grained biotite granodiorite, discordantly intruding sillimanite-bearing metasedimentary gneiss. The gneiss contains large, dextrally rotated garnets in melt pods (Chapter 20). In field photographs from the locality, the dyke is less than 45 cm wide, which is the width reported by van Nostrand in his original field notes, so Wasteneys *et al.*'s reported 1–2 m width is either an overestimate, or an otherwise undocumented observation from elsewhere on the outcrop. The rotated garnets were described and illustrated by van Nostrand (1992) and are up to 4 cm in diameter. The granodiorite dyke carries a foliation parallel to the fabric in the country rock, allowing the most straightforward interpretation that it was emplaced synkinematically (while not denying a separate much earlier migmatitic history for the metasedimentary gneiss). On the basis of two single zircons, the emplacement age of the dyke was determined to be 1047 ± 3 Ma by Wasteneys *et al.* (1997, sample VN91-264B), who also obtained a 1038 ± 3 Ma monazite age from the same sample.

A thin section of the granodiorite dyke consists of relict igneous and metamorphic plagioclase (49%), microcline (13%) and quartz (26%); dark-orange-brown biotite (11%), zircon and monazite; and secondary hematite, rutile and chlorite (the latter two derived from biotite). The modal percentages were reported by Wasteneys *et al.* (1997). Note that, according to these figures, terming it quartz diorite (*cf.* Gower and Krogh, 2002) was erroneous.

17.2.4 MECKLENBURG HARBOUR APLITIC VEIN

A 10- to 15-cm-wide pink aplitic vein (S23D) was sampled for dating at Mecklenburg Harbour by Scott *et al.* (1993) as part of a package from the outcrop that included the host K-feldspar megacrystic granite and two phases of deformed and metamorphosed mafic dykes. The granitic dyke intrudes the megacrystic granite and crosscuts both phases of mafic dykes. It is itself mildly deformed and locally foliated. The author does not have petrographic data from this locality.

The geochronological data obtained by Scott *et al.* remain slightly controversial (*cf.* Gower, 1996). The issue was addressed in Section 10.3.1.1 of this report. Regardless of conflicting interpretations, the lower intercept of 1062 +5/–6 Ma, based on three discordant multigrain zircon fractions, is reasonable for the time of emplacement of the aplitic vein (the alternative interpretation offered earlier renders it a few million years younger).

17.2.5 BEAVER BROOK MICROGRANITE DYKE

The Beaver Brook dyke is a creamy-white-weathering, fine- to medium-grained, weakly to moderately foliated microgranite to microgranodiorite. It discordantly intrudes highly tectonized, granulite-facies ultramylonitic gneiss associated with one of the several thrusts marking the boundary between the Lake Melville and Hawke River terranes. (Note that this is not the same Beaver Brook as that for the Upper Beaver Brook intrusion referred to later). Several parallel, steeply dipping dykes are exposed at the locality (VN84-431 and CG84-494), ranging in width from 1 to 30 cm, all at about 70° discordance to the mylonitic fabric (Plate 17.1D).

The rock, in thin section (CG84-494), shows primary, severely sericitized plagioclase; primary, poorly twinned K-feldspar; and partially recrystallized quartz. Red-brown biotite (defining a foliation and extensively chloritized) and opaque minerals (both oxide and sulphide) are also primary phases. Accessory minerals are apatite and allanite, and secondary white mica and chlorite are also present. The thin section is granodiorite rather than granite, but the (poorly stained) slab is ambiguous. No whole-rock chemical analysis is available.

The sample was investigated geochronologically by Schärer *et al.* (1986; sample CG[84]-494). Three fractions of equant to elongate prismatic zircon grains, one fraction of needle-like zircons and one fraction of monazite were analyzed. The monazite yielded a concordant age of 1029 ± 2 Ma. When regressed with the three fractions of equant zircon grains, an upper intercept of 1566 ± 13 Ma is obtained. The needle-like zircon analysis is close to the monazite result, but plots below the regression line. Schärer *et al.* (1986) interpreted the 1029 Ma monazite age to be the time of intrusion and that the needle-like zircons to be also Grenvillian, but experienced later Pb loss. The 1566 Ma result was interpreted as inheritance. Although field and petrographic data dictate that the rock must be Grenvillian, the distribution of ages shown in Figure 17.3, suggests that a 1029 Ma date is slightly anomalously 'young' for its location, by about 20 million years. As the date is defined by only one monazite result, and because the needle-like (Grenvillian) zircon plots off the regression line, a case can be made for doubting the reported emplacement age. Anchoring the regression line upper intercept at 1640–1630 Ma (the now-known time of emplacement of the WBAC host rock) to determine a new lower intercept might have marginal merit.

17.3 LATE SYN-GRENVILLIAN INTRUSIONS (M_{3B} *ca.* 1045–985 Ma)

17.3.1 FOLD-TEST INTRUSIONS (M_{3B}gp)

The Fold-Test intrusions are a series of lensoid K-feldspar megacrystic granodiorite to quartz monzonite bodies that are interpreted to be the dismembered remnants of a single intrusion, which (along with associated rocks) wrap around the nose of a northeast-closing reclined fold (Figure 17.4). The K-feldspar megacrystic granitoid rocks are confined to the southern 40 km of the fold axis that, in its entirety, can be traced in Labrador for 135 km from the Trans-Labrador Highway in the northeast to the Labrador–Québec border in the southwest. The Fold-Test intrusions are so-named because samples of the megacrystic granitoid rock were collected and dated from each limb of the fold to ascertain whether or not the K-feldspar megacrystic units do, in

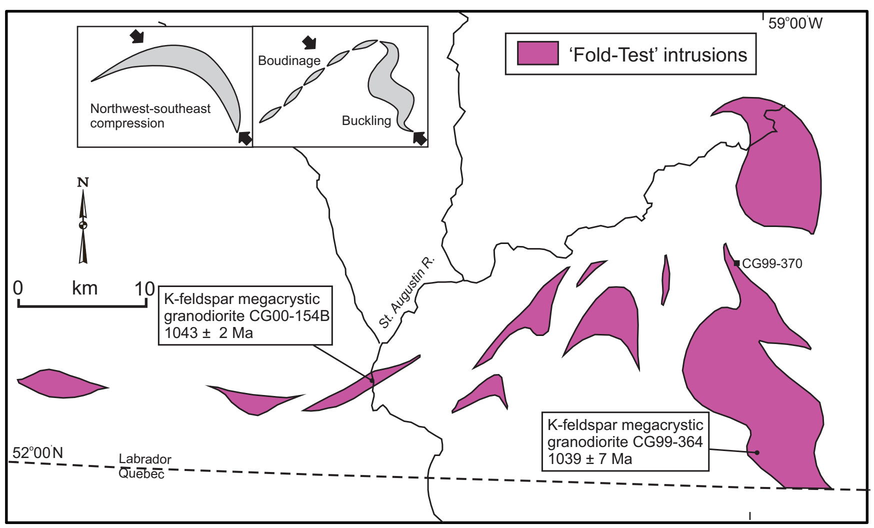


Figure 17.4. *'Fold-Test' intrusions, so-called because, by ascertaining if bodies of similar-looking K-feldspar megacrystic granitoid rocks correlate on either side of the fold, then the existence of the fold is demonstrated and a maximum age for folding determined. Inset illustrates (simplified) how present outcrop distribution could be achieved through differing deformation response on opposite limbs of a crescent-shaped body.*

fact, correlate. In addition, of course, if such a correlation is found, then a maximum age for folding is implied.

The Fold-Test intrusions are a fairly distinctive and easily mappable rock type that show only modest variation from one area to another (Plate 17.2A, B; Appendix 2, Slab 17.2). Gower (2000, 2001) considered that the separate bodies either originally belonged to a single intrusion that has subsequently been disrupted by deformation, or are still linked at depth. On the western flank of the fold, the unit is

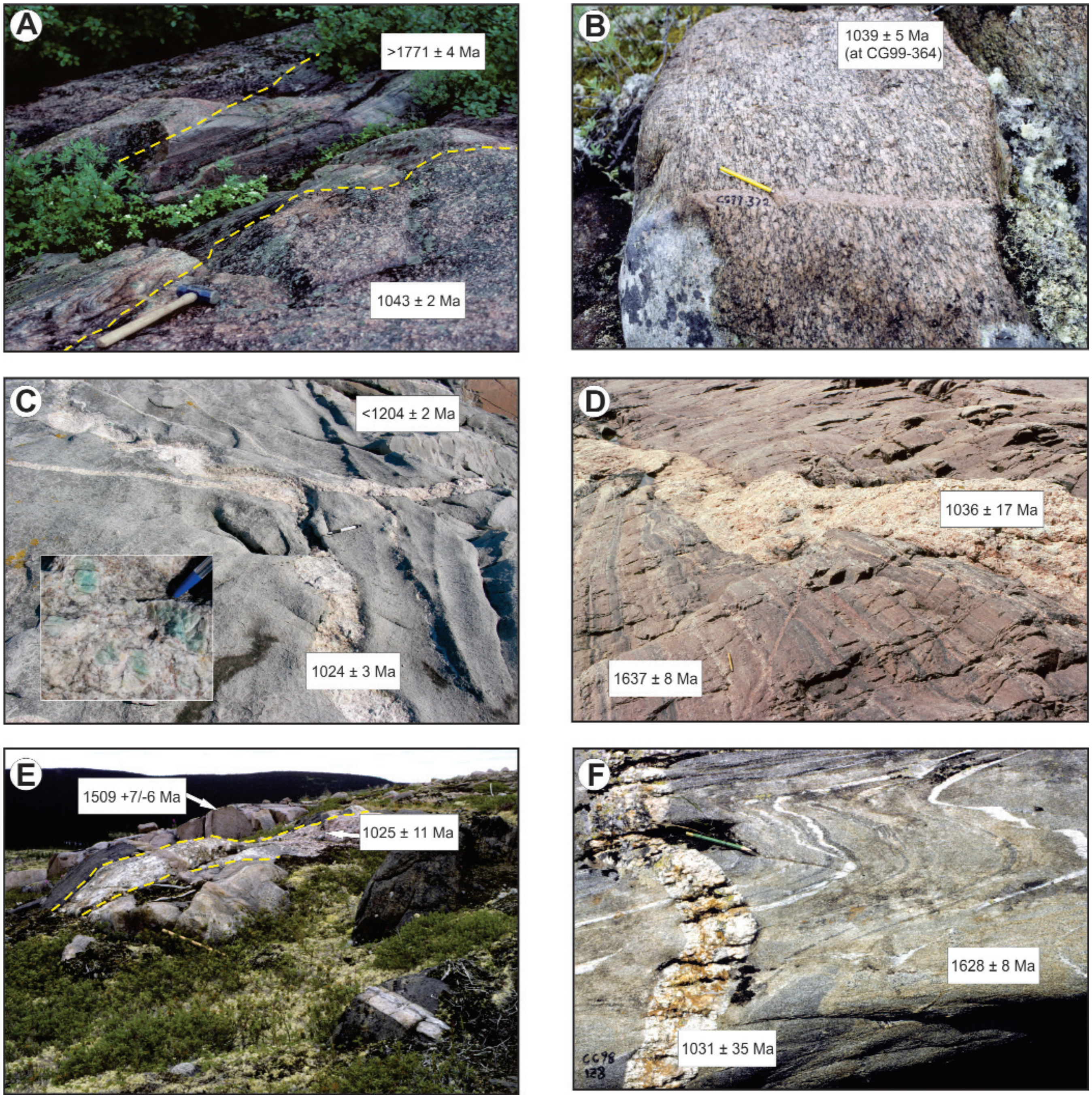


Plate 17.2. *Syn-Grenvillian 'Fold-Test' K-feldspar megacrystic granitoid unit and examples of dated syn-Grenvillian pegmatites. A. Enclave of quartzofeldspathic gneiss in 'Fold-Test' K-feldspar megacrystic granitoid unit, west flank (CG00-154), B. 'Fold-Test' K-feldspar megacrystic granitoid unit, east flank (CG99-370), C. Battle Island amazonite-bearing (*cf. *inset) pegmatite (CG07-138A).* See *also Plate 16.1D, D. L'Anse-au-Diable pegmatite (CG93-268).* See *also Plates 13.2D and 17.6B, E. Porphyroclastic pegmatite – outlined in yellow CG99-195).* See *also Plate 13.5E, F. Pegmatite emplaced during late stage of folding in host amphibolite gneiss (CG98-128).* See *also Plate 10.10A).*

associated with other K-feldspar megacrystic rocks, but is distinguished from them on the basis of relative high mafic mineral (biotite) content. Irregular amphibolite enclaves measuring roughly 30 by 10 cm are present sporadically and the rocks are discordantly intruded by planar microgranite dykes and a few minor, narrow pegmatites. A metamorphosed mafic dyke was seen at one outcrop (CG99-319).

The contrast in shape and distribution between segments on the western *vs.* eastern limbs can be explained as related to the differing orientations of the body within the limbs of the developing fold. Given that regional compression is northwest–southeast (as evidenced by thrust vergence in eastern Grenville Province allochthons), the western limb would tend to boudinage, whereas the eastern limb would buckle (Figure 17.4, inset).

The rocks are pink-weathering, coarse grained, homogeneous, weakly to extensively recrystallized and, typically, massive to moderately foliated. Some rocks have a strong foliation, and mylonitic fabrics are present locally. Nowhere are they gneissic or migmatized. K-feldspar megacrysts are subhedral to euhedral and have typical dimensions of 2 by 1 cm, but range up to 4 by 3 cm. The megacrysts are mostly uniform, without mantled textures (in contrast to the late- to post-Grenvillian granitoid intrusions). Rarely, however, some indication of internal plagioclase shells is present in the form of concentrically arranged plagioclase inclusions within the K-feldspar.

The unit has been well-examined petrographically (CG99-200, CG99-297, CG99-298, CG99-319, CG99-334, CG99-364, CG99-365, CG99-367, CG99-390, CG00-027, CG00-154B, CG00-177, CG00-211, CG00-229, CG00-269). As no major petrographic contrasts were detected, a collective description is given, with the caveat that sample CG00-027 may be more metamorphosed and belong to an earlier unit. Excluding that sample, the rocks have a primary to relict igneous texture. Plagioclase is anhedral to locally subhedral, poorly to moderately twinned, moderately sericitized, weakly to moderately zoned and shows albitic borders adjacent to K-feldspar (explaining white feldspar rims to mantle K-feldspar megacrysts seen in stained slab). The K-feldspar megacrysts are mostly well-twinned microcline, but show vestiges of flame perthite. Quartz is undulose and fractured, but is not extensively recrystallized. Both biotite and amphibole are present, except for CG99-298 and CG00-229, which lack amphibole. The biotite is poorly to moderately aligned and olive-green to buff, although has a stronger orange hue in some samples. Amphibole is mostly a green-brown to blue-green hornblende, but relict crystals of a colourless amphibole (*cf.* cummingtonite) are present in CG99-319. Vermiform quartz inclusions are common in biotite, and locally present in amphibole. The sole opaque mineral is an oxide, except for samples CG99-200 and CG99-390, which contain traces of sulphide. Other accessory minerals are apatite, titanite, allanite and zircon. Titanite typically occurs as mantles around the opaque oxide, but is also locally independently associated with mafic silicates. Allanite (fairly large grains) and zircon are also present. The mafic and accessory minerals occur in clusters that look like they formed at the expense of pyroxene and suggest, together with zoned plagioclase, evolution of the magma during emplacement.

Prior to geochronological study, the best judgement regarding age of emplacement was that the K-feldspar megacrystic unit postdates most of the other gneissic and foliated granitoid rocks in the region, but predates the late- to post-Grenvillian plutons. This inference was based on the bodies having relatively coherent form, homogenous aspect, and lacking severe recrystallization. Gower (2000, 2001) preferred a syn-Grenvillian time of emplacement, but allowed that an older age was possible.

For the Fold-Test dating, sample CG00-154B was selected from the western limb of the fold (an older gneiss enclave and younger microgranite were also dated from this site – CG00-154A, CG00-154C, respectively – *cf.* Sections 13.1.2.1, 17.3.4.4), and CG99-364 from the eastern limb. Both samples are pink-weathering, coarse-grained, recrystallized, moderately foliated and homogenous K-feldspar megacrystic biotite granodiorite to quartz monzonite. Sample CG00-154B yielded a concordant age of 1043 ± 2 Ma from zircon, interpreted to date emplacement. Sample CG99-364 yielded a concordant zircon emplacement age of 1039 ± 7 Ma (titanite ages were also obtained from both samples and are addressed elsewhere in this report). The emplacement ages obtained for the two samples are thus identical within analytical error and substantiate the hypothesis that the mapped unit is a single entity (Gower *et al.*, 2008b), and that the folding is Grenvillian.

17.3.2 TROUT RIVER HEADWATERS PLUTON? (M_{3B}gr/PMgr)

Although a roughly 8-km-wide granitoid body is addressed here under the name 'Trout River headwaters pluton' (Figure 17.5), considerable doubt exists as to its existence. The 'pluton' was not separately distinguished by Gower *et al.* (1988), the area being shown as Upper- or Middle Proterozoic 'Group II' granitoid rocks. In addition, it was neither shown on the 1:100 000-scale preliminary map for the St. Lewis River area, where it was depicted as Middle Proterozoic alkali-feldspar granite, nor on the geological compilation map for eastern Labrador by Gower (1995). Representation of a pluton made on the St. Lewis River map of Gower (2010a) is based on a reassessment of field descriptions, stained slabs, petrographic data, and greater interpretational weighting being given to a doughnut-shaped positive magnetic anomaly underlying the area. Assigning a syn-Grenvillian age is speculative.

The rocks are pink-weathering, weakly to moderately foliated, medium- to coarse-grained, granite to alkali-feldspar granite. They are also homogeneous, lacking in migmatitic fabrics and are not severely recrystallized. A few biotite-rich and amphibolite enclaves are present, as are sporadic minor granitic intrusions.

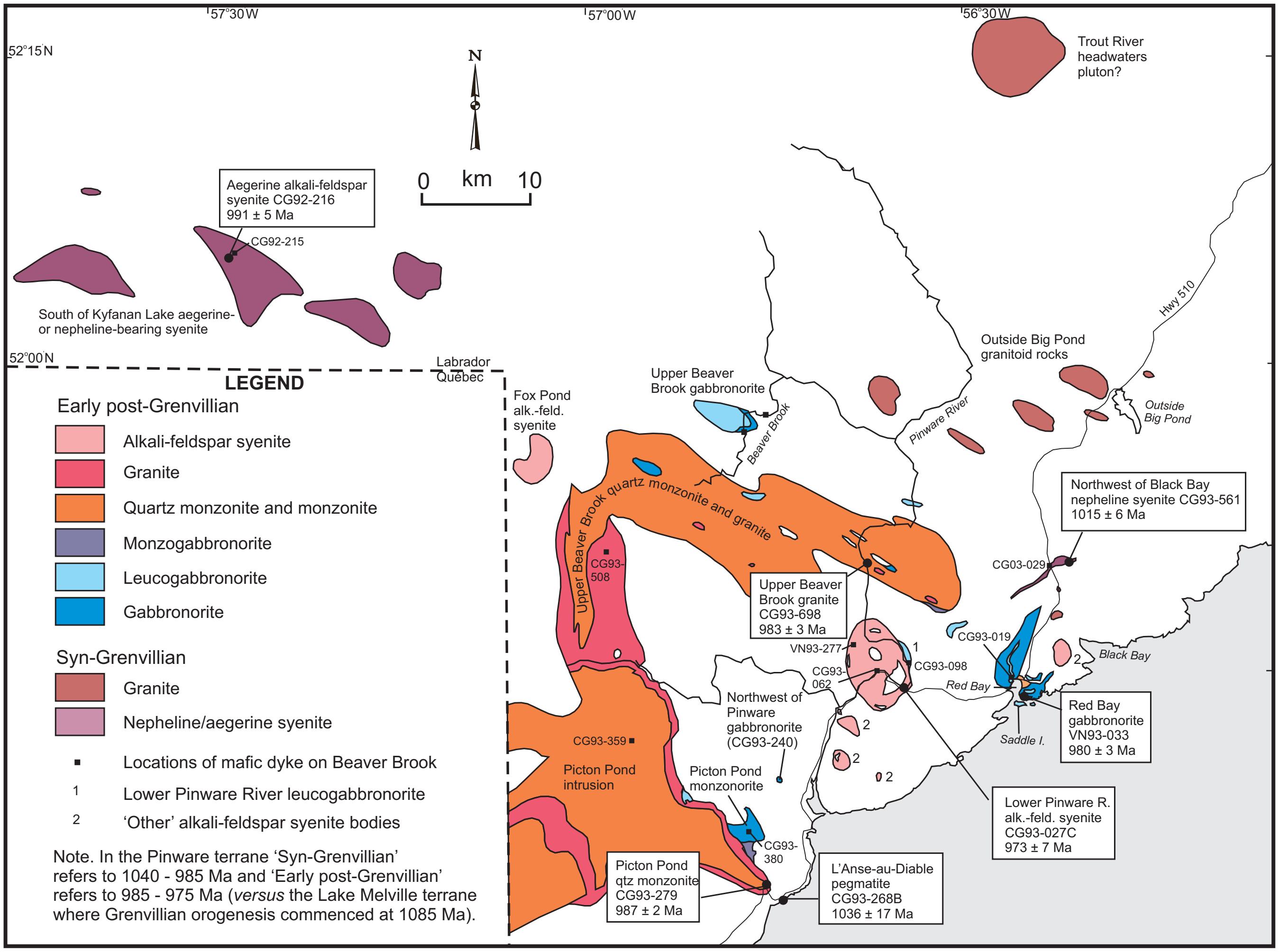


Figure 17.5. *Late syn-Grenvillian and early post-Grenvillian intrusions in the Pinware terrane.*

Two thin sections are available (CG87-101, CG87-114). Both contain anhedral, relict igneous plagioclase, microcline, quartz and orange-brown biotite, oxide and sulphide opaque minerals, and accessory apatite, titanite and zircon. In addition, one of them (CG87-101) contains relict igneous hornblende and clinopyroxene.

17.3.3 OUTSIDE BIG POND GRANITOID ROCKS (M_{3B}gr/PMgr)

Pale-pink- or creamy-buff-weathering, medium- to coarse-grained, weakly to moderately foliated granite to alkali-feldspar granite mostly seen west of Outside Big Pond (Figure 17.5) has been distinguished as a separate unit because: i) the rocks show textural differences, in particular being coarser grained, ii) the rocks appear to be less deformed and unmigmatized – in fact only slightly recrystallized, and iii) enclaves of foliated, fine- to medium-grained granitoid rocks were found in the granite at some outcrops, indicating that these rocks postdate some deformation. These features could be taken as an indication that they postdate foliated granitoid rocks elsewhere in the map area, but they do not demand a syn-Grenvillian age. The rocks could be older (*e.g.*, PMgr), but are unlikely to be younger.

Three thin sections examined (CG93-668, CG93-787, CG93-796) are all granite and are similar in that plagioclase is subhedral to anhedral and well twinned, K-feldspar is microcline and has an interstitial habit, and all contain allanite. The samples differ in that two are biotite bearing, and the other has accessory clinopyroxene altered to amphibole and biotite. The habit of microcline and the presence of allanite distinguish these granites from those described subsequently in this report.

The elliptical body of this unit indicated 8 km west of Outside Big Pond is largely pegmatite and is assumed to be a late differentiate of the granite, but may be unrelated.

A thin section of a sample (CG93-784) from an outcrop where there is a mixture of granitoid rocks in a leucogranite devoid of mafic silicate minerals, except minor secondary chlorite. Accessory minerals are limited to an oxide opaque mineral and some large, euhedral zircons.

Two small bodies of granite northwest of Black Bay were grouped with 'other alkali-feldspar syenite bodies' by Gower *et al.* (1994), although they acknowledged that the justification for doing so was weak.

A sample examined in thin section (CG93-309) is biotite granite containing minor hornblende, and is similar to the Outside Big Pond granitoid rocks, so it has been reassigned to this section, although the reclassification does not have a great deal more merit.

17.3.4 LATE SYN-GRENVILLIAN MINOR GRANITIC INTRUSIONS (p, f)

17.3.4.1 Battle Island Pegmatite

Although grouped here under the heading of syntectonic pegmatite it is clear that, based on varied state of deformation and crosscutting relationships, pegmatites on Battle Island were emplaced during several events, extending from syn- to posttectonic.

Pegmatite is found in all parts of Battle Island, but is particularly abundant along the spine of the island (Figure 16.7). The pegmatites vary in width from dykes tens of metres wide, to veins less than 1 cm, but most intrusions typically have decimetre- to metre-scale widths. Contacts against the host metasedimentary rocks are sharp and commonly irregular due to post-emplacement deformation. Concordant and discordant pegmatites are both present. Concordant screens of psammite and calc-silicate rock are common in the larger pegmatites, and have maintained their original pre-pegmatite-injection orientation, suggesting a passive, *lit-par-lit* type of intrusion. *En échelon* pegmatites exhibiting bayonet terminations and bridge features are common. The rocks are almost entirely coarse or very coarse grained; aplitic rocks are extremely rare. In addition to quartz and feldspar, the pegmatites may contain biotite, muscovite or hornblende, and accessory minerals such as Fe–Ti oxide, zircon, monazite or allanite, and, rarely, garnet or fluorite.

A pegmatite from the southern end of the island (Figures 16.7 and 17.3) was collected for U–Pb geochronological study by Peressini (2000, sample BI-06). Six zircon fractions (three single zircons and three multigrain) were analyzed by S. Carr at Carleton University, which gave $^{207}Pb/^{206}Pb$ ages between 883 +33/–34 Ma and 1138 +252/–301 Ma. High errors from three fractions were recognized to be due to analytical problems and discarded. The remaining fractions gave a $^{207}Pb/^{206}Pb$ age of 1017 ± 9 Ma.

Two pegmatites containing amazonite were found on the east side of Battle Island. Each was traced about 50 m. Both pegmatites are boudinaged and appear to be among the earliest present on the island.

One of the amazonite-bearing pegmatites was examined in thin section and selected for dating (CG07-138A; Plate 17.2C). It comprises slightly recrystallized quartz, moderately sericitized, well-twinned plagioclase having albitic borders, well-twinned microcline, interstitial muscovite, an opaque oxide, partially metamict monazite, zircon, traces of chlorite, and a dark-brown poorly preserved mineral that is suspected to be allanite. The accessory minerals are unusually abundant in this pegmatite.

High Pb content of the rock indicated by the amazonite is confirmed by a whole-rock geochemical analysis of the pegmatite. High Nb and Ta suggest that this type of pegmatite might have potential for columbite–tantalite mineralization (Gower, 2009). During dating, a large quantity of zircon was recovered from this sample but the grains were pervasively cracked and extensively altered. Data for three grains are collinear including one concordant grain. These give an upper intercept age of 1024 ± 3 Ma and a lower intercept of 284 ± 83 Ma. The time of emplacement of the pegmatite is taken as 1024 ± 3 Ma (Kamo *et al.*, 2011). This is within error of a 1030 ± 4 Ma zircon age from an amphibolite (Figure 16.7) on Battle Island that was interpreted to date time of metamorphism (Kamo *et al.*, 2011).

The amazonite-bearing pegmatites are crosscut by near planar, but still deformed, later pegmatites. In one of them, an unidentified, opaque, non-magnetic mineral showing iridescent-weathering is common (probably hematite, *cf.* Gower, 2010c, his Appendix 2). This pegmatite (CG07-138B) discordantly crosscuts the amazonite-bearing pegmatite (CG07-138A) and was also investigated geochronologically. It contains unrecrystallized quartz, moderately sericitized plagioclase, well-twinned microcline, but very little else (rare traces of muscovite and an opaque oxide). During geochronological investigation, four of the clearest, least-cracked grains gave 4 different ages: 1784 ± 2.2 Ma (1.1% discordant), 1701 ± 2.2 Ma (1.3% discordant), 1208 ± 3.0 Ma (1.1% discordant), and 1120 ± 2.0 Ma (0.9% discordant). Because the pegmatite intrudes sample CG07-138A and thus is younger than 1024 Ma, these grains must all be inherited. From the regional context, in all likelihood this pegmatite is not much younger than 1024 Ma, as the pegmatite is deformed and clearly affected by Grenvillian deformation (Kamo *et al.*, 2011).

17.3.4.2 L'Anse-au-Diable Pegmatite

One pegmatite that has received particular attention is located in the L'Anse-au-Diable area (locality CG93-268). The pegmatite is planar-sided, 1 m wide, and shows both internal and marginal deformation (Plate 17.2D). It discordantly intrudes a banded volcaniclastic(?) rock and is itself intruded by an alkaline mafic dyke that is, in turn, crosscut by a sheared felsic veinlet. From the pegmatite, a concordant analysis based on 6 zircon fragments broken away from the outer parts of larger grains, has an age of 1049 ± 30 Ma. If this result is combined with data from the host, banded, quartzofeldspathic rock (dated to be 1637 ± 8 Ma), then an age of 1036 ± 17 Ma is obtained for the pegmatite, which makes this pegmatite the oldest dated Grenvillian intrusion in the Pinware area.

The mineral assemblage (sample CG93-268B) is quartz, alkali feldspar, plagioclase, together with trace ragged green biotite, opaque minerals and zircon, and secondary white mica, chlorite and hematite (Wasteneys *et al.*, 1997).

17.3.4.3 Porphyroclastic Pegmatite

This pegmatite (CG99-195B; Plate 17.2E) was investigated as part of a geochronological study of a 'key' outcrop by Gower *et al.* (2008b). The host rock is a foliated, streaky-textured biotite granite, which yielded an age of 1509 +7/–6 Ma, with which a coarse-grained, massive to foliated meta-gabbro to amphibolite is associated. The metagabbro/ amphibolite is intruded by a white-weathering, heterogeneous-textured porphyroclastic pegmatite. All of these rocks are discordantly intruded by microgranite and pegmatite dykes.

The porphyroclastic pegmatite contains plagioclase, quartz, biotite, amphibole, oxide and sulphide opaque minerals, plus zircon and allanite. No K-feldspar was seen in either thin section or stained slab (*i.e.*, the pegmatite is tonalitic).

In addition to inherited zircon, the pegmatite contains a small quantity of euhedral, colourless zircon, two fractions of which indicate an upper intercept age of 1025 ± 11 Ma. Two monazite analyses give ages of 1027 ± 1 Ma and 1024 ± 1 Ma.

17.3.4.4 Microgranite on St. Augustin River

A microgranite dyke was investigated as part of a geochronological study of a 'key' outcrop. The microgranite discordantly intrudes foliated K-feldspar megacrystic granodiorite (CG00-154B), which itself contains enclaves of quartzofeldspathic gneiss (CG00-154A). Gower *et al.* (2008b) interpreted the quartzofeldspathic gneiss to be of sedimentary origin and to have a minimum depositional age of 1771 ± 4 Ma. The K-feldspar megacrystic granite yielded an age of 1043 ± 2 Ma (Plate 17.2A). The microgranite dyke (CG00-154C) postdates the foliation in the megacrystic granodiorite, but the felsic minerals are recrystallized and the dyke itself carries a foliation, defined by biotite. An age of 991 ± 6 Ma (U–Pb zircon) was reported by Gower *et al.* (2008b), allowing this intrusion to be assigned as late syntectonic Grenvillian, as suggested from field relationships and fabrics. Two fractions of titanite from the dyke yielded ages of 972 ± 2 Ma and 958 ± 3 Ma.

17.3.4.5 Second Choice Lake Pegmatite

A pegmatite (CG84-495C), less than 1 m wide, was analyzed as part of another 'key-outcrop' study (Plate 10.8C). The pegmatite discordantly intrudes banded migmatitic gneiss (CG84-495A; located on Figure 10.1) dated by Schärer *et al.* (1986) to be 1677 +16/–15 Ma. Three zircon fractions were interpreted as inherited, projecting to a *ca.* 1690 Ma upper intercept, and having a lower intercept consistent with a 1003 ± 6 Ma age based on two near-concordant titanite analyses (Gower *et al.*, 1991). From the same sample, Schärer (1991) reported Sm–Nd isotopic values of T_{DM} = 1975 Ma and εNd (1.003 Ga) = –9.63, concluding that the pegmatite was generated from Labradorian crust. This sample was not analyzed for Rb–Sr isotopic data.

17.3.4.6 Pegmatite, Mealy Mountains Terrane

As part of a geochronological study of a key outcrop in the Mealy Mountains terrane aimed primarily at dating quartzofeldspathic gneiss (Section 10.4.1.1), a late synkinematic pegmatite gave an age of 1031 ± 35 Ma, based on two single zircons, or 1029 ± 29 Ma, when integrated with data obtained from other samples at the same outcrop (Gower *et al.*, 2008b; sample CG98-128C). The pegmatite is slightly buckled in a manner consistent with it having been emplaced during the waning stages of folding that affected its host rocks (Plate 17.2F).

17.3.5 NEPHELINE-BEARING SYENITIC ROCKS

17.3.5.1 Northwest of Black Bay Nepheline Syenite (M_{3B}yn)

Nepheline-bearing alkali-feldspar syenite was discovered 10 km north-northeast of Red Bay during 1:100 000-scale mapping (Plate 17.3A). It is white-weathering, medium to coarse grained, recrystallized and weakly to moderately foliated. Nepheline occurs as easily recognizable chalky-white grains in hand sample. The body is probably less than 200 m wide. Its length is uncertain. It was initially reported to be about 1 km long (Gower *et al.*, 1994), but Gower *et al.* (1995) indicated that the body could be much larger, following re-examination (by the author) of thin sections prepared for H. Bostock during his investigation (Bostock, 1983). One thin section, from a site 3.5 km southwest of Gower *et al.*'s (1994) discovery locality, contains an altered mineral that Bostock, at the time, listed as an 'unknown'. Given: i) the characteristic alteration of the mineral, ii) that the hand sample is essentially identical to the nepheline syenite recorded by Gower *et al.* (1994), and iii) that the two localities are on strike, the 'unknown' can now be confidently identified as nepheline. (Other considerations aside; this discovery is a good example of the value of retaining samples from previ-

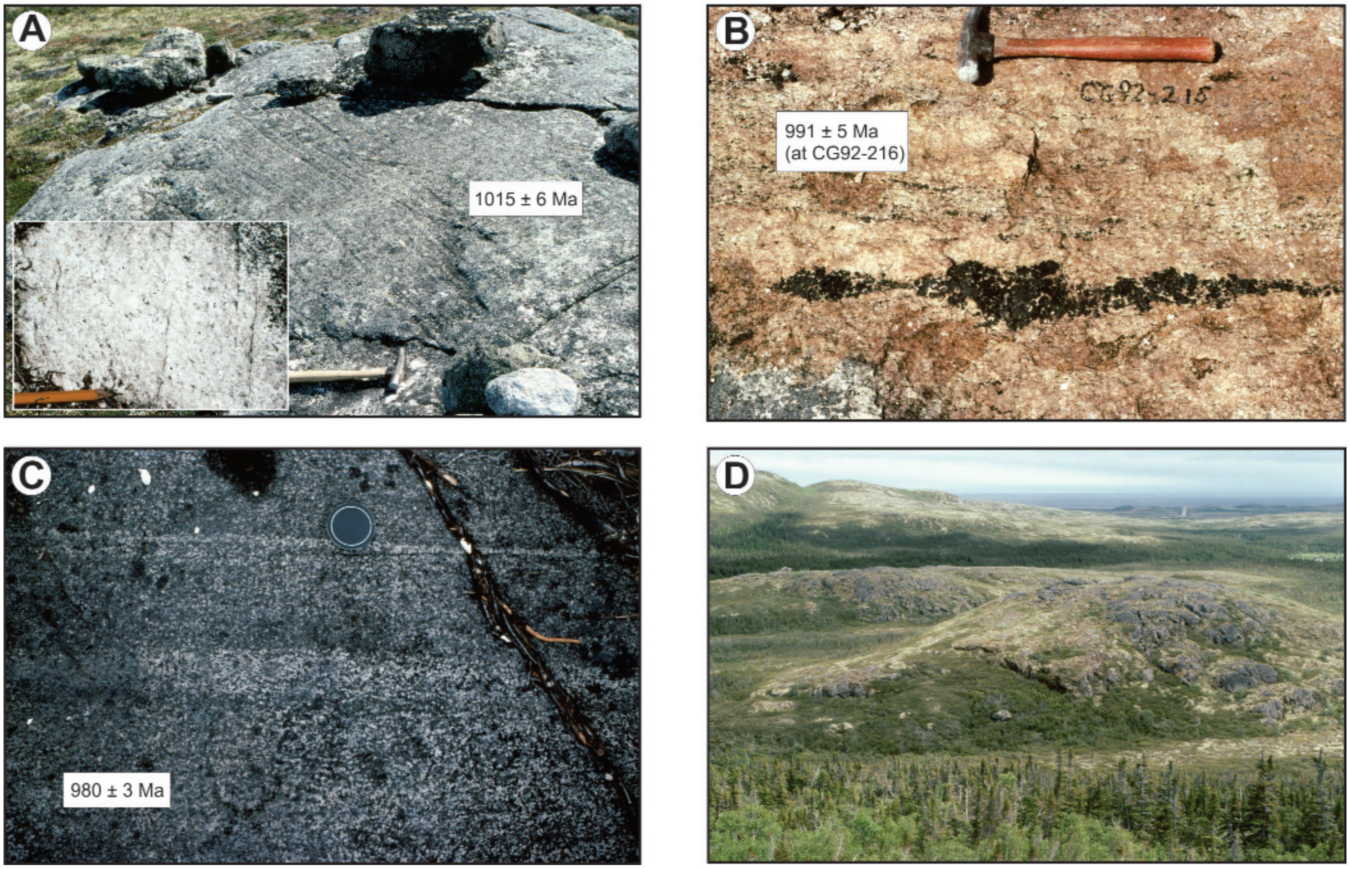


Plate 17.3. *Late syn-Grenvillian alkali-feldspar syenite intrusions, and early post-Grenvillian mafic bodies. A. Nepheline-bearing syenite. Nepheline is chalky-white mineral in inset (CG93-561), B. Aegerine-bearing syenite. Dated locality is 260 m southwest of this site (CG2-215), C. Red Bay gabbronorite showing diffuse primary igneous layering (VN93-033), D. Northwest of Pinware gabbbronorite (undated). Dark-weathering knolls are easily distinguished from granitoid rocks in surrounding hills (CG93-240).*

ous surveys.) The minimum strike length of the nepheline syenite is thus now inferred to be at least 4.5 km, trending in a northeast direction; aerial photographs suggest that it could be longer. The body, when fully mapped out, will form a valuable marker unit in a structurally complex area. Based on the above information, it was anticipated that the unit might be exposed by roadcuts resulting from construction of the road between Red Bay and Mary's Harbour. It was found within 100 m of where predicted.

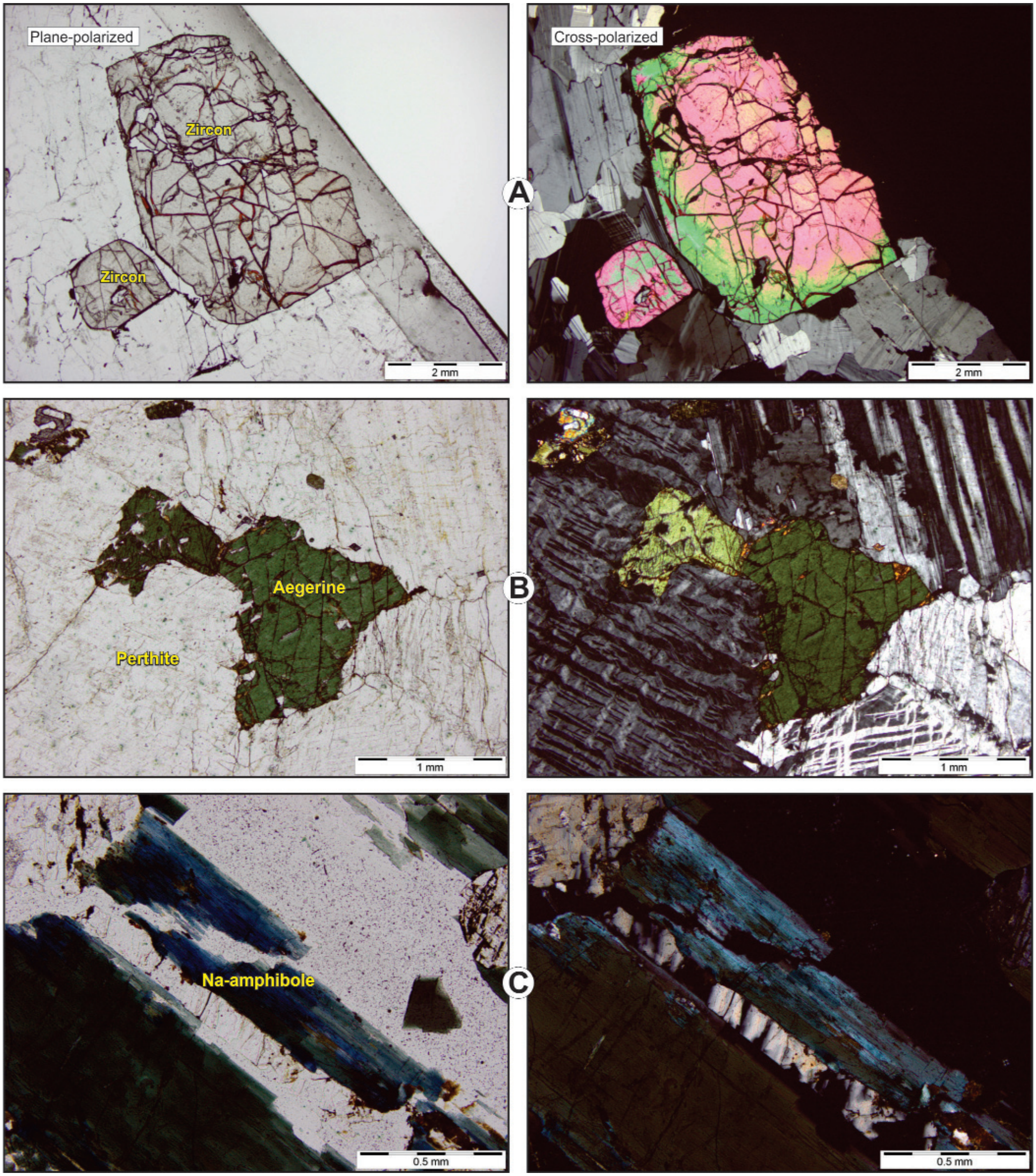
The nepheline syenite has been dated by Heaman *et al.* (2004; sample CG93-561) to be 1015 ± 6 Ma, based on three multigrain zircon fractions, one of which is concordant, and one nearly concordant.

The mineral assemblage from four sections examined (CG03-029B, CG93-478, CG93-561B, CG93-561C) consists of well-twinned albite, microcline, nepheline, large zircon grains (up to 0.5 cm; Photomicrograph 17.1A) and magnetite. A few small flakes of biotite are present marginal to the magnetite and may be secondary. Secondary white mica is also present. From hand-sample and thin-section estimates, nepheline forms about 40% of some rocks. Magnetite, aegerine(?) and garnet were provisionally identified in hand sample, but were not included in the thin sections cut, so their identification remains unconfirmed.

One sample lacking nepheline, but grouped with this unit is sample DL93-146. Quartz and ferromagnesian silicates are absent, the sample containing only sodic plagioclase, perthite (partially inverted to microcline), magnetite and some large, atoll-textured zircon grains, up to 2 mm in diameter. Apart from inclusions, the zircon grains are homogeneous, without either cores or rims. Minor white mica (*cf.* muscovite) is present as narrow plates oriented in various directions and as fringe to the opaque oxide. It is approximately on strike with the nepheline syenite located 4 km to the west, and may be a genetic affiliate. The large zircons, in particular, but also the abundant magnetite and white mica, strongly suggest that it is related.

17.3.5.2 South of Kyfanan Lake Aegerine-/ Nepheline-bearing Syenite (M_{3B}yn)

These rocks were not distinguished from other syenitic rocks in the Pinware terrane during 1:100 000 mapping, although were sufficiently distinctive enough to warrant sampling for dating of an aegerine-bearing syenite (CG92-216),



Photomicrograph 17.1. *Examples of late syn-Grenvillian nepheline-bearing syenite intrusions. A. Northwest of Black Bay nepheline syenite. Large zircon. Emplacement age 1015 ± 6 Ma (CG03-029B), B. South of Kyfanan Lake aegerine/nepheline-bearing syenite. Aegerine. Emplacement age 991 ± 5 Ma (CG92-215), C. South of Kyfanan Lake aegerine/nepheline-bearing syenite. Late-stage sodic amphibole (CG92-215).*

which yielded an age of 991 ± 5 Ma, interpreted to date the time of emplacement of the rocks (Wasteneys *et al.*, 1997). The dated aegerine-bearing syenite is strongly deformed and extensively recrystallized and cannot be readily distinguished from older Labradorian and Pinwarian components also known to exist in the Pinware terrane. The geochronological result, coupled with the discovery, during petrographic studies, of other aegerine-bearing syenite (Plate 17.3B) and a nepheline-bearing syenite in the region prompted a re-evaluation of the syenitic rocks and the separation on the map of those areas most likely to be underlain by correlative rocks (Figure 17.5). The present distinction is partly mineralogical, in that the areas included in Unit M_{3C}yn (Gower, 2010a, Kyfanan Lake map region), but re-assigned here as M_{3B}yn, south of Kyfanan Lake are underlain by aegerine- or (in one case) nepheline-bearing alkali-feldspar syenite, but also partly textural in that the rocks look like they were recrystallized from coarse-grained protoliths. The M_{3C}yn syenite bodies (as shown on the 1:100 000-scale map for the area) tend to be in the cores of areas of syenitic rocks designated as older (PMyq) and it is fair to claim at least some of the peripheral areas might represent more deformed gneissic equivalents of M_{3B}yn intrusions, rather than being earlier.

Overall, syenite assigned to unit M_{3B}yn is homogeneous, partially recrystallized and massive to weakly foliated. The rocks are medium to coarse grained, some having perthitic K-feldspar grains up to about 2 cm across. A few outcrops show a gradation from coarse-grained, fairly massive rock to a fine-grained, deformed equivalent. One outcrop of less-deformed syenite shows a crude layering, which could be primary (CG92-217).

The rocks are extremely potassic – over 95% K-feldspar is not unusual. They lack quartz, and commonly have only trivial amounts of mafic or opaque minerals. In the nepheline syenite, apart from two or three grains, the nepheline has been entirely altered to white phyllosilicates. Clinopyroxene is common, although locally pseudomorphed by serpentine and Fe-oxides. Its bright-green colour is an indicator that it is Na-rich. Amphibole is clearly derived from clinopyroxene in some rocks and has distinct bluish pleochroism, indicating that, it, too, is sodic (Photomicrographs 17.1B, C). Both clinopyroxene and amphibole occur as recrystallized lenses and aggregates. Garnet is a rare additional mineral. It was not seen in thin section but, in one exceptional outcrop, makes up to 3% of the rock and occurs as euhedral crystals up to 10 cm in diameter (VN92-243). Thin sections assigned to M_{3B}yn are CG92-178, CG92-215, CG92-216, CG92-221, HP92-176A, HP92-187A, HP92-187B, HP92-189, JA92-163, VN92-227, VN92-238, VN92-240B, VN92-241, VN92-243A, VN92-261, VN92-285, VN92-290A.

17.4 EARLY POST-GRENVILLIAN INTRUSIONS (M_{3C} *ca.* 985–975 Ma)

Magmatism in the eastern Grenville Province postdating Grenvillian orogenesis can be divided into two parts, namely: i) early posttectonic magmatism characterized by the emplacement of anorthosite, gabbronorite, fayalite-bearing syenite and alkalic mafic dykes, between 985 and 975 Ma, and ii) late posttectonic magmatism involving emplacement of monzonite, syenite and granite plutons, between 975 and 950 Ma. Early posttectonic magmatism graded into late posttectonic magmatism without time hiatus, but differences in the type of magmatic product delivered during each stage justifies recognizing a distinction between the two (Gower and Krogh, 2002).

As post-Grenvillian intrusions have not been subjected to the severe deformation experienced by older rocks, it is possible to distinguish confidently specific intrusions, which is the approach adopted for the remainder of this chapter. Note that the same rock type may occur in more than one intrusion and an intrusion may include more than one rock type. Repetition of unit designators after the pluton name heading clarifies the former situation and repetition of intrusion names addresses the latter. The presentation is broadly: i) mafic intrusions, ii) granitoid intrusions, and iii) alkali-feldspar syenitic intrusions. The latter two groups also have some associated mafic rocks that are interpreted to be cogenetic. Representative stained slabs are illustrated in Appendix 2, Slabs 17.4–17.6.

17.4.1 RED BAY GABBRONORITE (M_{3C}rg)

The Red Bay gabbronorite (Figure 17.5) is the largest of the syn- to late-Grenvillian mafic plutons and the only one for which geochronological constraints are available. Based on three analytically overlapping zircon fractions (but one point excluded), the age of the intrusion is 980 ± 3 Ma (Heaman *et al.*, 2004; sample VN93-033, Plate 17.3C).

The intrusion forms a crescent-shaped body (Figure 17.5), the outline of which can be partly inferred from aerial observation, as the distribution of the mafic rocks is indicated by the common occurrence of orange-brown feldspar sand surrounding weathered outcrops. The shape is interpreted to be due to folding of a tabular intrusion into a syncline, followed by faulting at a narrowly oblique angle to the axial trace. The syncline plunges steeply northeast having its eastern limb truncated by the coastline.

Rock types in the body include anorthositic gabbronorite, leucogabbronorite, gabbro and pyroxene-bearing monzonite, which is more-or-less the same range of rock types as previously noted by Bostock (1983). The anorthositic gabbronorite and leucogabbronorite are white-, grey-, green-, buff-, or brown-weathering, coarse grained, and generally massive or weakly foliated. Plagioclase crystals exceed 1 cm in length in places. The mineral assemblage in the anorthositic gabbronorite and leucogabbronorite comprises euhedral cumulate plagioclase, intercumulus clinopyroxene and orthopyroxene and an opaque mineral. Some coarse-grained patches have interstitial K-feldspar and, in these areas, a few quartz segregations occur. Magnetite and pyrite are present. The rocks are most modified close to the margins of the intrusion. Some of the clinopyroxene is uralitized and fringes of plagioclase grains typically show evidence of minor recrystallization.

Layering is obvious in many outcrops (Plate 17.3C). In coastal outcrops, igneous crossbedding and graded bedding, defined usually by concentrations of amphibole, are well displayed. Enclaves of similar material to the host gabbroid rocks are common, and range from a few centimetres across to several metres in diameter. The margins of the intrusion are complex. Hematite alteration of the granitoid rocks marginal to the gabbronorite is one indication that the Red Bay intrusion is younger than the surrounding foliated granitoid rocks.

Monzonite adjacent to the Red Bay layered mafic intrusion is distinguished from previously described monzonitic rocks by a relative lack of deformation and by coarser grain size, leading the author to suspect that they may be genetically related to the Red Bay gabbronorite. The rocks are pink-, buff- or red-weathering, coarse grained, equigranular and weakly foliated. They generally lack quartz and have biotite, hornblende and pyroxene as mafic minerals. Recrystallization is extensive, but not complete. The Red Bay gabbronorite is intruded by planar, or less regular, microgranite, aplite and pegmatite dykes. It is also intruded by planar plagioclase-porphyritic and non-porphyritic mafic dykes, in turn intruded by minor granitoid dykes.

Six rocks were examined in thin section (CG93-019, CG93-021, CG93-042, VN93-033A.1, VN93-033A.2, VN93-081) (Photomicrograph 17.2A). Plagioclase forms subhedral, well-twinned, elongate crystals obviously cumulate in some samples. Its antiperthitic texture was illustrated by Bostock (1983, his Figure 12). Pyroxene (both clino- and orthopyroxene) crystallization mostly postdates that of plagioclase, except in sample CG93-021, where it was one of the first phases. In reflected light, the dominant opaque mineral is seen to be a coarse intergrowth of two phases. A sulphide phase is also present and is common in sample CG93-021, which comes from the interpreted lower part of the intrusion. Other primary minerals are apatite, red-brown biotite, K-feldspar and quartz, the latter two being interstitial late-crystallizing minerals. Many of the minerals show considerable alteration to greenschist – lower amphibolite facies assemblages, especially pyroxene, which is altered to a multiple-twinned amphibole, carbonate, chlorite, titanite and an opaque mineral (*cf.* also uninvestigated texture in Photomicrograph 17.2B).

The Red Bay gabbronorite has been investigated petrologically by Greenough and Owen (1995). They term the body a jotunitic or Fe-Ti-P (FTP) gabbroic intrusion and categorize the rocks as leucocratic cumulates, melanocratic cumulates, relatively massive gabbro and granophyre. They emphasize that layering is common in the stratigraphically lowest exposed part of the body (at the southern side of Saddle Island). It is mostly planar-tabular, but trough cross-beds are locally present and allow determination of the top of the intrusion. Cumulous phases include aluminous augite, orthopyroxene (X_{Mg} between 0.58 and 0.78), plagioclase and apatite. Other silicate phases include intercumulus TiO_2-rich biotite and amphibole rimming augite. Titano-hematite and ilmenite are important rock-forming minerals in all samples.

17.4.2 NORTHWEST OF PINWARE GABBRONORITE (M_{3C}rg)

A small (less than 1 km long) elliptical mafic body, northwest of Pinware (Figure 17.5), was previously mapped by Bostock (1983), who included it as part of an amphibolite unit (his Unit Hm). The body is exposed in the centre of a valley as a group of three small, well-exposed, black-weathering knolls that are easily distinguishable at a distance from the flanking granitoid rocks along the valley walls (Plate 17.3D). The rock is medium grained at its margin, but coarse grained at its core. It is massive (apart from a fracture cleavage) and homogeneous and, although metamorphosed, retains vestiges of primary igneous texture. It is intruded by pegmatite.

One thin section examined (CG93-240) contains polygonal antiperthitic plagioclase, partially serpentinized orthopyroxene, clinopyroxene containing abundant exsolved opaque inclusions, amphibole, oxide and sulphide opaque minerals and minor hercynite. Although amphibole is an abundant retrograde product, the name ‘partially retrograded gabbronorite’ is considered here to be more appropriate than amphibolite.

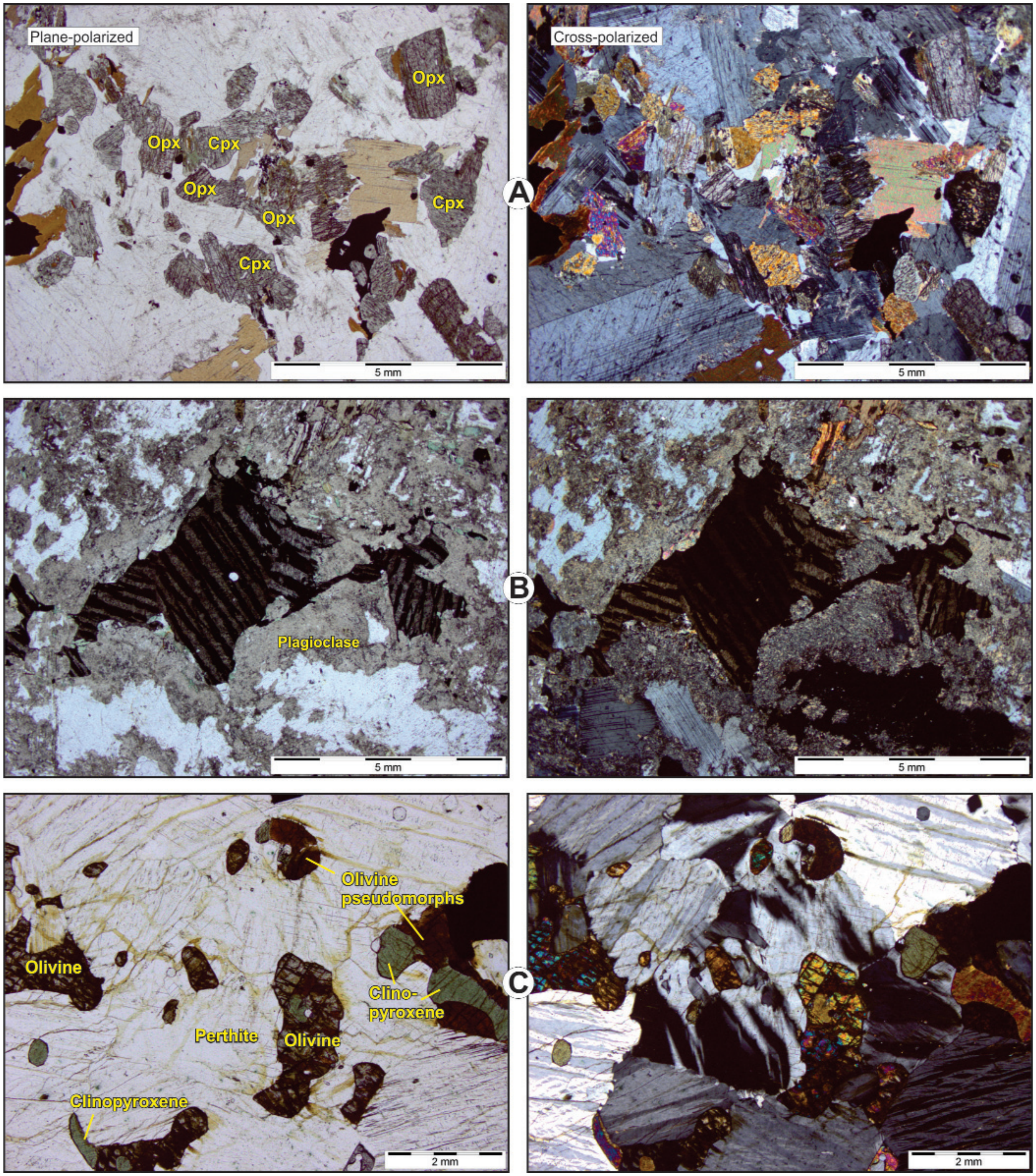
17.4.3 UPPER BEAVER BROOK INTRUSION

17.4.3.1 Gabbronorite (M_{3C}rg)

Two large bodies and one smaller body of mafic rock are associated within the eastern lobe of the Upper Beaver Brook quartz monzonite. One of these bodies is shown on the map of Bostock (1983) and information given here is based on the same two outcrops of the body (west of Beaver Brook) that are indicated on his map. The rock is a brown- to black-weathering, homogeneous, medium-grained, foliated gabbronorite, and is intruded by minor granitoid dykes.

It is composed of plagioclase, clinopyroxene, orthopyroxene, large poikilitic biotite crystals, interstitial quartz and K-feldspar, apatite and oxide and sulphide opaque grains (thin section CG93-594). The plagioclase is mostly primary and has elongate subhedral habit although there is evidence of incipient recrystallization at grain boundaries. Some secondary amphibole after clinopyroxene is also present.

The mafic body about 10 km to the east consists of white-, grey-, brown- or black-weathering, medium- to coarse-grained, homogeneous, partially recrystallized leucogabbronorite. Most of it is massive to weakly foliated but, in



Photomicrograph 17.2. *Examples of early post-Grenvillian major intrusions. A. Red Bay gabbronorite. Dated sample 980 ± 3 Ma (VN93-033A.2), B. Red Bay gabbronorite, altered. Striping is alternation of opaque mineral (hematite/ilmenite/magnetite?) and titanite (CG93-019), C. Lower Pinware River alkali-feldspar syenite, containing fayalitic olivine and clinopyroxene. Emplacement age is 973 ± 7 Ma (CG93-027B).*

contact with the Upper Beaver Brook quartz monzonite, the rock is fairly strongly foliated. An impression is gained in the field that the quartz monzonite–leucogabbro contact probably is sharp, but irregular and complex. The rock is intruded by minor granitoid dykes.

Primary texture is well preserved, especially euhedral plagioclase laths between 0.5 and 1.0 cm long. Mafic minerals are mainly clinopyroxene and biotite, but minor amphibole is present. K-feldspar and quartz are interstitial and accessory apatite and zircon are present (thin section CG93-540).

A separate body of grey-, green- or black-weathering, medium- to coarse-grained, recrystallized mafic rock (labelled Upper Beaver Brook gabbronorite on Figure 17.5) is exposed along Beaver Brook for a distance of about 2 km, although spatially separate from the Upper Beaver Brook intrusion, may be genetically related, as it shows textural similarities. Layering is evident in several places, defined by 1- to 3-cm-wide mafic-mineral- and plagioclase-rich bands. The mineral assemblage (VN93-723) comprises elongate laths of plagioclase, clinopyroxene containing exsolved opaque mineral inclusions, orthopyroxene, minor amphibole after clinopyroxene, orange-brown biotite, apatite, and opaque minerals (oxide and minor sulphide). Although the plagioclase has wavy, recrystallized borders it is mostly primary (even showing some oscillatory zoning) and the alignment of grains is probably cumulate, rather than due to deformation. The pyroxenes are also primary and the rock termed gabbronorite. The body is intruded by large pegmatites.

A rusty-weathering, medium- to coarse-grained, massive, fresh gabbro dyke that is 20 m thick and trends at 032° was previously mapped on Upper Beaver Brook by Bostock (1983) and located during the present survey (two locations shown on Figure 17.5). It is intruded by a fine-grained dykelet that trends west-northwest, is 3–4 cm wide and is grey- to rusty-weathering. Note that the dyke has the same trend and is regionally on strike with a major Long Range dyke mapped in the Port Hope Simpson map region. Gower *et al.* (1994) mentioned that it could be an extension of the same intrusion, although observing that the next closest outcrop is over 100 km to the northeast. Despite its trend and alignment with that Long Range dyke, this rock is no longer considered to belong to the Long Range suite.

A thin section prepared from sample VN93-718A is not petrographically similar to other samples of Long Range dykes, which are petrographically alike. Sample VN93-718A contains anhedral, interlocking primary plagioclase that is well twinned and markedly zoned. Pyroxene infills spaces between plagioclase grains and clearly crystallized later. It is completely pseudomorphed to chlorite, and an opaque mineral, orange-brown biotite(?), and carbonate (former pigeonite?). Dark-orange-brown biotite also occurs as a discontinuous fringe around pyroxene and is associated with an opaque oxide. Unusually large grains of apatite, and interstitial K-feldspar and quartz are present. Secondary minerals include chlorite, hematite, carbonate and, possibly, prehnite. The rock is not closely comparable petrographically to the above-described mafic rocks assigned to the Upper Beaver Brook intrusion, but it is very similar to rocks in the Red Bay gabbronorite.

The small body of mafic rock at the southeast end of the Upper Beaver Brook quartz monzonite is texturally distinct from the other two mafic rock occurrences within the quartz monzonite. It is black-weathering, massive to weakly foliated, medium grained, has a felted ophitic texture and contains orthopyroxene, clinopyroxene, amphibole and plagioclase.

17.4.3.2 Monzonorite (M_{3C}mn)

South of the southeast tip of Upper Beaver Brook quartz monzonite, a body of monzonitic gabbronorite was previously mapped by Bostock (1983), who grouped it as part of his "norite, augite-bearing amphibolite" unit. The rocks are mostly light-weathering, medium to coarse grained and relatively homogeneous. Parts of the body lack extensive recrystallization, so primary lath-shaped plagioclase grains, with interstitial mafic minerals and K-feldspar can be clearly seen. A smaller occurrence immediately to the west is, texturally, very similar and it seems likely that either they were originally part of the same body or that the intervening unexamined area is also monzonitic gabbronorite. The rock type is somewhat similar to a small mafic body east of the Picton Pond quartz monzonite, and it is possible that both are peripheral mafic intrusions co-genetic to the adjacent much larger quartz monzonite bodies. These mafic rocks were not examined in thin section.

17.4.3.3 Quartz Monzonite and Granite (M_{3C}mq, M_{3C}gr)

The Upper Beaver Brook quartz monzonite to granite consists of two lobes of differing composition. The west lobe is largely alkali-feldspar granite, in contrast to the east lobe, which is mostly quartz monzonite. Both lobes show similar textures and deformational effects, and for these reasons they have been grouped under a single pluton name. It is acknowledged that there may be two separate bodies, and so the lobes are described separately below. A U–Pb zircon age of 983 ± 3 Ma was reported by Wasteneys *et al.* (1997) for a sample at the southeast end of the intrusion (CG93-698), and is considered to date the time of emplacement of the pluton. Two concordant, analytically overlapping titanite ages were also obtained from the same sample and have an average age of 960 ± 5 Ma (Wasteneys *et al.*, 1997).

Bostock (1983) shows a larger area to be underlain by these rocks, mainly because the Stokers Hill granite

(Section 17.5.10.2) was also grouped with the Upper Beaver Brook intrusion. Armed with more detailed mapping, the author is confident that the Stokers Hill granite is not part of this unit. Fine- to medium-grained recrystallized quartzofeldspathic rocks are present between the two bodies, and the Stokers Hill pluton is unrecrystallized and massive, whereas the Upper Beaver Brook intrusion is partially recrystallized and weak to moderately foliated. There are also compositional contrasts.

West lobe. The western lobe of Upper Beaver Creek quartz monzonite consists mostly of granite to alkali-feldspar granite (Plate 17.4A), but there is gradation to quartz monzonite, especially on the eastern side of the body. The rocks are white-, pink-, buff-, red- or brown-weathering, massive to moderately foliated, homogeneous, coarse grained (locally medium grained), and recrystallized in part. Fabric ranges from non-existent to obvious and is mostly north trending. It is defined by alignment of mafic minerals and/or elongation of feldspar and quartz. It is perhaps more marked adjacent to the margins of the body. K-feldspar ranges up to 3 cm long and may be euhedral, subhedral or anhedral. Mantled-feldspar textures are locally evident, commonly shown as plagioclase cores surrounded by K-feldspar.

In thin section (CG93-510, DL93-163, DL93-181, VN93-437), the plagioclase is seen to be moderately twinned and sericitized and commonly has albitic rims. The K-feldspar is mostly string perthite, but some inversion to microcline has occurred in places. Mafic minerals are ragged, green hornblende and green-buff biotite. Accessory minerals are an oxide opaque phase, titanite (normally occurring as a veneer around the opaque mineral), apatite and zircon. Rare grains of an altered orange mineral may be metamict allanite.

Enclaves of dark-weathering, medium-grained, recrystallized leucoamphibolite and amphibolite were observed in the western lobe.

One enclave of mafic rock examined in thin section (VN93-443B) consists mainly of primary igneous plagioclase and metamorphic hornblende, with minor relict clinopyroxene and apatite. Red-brown biotite, an oxide opaque mineral and traces of titanite are other metamorphic minerals present.

A few narrow granitic veins intrude the unit, especially in its northern part.

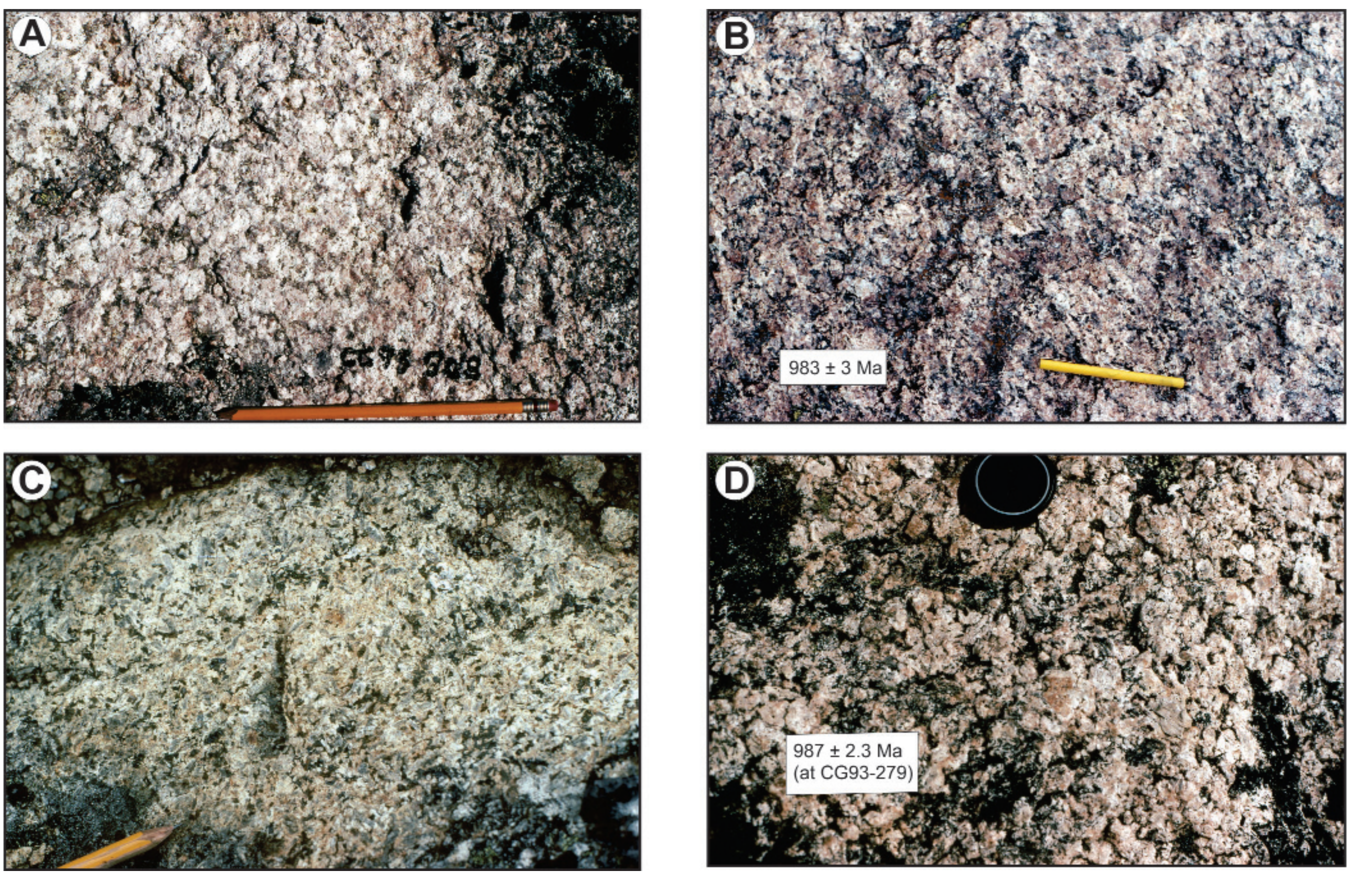


Plate 17.4. *Early post-Grenvillian granitoid intrusions; Upper Beaver Brook and Picton Pond bodies. A. Upper Beaver Brook granite, west lobe (undated) (CG93-508), B. Upper Beaver Brook quartz monzonite to granite, east lobe (CG93-698), C. Picton Pond monzonorite (undated) (CG93-380), D. Picton Pond quartz monzonite. Note mantled feldspars (VN93-359).*

East lobe. The eastern lobe of the Upper Beaver Brook intrusion is mostly quartz monzonite (Plate 17.4B), but, rarely, is granite or quartz syenite. The rocks are white-, creamy-, pink-, buff- or brown-weathering, weakly to strongly foliated, generally homogeneous, mostly coarse grained and partly recrystallized. Locally, there are zones of alternating coarse and medium grain size. K-feldspar is up to 3 cm long and is generally subhedral. In places, the texture verges on megacrystic. Mantled-feldspar textures are present in places, characterized by plagioclase cores and narrow-to-wide K-feldspar rims. Some more complex mantling is locally evident, involving up to five alternations of plagioclase and K-feldspar.

Most of the rocks are weakly foliated, but foliations are better developed near the margins of the intrusion. Some minor medium- and fine-grained granite intrusions occur sporadically. Enclaves are common, ranging from large rafts over a kilometre long down to almost equal in grain size to the host quartz monzonite. Three xenolithic rock types are found; supracrustal rocks, foliated granitoid rocks and medium- to coarse-grained mafic rocks. The large raft of supracrustal rocks straddling the Pinware River was described earlier (Section 13.1.3). Enclaves of supracrustal rock were also found where traverses crossed the northeast border of the body, and are well exposed where the northern margin is crossed by the Pinware River. Supracrustal rock types present include calc-silicate rocks, amphibolite, fine-grained quartzofeldspathic rocks and rare pelitic rocks. Lensoid shapes in one sample are particularly suggestive of a felsic volcanic protolith. The enclaves of foliated granitic rock are generally fine grained, rather structureless and generally non-descript.

In thin section, hornblende is seen to be the dominant mafic mineral and is invariably accompanied by biotite (CG93-530, CG93-573, CG93-584, CG93-589, CG93-698, VN93-464, VN93-471, VN93-615), but minor clinopyroxene is present in the eastern part of the body, especially near its borders (CG93-663A, DL93-194, VN93-247, VN93-593). Accessory minerals are an oxide opaque mineral (locally with traces of a sulphide phase and/or leucoxene in fractures), titanite (rare in the clinopyroxene-bearing rocks), apatite and zircon. No allanite is present.

As a final note of interpretation, the variation in composition, seen in both the east and west lobes of the Upper Beaver Brook intrusion suggests that it is a fractionated body. The least fractionated part is in the east, where clinopyroxene occurs (and biotite is red-brown-orange and titanite is rare to absent). Most of the body is hornblende quartz monzonite containing orange-buff biotite; the hornblende shows evidence of derivation from clinopyroxene. The western lobe is granite in which hornblende is minor or absent, biotite is buff-green and rare allanite is present.

17.4.4 PICTON POND INTRUSION

17.4.4.1 Monzonorite (M_{3C}mn)

A monzonorite intrusion was mapped west of Pinware and was previously identified by Bostock (1983). It is labelled Picton Pond monzonorite on Figure 17.5. Its shape is not known in detail as it was only crossed on one traverse and has no distinctive topographic or aeromagnetic expression. On the ground, outcrops belonging to the body are easy to identify from a distance because of fringing brown feldspar-rich sands. The boundaries have been modified slightly from those of Bostock (1983). It is creamy-grey- or brown-weathering, massive, medium to coarse grained and homogeneous (Plate 17.4C). There is a hint of layering in some outcrops defined by subtle grain size and mineral content. The dominant mineral, plagioclase, occurs as subhedral to euhedral crystals up to 1 cm long and is possibly aligned parallel to layering. Pyroxene is interstitial and traces of interstitial K-feldspar are also present. Bostock (1983) termed the largest body mangeronorite because of the high proportion of potassium embodied in antiperthite. It seems likely that the monzonorite (which is the term preferred here) is related to the nearby Picton Pond intrusion. Furthermore, the texture of the rock in the largest body is fairly similar to gabbronorite in Upper Beaver Brook quartz monzonite, and both are considered to belong to the same generation of mafic intrusions.

Four samples were examined petrographically (CG93-378, VN93-160, VN93-179, VN93-293). The stable assemblage in sample CG93-378 is antiperthitic plagioclase, clinopyroxene containing exsolved mafic inclusions, red-brown biotite, apatite, oxide and sulphide opaque minerals and interstitial quartz. Secondary serpentine may indicate the former presence of orthopyroxene. Amphibole is derived from clinopyroxene and the rock shows extensive late-stage carbonate, chlorite and prehnite. Sample VN93-179 from a small mafic body to the south, and sample VN93-293 from a small body to the northwest, are also characterized by antiperthitic plagioclase and interstitial quartz. Sample VN93-293 lacks clinopyroxene, but its former presence is indicated by clusters of amphibole, biotite, vermiform quartz, titanite and opaque minerals that define former clinopyroxene grains. Sample VN93-160 is texturally distinct, being more granoblastic and equigranular. It is also mineralogically distinct in that it contains both clino- and orthopyroxene and lacks amphibole. It could be termed two-pyroxene granulite and may be unrelated.

17.4.4.2 Quartz Monzonite and Granite (M_{3C}mq, M_{3C}gr)

The Picton Pond quartz monzonite and granite forms a large body underlying at least 300 km^2 (Figure 17.5). Its southern edge is partly obscured by unconformably overlying Lower Cambrian sediments, and the intrusion extends an unknown distance into Québec. Mapping at 1:100 000 scale broadly confirmed the outline of the intrusion as mapped by Bostock (1983), but his internal lithological divisions are not endorsed.

The age of emplacement of quartz monzonite interpreted to be part of the Picton Pond intrusion has been determined to be 987 ± 2.3 Ma, based on the weighted mean of two (of four) multigrain zircon fractions. The two excluded analyses are also close to concordia, but have slight discordance, which was interpreted as due to minor inheritance (Heaman *et al.*, 2004, sample CG93-279). It should be noted that the dated outcrop is separated from the main body by unconformably overlying Cambrian platformal deposits, so, although the dated sample closely resembles quartz monzonite in the main body, a small element of residual doubt exists that the date obtained must apply to the main body. The age obtained overlaps analytically with that reported for the Upper Beaver Brook intrusion, with which the Picton Pond intrusion is very similar.

Most of the intrusion consists of hornblende quartz monzonite, grading into granite in places (Plate 17.4D). Apart from compositional variation between monzonite and granite, the intrusion is uniform throughout. The hornblende quartz monzonite is pink-, white- or buff-weathering, coarse grained and generally massive. Grain size of the major minerals typically ranges between 0.3 and 1.5 cm, but some feldspar crystals reach about 3 cm long. A particularly distinctive textural feature is the presence of anhedral mantled feldspars. These either have the form of a plagioclase core, mantled by K-feldspar, or have a K-feldspar core, an internal mantle of plagioclase and a rim of K-feldspar.

In thin section, the plagioclase cores are seen to be corroded, relict grains, enveloped in mesoperthite, but plagioclase also occurs separately as anhedral, moderately twinned and commonly distinctly zoned grains. K-feldspar is almost invariably mesoperthite, only locally having inverted to microcline. Quartz and mafic minerals are interstitial to feldspar. Hornblende is the dominant mafic mineral and occurs as dark-green, ragged, anhedral grains containing abundant quartz and opaque mineral inclusions. The amphibole has clearly been derived from pyroxene (probably during a late magmatic stage on the basis of textural evidence). Both clino- and orthopyroxene occur in the Picton Pond intrusion, but the grains are found generally as relict cores in mafic clusters, and are extensively or completely altered to serpentine minerals. Orange-brown biotite is present in most samples, but is not abundant. The opaque mineral is mainly an oxide, although traces of sulphide are present in most samples. Some of the opaque oxide is primary, but, as most of the grains are anhedral and closely associated with hornblende and quartz, it is more likely that much of it was formed as a late magmatic product. Apatite, closely associated with an opaque mineral, and zircon, are common accessory minerals. Allanite is absent from all samples examined. Secondary products include chlorite, serpentine minerals, opaque minerals and biotite (thin sections CG93-397, CG93-445, DL93-072, DL93-079, DL93-116, VN93-320, VN93-355, VN93-362, VN93-384C, VN93-394).

The granitic variant of the intrusion is mineralogically and texturally similar, except that it has higher quartz content. Pyroxene was observed in only two of seven thin sections examined. It is relict clinopyroxene, largely pseudomorphed to amphibole and serpentinous minerals. As in the quartz monzonite, biotite (generally orange-brown) is a minor mafic mineral and allanite is absent. Titanite is less common than in the quartz monzonite (thin sections CG93-279A, CG93-279B, CG93-369, CG93-401, VN93-209, VN93-303, VN93-352, DL93-057,DL93-120).

Although most of the intrusion is coarse grained and massive, feldspar grain boundaries are locally recrystallized to fine- to medium-grained white aggregates (suspected to be albite) and local polygonization is seen in thin section. A weak to moderate northwest-trending foliation is evident sporadically.

Minor intrusions are generally rare in all parts of the Picton Pond intrusion, being confined to a few medium-grained quartz monzonite dykes or quartz-rich veins. Some of the quartz monzonite dykes show a weak foliation. One example examined in thin section (VN93-384D) is more extensively recrystallized than its host rock, suggesting that the Picton Pond body has been subjected to more deformation than its typically unfoliated appearance suggests. Enclaves are common in some parts of the body and consist mainly of either foliated amphibolite or fine-grained foliated syenitic to granitic rocks, typical of those in the surrounding country rocks.

17.4.5 LOWER PINWARE RIVER INTRUSION

The name 'Lower Pinware River alkali-feldspar syenite' was applied by Gower *et al.* (1996) to an elliptical body straddling the Pinware River in the central part of the Pinware map region (Figure 17.5). The body was termed mangerite by Bostock (1983) and has been studied by Chubbs (1988), who reported Rb–Sr whole rock geochronological data for the intrusion (obtained by R.F. Cormier) indicating an age of 1090 ± 190 Ma, I_{Sr} = 0.7134. U–Pb data obtained by Wasteneys *et al.* (1997) are reviewed in Section 17.4.5.2.

17.4.5.1 Leucogabbronorite (M_{3C}ln)

Leucogabbronorite on the east flank of the Lower Pinware River alkali-feldspar quartz syenite (Plate 17.5A) is exposed alongside a gravel road north of the highway and east of the Pinware River. Most of the rock is dark-brown-grey-weathering, coarse grained and massive. Some textural variation from fine to coarse grained is present, both types occurring together in the same outcrops as irregular, intermeshed patches. A few small quartz-feldspar veinlets intrude the leucogabbronorite.

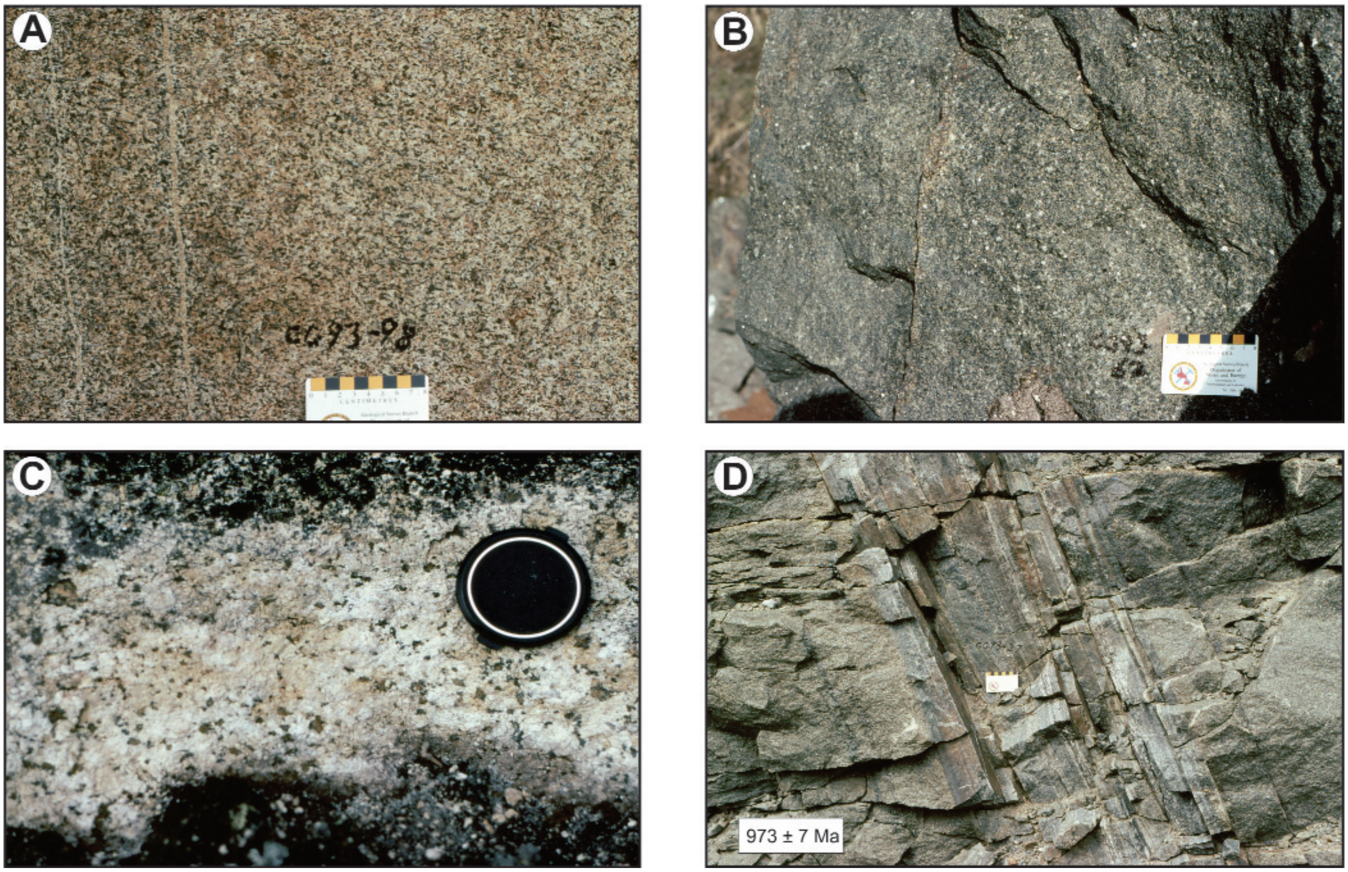


Plate 17.5. *Early post-Grenvillian Lower Pinware River intrusion. A. Leucogabbronorite on eastern edge of Lower Pinware River body (undated) (CG93-098), B. Lower Pinware River alkali-feldspar syenite on fresh surface (CG93-062), C. Lower Pinware River alkali-feldspar syenite on weathered surface. Brown cores to mafic grains are fayalite (VN93-277), D. Lower Pinware River alkali-feldspar syenite, dated at this outcrop. Quartz-rich metasedimentary gneiss raft in centre (CG93-027).*

The mineral assemblage (CG93-117) consists of plagioclase, clinopyroxene containing exsolved opaque grains, orthopyroxene, biotite, apatite, interstitial quartz and K-feldspar, minor amphibole and oxide and sulphide opaque minerals. Plagioclase occurs as well-twinned laths up to 4 by 0.3 cm and is slightly recrystallized. The grains show a strong preferred orientation, taken to indicate alignment during emplacement. Pyroxene is interstitial. Apart from amphibole, the minerals are primary.

17.4.5.2 Alkali-feldspar Syenite (M_{3C}yq)

The most common syenitic rock type in the body is coarse-grained alkali-feldspar quartz syenite, but other lithological types are present, especially a finer grained variant of the syenite, which is present at some exposures north of the Pinware River. A fine-grained alkali-feldspar syenite, with the typical coarse-grained syenite as veinlets through it, occurs on the west side of the body in roadside outcrops. A leucogabbronorite on the eastern border of the body is considered here to be genetically part of the same body (*see* previous section).

The pluton has been the target of two U–Pb geochronological studies, carried out by Wasteneys *et al.* (1997; sample CG93-027B) and Heaman *et al.* (2004; samples CG93-062, CG93-027C). The data of Wasteneys *et al.* (1997) remained inconclusive, despite eight U–Pb zircon analyses (including two single grains). The results showed only a narrow spread on the central part of a chord between an upper intercept of 1359 +87/–56 Ma and a lower intercept of 962 +76/–120 Ma. The sample was collected from the edge of the pluton, where the contact with quartz monzonite orthogneiss is exposed. It was argued by Wasteneys *et al.* (1997) that the Lower Pinware River alkali-feldspar syenite must postdate 985 Ma, because it is unmigmatized and is not known to be intruded by mafic dykes, which elsewhere in the district have been dated to be *ca.* 985 Ma (*cf.* Section 17.4.8.1). It was also suggested that the minimum age for the alkali-feldspar syenite is 972 ± 5 Ma, based on the age of titanite in the adjacent quartz monzonite gneiss, arguing that the high temperature emplacement of the alkali-feldspar syenite would have reset the titanite chronometer in the host rock, had it been younger.

A second sample was collected from the same pluton (CG93-062). In contrast to the first location, this sample site is from the centre of the body, away from known sources of country-rock contamination. U–Pb results obtained from this sample were also inconclusive, so a third sample was investigated (CG93-027C). This sample is from the same locality as that originally investigated by Wasteneys *et al.* (1997), but, in contrast to the medium- to coarse-grained alkali-feldspar syenite that typifies the intrusion, a pegmatitic phase was collected. This sample gave an upper intercept at 1411 ± 18 Ma when regressed with two data points for CG93-062, and a concordant lower intercept at 973 ± 7 Ma, the latter being taken as dating the time of emplacement of the body.

On fresh, blasted roadside outcrops, the rock is dark, greasy-green and appears massive and homogeneous (Plate 17.5B). On weathered surfaces, in dramatic contrast, the unit is white, creamy or brown and is rather crumbly, degenerating to a feldspar sand around the fringes of many outcrops (Plate 17.5C). It is difficult to obtain fresh samples from natural outcrops, as weathering penetrates several tens of centimetres. The syenite consists overwhelmingly of K-feldspar. Other minerals include amphibole, biotite, pyroxene, an opaque mineral and olivine. Locally distinct pods are present, consisting almost entirely of hornblende. In places, the shape of the outcrops suggests a crude layering. The "layering" seems to be parallel to the foliation. In one fresh roadside outcrop at the eastern margin of the body, an indistinct banding can be seen and abundant enclaves are parallel to it. The banding here may represent flowage marginal to the intrusion.

Enclaves in the body vary from small pods to the large rafts (one of which is at least 2 by 1 km in plan). The rock types in the enclaves include migmatized amphibolite, granodiorite to quartz diorite gneiss, foliated granitoid rocks of various compositions and metasedimentary gneiss. A good example of screens of metasedimentary gneiss can be seen at the east side of the body (Plate 17.5D). Especially noteworthy here is sillimanite- and garnet-bearing, ocherous-weathering schist and a visually attractive, extremely garnetiferous rock within a green matrix. A contact with country-rock orthogneiss and foliated granitoid rocks was well exposed at the same locality, but is now very overgrown. The contact is concordant to the fabric in the country rock.

The mineral assemblage in the Lower Pinware River pluton has been described by Bostock (1983) as mesoperthitic alkali feldspar (about 75%), sodic plagioclase, minor quartz, pale-green clinopyroxene, orthopyroxene, hornblende, opaque minerals, biotite and accessory zircon, apatite, carbonate, and rare titanite and allanite.

Bostock (1983) considered, but rejected, the possibility that the Lower Pinware River body unconformably underlies the surrounding gneisses. In rejecting the unconformity hypothesis, he reasoned that the body had experienced a less-complex metamorphic history than the surrounding gneisses. The author agrees, and to his argument adds that the body lacks minor granitoid intrusions, suggesting that it postdates other granitoid intrusive activity in the area. Where K-feldspar is the only mineral present, the rock appears massive, but if ferromagnesian minerals are present a foliation is obvious. In places, mafic minerals are elongate to thin veneers, attesting to a significant deformation parallel to the prevailing north-northwest regional trend. Such a foliation is absent from the 966 to 956 Ma late- to post-Grenvillian plutons (*cf.* Section 17.5), so this feature is consistent with the Pinware River pluton being earlier.

In thin section, K-feldspar shows spectacular flame and braided mesoperthite textures. The grains may be interlocked, or separated by colourless, well-twinned sodic plagioclase, which also forms patches within mesoperthite grains. The main mafic minerals are pale-green clinopyroxene and partially altered olivine (to an opaque oxide and a green or orange-brown serpentine mineral). Both form equant, anhedral grains (Photomicrograph 17.2C). The dominant opaque phase is an oxide mineral, probably magnetite, but a sulphide mineral is important in some thin sections. Apatite and zircon are accessory phases; Bostock (1983) noted that titanite and allanite are present, but only rarely. Secondary minerals are actinolitic amphibole, chlorite, carbonate and hematite (thin sections CG93-027B, CG93-027C, CG93-060, CG93-062, CG93-330A, CG93-336, VN93-120, VN93-280).

17.4.6 FOX POND PLUTON (M_{3C}yq)

A syenite body in the northwest part of the Pinware map region, previously mapped by Bostock (1983), is here termed the Fox Pond alkali-feldspar syenite (Figure 17.5). It is mapped as a crescent-shaped intrusion; the northeast and southeast boundaries are constrained from field data and aeromagnetic patterns, but there is very little control on the outline of the remainder of the body. The unit is very distinctive in the field, forming bouldery, buff-brown, very weathered outcrops fringed by white to yellow feldspar sand. The rock is moderately to strongly foliated and, where recrystallized, has a fine- to medium-grained granular appearance.

It consists mainly of mesoperthitic alkali feldspar, in grains up to about 1 cm across where not recrystallized. Interstitial primary minerals include partially serpentinized orthopyroxene, clinopyroxene, amphibole, apatite and an oxide opaque mineral (thin section CG93-513). Biotite is also present but is most likely secondary. Quartz is an accessory mineral in a few outcrops.

17.4.7 OTHER ALKALI-FELDSPAR SYENITE BODIES (M_{3C}yq)

Three small bodies of similar alkali-feldspar syenite were mapped south of the Lower Pinware River intrusion

(Figure 17.5). They are assumed to be satellites of the main body, but they may be unrelated.

A thin section from one of them collected during 1:100 000-scale mapping (VN93-120) consists of flame and braided mesoperthite, patch albite, bright to dark-green clinopyroxene, equivocally identified very minor olivine, opaque oxide and small euhedral zircon.

Knowledge of the other two satellites depends, in part, on traversing during 1:100 000-scale mapping and partly on thin sections from samples collected by Bostock (1983; BK71-443, BK71-449), which have been briefly examined by the author.

Both thin sections are alkali-feldspar syenite dominated by mesoperthite. The mafic minerals include orthopyroxene, hornblende, biotite and, in BK71-443, clinopyroxene. Accessory minerals are opaque oxides, apatite and zircon.

A small body of alkali-feldspar syenite is shown west of Black Bay. It has been included with this unit for want of a better choice, but it need not be closely related. Information comes from a field traverse across it during 1:100 000-scale mapping, plus (poorly) stained slabs. No petrographic data are available. In field notes, it is described as red-pink-weathering, medium- to coarse-grained, recrystallized, massive to foliated quartz syenite to granite.

17.4.8 MAFIC DYKES (M_{3C}d)

Alkalic mafic dykes are a widespread manifestation of early posttectonic intrusive activity in eastern Labrador, and have been given three separate names as they occur in different areas and are not identical. The L'Anse-au-Diable dykes occur in the south, the York Point dykes in the centre, and the Gilbert Bay dykes in the north (Figure 17.6). Representative stained slabs are illustrated in Appendix 2, Slab images 17.7.

17.4.8.1 L'Anse-au-Diable Dykes

Numerous, approximately planar, mafic dykes were mapped in the Red Bay district (Figure 17.7) that discordantly truncate fabrics in their host recrystallized, foliated granitoid rocks. The dykes range in thickness from about 30 cm to several metres. Trends are extremely variable and, judging from the way one discordant mafic dyke (CG93-057; Plate 17.6A) branches in various directions, it is unlikely that any particular trend is characteristic. As such dykes were not found in late-syntectonic to posttectonic plutons, the dykes are interpreted to be earlier. Although the dykes truncate the host-rock foliation, many of them also carry their own fabric, which is consistent with them having been emplaced before, or at the same time as, the foliated (syn- to late-Grenvillian) plutons. Some of the dykes are slightly boudinaged and many are offset along late-stage faults.

The most precise geochronological age available for the dykes is a U–Pb zircon age of 985 ± 6 Ma obtained from sample CG93-268C at L'Anse-au-Diable (Plate 17.6B) (Wasteneys *et al.*, 1997). In addition, a K–Ar whole-rock age of 931 ± 32 Ma (recalculated from 920 ± 32 Ma, the average of two dates that yielded results of 915 ± 32 Ma and 926 ± 32 Ma) was reported by Wanless *et al.* (1974). The sample was collected by Bostock (1983) and is a dark-grey, fine-grained mafic rock with plagioclase phenocrysts up to 3 mm long forming 5% of the rock. Bostock's data station (BK71-71.2) is almost certainly the same site as DL93-090, established during 1:100 000-scale mapping, where a sample of the dyke was collected for petrographic and whole-rock geochemical purposes. Bostock considered the dyke to belong to the same group as those from the York Point area (*cf.* Section 17.4.8.2).

The dykes are most abundant in the vicinity of Red Bay (even discounting potential bias due to better coastal and roadside exposure in that area). The Red Bay gabbro has been dated to be 980 ± 3 Ma (Heaman *et al.*, 2004), which is, within error, the same age as the dated L'Anse-au-Diable dyke. Spatial and temporal constraints leave little doubt that both belong to the same magmatic event.

Several texturally distinct types can be recognized. They include: i) net-veined dykes, ii) plagioclase-phyric dykes, iii) plagioclase- and mafic-mineral-phyric dykes, (iv) fine-grained, even-textured dykes, and (v) dykes containing abundant xenoliths. Whether these have any age significance is unknown.

Net-veined dykes. These contain irregular, anastomosing white-weathering, medium- to coarse-grained, quartz-feldspar veins. The feldspar is dominantly plagioclase, but K-feldspar is common in some dykes and may also pervade the mafic rock adjacent to the veins. In places, the net-veining looks like a later migmatitic effect (CG93-026C, CG93-298), and the higher proportion of biotite in some of the net-veined dykes might be attributed to potassium metasomatic effects. In other dykes, the net-veining is clearly a primary feature that developed at the time of dyke emplacement. A good example occurs on the north shore of Black Bay (CG93-300) where the mafic rock forms pillows enveloped by the felsic component and both are contained within a parallel-sided planar intrusion sharply truncating the previously strongly deformed host rocks (Plate 17.6C, D). Enclaves of the host granite are commonly caught up in the felsic component. The mafic pillows do not show a homogeneous texture, showing a range in grain size and presence or

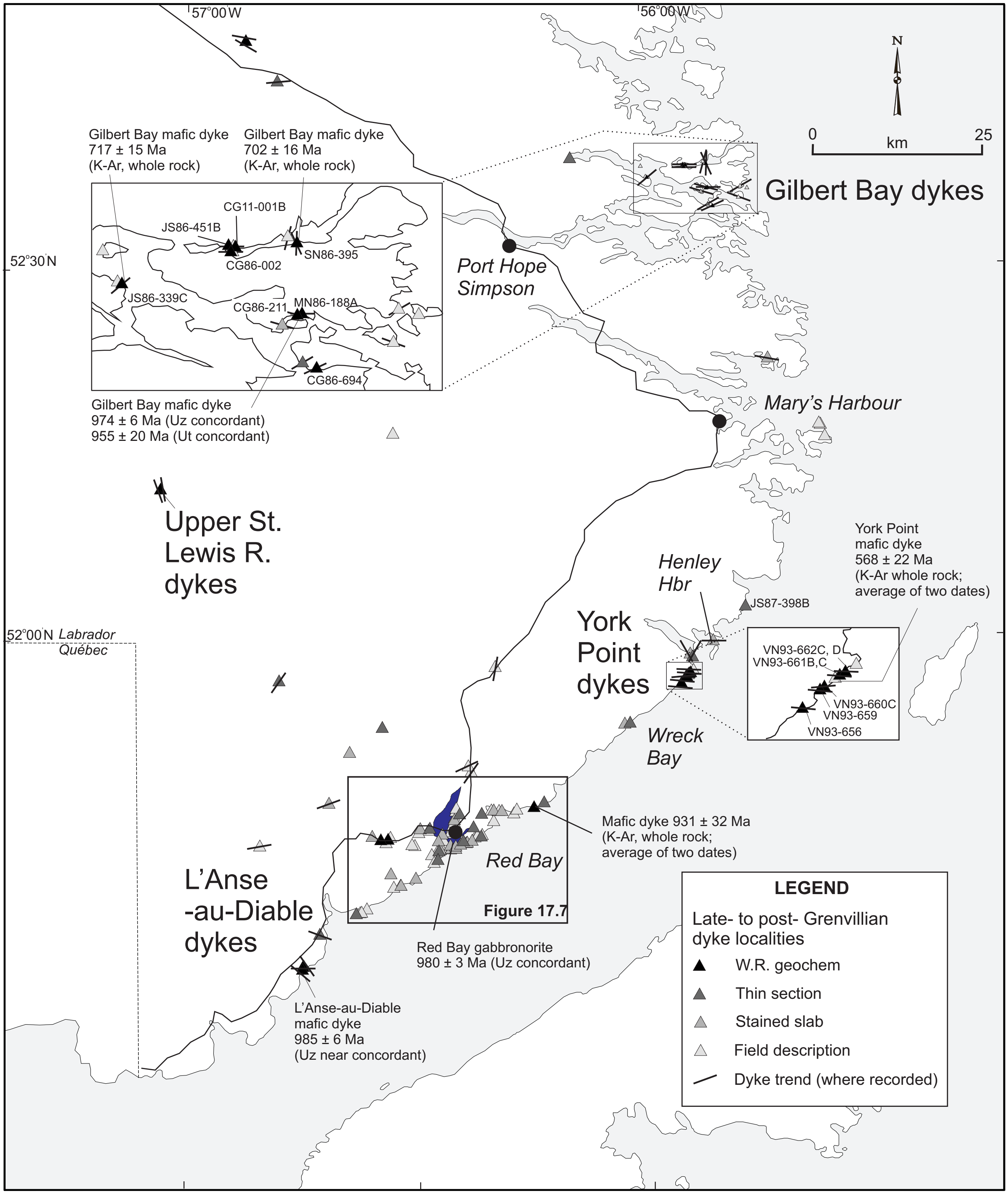


Figure 17.6. *Early post-Grenvillian mafic dykes; regional distribution, names and ages.*

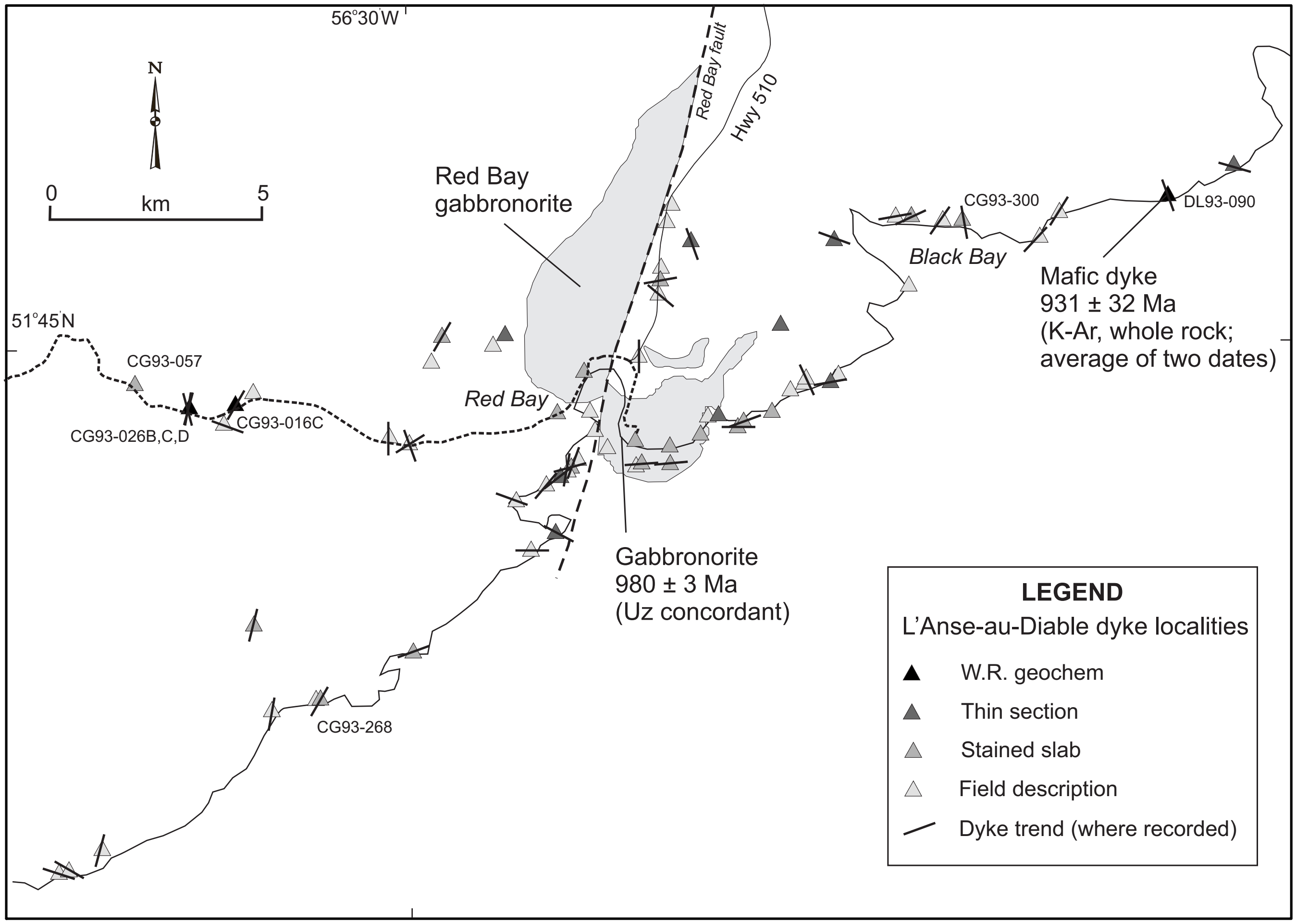


Figure 17.7. *Spatial relationship between L'Anse-au-Diable mafic dykes and Red Bay gabbronorite.*

absence of plagioclase phenocrysts. In at least two cases (CG93-026B, C), net-veined mafic dykes have been strongly deformed and an almost schistose fabric developed, accentuated by net-veining.

Plagioclase-phyric dykes. In these dykes, the matrix is generally fine grained, black- or grey-weathering, and uniform. Some of the dykes are intruded by late granitoid veinlets (CG93-032, CG93-268). The phenocrysts are euhedral, white, and range from not much larger than the matrix to over 1 cm long. Locally, the phenocrysts occur in clusters. A noteworthy feature, evident in many hand samples, is that the plagioclase crystals show quench textures.

Plagioclase- and mafic-mineral-phyric dykes. This group is considered to be an ill-defined subset of the plagioclase-phyric type, as most of the dykes having mafic mineral phenocrysts also have plagioclase phenocrysts. The dark phenocrysts are mostly less than 0.5 cm across, subhedral to anhedral and locally appear somewhat recrystallized. One dyke grouped in this category (CG93-455) is 3 m wide, discordantly intrudes mylonitized supracrustal rocks, has distinct chilled margins and, in addition to plagioclase and mafic-mineral phenocrysts, also contains abundant pyrite.

Fine-grained, even-textured mafic dykes. These lack phenocrysts, and are also commonly narrower dykes.

Mafic dykes containing abundant xenoliths. These dykes are rarest. One well-exposed example (CG93-071), although only about 30–50 cm wide, is packed with a wide range of mafic and felsic plutonic rocks that are very similar to those in the immediately surrounding area. Matrix material is a minor component. The sides of the dyke are straight and parallel sided. It is difficult to imagine how so many xenoliths became so tightly crowded together; perhaps most easily envisaged is that the xenoliths fell from above, while magma simultaneously ascended the fracture from below.

A large collection of thin sections of the discordant mafic dykes is available, but it is hard to make universal generalizations, and it remains very uncertain that all the dykes belong to a single suite. The

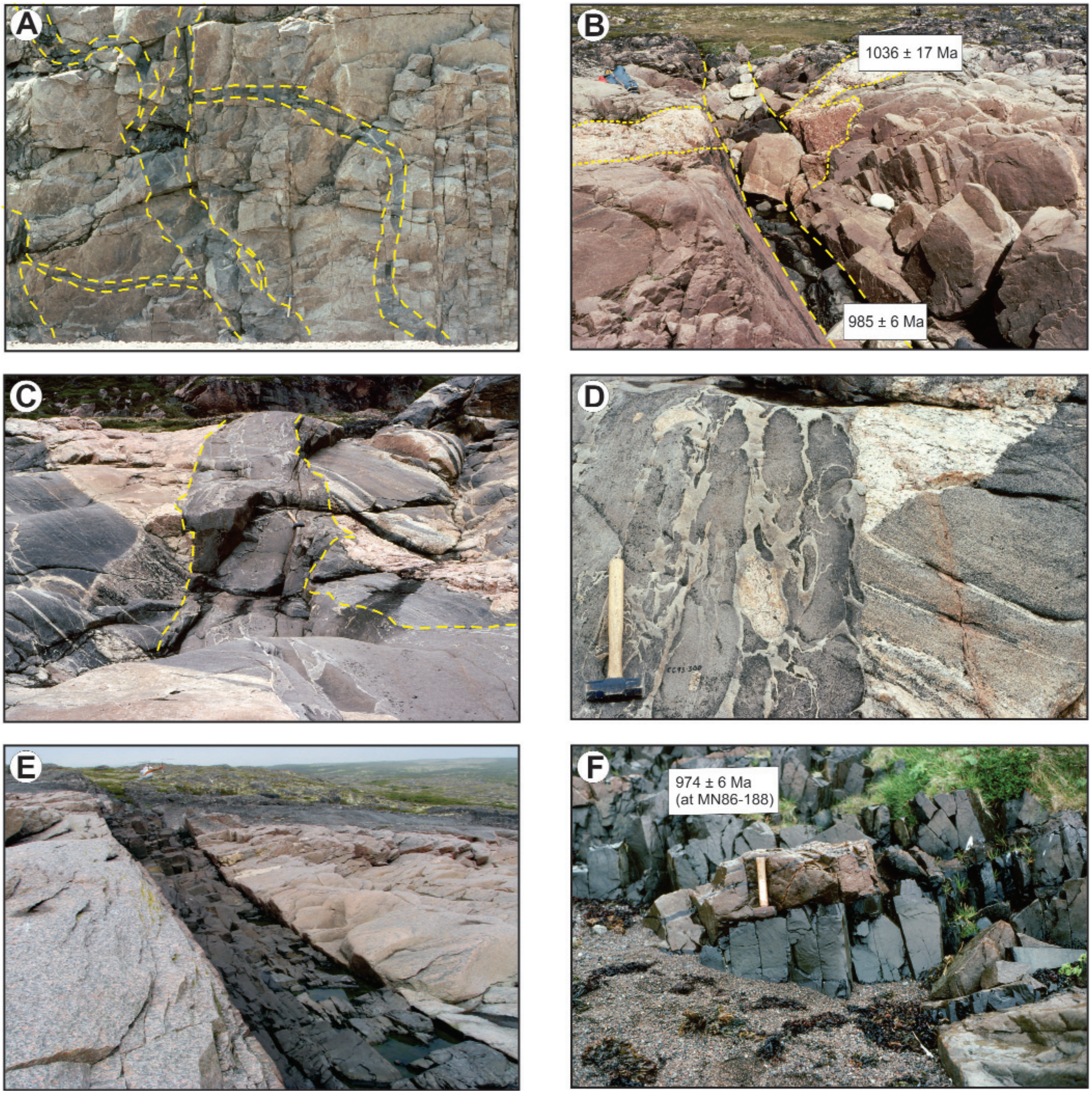
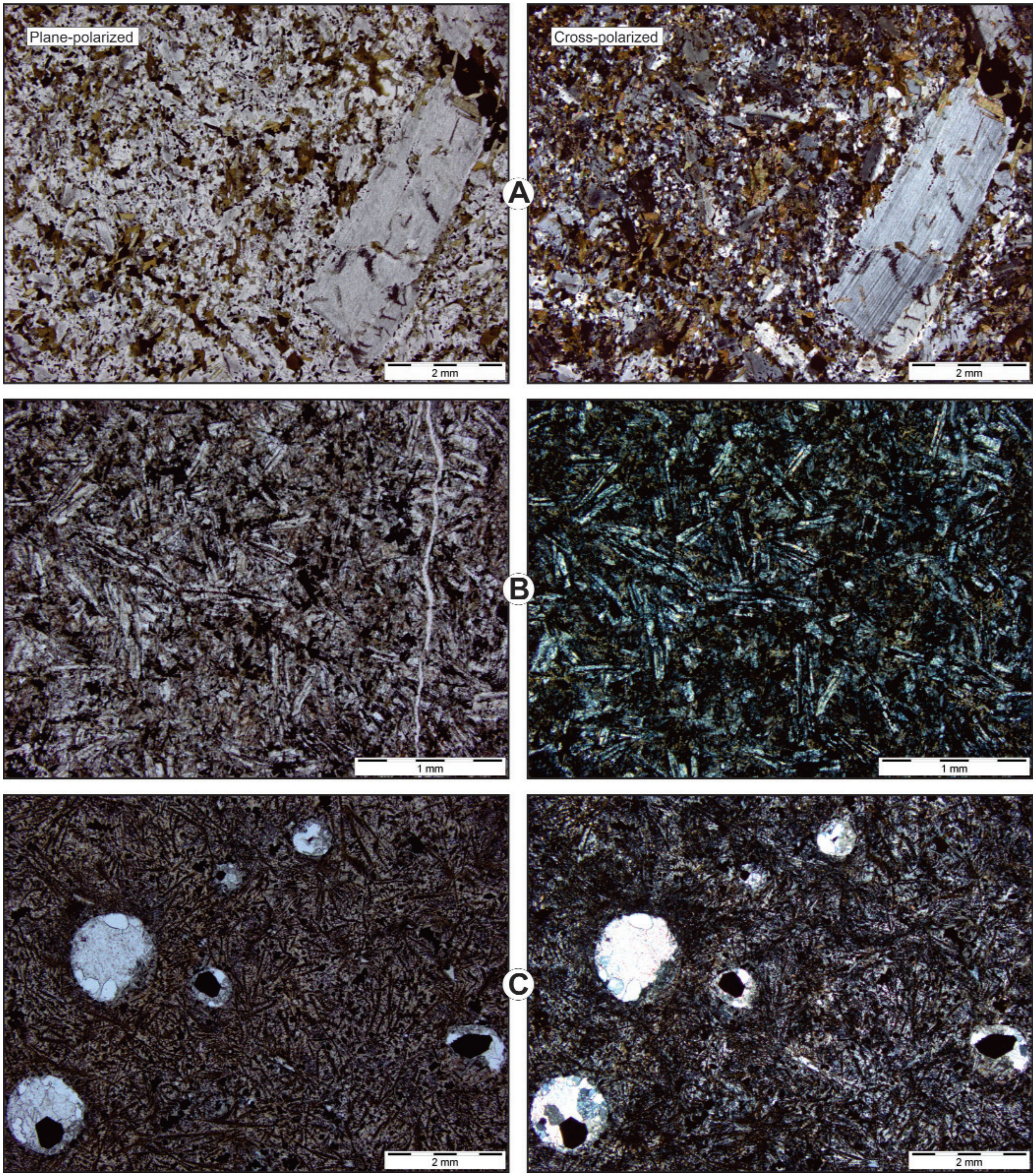


Plate 17.6. *Early post-Grenvillian mafic dykes (L'Anse-au-Diable, York Point and Gilbert Bay types). A. L'Anse-au-Diable mafic dyke showing complex branching and indications of magma mingling (CG93-057), B. Dated L'Anse-au-Diable mafic dyke truncating pegmatite, which is illustrated in Plate 17.2D (CG93-268), C. L'Anse-au-Diable net-veined mafic dyke discordantly intruding host gneiss (CG93-300), D. Detail from dyke in Plate 17.6C, showing dyke margin, magma mingling and granitic xenoliths (CG93-300), E. York Point mafic dyke, undated (VN93-661).* See *also Plate 13.7C, F. Gilbert Bay mafic dyke (JS86-339).*

approach adopted here is to use the two samples for which geochronological data are available as geological reference samples and compare the others to them. These are CG93-268C (Photomicrograph 17.3A) and DL93-090 (*cf.* BK71-71.2).

Group 1. Group 1 dykes, namely those most similar to CG93-268C, are CG93-026B, CG93-026D, CG93-050, VN93-041C, VN93-045A, VN93-609C and perhaps VN93-729B. They are all either plagioclase-phyric or have a seriate texture involving a gradation in plagioclase grain sizes. The plagioclase grains were originally euhedral, but are now characterized by ragged recrystallized grain margins, and a very fine dust of opaque-mineral(?) inclusions. All have red-brown, aligned flakes of biotite and all (except CG93-268C – the reference sample) have equant, anhedral grains of pale green clinopy-



Photomicrograph 17.3. *Early post-Grenvillian mafic dykes. A. L'Anse-au-Diable dyke showing relict plagioclase phenocryst in a largely recrystallized matrix retaining some relict primary plagioclase. Dated sample 985 ± 6 Ma (CG93-268C), B. York Point dyke displaying skeletal plagioclase texture. Undated (VN93-661C.1), C. Gilbert Bay dyke. Amygdaloidal, infilled by calcite, pyrite and quartz. Quenched ground mass. K–Ar whole rock age 702 ± 16 Ma from this site (SN86-395). Unit has 974 ± 6 Ma U–Pb age.*

roxene. Both oxide and sulphide opaque minerals are present, although oxide is dominant. Apatite is abundant, forming acicular, skeletal grains. Sample VN93-729B is slightly different in having groundmass K-feldspar and carbonate, and secondary pale green amphibole.

Group 2. Group 2 dykes, namely those most similar to DL93-090, are CG93-016C, CG93-026C, CG93-034C, CG93-034D, CG93-077B, CG93-206C, CG93-267, CG93-455C, DL93-090, DL93-098, VN93-072(?), VN93-79B(?), VN93-093A, VN93-106(?), VN93-244(?). The '(?)' indicates that these are less confidently included as members of this group. The same plagioclase-phyric or seriate textures are present as seen in the previous group, including some euhedral outlines, but, in general, the grains are more recrystallized and inclusion dusting not so obvious. Biotite forms aligned, orange-buff to green flakes and clinopyroxene is only present as ragged, relict grains. Both oxide and sulphide opaque minerals are present, and apatite (commonly acicular and/or skeletal) is abundant. The major difference from Group 1 is the abundance of amphibole, typically a blue-green hornblende, but locally actinolitic. Chlorite is also a major secondary mineral, especially in DL93-090 and CG93-267, and minor epidote, sericite, carbonate and titanite are other secondary phases. Sample CG93-034D contains extensive secondary titanite, chlorite, rutile and carbonate, which result from alteration due to proximity to the Red Bay fault. Noting that CG93-026C and CG93-267 occur close to dykes belonging to Group 1 and have similar orientations to Group 1 dykes, the conclusion is drawn that the dykes in Group 2 are fluid-modified metamorphic equivalents in which the clinopyroxene has been replaced by hydrous mafic silicates, and recrystallization concomitantly more advanced. These two groups include all the samples for which whole-rock geochemical analyses are available, all of which appear to define a single compositional entity.

17.4.8.2 York Point Dykes

A group of east-trending dykes was mapped on the coast halfway between Wreck Cove and Henley Harbour and termed the York Point dykes (Figure 17.6; Plate 17.6E). The dykes are straight-sided, and dip steeply to the north (at about 70°). A dyke found at the northern tip of Henley Island is macroscopically similar, is also east-trending and steeply north dipping (CG93-776; not examined petrographically). The dykes range in thickness from about 30 cm to several metres. In the field, although locally having hematite- and epidote-filled fractures, the dykes retain primary igneous minerals (comparing more closely with the Gilbert Bay dykes than the L'Anse-au-Diable dykes).

Eight dykes have been examined in thin section (VN93-656, VN93-659, VN93-660C, VN93-661B, VN93-661C.1 (Photomicrograph 17.3B), VN93-661C.2, VN93-662B, VN93-662C, VN93-662D). Plagioclase forms stubby to elongate, euhedral, well-twinned, strongly zoned, lightly altered, pale pinkish-brown crystals that have a seriate to porphyritic relationship to the enveloping groundmass. In detail, grain boundaries are somewhat irregular and corroded, suggesting incipient recrystallization. This is minor compared to that evident in the L'Anse-au-Diable dykes, and the pinkish-brown tinge to the crystals also distinguishes the two groups. Belt-buckle and tuning-fork skeletal, quenched plagioclase crystals are particularly evident in sample VN93-662C. An unusual feature in VN93-660C is euhedral plagioclase grains enveloping ovoid cores made of a fine-grained mosaic of uncertain composition (fine-grained, pea-sized xenoliths?). Elongate orthopyroxene is seen in VN93-662D. Both oxide and sulphide opaque minerals are present, the oxide commonly having skeletal form. Highly acicular, skeletal apatite is also characteristic. Most samples contain scaly-green or green-brown biotite. Titanite, K-feldspar, and carbonate are locally recognizable, but several of the samples have a groundmass too fine grained for mineral identification with a standard petrographic microscope. Much of the granular-looking matrix is probably altered pyroxene. A noteworthy feature of VN93-660C, VN93-661B and VN93-662C is the presence of amygdules, which are filled with carbonate or quartz. Shallow-level emplacement is clearly indicated from the pervasiveness of both quench and amygdaloidal textures.

Some K–Ar data are available (Wanless *et al.*, 1974) from Bostock's locality BK71-77.3B, which is equivalent to VN93-661. The age obtained was 568 ± 22 Ma (whole-rock; recalculated from 560 ±22 Ma, the average of two originally obtained dates of 566 ± 22 Ma and 553 ± 21 Ma).

It has been an issue whether the dykes correlate with the late-Grenvillian L'Anse-au-Diable suite, or are feeders to the Lighthouse Cove mafic volcanic flow. Given: i) the 568 ± 22 Ma K–Ar age, ii) the close proximity of these dykes to the volcanic rocks of the Lighthouse Cove Formation at Henley Harbour, and iii) the quench and amygdaloidal evidence of high-level emplacement, Gower *et al.* (1994) considered that these could be potential feeder dykes to the Lighthouse Cove Formation. Whole-rock geochemical compositions, however, indicate that they belong with the L'Anse-au-Diable dykes.

At time of writing, two samples have been submitted to the Jack Satterly geochronological laboratory for geochronological study. The samples are VN93-660D (dyke *ca.* 3.5 m wide; trend 265/74) and VN93-661D (dyke *ca.* 3 m wide; trend 260/72). A previous attempt was made to date a sample from locality VN93-661, but no dateable material was found. It was considered (M. Hamilton, personal communication, 2012) that a second try was worthwhile using improved techniques.

The York Point dykes have also being investigated paleomagnetically (J. Hodych, personal communication, 2006), but the data remain unpublished.

17.4.8.3 Gilbert Bay Dykes

At least two of the Gilbert Bay dykes were first mapped by Wardle (1976, 1977), who simply referred to them as posttectonic dykes. Nine dykes were located during the 1986 mapping by Gower *et al.* (1987), and one more was discovered by the author in 2003 following construction of Highway 510 in the region.

The name 'Gilbert Bay dykes' entered peer-reviewed literature *via* Wasteneys *et al.* (1997). In retrospect, it was an unfortunate choice of names in that the label had already been previously applied to the Gilbert Bay granite, initially by Wardle (1976, 1977) and in the peer-reviewed literature by Gower *et al.* (1991).

Wasteneys *et al.* (1997) established the age of one dyke to be 974 ± 6 Ma (MN86-188; concordant U–Pb age from skeletal zircon). A U–Pb concordant titanite age of 955 ± 20 Ma was obtained from the same sample. The material dated was a 1-cm-wide pegmatitic veinlet completely enclosed by the dyke and interpreted to be a late-stage fractionate of the mafic magma. Two whole-rock K–Ar ages (Figure 17.6) have also been determined for the Gilbert Bay dykes (Kruger Enterprises Inc.). The dates obtained are 717 ± 15 Ma (JS86-339C) and 702 ± 16 Ma (SN86-395). At time of writing, an additional sample has been submitted to the Jack Satterly laboratory for geochronological study – sample CG11-001B (dyke *ca.* 3. m wide; dip shallow, trend variable).

The Gilbert Bay dykes (Plate 17.6F) are mostly clustered near the entrance of Gilbert Bay, but extend at least 80 km inland from the coast in a 285° direction (Figure 17.6). This trend is similar, but not identical, to that of the Gilbert River fault (295°) and older structural fabrics in the region. Individual dykes have variable trends, but are mostly southeasterly with southwest dips. Their widths are equally variable, ranging from a few centimetres up to 20–25 m. Some are parallel-sided intrusions, whereas others show irregular, anastomosing form, enclosing blocks of country rock. At CG86-694, one dyke occurs as a series of *en échelon*, fat-pod-shaped lenses a few 10s of centimetres wide, in the same outcrop as a 1-m-wide parallel-sided dyke. The dykes are brown- or grey-weathering, and exhibit obvious chilled margins against their host rocks. Several of the dykes are amygdaloidal. Grain size ranges from extremely fine to medium. Generally, the dykes are aphyric, but an exception is JS86-451, where the rock contains plagioclase phenocrysts up to 2 cm long, although mostly between 3 and 4 mm. Locality JS86-451 is of further interest in that the body here is composite, showing an inner 3-m-wide dyke chilled against an outer dyke that was originally 1.5 m wide. It is clear that the dykes were emplaced at a shallow level in a brittle environment, for which brecciation and slickensided surfaces in the adjacent, intruded country rock provide further evidence. The dykes are commonly well jointed, breaking up into small, smooth-faced angular fragments.

The mineral assemblage in the Gilbert Bay dykes comprises plagioclase, amphibole (*cf.* actinolite), biotite, opaque minerals, apatite, zircon, and late-stage/secondary titanite, epidote and chlorite. None of the samples contains olivine or pyroxene. Plagioclase forms subhedral to euhedral, lightly to heavily sericitized, well-twinned grains. These are skeletal in part, but some are clearly out of equilibrium with their surroundings. This is especially true of the phenocrysts in JS86-451B, which have rounded, embayed, irregular, atoll-like, resorbed margins. The identification of amphibole in several samples is uncertain, relying on interpreting chloritized clusters showing acicular amphibole habit as pseudomorphs of actinolite. Biotite forms anhedral, scaly to ragged, orange-brown grains, mantling opaque minerals in part. Opaque minerals occur as subhedral to euhedral, single or clustered grains and also as acicular, quenched form showing herringbone dendritic habit. Sulphide and oxide are both present. Apatite is an abundant accessory mineral, commonly exhibiting skeletal, hollow capillary form. The skeletal zircon extracted from the dated dyke was not unequivocally identified in thin section. A felsic (quartz–K-feldspar?) fine-grained, interstitial intergrowth is locally present. Several of the dykes (CG03-376, CG11-002, CG86-195, CG86-693, JS86-339, JS86-451, SN86-395), have ovoid amygdules up to about 2 mm in diameter that contain quartz, carbonate and/or a sulphide opaque mineral (*cf.* pyrite) (Photomicrograph 17.3C). Sample CG86-693B is of particular interest in that it shows variolitic texture and also contains an ovoid cluster of xenolithic plagioclase, itself showing evidence of invasion by basaltic liquid in which a gas bubble was entrapped.

Clearly, the L'Anse-au-Diable dykes, the York Point dykes, Gilbert Bay dykes and Red Bay gabbronorite all belong to one magmatic episode, although all magmatism was not necessarily completely coeval. Wasteneys *et al.* (1997) argued that the 10-million-year nominal age difference between the Gilbert Bay dykes and L'Anse-au-Diable dykes is likely to be meaningful, pointing out that the dykes in the L'Anse-au-Diable area are mildly deformed and weakly metamorphosed, whereas those in the Gilbert Bay area are undeformed and only very slightly and sporadically recrystallized, implying that the L'Anse-au-Diable dykes were emplaced during the waning stages of Grenvillian orogenesis, whereas the Gilbert Bay dykes postdate it.

Note that the geochronological results disprove the assumption of Gower *et al.* (1987) that these dykes postdate the Long Range swarm. Gower *et al.*'s conclusion was rooted, at the time, in lack of discrimination between the 974 Ma Gilbert Bay and *ca.* 327 Ma Sandwich Bay dykes, both of which have similar southeast general trends. Both Wardle (1976, 1977) and Gower *et al.* (1987) included dykes that are unrelated, but, with the assistance of petrographic, geochemical and geochronological data (none of which were then available), the various suites can now be better distinguished.

17.4.8.4 Other Potentially Correlative Dykes

A few additional dykes were recorded that are suspected to belong to the same period of mafic dyke injection, but are less obviously related because of isolation from the above three groups. One example is an amygdaloidal dyke at JS87-398B situated 7.5 km northeast of Henley Harbour.

The sample contains plagioclase phenocryst laths, up to about 1 mm long, showing heavy sericitization and wavy recrystallized grain boundaries. The phenocrysts are set in a fine-grained groundmass of recrystallized plagioclase; ragged-green biotite and chlorite; granular, dark-brown titanite; an opaque oxide; and acicular apatite. Amygdules are not present in the thin section, but are clearly evident in the stained slab. The recrystallized mineral assemblage, lack of fabric, and amygdules are the reasons for assigning the dyke to this unit. An alternative affiliation is with the Long Range dykes.

17.4.8.5 Lithogeochemistry of Late-Grenvillian Mafic Dykes

Some lithogeochemical characteristics of the L'Anse-au-Diable, York Point and Gilbert Bay dykes are displayed in Figures 17.8 and 17.9 in standard diagrams for mafic rocks. The main purpose of Figure 17.8 is to demonstrate that overall, they form a coherent group of mafic dykes having alkalic features. Full rare-earth-element data are only available for two Gilbert Bay dykes and two York Point dykes (Figure 17.8B), but partial data and surrogate-element data (*e.g.*, Y) are available in the author's database for all of the samples depicted in the other diagrams, and indicate that they display the same pattern as the representative samples shown. Also included are two samples of Upper St. Lewis River mafic dykes (Section 17.5.13), which are obviously distinct. The Upper St. Lewis River mafic dykes are younger (post-966 Ma).

The plots in Figure 17.8 imply that the Gilbert Bay dykes are more fractionated relative to the L'Anse-au-Diable and York Point dykes, whilst reinforcing that all three dyke groups are mutually related. The fractionation aspect is more evident in Figure 17.9, as shown by higher P_2O_5 relative to TiO_2 and La relative Y although two of the L'Anse-au-Diable mafic dykes also display similar character. Figure 17.9 also shows the coherence between the L'Anse-au-Diable and York Point mafic dykes, thus quantitatively justifying the interpretation that the undated York Point dykes are late-Grenvillian, rather than younger.

Foreshadowing, Figure 17.9 also demonstrates that the late-Grenvillian mafic dykes are compositionally distinct from Phanerozoic mafic dykes in eastern Labrador (which are addressed in Chapter 19).

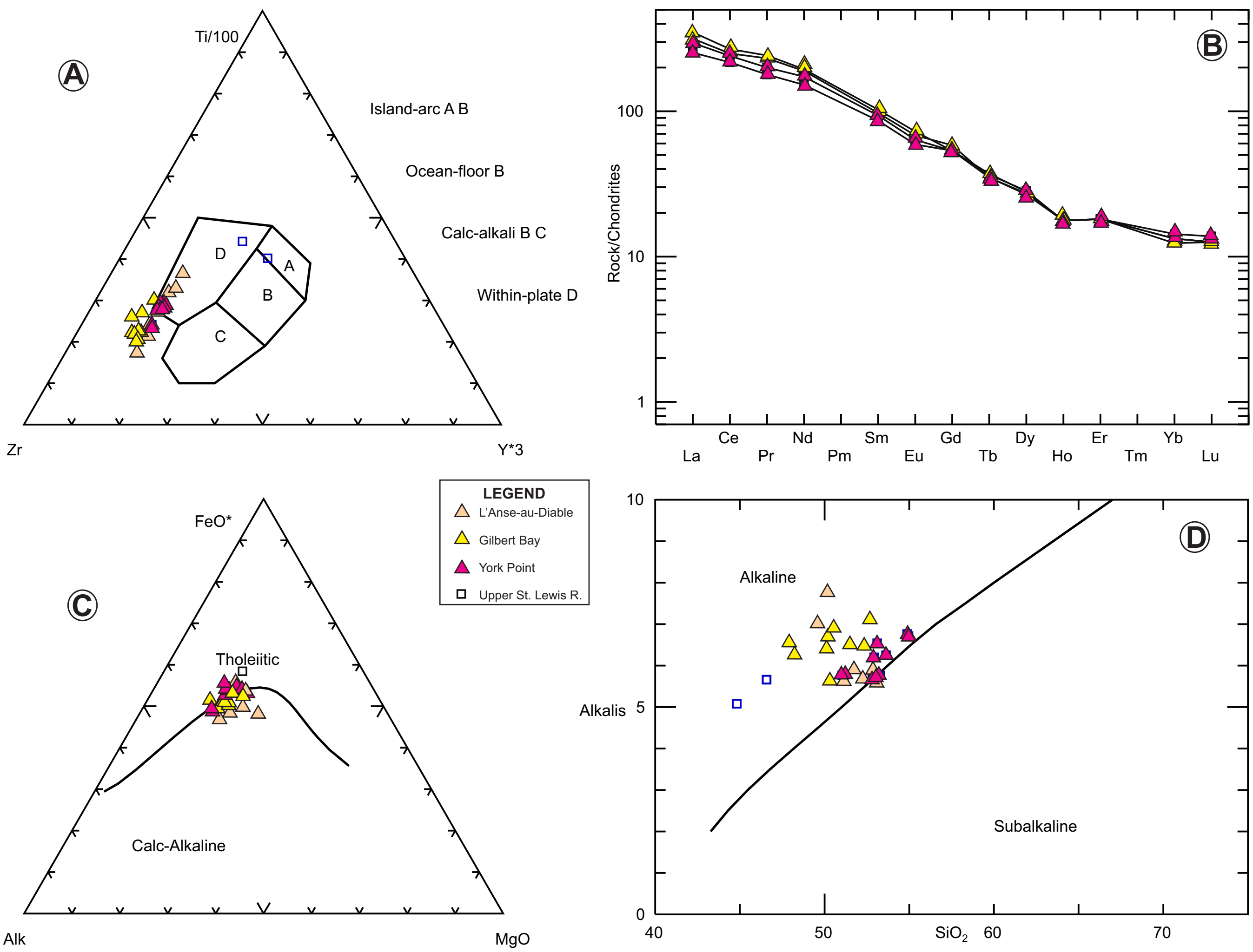


Figure 17.8. *Some lithogeochemical features of the L'Anse-au-Diable, York Point, Gilbert Bay and Upper St. Lewis River mafic dykes.*

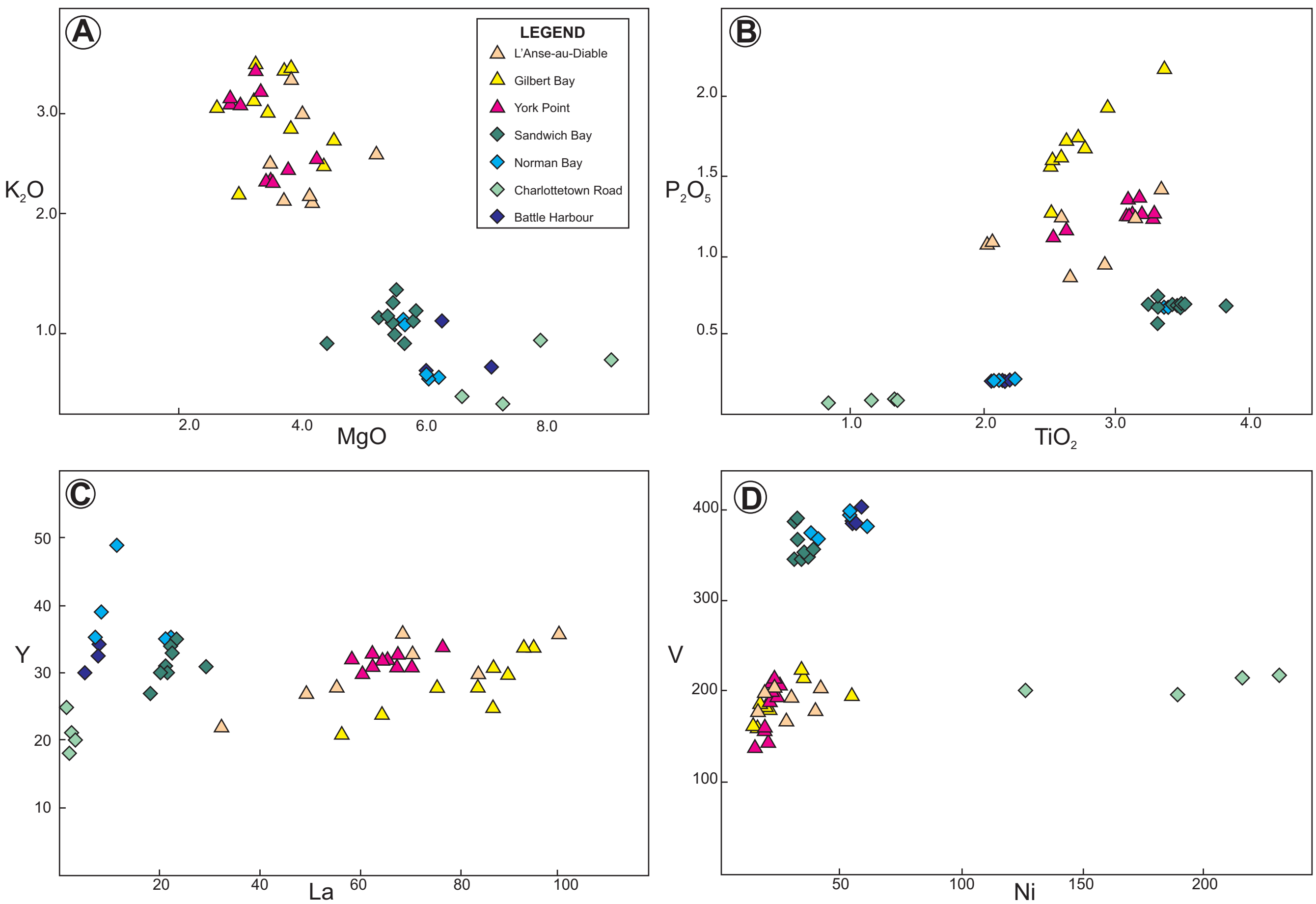


Figure 17.9. *Further lithogeochemical characteristics of late Grenvillian mafic dykes (L'Anse-au-Diable, York Point and Gilbert Bay) and contrast with Phanerozoic mafic dykes (Sandwich Bay, Norman Bay, Charlottetown Road and Battle Harbour).* See *Chapter 19 for latter aspect.*

17.5 LATE POST-GRENVILLIAN INTRUSIONS (M_{3D} *ca.* 975–955 Ma)

17.5.1 HISTORICAL BACKGROUND

The first sampling of any late- to post-Grenvillian intrusion in eastern Labrador was in 1984 during a reconnaissance investigation of doughnut-form, obvious aeromagnetic anomalies in the Kyfanan Lake map region. These anomalies are well south of the region (Paradise River) then being mapped. A sample of massive monzonite was collected from bedrock within one such magnetic anomaly, although the extent of the rock type was not mapped out at the time. A date of 966 ± 3 Ma for the monzonite was subsequently reported by Gower and Loveridge (1987). Further sampling (again, no mapping) of rocks within other doughnut-shaped anomalies in the same region was carried out in 1986. The same year, the Southwest Pond pluton was identified in the Port Hope Simpson map region. Other plutons were mapped during field work in the St. Lewis River map region the following year, including the Chateau Pond pluton, which is the largest body of the group recognized so far.

In the mid-1980s, much of the present knowledge on late- to post-Grenvillian plutons in the eastern Grenville Province was still in its infancy. The characteristic circular-to-elliptical shape of the intrusions was still largely surmised from aeromagnetic patterns and the monzonite–syenite–granite compositional range had not been established. More information was soon acquired, especially U–Pb zircon ages, leading Gower *et al.* (1991) to publish what was known at the time. Since then, many additional late- to post-Grenvillian plutons have been mapped and additional ages obtained, including from farther west in the Grenville Province in Labrador (*cf.* Parsons and James, 2003). The late- to post-Grenvillian plutons are now also distinguished from a group of early post-Grenvillian intrusions that were emplaced between 985 and 975 Ma (Gower and Krogh, 2002; Heaman *et al.*, 2004) that were addressed in the previous section. The distribution of the late post-Grenvillian plutons is shown in Figure 17.10.

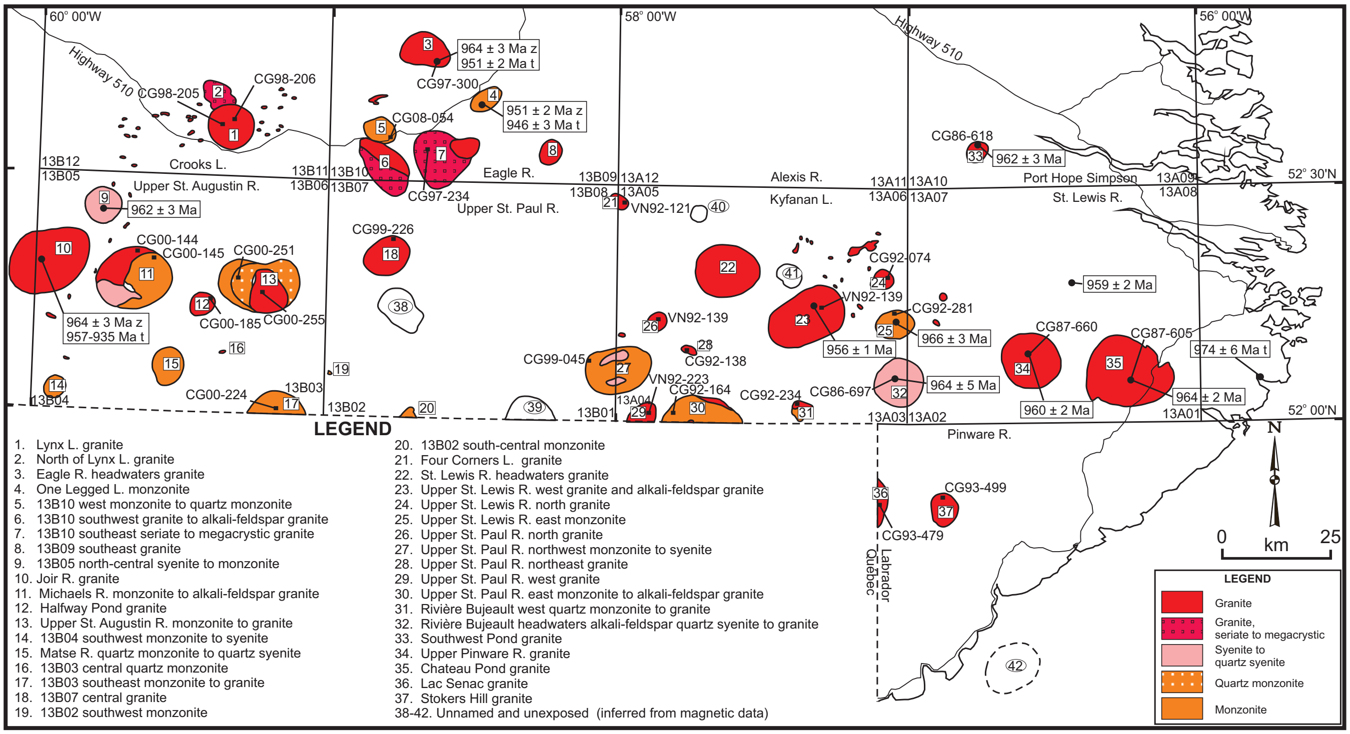


Figure 17.10. *Late post-Grenvillian granitoid intrusions; regional distribution, names and ages.*

17.5.2 CHARACTERISTICS

The plutons are not difficult to recognize in the field. They are: i) typically circular to ovoid in plan view, ii) coincide with positive magnetic anomalies (some evident in Figure 5.8), iii) have a tendency to resist weathering relative to the surrounding rocks (except those intrusions lacking quartz), iv) have a characteristic horizontal jointing pattern, v) are coarse grained, massive, and show no (or slight) recrystallization, and vi) commonly have mantled feldspars. Despite being more resistant to erosion than the surrounding rocks, their coarse grain size and high feldspar content makes them somewhat susceptible to crumbly weathering, producing rounded hills covered in trees that have taken advantage of the relatively favourable soil and drainage conditions. The horizontal jointing is an excellent field-recognition criterion (Plate 17.7). The joints tend to be continuous and regularly spaced and the intervening rock to weather to a smooth, convex-outward form between the joints, to give outcrop faces that resemble the edge of a stack of (thick) pancakes. Despite only one of the six plutons illustrated in Plate 17.7 having been dated (CG97-300), all are confidently assigned to this group of rocks.

Details of individual plutons are presented below by map region more-or-less from northwest to southeast, followed by short sections on potentially additional but unexposed plutons, and interpreted coeval, minor granitic intrusions of particular interest. Note that the plutons have been numbered in order of presentation and, where illustrated (Plates 17.8–11), that these numbers are included in the plates. Representative stained slabs are illustrated in Appendix 2, Slabs 17.8 to 17.11.

17.5.3 CROOKS LAKE MAP REGION

17.5.3.1 Lynx Lake Granite (M_{3D}gr)

The Lynx Lake granite (#1) was mapped by Gower (1999) who simply referred to it as the southern of two late- to post-Grenvillian plutons within the Crooks Lake map region. The name 'Lynx Lake granite' is newly coined here from an informal name for the lake used locally in Cartwright. The pluton is inferred to be circular (10.5 km diameter) based on topography and a distinct aeromagnetic high. From outcrop and topographic constraints, the aeromagnetic expression of the granite is displaced 3 km to the east relative to the pluton. Eade (1962) provides a hint for the pluton's existence, inasmuch as he distinguished a 3-km-diameter granitoid body in the vicinity, based on his data station M61-042.

The constituent rock is pink-weathering, massive, homogenous, 2-feldspar, biotite granite (Plate 17.8A). It contains roughly equal proportions of plagioclase, K-feldspar and quartz. K-feldspar commonly mantles plagioclase, but some plagioclase has K-feldspar cores. Staining reveals three types of feldspar, namely: i) K-feldspar that

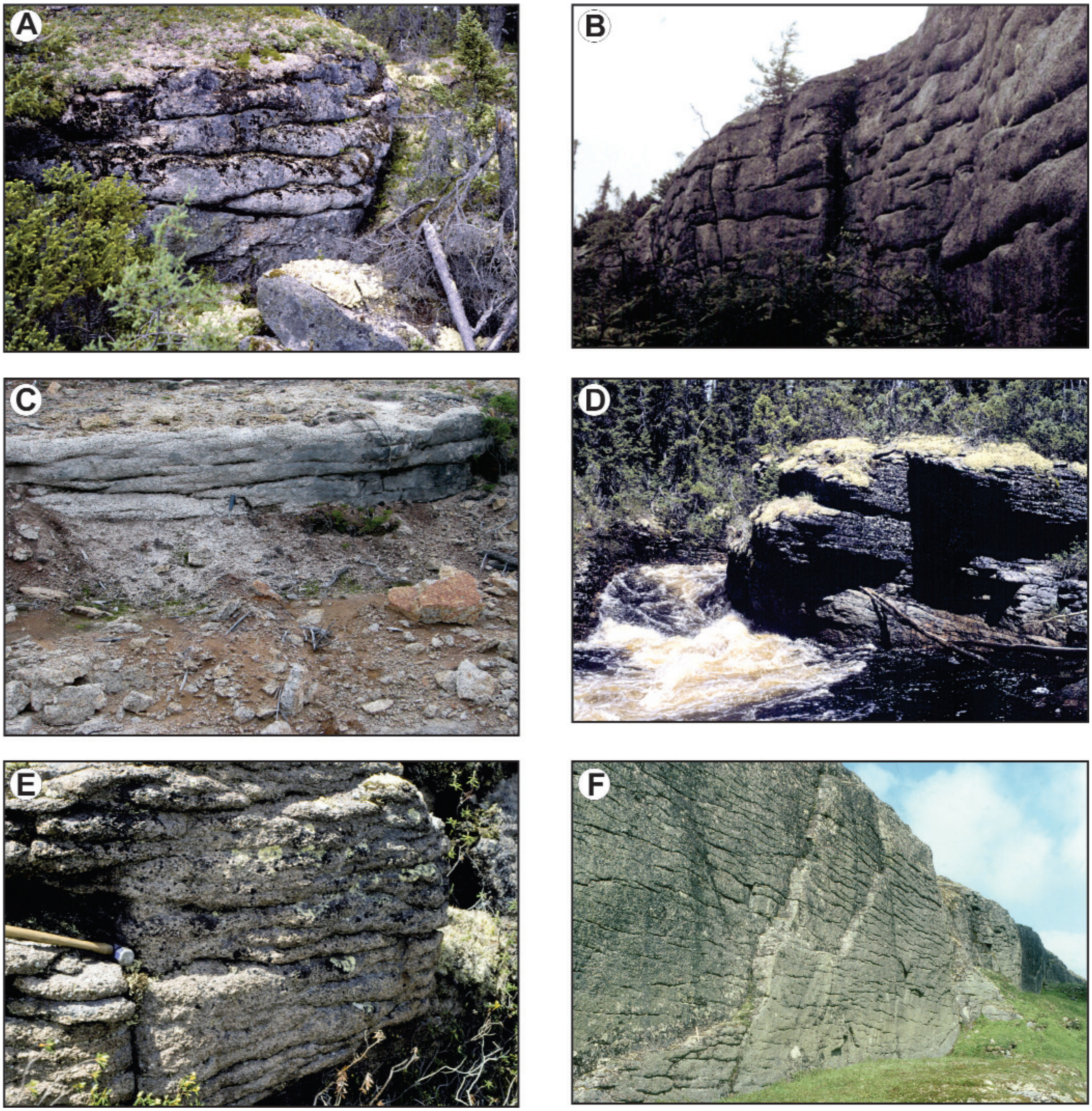


Plate 17.7. *Examples of characteristic horizontal jointing commonplace in post-Grenvillian granitoid plutons. A. Lynx Lake granite (CG98-206), B. Eagle River headwaters granite (CG97-300), C. 13B10 west monzonite to quartz monzonite (CG08-054), D. Michaels River monzonite to alkali-feldspar granite (CG00-145), E. Upper St. Augustin River monzonite to granite (CG00-251), F. Lac Senac granite (CG93-497).*

stains yellow, ii) an unstained pale-pink feldspar, and iii) an unstained white feldspar. Textural comparison between thin section and slab indicates that the pink, unstained feldspar is albite and the white unstained feldspar is a more calcic plagioclase.

In thin section (CG98-205), K-feldspar is seen to be well-twinned microcline and plagioclase revealed as having anhedral, heavily sericitized cores, surrounding and containing patches of clear, well-twinned albite. Quartz is only weakly undulose. Other minerals are pale green, partially chloritized biotite, titanite–opaque mineral intergrowths, apatite and zircon.

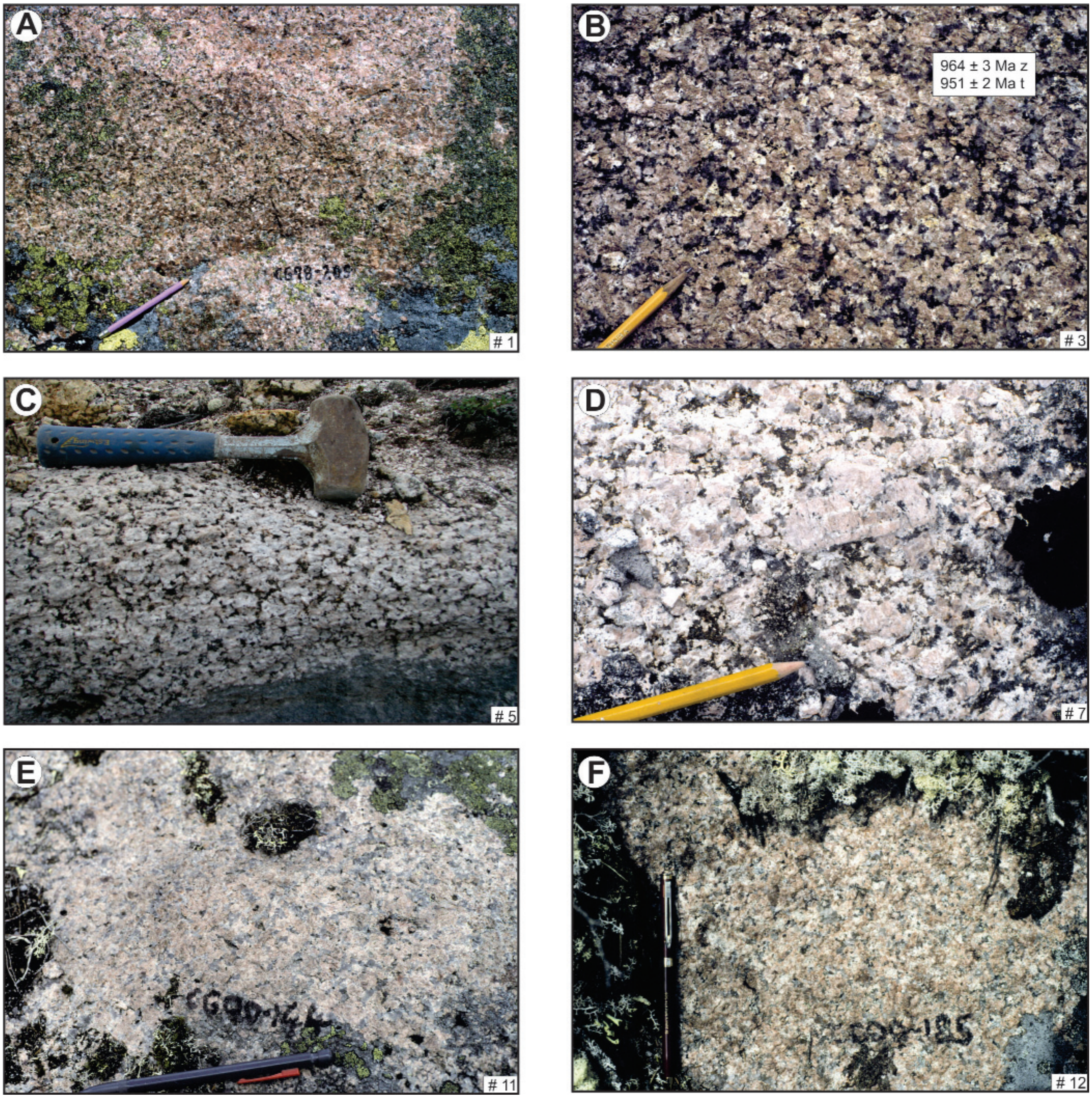


Plate 17.8. *Examples of post-Grenvillian granitoid plutons - part 1. A. Lynx Lake granite (CG98-205), B. Eagle River headwaters granite (CG97-300), C. 13B10 west monzonite to quartz monzonite (CG08-054), D. 13B10 southeast seriate to megacrystic granite (CG97-234), E. Michaels River monzonite to alkali-feldspar granite (CG00-144), F. Halfway Pond granite (CG00-185).*

One another thin section (CG98-200) from a different locality within the pluton is an enclave of medium-grained granite. It consists of plagioclase, K-feldspar and quartz, all thoroughly recrystallized and forming a mosaic of sutured grains. Associated is a wide range of accessory minerals that include ragged green biotite, irregular patches of granular epidote, titanite, an opaque oxide, allanite, chlorite, zircon (showing cores and rims) and apatite. The granite does not show much similarity to the surrounding orthogneiss, so may be an autolith.

17.5.3.2 North of Lynx Lake Granite (M_{3D}gp/M_{3D}gr)

This intrusion (#2) was mapped by Gower (1999), who termed it the northern pluton (of two late- to post-Grenvillian bodies in the Crooks Lake map region). The new informal name is introduced here. The depicted boundary of the pluton assumes that the magnetic anomaly is not displaced, because, if an equal displacement to that inferred for the Lynx Lake pluton is inferred, then the single exposure found would lie outside the anomaly-determined 'displaced' position for the pluton. It is recognized that interpretation of extent of this pluton remains unsatisfactory.

Like the Lynx Lake pluton, the rock is pink-weathering, homogeneous, two-feldspar, biotite granite. It differs texturally, however, in containing seriate to megacrystic K-feldspar up to 2 by 1 cm (CG98-126) and some diffuse, fine-grained enclaves that are slightly more melanocratic than their host. A fabric is defined by megacrysts and enclaves, both having an east-northeast alignment. The rock was not examined in thin section.

17.5.4 EAGLE RIVER MAP REGION

17.5.4.1 Eagle River Headwaters Granite (M_{3D}gr)

The Eagle River headwaters granite (#3) is a 12 by 8 km ovoid pluton, elongate in an easterly direction. It was mapped by Gower (1998), but the name is newly introduced here. Outcrop control and topography (an elevated area of low, rounded, wooded hills rising above the surrounding marshlands) effectively define the extent of the intrusion. The pluton can also be correlated with a positive magnetic anomaly, although the anomaly is displaced 3 km to the east-southeast relative to the outline of the body.

A U–Pb zircon age of 964 ± 3 Ma and titanite age of 951 ± 2 Ma were reported by Gower *et al.* (2008b), obtained from a sample (CG97-300; Plate 17.8B) collected from near the southeast border of the pluton.

The pluton is made up of pink-weathering, massive, coarse- to very coarse-grained granite. Only near the marshland–wooded hill interface does it grade into a medium-grained compositional equivalent – a textural variation that serves to confirm that the vegetation and topographic break is, indeed, at the pluton margin. No minor granitoid or mafic minor intrusions or mafic enclaves were observed in any part of the body. Throughout most of the pluton, alkali feldspar is anhedral to subhedral and 1–2 cm in diameter; quartz and plagioclase are anhedral, and both are 0.5–1.0 cm across. The plagioclase is bright-pink in outcrop; staining demonstrates that not all pink feldspar is potassium bearing.

In thin section (CG97-176, CG97-179, CG97-182, CG97-300) alkali feldspar is seen to be mostly well-twinned microcline containing irregular patches of albite and also enclosing small plagioclase crystals. A characteristic feature of the pluton is extensive sericitization of plagioclase, which has masked well-developed polysynthetic twinning and resulted in large, irregular plates of white mica. Plagioclase is typically zoned and has clear albitic borders. Twin lamellae are kinked in places. Quartz is weakly undulose, but locally shows incipient grain-boundary recrystallization. The main mafic mineral is biotite, which has a washed-out orange-green colour, and commonly is either partially chloritized or has deeper orange, oxidized margins. Ubiquitous accessory minerals include partially hematized magnetite, traces of limonitized sulphide, apatite and zircon. In addition, fluorite, garnet(?) and primary(?) muscovite were seen in CG97-179, titanite in CG97-182, and fluorite and rare allanite in CG97-300. The fluorite is colourless to purple-tinged. The identification of garnet in CG97-179 is considered uncertain because of its unusual anastomosing habit, following grain boundaries between feldspar and quartz. The petrographic differences in thin section CG97-179 are attributed to the sample locality being near the edge of the pluton.

17.5.4.2 One-Legged Lake Monzonite (M_{3D}mq)

Three outcrops of the monzonite pluton (#4) straddling the boundary between NTS map area 13B/09 and 13B/10 were mapped by Gower (1998), but the terrain in this area is sufficiently varied to anticipate finding additional exposures with more detailed mapping. The informal name 'One Legged Lake monzonite' is introduced here. The monzonite forms an 8 by 4.5 km, ovoid, northeast-trending pluton, the outline of which can be inferred from an aeromagnetic high, topographic lineaments and country-rock outcrop control. The aeromagnetic anomaly is displaced about 1 km in a northeast direction, with respect to the mapped pluton. The monzonite is buff- to pale-pinkish-cream-weathering, medium to coarse grained, homogeneous, and massive to weakly foliated. It is less coarse grained than typical of late- to post-Grenvillian plutons. Horizontal jointing is particularly well developed in this pluton.

A concordant U–Pb zircon age of 951 ± 2 Ma and a concordant titanite age of 946 ± 3 Ma for sample CG97-173 were reported by Gower *et al.* (2008b). The 951 Ma U–Pb zircon age means that this is the youngest known pluton related to Grenvillian orogenesis in the Grenville Province (however, note that Karabinos and Aleinikoff (1990) earlier reported zircon ages between 965 ± 4 Ma and 945 ± 7 Ma for the Bull Hill Gneiss Member in the Grenvillian Green Mountain inlier in the Appalachians in Vermont).

Stained slabs show the rock to consist of K-feldspar and plagioclase in approximately equal proportions, with minor quartz (less than 3%), hornblende, biotite and magnetite.

In thin section (CG97-160, CG97-173), K-feldspar is seen to be mostly microcline with some flame perthite. Plagioclase is moderately sericitized and has albitic borders. Quartz is anhedral and unrecrystallized. Of the mafic minerals, amphibole is ragged and tending toward a blue-green variety and biotite is olive-green and contains vermiform quartz inclusions. Accessory minerals are magnetite, titanite, apatite and zircon, accompanied by secondary hematite, chlorite, white mica and rutile. Thin section CG97-160 contains visually striking rutile in chlorite.

17.5.4.3 13B10 West Monzonite to Quartz Monzonite (M_{3D}mz, M_{3D}mq)

The monzonite to quartz monzonite pluton (#5) near the west-centre of NTS map area 13B/10 was originally mapped by Gower (1998) on the basis of a lone outcrop – despite a thorough search at the time for others. The slightly elliptical outline of the body (8 by 6 km, elongate in a southeast direction) was inferred from its aeromagnetic signature, which placed the single outcrop close to the intrusion's centre. Gower (1998, page 136) commented, 'given that most of the late- to post-Grenvillian plutons are homogeneous throughout, the lone outcrop could probably be accepted as representative of the bulk of the body'. Since then, construction of the Trans-Labrador Highway has resulted in the creation of several additional exposures in the southeast part of the pluton. These demonstrate, ironically, that significant compositional heterogeneity exists, so, whereas the remainder of the pluton now mapped as quartz monzonite, a crescent-shaped area of monzonite to monzodiorite is depicted in fringing the eastern and southern borders on the 1:100 000-scale map (Gower, 2010a; Eagle River map region). This depiction is more a device for demonstrating compositional variation, rather than defining genuine distribution of rock types. The additional exposures did not assist in refining the margin of the pluton, which remains unchanged. More detailed study could clarify the nature of the contact between this intrusion and the 13B10 southwest pluton (*see* below) to the south.

The monzonite to quartz monzonite in the centre of the pluton is pink- to buff-grey-weathering, coarse grained, massive and homogeneous (Plate 17.8C). The exposures along the Trans-Labrador Highway are grey or purplish-grey, coarse-grained, homogeneous, massive to weakly foliated monzonite to monzodiorite. Also along the highway, horizontal jointing is characteristic; mafic to 'dioritic' enclaves are fairly common; and the rocks are cut by hematite- and epidote-filled fractures.

Thin sections were prepared from the lone central outcrop and one of the Trans-Labrador Highway exposures. The lone-outcrop sample (CG97-298) contains anhedral, perthitic K-feldspar, patchily sericitized plagioclase, and very minor, interstitial quartz. Mafic silicate minerals are clinopyroxene (containing minute exsolved rods of opaque material), hornblende, and biotite. The hornblende, which contains symplectic, vermiform quartz, is largely, if not entirely, derived from alteration of clinopyroxene. Orange-brown biotite, also containing vermiform quartz, is preferentially associated with opaque minerals. Other minerals are an opaque oxide, traces of sulphide, apatite and zircon. The Trans-Labrador Highway sample (CG08-054B) contains locally subhedral plagioclase, perthitic K-feldspar, minor quartz, olive-green biotite, blue-green amphibole, oxide and sulphide opaque minerals, titanite (mantling the opaque oxide) and zircon. The stained slab shows incompletely developed mantled feldspar textures. Apart from the presence of clinopyroxene, CG97-298 is distinguished from CG08-054B by having much more K-feldspar and a much lower mafic mineral content.

17.5.4.4 13B10 Southwest Granite to Alkali-feldspar Granite (Megacrystic in Part) (M_{3D}gp/M_{3D}gr)

The pluton in southwest NTS map area 13B/10 (#6), is elliptical, measuring 12 by 7.5 km, elongate in a northwest direction. It was mapped by Gower (1998, 2000). It is pink-weathering, coarse-grained, generally massive granite, grading into alkali-feldspar granite. From outcrop and stained slabs, textures can be adequately described as homogeneous, but terms such as seriate, megacrystic or rapakivi may be applied with some justification. On the 1:100 000-scale geological map, the northeast half is indicated as non-megacrystic, and the southwest megacrystic, but the contrast is not as sharp as the assigned units imply. The prevailing rock type contains ovoid to euhedral alkali-feldspar (commonly 1.5–2 cm long), anhedral to subhedral quartz and plagioclase (up to 1 cm in diameter). The Trans-Labrador Highway crosses the northwest edge of the pluton. Active road construction at the time of the author's visit prevented detailed examination of the newly exposed rocks (*e.g.*, CG08-062), but the impression was gained that they were not typical of the rest of the body, having more amphibolite enclaves in particular. Some revision of the mapped border may be required.

An outcrop (CG97-268) that departs from the general description of the pluton, but grouped with it, consists of massive, homogeneous, K-feldspar-poor monzonite associated with microgranite situated at the interpreted western margin of the intrusion. The rock is texturally distinctive, having subhedral plagioclase grains up to about 1 cm across in a matrix composed almost entirely of hornblende and K-feldspar. The rocks lack similarity with the surrounding country rocks, therefore the outcrop is considered to indicate a more melanocratic border phase of the pluton.

A few small (10 by 5 cm), medium-grained, elliptical, biotite–plagioclase enclaves were recorded in the southern part of the body. An isolated outcrop of black- to buff-weathering, medium-grained, homogeneous, foliated, recrystallized plagioclase-hornblende rock, with subsidiary biotite and K-feldspar (leucomonzodiorite) from near the centre of the body is interpreted to be a roof pendant. One microgranite dyke was recorded.

In thin section (CG97-258, CG97-263, CG97-265, CG97-280, CG99-249, CG99-267), K-feldspar is about equally divided between flame perthite and well-twinned microcline, plagioclase is locally recrystallized, and quartz is unrecrystallized. Mafic minerals are washed-out, pale-orange to buff-green biotite and relict blue-green amphibole (not seen in CG97-263). Accessory minerals are opaque minerals, titanite, apatite, zircon and allanite. Most of the opaque mineral is magnetite, but rare sulphide is also present and leucoxene, infilling fractures, is a distinctive feature in CG97-280. Unusually abundant, large titanite grains and common, zoned allanite are features shared with the 13B10 southeast pluton (#7), hence supporting the thesis of genetic linkage between the two bodies.

17.5.4.5 13B10 Southeast Seriate to Megacrystic Granite (M_{3D}gp/M_{3D}gr)

Main pluton. The 13B10 southeast granite (#7) is subdivided into a 'main' pluton and a 'nested' subsidiary. The main pluton in the southeast part of NTS map area 13B/10 is roughly circular, having a diameter of about 12 km. It was mapped by Gower (1998, 2000). It is grey-pink- or pink-weathering, coarse-grained, homogeneous seriate to megacrystic granite. It is mostly massive, but is locally weakly to moderately foliated, the foliation being either parallel to the inferred margin of the body or northwest in interior parts of the body. Textures range between uniform, seriate and megacrystic, but with insufficient textural contrasts to merit subdivision. K-feldspar grains range up to 5 by 3 cm, but are generally less than 2 by 1 cm. The crystals are euhedral to anhedral and show zoning in some instances (Plate 17.8D). Mantled feldspars are common, mostly K-feldspar mantling plagioclase, but locally the reverse. One interesting megacryst seen in a stained slab (CG99-150) has an inclusion-rich plagioclase core surrounded by inclusion-free plagioclase and then a rim of K-feldspar, taken as indicating disequilibrium conditions during emplacement as a crystal mush.

Enclaves are rare. One exception, recorded from the southwest part of the pluton (CG97-299), is a 5- by 1-m, foliated, fine-grained quartzofeldspathic xenolith of uncertain protolith, but probably granite. No minor granitic or mafic minor intrusions were seen.

Six samples were examined in thin section. The following description may be biased in that five are close to the border of the pluton (CG97-232, CG97-240, CG97-254, CG99-176, CG99-178), and only one is from its interior (CG97-299). Minerals present are moderately twinned, heavily sericitized plagioclase, K-feldspar, quartz, olive-green biotite, blue-green amphibole, opaque minerals, apatite, allanite, titanite and zircon. Plagioclase is locally recrystallized, but quartz is not. This feature perhaps might be attributed to intrusion as a crystal mush (consistent with the foliation mentioned above), with quartz crystallization postdating emplacement. K-feldspar is mostly well-twinned microcline, but some relict flame perthite is present. Amphibole (CG99-178) is extensively altered to an orange-brown phyllosilicate. Of the remaining minerals, biotite occurs as fairly large pale-orange–buff-green plates and is closely clustered with the accessory minerals. Titanite is abundant as large, brown, anhedral to subhedral grains, especially near the periphery of the pluton. It is anomalous in that it locally mantles allanite, or shows alternating growth zones with it. Apatite, zircon and hematite are also present. Both oxide and sulphide opaque minerals are present, although sulphide only occurs in trace amounts.

Nested pluton. A small, roughly 7 by 5 km, partially nested pluton is interpreted to straddle the northeast margin of the 13B10 southeast intrusion. Aeromagnetic patterns, and two distinct outcrops in that area, are the basis for the depiction. One outcrop is a pink- and white-weathering, coarse-grained granite and graphic-textured pegmatite, the latter containing biotite books up to 7 cm across and magnetite crystals up to 1.5 cm in diameter. The other is pink-weathering, coarse-grained, homogeneous biotite granite in which both the K-feldspar and plagioclase weather pink (very similar to the Eagle River headwaters granite).

The latter rock was examined in thin section (CG98-237) and seen to consist of microcline (some perthite), plagioclase, quartz, orange-green biotite, an opaque oxide, titanite, zircon and apatite. Some of the plagioclase is polygonal showing straight grain boundaries and 120° triple points. The rock texturally resembles the adjacent larger seriate to megacrystic pluton to the west and the simplest interpretation for the granite is that it is a fractionated derivative of it.

17.5.4.6 13B09 Southeast Granite (M_{3D}gp/M_{3D}gr)

Five outcrops found in the southeast part of NTS map area13B/09 were depicted by Gower (1998) as representing a roughly 6-km-diameter late- to post-Grenvillian pluton (#8), an interpretation supported by: i) arcuate foliation trends in the surrounding gneisses that wrap around the inferred northwest side of the body, and ii) the massive, unrecrystallized nature of its constituent rocks. This conclusion is considered less robust than for most other late- to post-Grenvillian plutons because the mapped body coincides with a magnetic low, whereas other plutons correlate with obvious magnetic highs. Gower (1998) indicated the southeast flank to be a post-Grenvillian fault, but subsequently excluded the fault (Gower, 2010a; Eagle River map region) on the basis of insufficient evidence.

The rocks are all pink-weathering, medium- to coarse-grained, homogeneous, massive biotite granite. They show more textural variability than typical of other late- to post-Grenvillian plutons, both in average grain-size variation and texture (homogeneous, seriate or tending to megacrystic). K-feldspar proportion is slightly greater than plagioclase and quartz content almost matches that of plagioclase.

Samples from two of the four outcrops were examined in thin section (CG97-199, CG97-200) and are sufficiently similar to accept a common heritage. These include moderately to heavily sericitized, well-twinned plagioclase with albitic rims; a mixture of flame perthite and cross-hatched microcline; unrecrystallized quartz; pale-orange-green, slightly chloritized biotite; an oxide opaque mineral; abundant, commonly euhedral titanite; euhedral, orange, zoned, unusually large allanite; rutile needles in chlorite; apatite and zircon.

17.5.5 UPPER ST. AUGUSTIN RIVER MAP REGION

17.5.5.1 13B05 North-central Syenite to Monzonite (M_{3D}yq/M_{3D}mq)

On the basis of a distinct positive aeromagnetic anomaly but sparse outcrop, a 7 km diameter circular body of syenite to monzonite (#9) is inferred to exist in the centre of NTS map area 13B/05. Although its aeromagnetic signature is characteristic of late- to post-Grenvillian plutons, it was hazarded to be late Labradorian by Gower (2001) because it has atypical compositional and textural features, namely: i) recrystallized character, distinct from the near-pristine textures seen in most late to post Grenvillian intrusions, ii) similarity to monzonite-to-syenite satellite plutons that exist in various places along the eastern and southern fringes of the Mealy Mountains intrusive suite (Gower and van Nostrand, 1996; Gower, 1998; James and Nadeau, 2000), and iii) its petrographic characteristics. Its extensive recrystallization, very fine perthite, disequilibrium plagioclase, and inverted pigeonite are all very characteristic of the Mealy Mountains intrusive suite. The body is not late Labradorian, however. High-quality zircon from sample CG00-135 yielded a concordant unambiguous age of 962 ± 3 Ma (Gower *et al.*, 2008b), removing any doubt regarding it being a late- to post-Grenvillian intrusion. The reasons for its anomalous features remain unknown.

The outcrops weather pink, red, buff or rusty brown, and the rocks are homogeneous and do not show planar or linear fabrics. Grain size varies from fine to coarse. The rocks lack quartz but have abundant K feldspar. Plagioclase is interstitial, or occurs as relict, embayed grains within a sea of K feldspar. Mafic mineral content is low and is judged to be pyroxene on the basis of stained slabs.

In the two thin sections (CG00-077, CG00-135), very fine stringlet perthite is dominant, occurring in a wide range of grain sizes from large grains several millimetres across to mosaics of tiny, untwinned K-feldspar grains between the larger ones. Boundaries between grains are mostly highly sutured. Plagioclase forms relict, anhedral cores to K-feldspar as moderately twinned and altered grains. It is clearly in disequilibrium with its surroundings and best considered xenocrystic. Sericitized, untwinned feldspar in the groundmass mosaics is probably sodic plagioclase, especially albite. Mafic minerals in CG00-077 are clinopyroxene, amphibole and biotite, whereas in CG00-135, which is much more extensively altered, only serpentine/chlorite pseudomorphs remain (judged to be derived from clinopyroxene from their shape). The clinopyroxene displays well-developed herring-bone exsolution of augite along the (001) plane, as is typical of twinned crystals of inverted pigeonite. The grains, overall, are somewhat ragged and partially replaced by green amphibole. Other minerals are orange-brown biotite, an opaque oxide, apatite and zircon.

17.5.5.2 Joir River Granite (M_{3D}gr)

The Joir River granite (#10) (Gower, 2001) is exposed along part of the Joir River and three of its more incised tributaries. The body continues west of the map region, where it was originally mapped by Stevenson (1967b) and subsequently by James and Nadeau (2000). The depiction of Stevenson (1967b) was the basis for its small extrapolation eastward into NTS map area 13B on the compilation of Avramtchev (1983c). Combining outcrop data from the present study, together with a brief incursion into NTS map area 13C/01 by the author during mapping of the St. Augustin River map region, and information from Stevenson (1967b) and James and Nadeau (2000), the Joir River granite is constrained to extend farther north than depicted by Stevenson (1967b), to be larger to the east than the guess of Avramtchev (1983c), and smaller to the west than indicated by James and Nadeau (2000). Based on its aeromagnetic signature, the intrusion measures roughly 20 by 14 km, elongate in a northeast direction. Note that sparse exposure still allows for some latitude in interpretation of its size.

The Joir River granite has yielded a U–Pb zircon age of 964 ± 3 Ma and titanite ages between 957 and 935 Ma (James *et al.*, 2001). The geochronology locality (DJ99-015) is within the Upper St. Augustin map region and coincides with CG00-004, except being on the opposite side of Joir River.

Typically the granite is pink-weathering, coarse grained, massive and texturally uniform. Only on its northwest side is any textural variation evident, the rocks being less coarse grained and having a slightly seriate appearance, possibly indicating proximity to the margin of the intrusion. Grain size is between 0.5 and 1.0 cm, although some K feldspar crystals are locally up to about 1.5 cm. Quartz is unrecrystallized, but fractured. Based on previous experience, pink feldspar seen in stained slabs that is neither K feldspar nor typical plagioclase is probably albite. The dominant mafic mineral is biotite, but minor amphibole is present locally.

Elliptical to subangular enclaves of fine to coarse grained, black weathering amphibolite, measuring up to 50 cm long, were seen at two outcrops on Joir River. Enclaves of foliated to gneissic material up to 40 cm across are also present, and it is clear that the fabric in the enclaves predates emplacement of the granite. The most obvious source for the mafic enclaves is the metamorphosed mafic intrusion to the north. Microgranite dykes are present locally, but generally the granite is lacking in minor intrusions.

Four samples were examined in thin section (CG00-004, CG00-016, CG00-093, CG00-099). They are all similar, consisting of anhedral, moderately to well-twinned plagioclase; anhedral microcline; weakly undulose, unrecrystallized quartz; pale-olive-green, ragged biotite; common titanite; apatite; opaque minerals (both oxide and sulphide present); and zircon. In addition, CG00-004 and CG00-016 both contain ragged, relict hornblende, in contrast to slightly more fractionated(?) CG00-093 and CG00-099, both of which lack amphibole, but contain albite (especially as rims to plagioclase) and more quartz. Quartz in all rocks appears to be mostly later crystallizing than much of the feldspar. Alternatively to fractionation differences, the amphibole could be due to contamination, as mafic enclaves were seen in the vicinity of both outcrops from which the samples were collected. Sample CG00-099 also contains secondary clinozoisite/epidote in the cores of a few plagioclase crystals and has minor chlorite. Zircon in all rocks tends to be more elongate than typical for the late- to post-Grenvillian granites. Zircon has two habits in the amphibole-bearing rocks; as small needles in biotite and larger, stubby grains elsewhere.

17.5.5.3 Michaels River Monzonite to Alkali-feldspar Granite (M_{3D}mq, M_{3D}yq, M_{3D}gr)

The Michaels River monzonite to alkali-feldspar granite (#11) (Gower, 2001) is a circular to slightly elliptical pluton measuring 18 by 14 km, elongate in an east-northeast direction. The body differs from most other late to post Grenvillian intrusions in that it contains several rock types. From available stained slabs, compositions appear to be increasingly fractionated in a clockwise direction around a country-rock xenolithic core, starting with monzonite in the 2 o'clock position, changing to syenite at 6 o'clock, to quartz syenite by 8 o'clock and to alkali-feldspar granite by 12 o'clock. Such a fractionation pattern is unusual and clearly requires further evaluation, but the author knows of no reason to deny its feasibility. All the rocks are homogeneous in themselves but texturally, as well as compositionally, different from their neighbours. The rocks are either massive or, rarely, very weakly foliated and contain unrecrystallized quartz (Plate 17.8E). Horizontal jointing was seen in a few exposures.

The monzonite and syenite are pink- to buff-weathering, and ubiquitously coarse grained. The dominant mineral is perthitic K feldspar, associated with plagioclase that mostly forms relict ovoids enveloped in perthite. Quartz, slightly bluish in places, is interstitial. Hornblende is the dominant mafic mineral, but both biotite and titanite are also present. The rocks lack minor granitoid intrusions, although a few quartzofeldspathic stringers were seen in one outcrop. An interesting feature in some monzonite is the presence of vugs up to about 1 cm across (*e.g.*, CG00-145; Appendix 2, Slab 17.8). They were only seen after cutting rock slabs and hence must be primary, rather than weathering cavities. No unusual minerals lining vug walls were seen. The syenite to alkali feldspar granite is pink- to locally reddish-weathering and medium to coarse grained. As in the monzonite-to-syenite, plagioclase forms relict grains, locally exhibiting alternating plagioclase–K-feldspar concentric zonation. K-feldspar is perthitic and texturally similar to that in the monzonite to syenite. Biotite is the dominant mafic mineral, but some relict amphibole is present. No minor granitoid intrusions were recorded, but a few hematite filled irregular fractures were seen.

Seven samples were thin sectioned from the granitoid rocks of the Michaels River intrusion, and span the range of rock types present (CG00-145 – monzonite; CG00-047 – monzonite to syenite; CG00-038, CG00-045 – syenite; CG00-029, CG00-079 – quartz syenite; CG00-144 – alkali-feldspar granite). All samples contain plagioclase, K-feldspar, quartz, amphibole (except CG00-029, CG00-144), biotite, an opaque oxide, zircon and apatite (except CG00-144). The monzonite sample CG00-145 also contains relict stubby grains of clinopyroxene showing evident of exsolution. Traces of epidote were recorded in syenite CG00-045). Plagioclase is anhedral, moderately twinned and altered and weakly to strongly zoned. Particularly in the syenitic rocks, it is evident that it is in disequilibrium, showing corroded or atoll-like outlines and having been replaced by K-feldspar. K-feldspar is mostly stringlet perthite, grading locally into coarsely exsolved flame or patch perthite, closely associated with checkerboard albite. Albite also occurs at grain boundaries, where it appears to be the product of more complete exsolution. In places, perthite has partially inverted to microcline. All samples indicate intimate and complex crystallization relationships between plagioclase and K-feldspar, being one of the defining characteristics of the pluton. Amphibole is an anhedral, equant to ragged hornblende, clearly derived in part from clinopyroxene in CG00-145 – as indicated by associated vermiform quartz inclusions where adjacent to clinopyroxene. Its ragged form in some samples suggests that it, in its turn, became unstable, reacting to give orange-green biotite, an opaque oxide and titanite. Titanite also occurs as thin veneers mantling opaque grains and as isolated crystals. Zircon, in most samples, forms fairly large euhedral crystals, showing rims in CG00-079.

The xenolithic core of the body comprises grey buff-weathering, strongly foliated, plagioclase rich rocks having northwest structural trends. Two samples collected are fine grained, finely laminated and very leucocratic, whereas the third is medium grained, unlaminated and mesocratic. The protolith of these rocks is uncertain, but contenders include plagioclase-rich greywacke, leucodiorite or metamorphosed leucogabbro.

A thin section from a sample of one of the finely laminated rocks (CG00-036) does little toward deciding protolith. It contains anhedral to ragged, well-twinned, lightly altered plagioclase; recrystallized quartz; myrmekite; anhedral, untwinned K-feldspar; blue-green amphibole; ragged orange-brown biotite; accessory opaque minerals (mostly oxide, minor sulphide), apatite and zircon; and secondary minor white mica and carbonate. Both the amphibole and biotite are sieved with vermiform quartz inclusions and occur in clusters with opaque/accessory minerals, associations that mostly likely reflect breakdown from clinopyroxene. The sample has been termed leucodiorite.

One other outcrop deserves mention. It occurs at the eastern margin of the pluton and consists of a grey-black-weathering, schistose, fine-grained, recrystallized, two-pyroxene, amphibole-bearing mafic granulite. The granulite is intruded by a few white-weathering, quartzofeldspathic veins. A nearby (100 m to the southeast) outcrop of massive to weakly foliated monzonite implies that the mafic granulite is most likely within the pluton, and therefore a xenolith.

A sample from this outcrop examined in thin section (CG00-146) confirmed the field identification. The mineral assemblage comprises well-twinned plagioclase, minor quartz, pale-green clinopyroxene, pleochroic orthopyroxene, orange-brown biotite, dark-green hornblende, an oxide opaque mineral, and apatite. Secondary titanite and carbonate are also present. The texture is granulitic, especially evident in thoroughly polygonized plagioclase and equant mafic minerals.

17.5.5.4 Halfway Pond Granite (M_{3D}gr)

The Halfway Pond granite (#12) (Gower, 2001) is a 6-km-wide circular pluton. It takes its name from Halfway Pond, roughly the mid-point on a flight route between Goose Bay and St. Augustin. It is pink-weathering, massive, coarse grained, homogeneous, and has a seriate-, tending to K-feldspar-megacrystic texture (Plate 17.8F). Biotite is the dominant mafic mineral. Enclaves or minor granitoid intrusions are lacking, except at one outcrop at the western border of the intrusion, where well-banded granitic gneiss is intruded by late- to post-Grenvillian granite.

Only one thin section was prepared from the intrusion (CG00-148). Plagioclase is poor to moderately twinned, light to moderately sericitized and weakly zoned. K-feldspar is well-twinned microcline, commonly containing plagioclase inclusions. Quartz forms large, unrecrystallized crystals. Biotite forms large, buff-green, non-aligned flakes. Accessory minerals are an opaque oxide (traces of sulphide are also present); large, subhedral titanite, allanite, apatite, rare zircon and secondary white mica. The rock is typical granite.

17.5.5.5 Upper St. Augustin River Monzonite to Granite (M_{3D}mz, M_{3D}mq, M_{3D}yq, M_{3D}gr)

The Upper St. Augustin River pluton (#13) (Gower, 2001) is mapped as a kidney-shaped body measuring 19 by 11 km, elongate in an easterly direction. It is subdivided into monzonite, quartz monzonite and granite. Compositional and textural variations are evident from slab to slab within each of the three subunits defined, and are considered to indicate that there are gradational spatial lithological changes within subunits. Rocks within the intrusion are pink-weathering (very locally pale-grey or buff), massive to very weakly foliated, coarse grained, homogeneous and unrecrystallized (Plate 17.9A). The rocks are even-textured, but not equigranular – K-feldspars are generally the largest crystals present and reach about 3 by 2 cm locally, although usually about 1 cm or less. Biotite and hornblende are the characteristic mafic minerals. Minor granitoid intrusions are absent, but an exception was recorded at a site near the southern boundary of the intrusion. Horizontal jointing was seen in some outcrops. One rock, mapped as a syenite, is fine to medium grained, has a weak foliation, and was noted on outcrop as containing biotite-rich portions. Although clearly not typical pluton material, it remains uncertain whether the rock is an enclave or represents an internal border between separate pulses of magma comprising the pluton. Present ground mapping provides no endorsement for magmatic individuality, although magnetic patterns can be interpreted to indicate otherwise.

Thin sections were prepared of two monzonite samples (CG00-237, CG00-310), one quartz monzonite (CG00-194) and three granites (CG00-236, CG00-256, CG00-280). The mineral assemblage is the same in all rocks, except that the monzonite contains hornblende and trace allanite. Plagioclase is anhedral, generally well twinned and lightly to moderately sericitized. Albite borders are present. K-feldspar is mainly well-twinned microcline, but some residual string perthite is also present. Plagioclase and K-feldspar are intimately associated, especially in monzonite. Quartz is unrecrystallized, but only a very minor, interstitial phase in monzonite. Biotite forms fairly large flakes ranging from orange-brown in monzonite, orange-green in quartz monzonite to pale-green in granite. Two opaque minerals exist in all samples, mainly oxide with trace sulphide. Titanite occurs in a variety of habits, from large anhedral masses to clusters of small, acicular secondary grains. Apatite shows a habit change from elongate in monzonite to equant in granite. Zircon forms large, euhedral grains in all samples. The crystallization order is: zircon, apatite, opaque mineral, titanite, and, finally, biotite. Amphibole in the monzonite is dark green, subhedral to ragged, and has cores of an orange, serpentinous material that in one instance looks like relict clinopyroxene. The similarity of all samples examined petrographically supports the contention based on field evidence that the various rocks are part of a single, evolving magma.

17.5.5.6 13B04 Southwest Monzonite to Syenite (M_{3D}mq/M_{3D}yq)

A circular monzonite to syenite body (#14) 5 km in diameter was mapped in the southwest corner of the map region (Gower, 2001), its extent correlating with more rugged topographic relief than the surrounding area, and its border being inferred from arcuate topographic trends. The intrusion is also expressed by a coincident and pronounced positive aeromagnetic anomaly.

Rocks comprising the intrusion range from monzonite to syenite, and are pink to buff weathering, mostly coarse grained (medium grained in places), homogeneous and massive. Quartz is minor or absent. The dominant mafic mineral is biotite, but some hornblende is also present. A distinctive textural feature is the presence of mantled feldspars, evident in outcrop by grey cores and pink rims. Stained slabs show that the cores are plagioclase and the rims K-feldspar. Normally a simple core rim relationship is present, with the rim making roughly 30–50% of the volume of the composite grain. In a few instances, multiple zonation is seen, although individual zones are commonly narrow and discontinuous. The pluton appears to lack minor intrusions or enclaves.

One sample (CG00-021) thin sectioned from this body contains poorly twinned antiperthitic plagioclase, well-twinned microcline, ragged hornblende, olive-green biotite, minor quartz, an oxide opaque mineral, dark-brown titanite (mantling the opaque oxide and as a secondary mineral associated with chlorite after biotite), apatite and zircon. The section contains an example of mantled feldspar, in which the plagioclase and K-feldspar zones each contain subordinate quantities of the other phase.

17.5.5.7 Matse River Quartz Monzonite to Quartz Syenite (M_{3D}mq)

The Matse River quartz monzonite to quartz syenite (#15) (Gower, 2001) forms a near circular body about 7 km

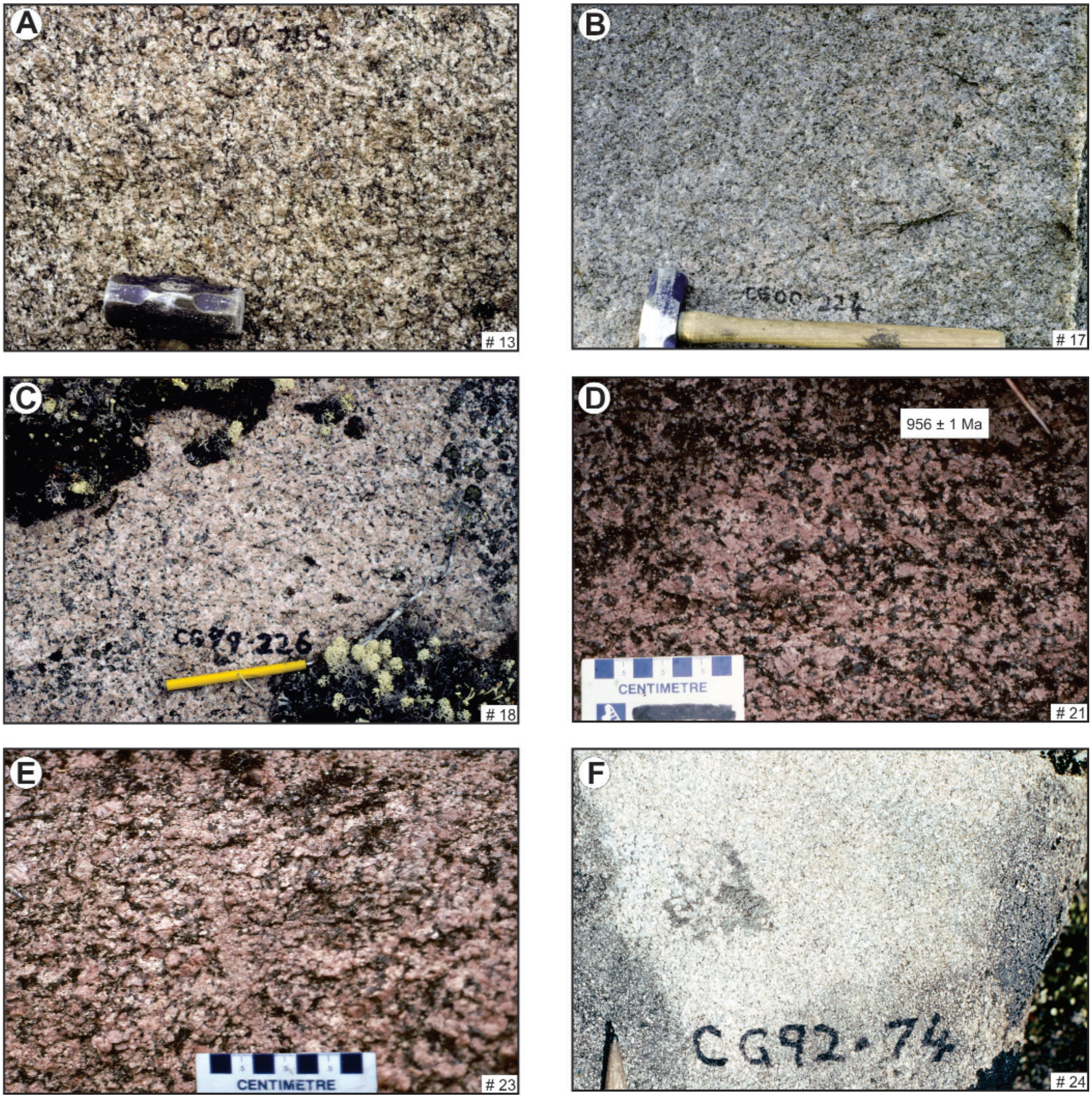


Plate 17.9. *Examples of post-Grenvillian granitoid plutons - part 2. A. Upper St. Augustin River monzonite to granite (CG00-255), B. 13B03 southeast monzonite to granite (CG00-224), C. 13B07 central granite (CG99-226), D. Four Corners Lake granite (VN92-121), E. Upper St. Lewis River west granite and alkali-feldspar granite (VN92-139), F. Upper St. Lewis River north granite (CG92-074).*

in diameter. The outline of the intrusion as shown here does not differ radically from how it is depicted on the map of Eade (1962), a remarkably acute judgement on his part, as he lacked aeromagnetic data, and based his interpretation on topographic patterns and on one observation of the rock (EA61-022) close to the centre of the body. Unfortunately, this depiction was later distorted in the compilation of Avramtchev (1983b), who combined this body and one farther to the southeast as a single intrusion.

The pluton is made up of a pink- to buff-weathering, coarse grained, massive, homogeneous monzonite, showing only limited lithological variation. As with other late to post Grenvillian monzonitic intrusions in the region, it is characterized by mantled feldspars, typically having grey plagioclase cores and pink K-feldspar rims. Some multiple concentric zonation between plagioclase and K-feldspar was also observed. K-feldspar also occurs intergrown with plagioclase, as well as interstitial to plagioclase and quartz. Both hornblende and biotite are present and clinopyroxene was equivocally identified in two samples. Unlike other late to post Grenvillian intrusions in the area, minor granitoid intrusions are common and pegmatite dykes locally present, one of which is cored by a 60 by 20 cm pod of quartz. Exposures of the body on the Matse River are close to its western margin (which was located to within 100 m in one place) and differ in having higher plagioclase content and commonly containing angular mafic enclaves (*e.g.*, CG00-108). An unusual mafic rock seen at locality CG00-108 contains large (3 by 2 cm) recrystallized, elliptical plagioclase phenocrysts enveloped by a fine grained, recrystallized, strongly foliated and slightly migmatized plagioclase–mafic mineral matrix. As far as exposure allows judgement, the rock appears to form a narrow elongate body. It might be a deformed mafic dyke, but as the host rock is massive and unmetamorphosed it is more likely an anomalous mafic enclave.

Four thin sections are available of samples from the monzonite (EA61-022, CG00-075, CG00-086, CG00-108A) and two of the mafic rocks (CG00-108B, CG00-108C). Inasmuch as the first three monzonite samples listed are almost identical petrographically, one thin section would have been sufficient. Plagioclase is anhedral, has embayed, corroded outlines in places, is well twinned and patchily sericitized. Weak zoning is evident. K-feldspar is a mixture of flame/patch perthite and forms discrete grains and intimate relations with plagioclase as mantles, alternating zones, inclusions and in replacement textures. Myrmekite is also common. Quartz is minor and mostly unrecrystallized. Biotite is dark-green to buff and somewhat ragged. Relict, blue-green amphibole is closely associated with biotite, forming mafic clusters that also include an opaque oxide, titanite and apatite. In addition to an oxide opaque mineral, minor sulphide is also present. Most of the titanite occurs as mantles around the opaque oxide, but it also occurs as irregular discrete grains and along boundaries of mafic minerals. Apatite and zircon are ubiquitous accessory minerals and rare allanite is also present. Trivial amounts of secondary epidote are present in EA61-022. Sample CG00-108A differs in having less quartz and secondary bastite kernels in some of the mafic clusters. As in the other samples, these clusters are dominated by amphibole and biotite, although in this sample both of the latter minerals are thoroughly sieved with vermiform quartz inclusions. The textures reflect breakdown of pyroxene, which was suspected in outcrop and would almost certainly be found (in residual form) if more samples from close to the margin of the body were examined petrographically.

The two mafic rocks from locality CG00-108 have little in common, except that both are thoroughly recrystallized and hence most likely xenoliths, as suggested above.

Sample CG00-108B contains well-twinned plagioclase, clinopyroxene, orthopyroxene, amphibole, biotite, opaque minerals and apatite. The clinopyroxene is extremely poikilitic, containing a superabundance of small plagioclase and opaque oxide inclusions. Its mottled appearance is accentuated by patchy alteration to green hornblende. Orthopyroxene is minor and also rather ragged in appearance. Clearly neither clino- nor orthopyroxene is in equilibrium with the associated minerals. Biotite is red-brown and clustered around cores of an opaque oxide. Sulphide occurs as a secondary infilling. In contrast, sample CG00-108C lacks pyroxene and has hardly any amphibole. Amphibole still present forms irregular, embayed blue-green relicts in the final stages of transformation to biotite, titanite, an opaque oxide and epidote. The overwhelmingly dominant mafic mineral is biotite, which forms stubby, olive-green flakes. Minor chlorite is present and a blue-green epidote-like mineral that might be pumpellyite. The plagioclase megacrysts in this sample are equally recrystallized as the matrix in which they reside.

17.5.5.8 13B03 Central Quartz Monzonite (M_{3D}mq)

On the basis of one outcrop, a 1-km-long stock (#16) is depicted in the centre of NTS map area 13B/03. Its outline is drawn on the basis of a small positive magnetic anomaly. The rock is pink- to buff-weathering, homogeneous, coarse-grained, unrecrystallized, hornblende biotite quartz monzonite.

A thin section (CG00-163) contains plagioclase, well-twinned microcline, unrecrystallized quartz, green-brown biotite, relict dark-green amphibole, an opaque oxide, titanite, apatite, allanite, zircon, and trace secondary biotite. The plagioclase is poorly to moderately twinned, moderately altered, weakly zoned and has albitic borders. Titanite mantles the opaque oxide and also forms separate discrete grains. Some of these have a dark-brown core with a light-brown rim. The rock is texturally very similar to the Halfway Pond granite.

17.5.5.9 13B03 Southeast Monzonite to Granite (M_{3D}mz, M_{3D}mq, M_{3D}gr)

Only part of this pluton (#17) is situated within the Upper St. Augustin River map region, the remainder being located in Québec, where its presence is recognized (although extended much too far west) on the map of Avramtchev (1983b). Within Labrador, the intrusion is mostly a pale-pink to rusty grey-buff, massive to very weakly foliated, homogeneous, unrecrystallized, coarse-grained monzonite, locally grading into quartz monzonite (Plate 17.9B). Textures are seriate to megacrystic and mantled feldspars are common, characterized by grey plagioclase cores and pink K-feldspar rims. Both biotite and hornblende are present. No minor granitoid intrusions or enclaves were recorded, but an epidote-filled fracture seen at one outcrop demonstrates some late-stage fluid activity. Two outcrops of coarse-grained granite on the east flank of the intrusion have also been assigned to the body, although they differ somewhat texturally.

Three thin sections of monzonite to quartz monzonite (CG99-405, CG00-206, CG00-224) were examined from the pluton and all contain the same mineral assemblage, varying only slightly in proportions of minerals present. Plagioclase has an anhedral, resorbed, embayed form due to reaction with K-feldspar, with which it is intimately spatially associated. Commonly, plagioclase forms sericitized atolls enclosing and enveloped by K-feldspar, giving rise to the mantled appearance seen in outcrop. Because of extensive sericitization, twinning is masked and mostly poor. K-feldspar is a mixture of well-twinned microcline and fine, stringlet perthite. K-feldspar grain boundaries are locally polygonized, made up of beads of secondary K-feldspar, intermixed with albite. Quartz is mostly unrecrystallized, but shows polygonized form in a few places. Biotite forms anhedral, green-buff to orange-buff flakes, locally containing vermiform quartz inclusions. Amphibole has a ragged form, is dark-green to blue-green and is clearly a relict mineral having been partially replaced by biotite and accessory phases. The dominant opaque mineral is an oxide but minor sulphide is also present. Titanite is present in two forms, as narrow mantles to the opaque oxide and as anhedral, amoeboid-looking isolated, fairly large grains. Apatite is common and euhedral. Moderately large zircon is also common. Trace allanite is present in CG99-405. Despite the epidote-filled fracture seen in outcrop, no epidote is present in any of the thin sections.

Samples from both outcrops of granite on the eastern flank of the intrusion (CG99-388, CG99-396) were examined petrographically because of their equivocal status as part of this intrusion. The best that can be concluded is that they have more in common with above described monzonite to quartz monzonite than they do with the surrounding granite to granite gneiss. Plagioclase does not show the embayed margins seen in the monzonitic rocks, but is equally sericitized and poorly twinned. The two features that provide the strongest links are the presence of fine, stringlet perthite (in contrast to microcline in the surrounding rocks) and only very mild recrystallization of quartz. Biotite is orange-green. Both samples lack amphibole. Accessory minerals are sparse in CG99-396, consisting only of zircon and an opaque oxide. Sample CG99-388 has trace apatite and titanite in addition.

17.5.6 UPPER ST. PAUL RIVER MAP REGION

17.5.6.1 13B07 Central Granite (M_{3D}gr)

On the basis of four outcrops and a distinct, ovoid magnetic anomaly, a late- to post-Grenvillian granitoid pluton (#18) is mapped in the centre of NTS map area 13B/07 (Gower, 2000). The pluton measures roughly 11 by 9 km, slightly elongate in a northeast direction. The rock is pink-weathering, coarse grained, massive, homogeneous, unrecrystallized biotite granite (Plate 17.9C).

Samples were thin sectioned from three of the four outcrops (CG99-227, CG99-243, CG99-263). Plagioclase is anhedral to subhedral, moderately twinned, generally lightly sericitized, except in grain cores, zoned and shows albitic rims. K-feldspar is mostly well-twinned microcline, but some vestiges of flame perthite remain. Quartz is unrecrystallized, but fractured. The dominant mafic mineral is pale-green-buff biotite (forming large inclusion-filled flakes), but minor relict hornblende is also present in CG99-227. Accessory phases are opaque minerals (oxide and traces of sulphide), apatite, titanite (only secondary titanite in CG99-263), allanite, and zircon. Secondary rutile and chlorite are present in CG99-263. Although the three samples share many similarities, they are not uniform, thus allowing suspicions that all might not have come from the same batch of magma. The similarities are sufficient, however, that it seems unlikely that rocks of disparate origin have been grouped.

17.5.6.2 13B02 Southwest Monzonite (M_{3D}mz)

A single outcrop of massive monzonite (#19) was found in the southwestern part of NTS map area 13B/02. The rock is pale-pink- to creamy-weathering, massive, coarse grained, homogenous and shows obvious horizontal joints. The rock is different from those in the immediate vicinity and it is assumed to be a small intrusion into them. It is interpreted here to be a late- to post-Grenvillian intrusion, although included by Gower (2010a; Upper St. Paul River map region) with the surrounding K-feldspar megacrystic granitoid rocks.

A thin section (CG99-325) contains anhedral to subhedral plagioclase; finely beaded perthite; quartz; subhedral, pale green clinopyroxene; hornblende; an oxide opaque mineral, plus traces of sulphide; accessory apatite, titanite and zircon. Some secondary quartz (in hornblende), granular, dark brown, titanite/leucoxene (associated with the opaque oxide) and chlorite are also present. Quartz shows minor recrystallization, allowing the interpretation that the rock was emplaced earlier than assigned here. The likely alternative affiliation is with the K-feldspar megacrystic granitoid rocks in the vicinity.

17.5.6.3 13B02 South-central Monzonite (M_{3D}mq/M_{3D}mz)

Three outcrops of massive monzonite (#20) were recorded adjacent to the southern margin of NTS map area 13B/02 and interpreted to be part of a late- to post-Grenvillian pluton of unknown size that straddles the Labrador–Québec border (Gower, 2000). The continuation of the intrusion is not shown on the compilation map of Avramtchev (1983a) south of the Labrador–Québec border, so the body may be quite small. The rock is brown-, black- or rusty-weathering and coarse grained. In hand sample, euhedral plagioclase crystals averaging 1 cm long and 0.5 cm in cross-section can be seen, enveloped in a matrix of K-feldspar, quartz and mafic opaque minerals.

Two samples (CG99-194, CG99-273) were selected for petrographic study. Plagioclase is well twinned, lightly to moderately sericitized, and distinctly zoned. Mosaics of polygonal recrystallized feldspar are developed at grain boundaries. Both K-feldspar and quartz are late-crystallizing phases, forming interstitial minerals, or associated with myrmekite, or contributing to the grain boundary recrystallized mosaics. Clinopyroxene is the dominant primary mafic mineral, occurring as colourless to pale-green grains containing abundant spindles of opaque mineral inclusions exsolved along cleavage traces, and showing patchy alteration to green amphibole and orange-brown biotite, both of which contain vermiform quartz inclusions. The alteration has also caused clinopyroxene grains to develop ragged exterior form. Some biotite, especially in CG99-194, looks primary. Accessory phases are opaque minerals (mostly oxide, but minor sulphide), apatite (large, euhedral, common crystals), rare zircon, and, in CG99-273, common titanite. The presence of titanite in CG99-273, but its absence from CG99-194 is a noteworthy contrast between these, otherwise, very similar rocks.

17.5.6.4 Four Corners Lake Granite (M_{3D}gr)

The Four Corners Lake granite (#21) straddles the boundary between the Upper St. Paul River map region to the west and the Kyfanan Lake map region to the east. The name is newly introduced, being based on a lake (informally named) at the common corner of four 1:50 000 NTS maps. The pluton was visited during the mapping of Eade (1962) and described in the field notes of one of his assistants as massive, biotite granite. Gower *et al.* (1993), mapping the eastern part, termed it massive, two-feldspar granite (Plate 17.9D) and interpreted it as a late- to post-Grenvillian granite. Its western part was mapped by Gower (2000), who described an outcrop as pink, coarse-grained, unrecrystallized, homogeneous, severely weathered biotite granite exhibiting horizontal jointing. The pluton is depicted as 4.5 km by 3 km, elongate in a southeast direction, but the exact size of the body remains uncertain due to lack of surrounding host-rock outcrop.

Two thin sections are available; VN92-121 from the east and CG99-014 from the west. The mineral assemblage is plagioclase, microcline, unrecrystallized quartz, green chloritized biotite and accessory phases. The plagioclase is subhedral to anhedral, well twinned, moderately sericitized and has some albitic borders. Biotite is olive-green, somewhat ragged in outline and contains quartz and zircon inclusions, and is partly oxidized to an orange-brown product. The accessory minerals are muscovite, an opaque oxide, zircon (common, euhedral), apatite and rutile. Muscovite occurs as anastomosing, late-stage, fracture infillings and in interstices within K-feldspar. Rutile forms very fine needles in quartz and, along with muscovite, are distinctive features of this pluton. No allanite, epidote or titanite is seen.

17.5.7 KYFANAN LAKE MAP REGION

17.5.7.1 St. Lewis River Headwaters Granite (M_{3D}gr)

The St. Lewis River headwaters granite (#22) (Gower *et al.*, 1993) is a very poorly exposed body situated west of Kyfanan Lake. The aeromagnetic pattern suggests three nested intrusions having their centres progressively displaced toward the west, but, as only six outcrops were located within the pluton's border, this cannot be confirmed in the field.

The granite is pale-pink- to brown-weathering, homogeneous, coarse grained, unrecrystallized and massive to weakly foliated. A few feldspar crystals have plagioclase cores and K-feldspar rims, although distinctive mantled feldspar textures, as seen in the more southerly intrusions, are lacking. It is somewhat similar to the two-feldspar granite in the Upper St. Lewis (west) pluton. One pegmatite was recorded, but no enclaves were seen. One outcrop in the centre of the body differs from the other five in that, although it has similar mineral proportions, the rock is finer grained. The relationship of this rock to the remainder of the body is not known – it may be part of a separate phase, or simply a large minor intrusion.

The granite contains both K-feldspar and plagioclase (K-feldspar >plagioclase) and biotite is the mafic silicate mineral. Accessory minerals are titanite (abundant), opaque mineral, zircon (common), apatite, allanite (rare) and secondary chlorite and white mica (both rare). Euhedral titanite is distinctive feature of this rock (*cf.* thin sections CG92-025, CG92-027, CG92-105).

17.5.7.2 Upper St. Lewis River West Granite and Alkali-feldspar Granite (M_{3D}gr)

The St. Lewis River west granite (#23) (Gower *et al.*, 1991, 1993) measures 20 by 12 km and is elongate in a northeast direction. The southeast margin of the pluton is interpreted to be a fault. A sample of granite from near the centre of the pluton yielded a near-concordant U–Pb zircon age of 956 ± 1 Ma and a K–Ar biotite age of 911 ± 10 Ma (Gower *et al.*, 1991; CG86-700). When Gower *et al.* (1991) published the age, the pluton had not been mapped and its outline was inferred from aeromagnetic patterns. Mapping of the pluton was carried out by Gower *et al.* (1993).

Throughout the pluton, the rocks are pink-weathering, homogeneous, coarse grained and massive or (rarely) weakly foliated (Plate 17.9E). The pluton consists of two-feldspar granite in the northeast and centre (the dated rock type), and alkali-feldspar granite in the southwest. This rock type contrast is reflected in: i) magnetic patterns, which are much more pronounced in the northeast than in the southwest, and ii) in weak foliations, which are east-northeast in the two-feldspar granite and north-northwest in the alkali-feldspar granite. In the two-feldspar granite, textures range from seriate, or rarely, K-feldspar megacrystic.

Biotite is the dominant mafic mineral and accessory minerals include titanite, allanite, apatite, opaque minerals and zircon. A modal analysis reported by Gower *et al.* (1991) gave 33% quartz, 26.5% plagioclase and 34.5% K-feldspar (CG86-700). Other samples examined are petrographically similar (JA92-075, JA92-077, VN92-134B, VN92-136, VN92-142, VN92-199A), although minor amphibole is present in a sample (CG92-053A) collected near the northern border of the intrusion and accessory late-stage muscovite is locally present. Rare mantled feldspar textures are present in the south; both 'plagioclase mantled by K-feldspar' and 'K-feldspar mantled by plagioclase with a K-feldspar rim' textures are present.

Enclaves and minor granitic intrusions are present as subsidiary rock types in the two-feldspar granite. Most enclaves consist of fine-grained, foliated granitoid rocks similar to those seen surrounding the pluton, and have comparable mineral assemblages (JA92-079B, JA92-080). One rock is coronitic troctolite, similar to that found within the Kyfanan Lake layered mafic intrusion (VN92-199B). For olivine to still be preserved in a rock that is an enclave in an alkali-feldspar granite is somewhat unusual and, given that the locality from which the sample was obtained was described as 'subcrop' in the field, the rock might be an erratic. The minor granitic intrusions are mainly aplite dykes, but pegmatite is locally present. An example of a minor granitic intrusion emplaced into its granitic host can be seen on the southern shore of Kyfanan Lake.

The alkali-feldspar granite has an equigranular texture and low mafic mineral (biotite) content, but otherwise is similar (CG92-095). As the two-feldspar granite in the northeast contains enclaves of pre-Grenvillian rocks, has minor granitoid intrusions and its east-northeast foliations appear to trend into the north-northwest directions in the alkali-feldspar granite in the southwest part of the body, it would seem likely that that the two-feldspar granite is older of the two.

17.5.7.3 Upper St. Lewis River North Granite (M_{3D}gr)

An elliptical pluton (#24) measuring 6 by 5 km has been outlined (Gower *et al.*, 1993) near the eastern border of the Kyfanan Lake map region north of the St. Lewis River, but its existence as depicted is far from certain. All the samples collected within the area are pale-pink-weathering, homogeneous, fine- to medium-grained, unrecrystallized two-feldspar biotite granite (*see* Plate 19.9F) typical of that seen in microgranite/aplite dykes elsewhere in the map region. As outcrop in the area is very poor, it is possible that all are minor intrusions intruding unexposed host rocks (which, most likely, would be the foliated recrystallized granitoid rocks seen in river sections to the south). Alternatively, the outcrops could indicate the roof of a pluton, or dykes within it.

A sample examined in thin section (CG92-015) contains plagioclase (sericitized cores and clear rims), microcline, quartz, biotite, allanite (an unusually abundant euhedral accessory), an opaque mineral, titanite, apatite, and zircon.

17.5.7.4 Upper St. Lewis River East Monzonite (M_{3D}mq)

The Upper St. Lewis River east monzonite (#25) is situated near the eastern border of the Kyfanan Lake map region and is elliptical in plan, measuring 9 by 6 km. The body, originally described by Gower and Loveridge (1987), was the first late- to post-Grenvillian pluton to be dated in the Grenville Province in eastern Labrador. The intrusion was mapped by Gower *et al.* (1993).

Gower and Loveridge (1987) reported a concordant U–Pb zircon age of 966 ± 3 Ma for a sample (CG84-195) taken near the centre of the body. Subsequently, Gower *et al.* (1991) reported a K–Ar hornblende age of 946 ± 13 Ma and a K–Ar biotite age of 914 ± 13 Ma for the same sample.

The monzonite is grey-weathering, homogeneous, coarse grained and massive (Plate 17.10A). The mineral proportions in the dated sample are as follows: quartz 1.2%, plagioclase 46.1%, K-feldspar 37.5%, biotite 3.3%, amphibole 5.0%, clinopyroxene 2.6%, apatite 1%, opaque minerals 3.1% and traces of titanite and zircon (Gower and Loveridge, 1987, who also give other petrographic details). A sample close to the northern margin of the body (CG92-281A) differs considerably in mineral proportions from the dated rock in the centre of the body, although it is texturally similar and clearly part of the same intrusion. The border rock lacks quartz and amphibole and has common orthopyroxene. It only contains alkali feldspar as finely exsolved perthite in plagioclase. It can be termed leuconorite to leucomonzonorite.

The intrusion contains enclaves of the surrounding foliated granitoid rocks. Pink- to creamy-weathering, leucocratic, biotite-bearing, aplite/microgranite dykes are also present (CG92-281D). It is also intruded by two small plagioclase-phyric mafic dykes (*cf.* Section 17.5.13; Plate 17.10A).

17.5.7.5 Upper St. Paul River North Granite (M_{3D}gr)

The boundaries of this pluton (#26) (Gower *et al.*, 1993) are not precisely known because of inadequate outcrop and lack of clear expression on aeromagnetic maps. The pluton is indicated as an elliptical 6 by 4 km body having a northeast trend, but it could underlie at least twice the area shown and be circular, or even elliptical in northwest direction.

The granite is pink- to grey-weathering, homogeneous, coarse grained, unrecrystallized, massive and seriate textured (Plate 17.10B). Mantled feldspars are present, but the texture is not the same as in the monzonites to the southwest. In this granite, the feldspars commonly have an anhedral core of K-feldspar and a plagioclase mantle, resulting in grains having an overall subhedral shape.

Other minerals are quartz, green biotite and accessory titanite, apatite, allanite, zircon and an opaque mineral (thin sections JA92-128, VN92-128). Allanite is particularly common and unusually large in sample VN92-128.

One anomalous rock (a recrystallized? monzonite), was mapped within the pluton and is assumed to be an enclave.

17.5.7.6 Upper St. Paul River Northwest Monzonite to Syenite (M_{3D}mq, M_{3D}yq)

The Upper St. Paul River northwest monzonite to syenite pluton (#27) straddles the boundary between the Kyfanan Lake and Upper St. Paul River map regions. The name of the

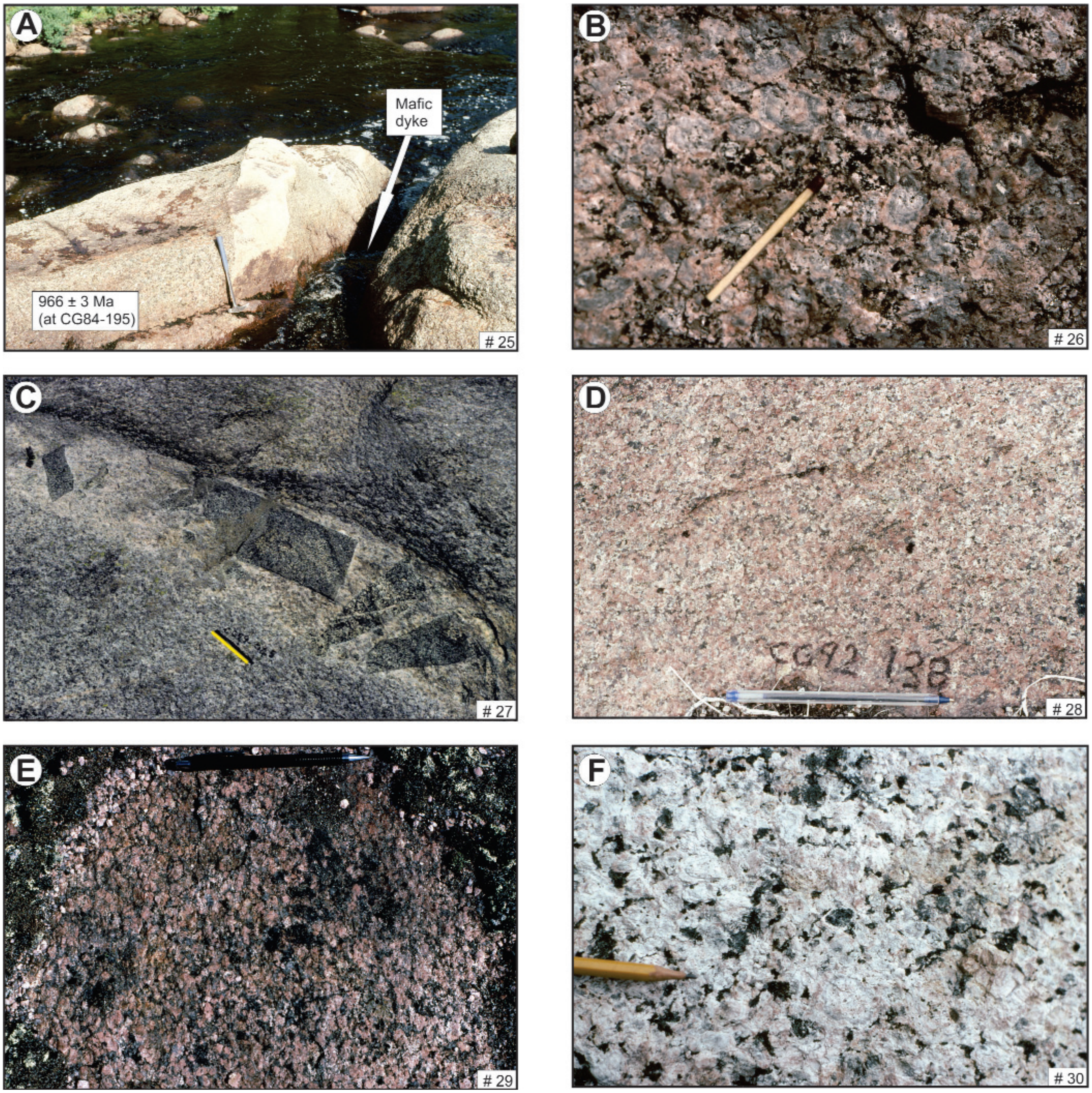


Plate 17.10. *Examples of post-Grenvillian granitoid plutons - part 3. A. Upper St. Lewis east monzonite (CG92-281), B. Upper St. Paul River north granite (VN92-125), C. Upper St. Paul River northwest monzonite to syenite and microgranite dyke containing mafic enclaves (CG99-045), D. Upper St. Paul River northeast granite (CG92-138), E. Upper St. Paul River west granite (VN92-223), F. Upper St. Paul River east monzonite to alkali-feldspar granite (CG92-164).*

pluton was assigned by Gower *et al.* (1993) during mapping of its eastern half. The western half was mapped by Gower (2000). The pluton is elliptical, measuring 16.5 by 10.5 km, elongate in an east-northeast direction.

The dominant rock is monzonite grading locally into alkali-feldspar syenite. It is pale-pink-, white-, buff-, or grey-weathering, homogeneous, coarse grained, and massive to rarely foliated. Texturally, the monzonite and syenite are very similar, although mantled feldspars textures are not so well developed in the syenite.

Ten samples were examined in thin section; nine of monzonite (CG92-190, JA92-119, JA92-145, VN92-207, VN92-208, VN92-

213, VN92-217, CG99-028, CG99-045), and one syenite (CG99-003). Most of the samples are from localities close to the margin of the pluton, so there may be some bias in the description. Characteristic features are unrecrystallized quartz and mantled feldspars. The mantled feldspars typically have a plagioclase core 0.5 to 1.0 cm in diameter with a K-feldspar border a few millimetres wide, but there are common instances where plagioclase is reduced to a narrow-to-broad shell between an inner core and outer rim of K-feldspar. Plagioclase is anhedral to subhedral, poor to well twinned, markedly zoned and lightly sericitized. It appears to be largely out of equilibrium with the remainder of the mineral assemblage. K-feldspar occurs both as perthite and microcline. The perthite has fine stringlet and patch textures. Albitic rims are present in places and albite also occurs as polygonal, interstitial grains associated with myrmekite and quartz. Quartz is not abundant in any of the samples examined in thin section, being present as an accessory, interstitial mineral. The mafic silicates tend to occur as clusters associated with opaque and accessory phases. Hornblende, biotite and relict clinopyroxene are the mafic minerals. Hornblende is the most common, characteristically containing vermiform inclusions, probably reflecting derivation from clinopyroxene, which forms a pale-green, relict phase, containing, in places, Fe-oxide-filled fractures. Clinopyroxene is present in all thin sections, except CG99-045. Biotite is olive-buff to red-brown, commonly also containing vermiform quartz inclusions and, similarly, appears to be the product of pyroxene breakdown. It is a very minor mineral in sample CG99-028. The accessory phases are opaque minerals (mostly oxide, but also traces of sulphide), apatite, titanite (not seen in CG99-028), allanite and zircon (small and minor in CG99-045, but large and euhedral in CG99-003).

Other rock types seen within the pluton include enclaves and microgranite dykes. The enclaves tend to occur as elongate lensoid bodies and are rarely more than a few centimetres long. A variety of rock types are present, including amphibolite, coarse-grained metagabbro, two-pyroxene monzonite (thin sections JA92-114A, JA92-114B), foliated clinopyroxene monzonite (thin section JA92-147A), fine-grained, foliated, amphibole-bearing syenite (amphibole crystals up to 2 cm long), and recrystallized granite. The metagabbro may have been derived from the remnants of the layered mafic–felsic intrusion immediately to the northeast (Section 13.3.4.1), as might the two-pyroxene monzonite and foliated clinopyroxene monzonite. Amphibolite enclaves are well displayed at an excellent exposure on St Paul River (CG99-045). At this locality, the enclaves are rounded, up to a metre in diameter, and can be traced across the southern part of the outcrop.

At the same locality (CG99-045), microgranite dykes occur in three sets, trending, in order of decreasing age, at 160°, 120° and 065°. The 160°-trending dyke is 30 cm wide and is of particular interest in that it contains abundant, angular amphibolite enclaves (Plate 17.10C). A few of the enclaves are composite, consisting of two texturally distinct types of amphibolite. The 120°-trending dykes are most common, are 10–30 cm wide and are characterized by cross-linked bridges. The youngest dyke (065°) is the most irregular in form and also the widest at about 1 m. The frequency of dykes at this locality can be attributed to close proximity of the outcrop to the inferred margin of the pluton. Unrecrystallized biotite microgranite intruding the north side of the pluton was examined in thin section (JA92-117).

17.5.7.7 Upper St. Paul River Northeast Granite (M_{3D}gr)

Inasmuch as only a single rock type was seen in the vicinity, it is assumed that the pluton (#28) boundary coincides with the base of a hill that forms a very distinct feature above the surrounding swampland plain. By this reasoning the pluton is elliptical, measures roughly 4 by 2 km having an east-southeast long axis (Gower *et al.*, 1993). The granite is pink-weathering, medium to coarse grained, homogeneous, lacking noteworthy recrystallization and massive (Plate 17.10D).

The mineral assemblage is plagioclase, microcline, quartz, buff-green biotite, titanite (abundant), apatite, zircon (common) and secondary or late-stage muscovite and chlorite (thin section CG92-138).

No enclaves were seen and, apart from two 20-cm-wide pegmatite dykes, no minor intrusions were recorded.

The intrusion is texturally similar (but not identical) to the Upper St. Paul River (north) granite. Both bodies may belong to a single intrusion at the surface, or are linked at depth. The latter suggestion is considered more likely as both granites are topographic highs and, if there was similar bedrock between, it would be expected that this region would also be elevated.

17.5.7.8 Upper St. Paul River West Granite (M_{3D}gr)

The Upper St. Paul River west granite (#29) (Gower *et al.*, 1993) is an alkali-feldspar granite intrusion in the southwest corner of the Kyfanan Lake map region. The part of the body within the field area measures roughly 7 by 5 km.

The alkali-feldspar granite is pink, homogeneous, coarse grained, unrecrystallized, and massive to locally foliated (Plate 17.10E). Biotite is the main mafic mineral. Zoning and exsolution textures are locally evident in K-feldspar crystals. The granite lacks minor intrusions.

The mineral assemblage comprises corroded plagioclase, microcline, quartz, green biotite, titanite, apatite, zircon, allanite and an opaque mineral (thin sections CG92-182, VN92-223A, part of VN92-233B). The allanite grains are unusually large (0.7 cm).

A particularly noteworthy feature of the pluton is an enclave of leucosome-bearing biotite–sillimanite–garnet metasedimentary gneiss (Section 13.1.2.3). At this locality (VN92-223), the granite contains a few small relict cores of amphibole enveloped in a secondary orange-brown phyllosilicate. An enclave (2 by 1 m) of pink, medium-grained, strongly foliated granite, similar to that surrounding the pluton was also observed at the same outcrop.

17.5.7.9 Upper St. Paul River East Monzonite to Alkali-feldspar Granite (M_{3D}mq, M_{3D}gr)

The Upper St. Paul River east monzonite to alkali-feldspar granite (#30) (Gower *et al.*, 1993) straddles the Labrador–Québec border in the southwest part of the Kyfanan Lake map region. Assuming it is circular in plan, the pluton is about 20 km in diameter and probably less than one third of it is within the map region. Foliations in the surrounding rocks are conformable with the border of the intrusion and mostly inward dipping.

The monzonite is pink-, brown- or buff-weathering, homogeneous, coarse grained, uncrystallised, and massive to rarely foliated. A distinctive feature is the presence of subhedral mantled feldspars up to 3 cm long (Plate 17.10F). Two types dominate; those having a core of plagioclase and rimmed by K-feldspar, and those having a K-feldspar core, an intermediate layer of plagioclase and an outer border of K-feldspar. Commonly the intermediate plagioclase layer is incomplete, suggesting partial precipitation, or resorption, of plagioclase before the outer K-feldspar layer was formed. Quartz is interstitial. Both biotite and amphibole are ubiquitous, but clinopyroxene is locally evident in hand specimen.

Petrographic study (CG92-163B, CG92-164, CG92-192, CG92-197, HP92-162A, part of JA92-157B, VN92-231) shows that, in the mantled feldspars, the core plagioclase shows strong zonation and corroded outlines, pointing to it being an early magmatic phase that became in disequilibrium with the evolving liquid. Similarly, the clinopyroxene in all samples is present as ragged, relict and altered remnants, largely replaced by amphibole. In its turn, amphibole is replaced by biotite, quartz, titanite and an opaque phase. Other minerals include apatite and minor zircon.

Granite to alkali-feldspar granite was found close to the centre of the mapped part of the body and along its northeast margin. The granite near the centre of the body is texturally distinct enough to belong to a separate emplacement phase, in contrast to that at its border (thin section CG92-205), which is probably simply a compositional variant.

Enclaves are common in the pluton, especially in its outer part, and are well exposed on St. Paul River. The enclaves vary from a few centimetres to several metres long. They tend to be tabular and are mostly aligned parallel to the pluton's margin. All are foliated granitoid rocks (thin sections CG92-163A, part of JA92-157B) similar to those present outside the pluton. Pegmatitic and aplitic veins, less than 10 cm wide, intrude the monzonite, but they are not common.

The monzonite in the Upper St. Paul River (west) pluton is very similar to that in the Upper St. Paul River (east) pluton. In both, mantled feldspars are characteristic and show the same patterns of mantling and marked zonation of core plagioclase (Plate 17.10F). Because these two intrusions have such similar textures and mineral assemblages, there can be little doubt that they are cogenetic.

Both contain the same mineral assemblages and are characterized by lack of allanite. One small difference is that clinopyroxene is present in all, except one, thin sections examined in the Upper St. Paul River (west) monzonite, whereas it is only present in about 60% of those from the Upper St. Paul River (east) monzonite.

17.5.7.10 Rivière Bujeault West Quartz Monzonite to Granite (M_{3D}mq, M_{3D}gr)

This irregular-shaped pluton (#31) measures 4 by 4 km and can be subdivided into two parts, dominantly monzonite to quartz monzonite in the south and granite (Plate 17.11A) in the north (Gower *et al.*, 1993). Both rock types are pink-weathering, homogeneous, coarse grained and massive, and each contains hornblende and biotite. They differ mainly in colour index and quartz content. No mantled feldspar textures were noted in either the quartz monzonite or the granite. Garnet was noted in a sample near the northeastern margin of the body. Enclaves and minor granitoid intrusions are scarce. A melanocratic monzonite in the centre of the body is tentatively interpreted to be a border facies of the southern quartz monzonite. Pegmatite dykes that intrude it may have emanated from the granite to the north, which would therefore be the younger intrusive phase.

Thin sections examined (quartz monzonite CG92-226; granite CG92-234, VN92-271), show the rocks to consist of slightly sericitized, anhedral plagioclase having albitic rims; some perthite, but mostly microcline K-feldspar; unrecrystallized quartz; partially relict amphibole and green biotite; and accessory titanite (abundant), apatite, allanite, zircon and an opaque mineral. Allanite is clearly a late-formed mineral.

17.5.7.11 Rivière Bujeault Headwaters Alkali-feldspar Quartz Syenite to Granite (M_{3D}yq, Locally M_{3D}gr)

The Rivière Bujeault headwaters alkali-feldspar quartz syenite to granite (#32) straddles the boundary between the Kyfanan Lake and St. Lewis River map regions and was named by Gower *et al.* (1991). The St. Lewis River part was first mapped by Gower *et al.* (1988) and classified as a late-Grenvillian intrusion. The Kyfanan Lake part of the body was mapped in 1992 (Gower *et al.*, 1993). Eade (1962) had earlier hinted at the pluton's existence by identifying arcuate bedrock trends and by noting that foliations wrap around massive granite bodies in the region. Enveloping bedrock trends in the country rocks on the west side of the pluton (Kyfanan Lake map region) are especially obvious on airphotos.

The pluton was dated by Gower *et al.* (1991) who reported ages based on several methods for two samples col-

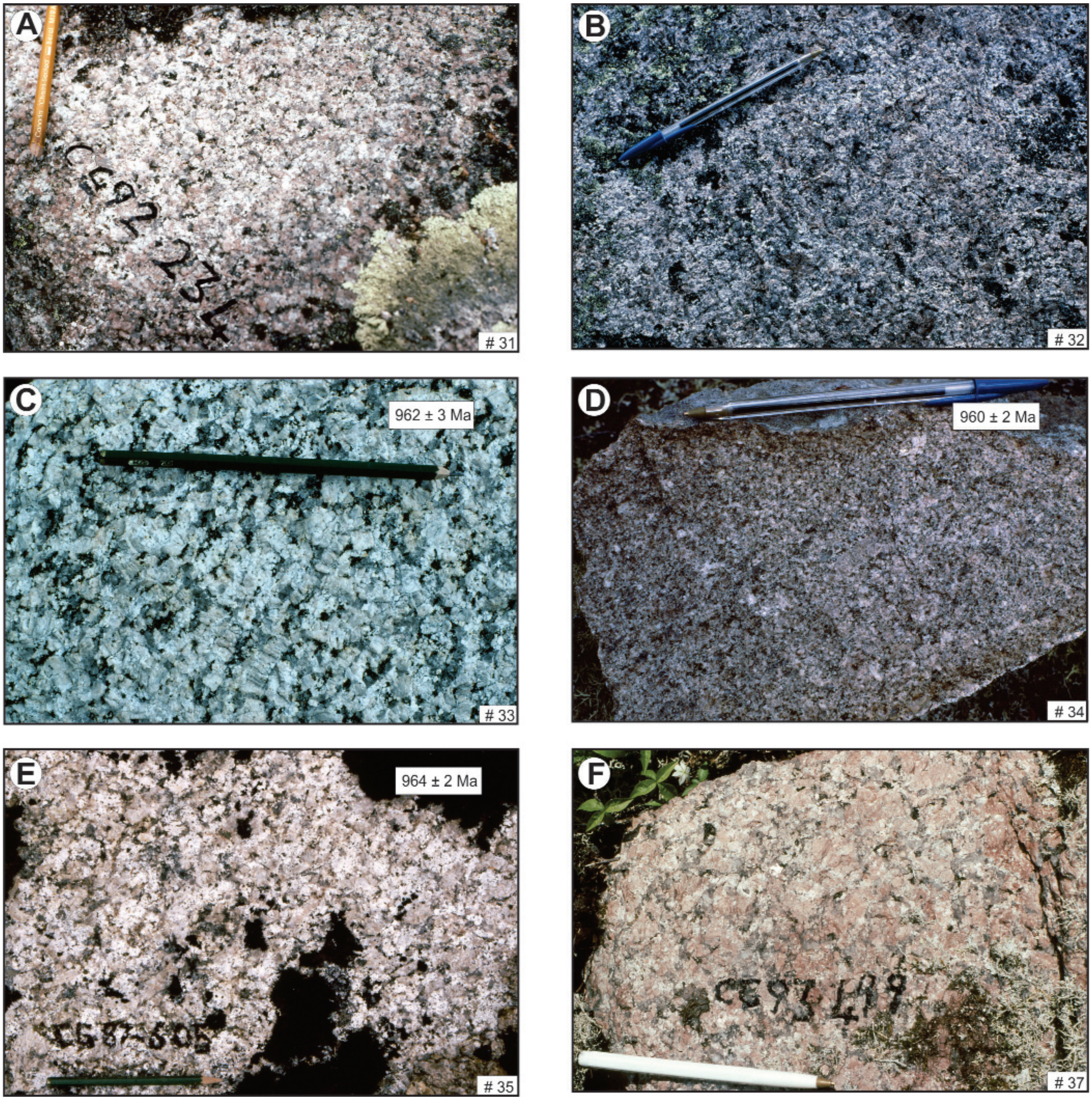


Plate 17.11. *Examples of post-Grenvillian granitoid plutons - part 4. A. Rivière Bujeault west quartz monzonite to granite (CG92-234), B. Rivière Bujeault headwaters alkali-feldspar quartz syenite to granite (CG86-697), C. Southwest Pond granite (CG86-618), D. Upper Pinware River granite (CG87-660), E. Chateau Pond granite (CG87-605), F. Stokers Hill granite (CG93-499).*

lected near the centre of the intrusion (CG86-697B, CG86-698). The emplacement age was determined to be 964 ± 5 Ma based on lower intercept U–Pb zircon data. The upper intercept of 1530 ± 30 Ma was inferred to date the age of inherited zircon. In addition, K–Ar hornblende ages of 953 ± 12 and 926 ± 16 Ma, a K–Ar biotite age of 927 ± 18 Ma and Rb–Sr biotite ages of 888 ± 12, 811 ± 9 and 822 ± 9 Ma were obtained.

The pluton is almost circular in plan, measuring 12 km across, which is slightly smaller than the 15 km estimated by Gower and Loveridge (1987) and Gower *et al.* (1991) from aeromagnetic patterns. The body forms an area of high topographic relief. The rocks are pink- to rusty-weathering, homogeneous, medium to coarse grained and massive to weakly foliated (Plate 17.11B). Scattered enclaves of foliated granitoid rocks and a few aplite dykes are found within the pluton.

Twelve thin sections are available from the body (EA61-030, CG86-697A, CG86-697B, CG86-698, CG92-275, HP92-192, HP92-196, VN87-161, VN87-165, VN87-170, VN87-173, VN92-291). Visual comparison of all the thin sections suggests that the pluton may be compositionally zoned, the outer portion having a higher proportion of mafic minerals. The essential minerals are large grains of stringlet perthite, lesser quartz and minor plagioclase. Plagioclase includes both poorly twinned, sericitized grains and unaltered, well-twinned crystals that appear to be later than the sericitized variety. The most common mafic mineral is amphibole, occurring as large, green grains containing exsolved quartz, together with allanite and opaque mineral inclusions. Clinopyroxene forms a pale-green, anhedral partly relict mineral, altered to an orange-brown phyllosilicate (clinopyroxene is absent from CG86-697A, CG86-697B, HP92-192; these samples are from localities closest to the centre of the pluton). Biotite occurs as orange-brown flakes in minor amounts. Accessory minerals include allanite, opaque mineral, apatite, rare titanite and zircon. Two modal analyses (from the Kyfanan Lake map region) were reported by Gower and Loveridge (1987; CG86-697A, CG86-698)), and give some indication of the compositional range present in the pluton. The felsic minerals show the following modal values; quartz 12.8% and 35.5%, plagioclase 6.1% and 12.5% and K-feldspar 75.5% and 48.6%.

17.5.8 PORT HOPE SIMSON MAP REGION

17.5.8.1 Southwest Pond Granite ($M_{3D}gr$)

The name Southwest Pond granite (#33) was mapped and named by Gower *et al.* (1987). Southwest Pond is a local, informal name used by residents of Port Hope Simpson for a large lake in the area, adjacent to which most of the outcrops of the intrusion are found. The location of the Southwest Pond pluton is anomalous in being significantly to the northeast of other late- to post-Grenvillian plutons in eastern Labrador, and having been emplaced close to, or on, the boundary between the Lake Melville and Mealy Mountains terranes.

The pluton is a 5.5- by 4.5-km-circular to ovoid body, slightly elongate in a northeast direction. Apart from mapping by Gower *et al.* (1987), knowledge of the body comes from a lakeshore traverse in 1961 conducted by one of Eade's field assistants. The pluton was not recognized as a separate body during Eade's survey, but field descriptions on the aerial photograph used make it clear that the northern boundary of the pluton was drawn about 0.5 km too far north on the preliminary map of Gower *et al.*, who had not accessed Eade's field notes at that time. Topographically, the pluton is characterized by low ground, relative to a surrounding ring of hills, which is unusual in eastern Labrador, where most of the late- to post-Grenvillian quartz-bearing plutons form low hills. Magnetically, the body is characterized by a distinct high, as is the case for most late- to post-Grenvillian plutons in southern Labrador.

Gower *et al.* (1991) reported a U–Pb age of 962 ± 3 Ma for sample CG86-618, interpreting it as the time of emplacement. The date was based on three concordant zircon analyses, one very slightly discordant point being excluded on the basis of it possibly containing an inherited component.

The pluton consists of pink- to buff-weathering, coarse-grained, massive, homogeneous granite (Plate 17.11C), with which medium-grained granite and minor pegmatite are associated. In places, the medium-grained granite forms the whole outcrop, but, elsewhere, similar medium-grained granite forms parallel-sided dykes intrusive into the coarse-grained granite, as well as discordantly intruding the surrounding metasedimentary gneiss. The pluton appears to lack enclaves, but one outcrop (M61-066) in the centre of the body, described by Eade's assistant as granite gneiss, may be an exception. The country rock surrounding the Southwest Pond pluton is intruded by microgranite and pegmatite dykes, the appearance and distribution of which suggests they are satellite dykes of the parent body (which is unusual, as satellite dykes surrounding late- to post-Grenvillian plutons are rare).

One thin section from the coarse-grained (CG86-618) and one from the medium-grained granite (CG86-616) are available. The coarse-grained granite comprises anhedral well-twinned plagioclase having sericitized cores, anhedral, weakly undulose quartz, microcline, green biotite, secondary chlorite, white mica and rutile (all replacing biotite), and accessory titanite (large grains), apatite, orange-brown allanite, an oxide opaque mineral and zircon. The medium-grained granite has a similar mineral assemblage except that muscovite forms a minor primary phase, and primary biotite and accessory phases are much less abundant.

17.5.9 ST. LEWIS RIVER MAP REGION

17.5.9.1 Upper Pinware River Granite ($M_{3D}gr$, Locally $M_{3D}gp$)

The Upper Pinware River pluton (#34) (named by Tucker and Gower, 1994) was not identified during mapping by Gower *et al.* (1988). Examination of stained slabs and thin sections, combined with reassessment of field notes and re-evaluation of aeromagnetic patterns formed the basis for its interpretation as a late- to post-Grenvillian intrusion by Gower *et al.* (1991). A sample from the centre of the suspected pluton was collected for geochronological analysis and yielded a concordant zircon age of 960 ± 2 Ma (Tucker and Gower, 1994; sample CG87-660).

Partly because of the 'retroactive' recognition of the pluton, its extent remains a little less confidently delineated than other late to post-Grenvillian intrusions in eastern Labrador. Adequate data station control only exists on the northeast and southwest sides of the body. The eastern and southern sides are confidently positioned on the basis of aeromagnetic patterns and data stations. The northwestern side remains a problem because of conflicting indications from data stations *vs.* magnetic patterns. Weighting interpretation in favour of magnetic data encourages the interpretation that the body is pear-shaped, stretched in a northwest direction. It was depicted in this manner by Tucker and Gower (1994). Relying on data station information alone, however, suggests that it is circular. Both approaches have drawbacks; magnetic data cannot always be unequivocally interpreted, and isolated outcrops are not always representative. In particular, some of the late- to post-Grenvillian plutons contain outcrop-sized xenoliths of country rock. The body has been redrawn as a circular body, partly because a simple circular or elliptical shape is most typical. The pluton is transected in a northeast direction by a late fault, evident from topographic and aeromagnetic trends. This fault is parallel to others in the region that host huge quartz veins (Section 18.2.2) and was probably formed at the same time. No offset along the fault is apparent.

In outcrop, the granite is pink-, buff-, grey- or white-weathering, coarse grained, massive to rarely weakly foliated, unrecrystallized and homogeneous (Plate 17.11D). It contains sparse enclaves and very rare micrograpite dykes. It lacks pegmatite and is not intruded by mafic dykes. The central part of the pluton grades into a K-feldspar seriate or megacrystic texture.

Five thin sections are available from the pluton (CG87-127, CG87-134, CG87-660, JS87-184, JS87-186). They are texturally similar. Although sample CG87-660 is slightly finer grained than the others, it is not so different as to entertain doubts that the geochronology sample from this site is not representative of the pluton. The mineral assemblage comprises anhedral to rarely subhedral plagioclase, K-feldspar, quartz, green to orange biotite, relict dark-green amphibole (not in CG87-660), an opaque oxide, trace sulphide, titanite (brown cores and yellow rims), apatite, allanite in some samples, and euhedral zircon. K-feldspar is mostly well twinned microcline, but some relict string or flame perthite is present locally. Myrmekite is fairly common. A modal analysis of sample CG87-660 gave the following result; plagioclase 33%, K-feldspar 36%, quartz 22%, biotite 6%, titanite 2%, others 1%.

17.5.9.2 Chateau Pond Granite (M_{3D}gr, Locally M_{3D}mq)

The Chateau Pond granite (#35) (Gower *et al.*, 1988) is circular to elliptical in outline and its emplacement has imparted, and reoriented, foliations in the surrounding rocks into parallelism with the margin of the pluton. Gower *et al.* (1988) interpreted the northwest half of the pluton to have been displaced 1.5 km along a northeast-trending fault in an apparent sinistral sense. Evidence for the existence of this fault is based on strong aeromagnetic and topographic lineaments that coincide with major quartz veins (Section 18.2.2). Examination, in 2003, of roadcuts along the newly constructed Trans-Labrador Highway proved that part of the northeastern border had been drawn 2 km too far north. In the absence of much topographic relief, either an indentation must be drawn in the boundary or an additional fault inferred to accommodate the additional information. Neither topographic nor aeromagnetic evidence, nor country rock foliation trends are persuasive for either option. A fault has been indicated because they are typical of the region, whereas irregular boundaries in late post-Grenvillian plutons are not.

A sample from the pluton was dated to be 964 ± 2 Ma by Gower *et al.* (1991; sample CG87-605), based on four zircon fractions all overlapping concordia, within error.

The pluton is mostly granite, but is gradational into quartz monzonite in places. It is pink- to white-weathering, coarse to very coarse grained, massive and homogeneous (Plate 17.11E). The pluton contains large rafts of foliated biotite granite and remnants of quartzofeldspathic supracrustal rocks, which are inferred to be xenoliths of the surrounding rocks. Gower *et al.* (1988) thought that rafts might be more common than their map implied. New information does not substantially support this notion, as the granite is relatively enclave-free in roadcuts. Nevertheless, such might still be true for the western part, where most of the rafts were mapped originally. Gower *et al.* (1988) also reported that the body does not contain mafic enclaves. A few mafic to dioritic enclaves were observed in roadcuts, but the earlier observation remains largely valid. Previous observations that the pluton is not intruded by mafic dykes or by very many minor granite intrusions still apply.

Two outcrops outside the border of the pluton contain rocks that are identical to those within the body (CG03-068, VN87-274). In neither case can the boundary of the pluton be redrawn to accommodate them, as they are separated from the main body by unrelated foliated granitoid rocks. At CG03-068, the Chateau Pond granite look-alike rock only forms a minor part of the outcrop, whereas field notes at VN87-274 make no mention of other lithological types present. Satellite intrusions flanking late-tectonic plutons are rare, but it seems likely that these are examples.

Thin sections were prepared from nine samples (CC87-093, CG87-231, CG87-240, CG87-293, CG87-605, JS87-306, JS87-330, VN87-223, VN87-237). All samples are texturally very similar, with the exception of VN87-223, which has a higher mafic mineral content and is not quite so coarse grained. These differences can perhaps be attributed to VN87-223 being the sample taken closest to the edge of the pluton, although the roadcuts do not offer much support for marked lithological variation related to distance from the pluton border. The essential minerals are anhedral plagioclase, weakly undulose quartz and K-feldspar. Plagioclase is poor to well twinned, moderately sericitized and commonly has clear albitic borders locally associated with myrmekite. K-feldspar, which occurs in grains up to 3.5 cm across, consists partly of poorly exsolved, stringlet or patch perthite, and partly of well-twinned microcline. Olive-green-brown biotite is the dominant mafic mineral (with vermiform quartz inclusions), although relict blue-green hornblende, partially pseudomorphed to an orange-brown phyllosilicate, is present in most samples. Accessory minerals include titanite (a common, anhedral phase), rare allanite, apatite, ilmenite, pyrite and zircon. Chlorite, epidote, rutile and white mica are minor secondary minerals after biotite and/or hornblende.

17.5.10 PINWARE MAP REGION

17.5.10.1 Lac Senac Granite (M_{3D}gr, Locally M_{3D}mq)

The name, 'Lac Senac granite', taken from a lake in Québec, is informally given here to a massive, unrecrystallized pluton (#36) at the western edge of the Pinware River map region. The pluton is estimated to be about 20 km wide, of which only the eastern fringe is in Labrador. The outline of the remainder of the body, in Québec, is shown on the map of Avramtchev (1983b). Bostock (1983) mapped the eastern third of the body and divided it into a 3- to 4-km-wide exterior zone of quartz monzonite to granite, and a core of granodiorite to quartz monzonite. The mapping of Gower *et al.* (1994) did not result in modifications to Bostock's depiction.

In Labrador, the Lac Senac pluton consists of white- to pink-weathering, coarse-grained quartz monzonite, locally grading into granite. The rock is homogeneous; it lacks minor intrusions, but does contain a few fine-grained quartzofeldspathic and amphibolite enclaves. A noteworthy feature of the body is the presence of very obvious horizontal joints (*see* Plate 17.7F). Feldspar crystals are up to 3 cm long and quartz grains up to about 1 cm across. The rock shows well-developed mantled-feldspar textures having K-feldspar cores, a middle zone of plagioclase and a rim of K-feldspar. The texture is very similar to that seen in the Picton Pond quartz monzonite and the Upper St. Paul River (east and west) quartz monzonites (Gower *et al.*, 1993). Minerals are anhedral.

In thin section (CG93-487, DL93-167, DL93-182), the rock shows several indications of magma evolution. Plagioclase is distinctly zoned, having sericitized cores and narrow albitic rims. K-feldspar is partly mesoperthite and partly microcline. The irregular shape of hornblende, which is the dominant mafic mineral, and common inclusions of quartz, irregular opaque grains and other common accessory minerals, are all typical of derivation from clinopyroxene. One relict core of clinopyroxene was seen (DL93-167). The accessory phases are an oxide opaque mineral, apatite, zircon and titanite. Titanite occurrence varies from thin veneers on opaque grains to being a separate, and common, phase (DL93-182). No allanite is present. Opaque minerals are more abundant than is typical for quartz monzonite.

17.5.10.2 Stokers Hill Granite (M_{3D}gr)

Stokers Hill granite is a small granite pluton (#37) underlying high ground in the west-central part of the Pinware map region (Gower *et al.*, 1994). It was not separately identified by Bostock (1983), who included as part of his Unit Hqm-h (*cf.* Section 17.4.3.3). The west side of the body is interpreted as faulted because of a distinct, straight photo lineament in the area and breccia seen at the contact of the body. That the granite is a discrete body is evident from mapping out its contacts and from its aeromagnetic signature, as it forms a distinct magnetic high, contrasting with the surrounding rocks.

The granite, grading to alkali-feldspar granite, is pink- to buff-weathering, massive, coarse to very coarse grained, and completely homogeneous within individual outcrops (Plate 17.11F). There is an increase in grain size toward the centre of the body. The rock consists mostly of K-feldspar and quartz with lesser plagioclase. Biotite is the main mafic mineral, but minor hornblende is also present. In places, K-feldspar grains are up to about 2.5 cm and quartz grains up to about 1 cm, although more commonly both minerals are about half this size. The granite lacks enclaves and minor granitic intrusions.

In four thin sections examined (CG93-498, CG93-628, DL93-108, DL93-155), the granite shows some variation. All samples contain moderately sericitized, well-twinned plagioclase, weakly undulose quartz, microcline with some relict perthitic texture, green, slightly chloritized biotite, apatite, titanite, common zircon and opaque minerals (both oxide and sulphide). One sample, however, contains minor amphibole and two others contain muscovite and fluorite; allanite is very common in two samples, but almost absent in two others; and titanite is rather altered in three samples, but completely fresh in one other. It seems likely that the pluton is zoned compositionally as well as in grain size.

17.5.11 UNEXPOSED PLUTONS (M_{3D}?)

The correlation between circular aeromagnetic anomalies and late- to post-Grenvillian plutons is consistent enough to infer unexposed comparable plutons. The most probable examples are addressed as follows:

Upper St. Paul River Map Region (boundary between NTS map areas 13B/02 and 07) An area characterized by a pronounced ovoid magnetic anomaly in the western part of the Upper St. Paul River map region is interpreted by Gower (2000) to be underlain by a late- to post-Grenvillian monzonite (#38). That it is a late- to post-Grenvillian intrusion is based on the aeromagnetic anomaly, and that it is probably monzonite is an assumption based on the qualitative generalization that monzonite is typically the most poorly exposed late- to post-Grenvillian rock type (in contrast to quartz monzonite, which is commonly fairly well exposed).

Upper St. Paul River Map Region (southern boundary of NTS map area 13B/01) An unexposed area in the southern part of the Upper St. Paul River map region is characterized by a positive magnetic anomaly and is interpreted to be underlain by a late- to post-Grenvillian monzonite (# 39) by Gower (2000) on the basis of a single outcrop briefly examined in Québec, 1.2 km south of the Upper St. Paul River map region boundary (co-ordinates 409956 5760350 NAD27 Zone 21). The outcrop is pink-buff-weathering and very rubbly weathered, despite forming a sizable hilltop exposure. The rock is massive, coarse grained, and consists almost entirely of perthitic K-feldspar, except for an interstitial mafic mineral suspected to be pyroxene. The rock type and its style of weathering, coupled with its magnetic expression are strong grounds for interpreting this to be a late- to post-Grenvillian monzonite. On the compilation map of Avramtchev (1983a), the area is indicated as underlain by non-deformed granite extending about 25 km southward from the Labrador–Québec border.

Kyfanan Lake Map Region (north-central NTS map area 13A/05) A distinctive 6-km-diameter magnetic anomaly is interpreted to be a granite pluton (# 40) on the bedrock map interpretation for the area (Gower *et al.*, 1993).

Kyfanan Lake map region (west of Kyfanan Lake) An ovoid pluton (#41) is shown on the Kyfanan Lake 1:100 000-scale map. Exposure is entirely lacking in the area and its interpretation is based solely on a positive aeromagnetic anomaly in the area. Gower *et al.* (1993) did not find the regional aeromagnetic evidence compelling, thus omitted depiction of a late- to post-Grenvillian pluton on their map. High-resolution aeromagnetic data has been obtained for the surrounding area, but, unfortunately, a gap in coverage exists over the potential pluton, except where the southwest margin of the pluton is depicted. In this area, a northwest-trending magnetic high (the pluton margin?) appears to truncate a northeast-trending signature.

Strait of Belle Isle A very obvious positive magnetic feature (#42) is evident in the Strait of Belle Isle, 11 km (centre of anomaly) offshore from the Labrador coast. The anomaly measures 14 by 10 km elongate in a northeast direction, and has the magnetic hallmarks of a late- to post-Grenvillian pluton.

17.5.12 LATE- TO POST-GRENVILLIAN MINOR INTRUSIONS (M_{3D}gr, f, p)

Planar-sided to irregular minor granitoid intrusions (microgranite, aplite, and pegmatite) are common in all rocks that predate the late- to post-Grenvillian granitoid rocks, but are rare in late- to post-Grenvillian plutons. They are generally pink-weathering, homogeneous and massive. In some instances, where there are surrounding outcrops of contrasting rock types, it is clear that the occurrences cannot represent major bodies, but outcrop control is so poor elsewhere that is conceivable that they could be sizable intrusions. Undoubtedly, several ages of minor granitoid intrusion are present, and mention of them here should not be taken to mean that all, or, indeed, even the majority, were emplaced at this stage in the geological history. No pegmatites intrude Neoproterozoic or Early Cambrian supracrustal rocks in southeast Labrador. Examples of some interest are addressed as follows:

Crooks River Map Region At many outcrops in the southern half of the Crooks River map region, the sole rock type is pegmatite. Clustering of several such outcrops, might suggest that some very large pegmatites exist, but given that it is a rock type resistant to weathering, only relatively small, but preferentially exposed, bodies need be present, which would mean that the overall proportion of pegmatite is quite low. At outcrops where other rock types are also exposed, it is commonly clear that the pegmatites are minor discordant intrusions truncating older fabrics. Despite these caveats, a 20-m-high cliff of composite pegmatite–microgranite was found east of Joir River, so, obviously, not all pegmatites in the region are small.

The rocks are pink-, creamy- or white-weathering and very heterogeneous, ranging from aplite, through microgranite to very coarse pegmatite having an average grain size exceeding 10 cm. Some pegmatites are recrystallized and show obvious foliations, defined by heterogeneity of minerals in particular layers or by elongation of quartz veins, but others are massive and unrecrystallized. Associated quartz veins (locally irregular masses) vary from 1 cm to 2 m in width. In rare instances, enclaves of gneiss or amphibolite are present, the largest about 2 m long. Where pegmatite is, otherwise, the only rock exposed, such enclaves are useful guides to the nature of surrounding rock types. Compositions and textures in the intrusions are variable, showing abrupt transitions between pegmatite, granite, microgranite and aplite in the same body.

The quartz content and proportion of K-feldspar to plagioclase vary dramatically and, empirically, there is a hint that high plagioclase content correlates with emplacement into mafic rocks (explicable in terms of potassium consumption during metasomatism of the host rock at time of pegmatite emplacement?). Graphic intergrowths of quartz and K-feldspar are common. The dominant mafic mineral is biotite; the largest biotite books seen are 2 cm across and 0.2 cm thick. Muscovite was seen at one outcrop and garnet noted in a stained slab from another. The garnets are very small (1 mm in diameter), euhedral, orange-brown and guessed to be igneous. Minor magnetite is ubiquitous. No pegmatites from this area were examined in thin section.

Variability of deformational state suggests that several generations of pegmatite are present, possibly reflecting the same time span as that represented between the early gneisses and the late- to post-Grenvillian granitoid plutons.

Upper Eagle River Map Region Pegmatite in central NTS map area 13B/10 is singled out for special mention because there is so much of it in one small area. It forms the sole rock type in a cluster of outcrops forming low, steep-sided hills surrounded by marshland lacking exposure. The pegmatites are pale-pink to white-weathering, coarse to extremely coarse grained, massive, inhomogeneous, and graphic textured. The lack of any indication of deformation suggests that they are part of the late- to post-Grenvillian suite, perhaps representing the roof of a small pluton, analogous to the 13B10 southeast nested pluton described earlier, which also contains graphic-textured pegmatite. Interestingly, the only other graphic-textured pegmatite recorded in this area occurs as a dyke intruding gneissic granite at an outcrop (CG97-260) halfway between the pegmatite cluster and the nested pluton.

Upper St. Augustin Map Region–Joir River Area Late-stage, planar microgranite/aplite and pegmatite outcrops are distributed in an arcuate zone flanking the east side of the Joir River granite and the 13B05 north-central monzonite to syenite to the north. Gower (2001) regarded the exposures as representing minor intrusions, preferentially exposed in an area otherwise devoid of outcrop. It is possible, however, that a large pluton of medium-grained granite, into which the Joir River granite and the circular syenite have been emplaced, is present underlying surficial deposits throughout much of the northwest area. This interpretation is not favoured, partly because of lack of support from aeromagnetic data. The hypothesis proposed here is that the Joir River granite and the 13B05 north-central monzonite to syenite (perhaps also including the Upper Michaels River monzonite to granite) expand to batholith dimensions at depth, and that the microgranite/granite outcrops are upward offshoots from the subsurface body or bodies.

Three samples of microgranite (CG00-040, CG00-078, CG00-139) thin sectioned from this group are similar enough to each other to accept a common origin as likely. Plagioclase is anhedral, moderately twinned and lightly altered except at grain cores. The core alteration is consistent with zoning evident in all samples. K-feldspar is well-twinned microcline, and quartz is unrecrystallized and only slightly undulose. The mafic mineral is orange-green biotite, partially altered to chlorite (plus minor rutile), having spindles of titanite or an oxide opaque mineral developed along cleavages. Accessory minerals are an opaque oxide, apatite, zircon and titanite, although titanite is rare in CG00-040, and both titanite and apatite are absent from CG00-078. White mica is present in microfractures in CG00-139.

Upper St. Paul River Map Region Pegmatite, microgranite and quartz veins are a minor component of many outcrops. The granitic minor intrusions are pink-, white- or red-weathering, and occur both as concordant and discordant intrusions from narrow veins to dykes several metres wide. Several generations of intrusion are present, but no attempt to distinguish them was made during mapping. For the most part, the pegmatite and microgranite are only a minor part of an outcrop, and only one instance was found where the entire outcrop consists of pegmatite. Biotite is the typical mafic mineral, locally occurring in books up to 6 cm in diameter, although rarely more than a few millimetres thick. Pegmatite containing significant amounts of muscovite, or any exotic minerals, was not seen.

Quartz veins are common, and are characteristically associated with the foliated granitic rocks as concordant and discordant lenses and layers, ranging in size from a few millimetres to tens of centimetres in width, and up to about 2 m long.

Kyfanan Lake Map Region, North and East of Kyfanan Lake. Several small granitoid bodies are represented on the bedrock map of the Kyfanan Lake region as isolated intrusions because the rocks are mostly aplite/microgranite or pegmatite (Gower *et al.*, 1993). In several outcrops, the pegmatite and aplite/microgranite are closely associated as irregular patches of one rock type in the other. The pegmatites locally contain biotite books up to 6 cm across. A 2-km-diameter intrusion situated 15 km northeast of Kyfanan Lake is distinctive in that pegmatitic phases are graphic-textured and contain garnet and muscovite.

Granite 4 km east of the southern end of Kyfanan Lake examined in thin section (CG92-085) is probably typical of the minor intrusions in this area. It contains plagioclase with albitic rims, microcline, quartz, chloritized green biotite, common titanite, apatite, allanite, zircon and an opaque mineral.

K*yfanan Lake Map Region, South of Kyfanan Lake* Minor granitic intrusions were seen south of Kyfanan Lake (HP92-181).

Kyfanan Lake Map Region, Confluence of Tributary with St. Paul River At this locality, biotite-bearing alkali-feldspar quartz microgranite (thin section VN92-197C) discordantly intrudes quartz monzonite dated to be 1649 ± 7 Ma. The lower intercept of the discordia gave an age of 1009 ± 10 Ma and titanite gave an age of 947 ± 10 Ma (Wasteneys *et al.*, 1997). The latter two dates provide some indication that the microgranite is Grenvillian, but no certainty that it is necessarily late- to post-Grenvillian.

Kyfanan Lake Map Region, Western Boundary 3 km North of St. Paul River At this locality, biotite-bearing alkali-feldspar quartz syenite (thin section CG92-120B) clearly intrudes monzogabbro (*see* earlier).

St. Lewis Map Region, Upper Trout River White-weathering, massive granodiorite (CG87-105B) discordantly intrudes older strongly foliated granodiorite. The massive granodiorite is inhomogeneous, the rock ranging from medium grained to pegmatitic. Tucker and Gower (1994) reported a concordant zircon age of 959 ± 2 Ma for the massive granodiorite. A similar, but undated, rock exists at locality CG87-081 and has been examined in thin section. It differs in containing minor relict hornblende, partially pseudomorphed by epidote, titanite and biotite.

St. Lewis Map Region, St. Peter Bay As part of the geochronological study at St. Peter Bay, a late-stage minor granitic dyke was investigated by Tucker and Gower (1994). The dyke (sample CG87-426C) represents the last emplacement event at the outcrop, postdating emplacement of pegmatite and microgranite injection into their host (*see* CG87-426A, CG87-426B) and two periods of subsequent deformation. The late-stage dyke is a buff-weathering aplite that contains enclaves of the earlier deformed host rocks (Plate 13.5F). It consists of plagioclase (37%), microcline (39%), quartz (19%), muscovite (2%), biotite (0.5%), an opaque oxide (0.5%), apatite, allanite titanite, and secondary chlorite (collectively 1.5%).

During the geochronological study, some of the sample had to be discarded due to xenolith contamination. From the remaining material, three zircon fractions and two titanite zircons were analyzed. The $^{207}Pb/^{206}Pb$ ages from the zircon analyses range between 1478 and 1463 Ma, consistent with being xenocrysts from the 1479 Ma host rock (CG87-424A). The titanite analyses gave a concordant age of 974 ± 6 Ma, which was interpreted as a minimum age for the emplacement of the aplite.

Pinware Map Region, L'Anse-au-Diable An undated minor granitoid intrusion of interest is present at the same locality as a dated 1036 Ma pegmatite (Section 17.3.4.2). It is a 1-cm-wide aplite that intrudes a dated 985 Ma alkalic mafic dyke. The aplite has been dextrally sheared. The 985 Ma data thus provides an older age limit for both the granitic magmatism represented by the vein and the shearing.

In thin section (CG93-268D), the aplite is seen to comprise relict igneous plagioclase, microcline, quartz, chloritized biotite and minor opaque mineral.

Pinware Map Region, Red Bay A particularly noteworthy pegmatite intrudes the Red Bay mafic intrusion (locality DL93-001). The pegmatite contains abundant allanite, titanite and magnetite. The allanite grains are commonly larger than 0.5 cm and are easily visible in almost every hand sample from the pegmatite. In the adjacent amphibolite, titanite forms elongate bladed red-brown euhedral prisms up to 3 cm long at the centre of white elliptical pods of quartz, plagioclase and microcline perthite up to 6 cm long. Similar pods also enclose magnetite. The leucosome pods surrounding the magnetite are deemed to have been formed by the oxidation reaction:

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

The leucosome pods containing titanite presumably formed by an analogous reaction.

Two thin sections (DL93-001B1, DL93-001B2) were prepared from the pegmatite intruding the Red Bay mafic body. The mineral assemblage is plagioclase, microcline (some perthite in DL93-001B1), quartz, bronzy-orange biotite, apatite, zircon and minor secondary white mica and chlorite.

Pinware Map Region, Temple Bay A pegmatite in the Temple Bay area is of interest because of its unusual enclaves, which are rounded, of various sizes and anomalously rich in magnetite and a non-magnetic opaque mineral (ilmenite/hematite?).

One of the enclaves was examined in thin section (CG93-730). It contains sodic plagioclase, microcline, abundant quartz, a bright green, pleochroic clinopyroxene, large, anhedral titanite, apatite, large, euhedral zircons, common interstitial carbonate and traces of dark orange-brown biotite. The petrographic character of the clinopyroxene, plus its association with magnetite and carbonate, dictates that it is diopsidic. The quartz-rich nature of the enclave and concentration of Ca-bearing minerals suggest that the enclave is from a calc-silicate supracrustal source.

17.5.13 UPPER ST. LEWIS RIVER (EAST) MAFIC DYKES (M_{3D}d)

The Upper St Lewis River (east) pluton is intruded by two phases of mafic dykes (Plate 17.10A), both of which contain plagioclase phenocrysts. Because similar dykes were not observed elsewhere in the map region, they are regarded as being genetically related to the pluton. The most obvious macroscopic difference in the two dyke phases is phenocryst abundance, being roughly 10% in one group (CG92-281B) and about 40% in the other (CG92-281C). The plagioclase phenocrysts are euhedral, up to 1 cm long.

In thin section, the phenocrysts are seen to be distinctly zoned and contain abundant inclusions of orthopyroxene, clinopyroxene, apatite and an opaque mineral. These minerals, along with plagioclase and poikilitic red-brown biotite, also make up the groundmass. An appropriate name for both rocks is plagioclase-phyric micronorite.

17.5.14 GENERAL OBSERVATIONS ON POST-GRENVILLIAN PLUTONS

A key feature of the distribution of the late- to post-Grenvillian plutons is the dog-leg change in trend of the northern limit of the plutons (with the exception of the

Southwest Pond intrusion). In the west the trend is northeast, whereas, in the centre and east, it is southeast and somewhat arcuate, convex to the southwest. This change in trend has been interpreted by Gower *et al.* (2008a, b) to be related to Grenvillian indentor tectonism (*see* Chapter 23).

Another key feature is that most of the granite is situated in the north, whereas most of the monzonite is in the south (with some exceptions). There are too few syenites to comment on their distribution.

A feature shared by the two dated late- to post-Grenvillian plutons syenitic intrusions is that both show indications of an earlier history (which are not evident in the monzonites and granites). The 13B05 north-central syenite to monzonite has textures and fabrics that hint at an older age (discounted by a precise 962 ± 3 Ma zircon age), and dating of the Rivière Bujeault headwaters alkali-feldspar quartz syenite to granite encountered complications due to abundance of inherited zircon. Note that dating of the slightly older Lower Pinware River pluton, an alkali-feldspar syenite, also involved similar issues.

17.5.15 SOME LITHOGEOCHEMICAL FEATURES OF LATE MESOPROTEROZOIC GRANITOID PLUTONS

Some lithogeochemical features of late Mesoproterozoic granitoid plutons are shown in Figure 17.11. Figure 17.11A, B shows the Gilbert Bay granite, the Fold-Test intrusions and the Lower Pinware River alkali-feldspar syenite. All three show geochemical coherence, but very little compositional overlap between units, which reinforces interpretation of them as discrete entities, although this is not an issue with the Gilbert Bay granite and the Lower Pinware River alkali-feldspar syenite, as they are fairly distinctive in the field.

The Gilbert Bay granite is characterized by high Rb. Interestingly, although not shown on Figure 17.11A, B), the closest-in-age Grenvillian minor intrusion for which geochemical data are available (Southwest Brook granite – 1079 ± 6 Ma) also plots in this group. With respect to the *ca.* 1040 Ma Fold-Test intrusions, the main point is the compositional similarity between the two dated samples (an observation that can be extended beyond the Rb, Y and Nb components utilized in the diagram), thus offering further validation for correlation of these rocks on either side of the fold. The Lower Pinware River alkali-feldspar syenite is a little out-of-place in Figure 17.11A B, as it is much younger and is simply included here to avoid clutter in Figure 17.11C D. The samples for this unit show more scatter, most likely due to contamination, as indicated from field and geochronological investigations of the unit.

Figure 17.11C, D show data for the early and late posttectonic Grenvillian granitoid rocks. The representatives of the early posttectonic intrusions are the Upper Beaver Brook and Picton Pond bodies, both of which are fairly well defined in the field and both of which have the same 985 Ma date (within error). The data points for the bodies are somewhat dispersed, but also show some coherence, inasmuch as they have a fairly constant Nb/Y ratio. The late-posttectonic plutons show much more scatter, which does not seem to be related to spatial or temporal factors (cross-reference to Figure 17.10). One possibility is that the late posttectonic granitoid rocks are evolved products from early posttectonic granitoid magmas, representing both residual and fractionated parts. The Upper St. Lewis River (east) monzonite (sample CG84-195 – identifiable on the figures by its 966 ± 3 Ma age) is significant in this regard as, not only is it among the samples having the lowest Rb, Y and Nb, but it is also different in the field, having leuconorite along its northern border and being intruded by mafic dykes (Section 17.5.13).

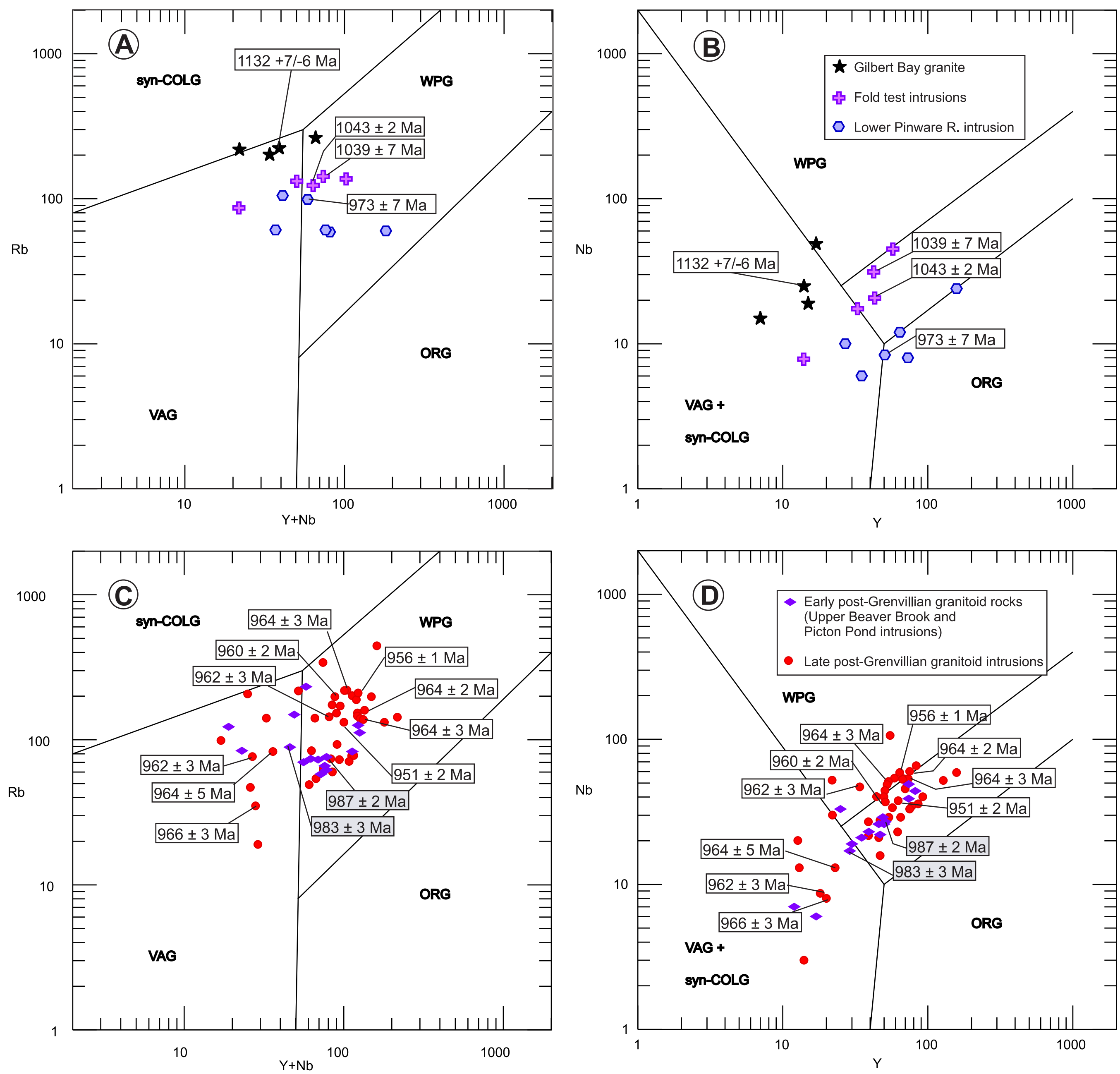


Figure 17.11 *A, B. Selected pre- and syn-Grenvillian granitoid intrusions in Y + Nb* vs. *Rb and Y* vs. *Nb space, C, D. Early- and late-post-Grenvillian granitoid intrusions in Y + Nb* vs. *Rb and Y* vs. *Nb space. Shaded boxes distinguish early post-Grenvillian dates.*