Chapter 3

FIELD RELATIONS

3.1 Major Rock Types

The following section outlines the important geological features and of the major rock types of the batholith, including biotite granodiorite, biotite monzogranite, muscovite-biotite monzogranite, coarse grained leucomonzogranite, fine grained leucomonzogranite and muscovite leucogranite. There are mineralogical and textural differences between individual map units and, consequently, this section presents the overall characteristics of rock types that are common to all units. A summary of textural and mineralogical features of these rocks is given in Table 3.1.

Table 3.1. Summary of overall textural and petrographic characteristics of the main rock types in the South Mountain Batholith.

ROCK TYPE	% of SMB	GRAIN SIZE	DOMINANT TEXTURES	BIOTITE %	MUSCOVITE %	MUSCOVITE Type	PLAGIOCLASE An	PLAGIOCLASE Zoning	K-SPAR EXSOL	CORD %	AND %	TOPAZ %	XENOLITHS
Leucogranite	0.7%	f-m(c)	porp, equi, pegm	0-2	3-28	euh > repl	<5	unzoned	non-exsolved	tr.	0-2	0-8	none
Fine-grained leucomonzogranite	6.8%	f-m(c)	porp, equi	2-7	3-13					tr.	0-tr	0	rare
Coarse-grained leucomonzogranite	21.8%	m-c(f)	mega, seri	2-7	4-8	repl > euh		zoned > unzoned	patch > rod & bead perthite	tr-5	0-tr	0	rare
Muscovite-biotite monzogranite	8.9%	m-c(f)	mega, seri, equi	7-12	1-3					tr-5	0	0	common
Biotite Monzogranite	52.2%	m-c(f)	mega, seri	10-17	tr-1					tr-1	0	0	common-abundant
Biotite granodiorite	9.6%	m-c(f)	mega, seri	15->25	tr	repl	<5-35	zoned	rod & bead perthite	tr.	0	0	abundant

EXPLANATION: GRAIN SIZE - f - fine (<0.1 cm), m - medium (0.1-0.5 cm), c - coarse (>0.5 cm) brackets denote minor occurrence
DOMINANT TEXTURE - equi - equigranular, porp. - porphyritic, pegm - pegmatitic, mega - megacrystic, seri - seriate, listed in descending order of importance
BIOTITE, MUSCOVITE, CORD (CORDIERITE), AND (ANDALUSITE), TOPAZ % - modal determinations from point counting (500-1000 points) of stained rock slabs and thin sections
MUSCOVITE TYPE - euh - euhedral (primary?), repl - replacement (secondary)
PLAGIOCLASE An - anorthite content (from microprobe analysis)
K-SPAR EXSOL - alkali feldspar exsolution textures
XENOLITHS - abundance of metasedimentary xenoliths: abundant - several in all outcrop; common - a few in most outcrop; rare - minor occurrence in some outcrop.

The distribution of rock types for the entire batholith is given in the 1:250,000 scale compilation map (Figure 2.3, in pocket at back). Each rock type description includes the modal amounts of biotite, cordierite, garnet and andalusite, which were obtained from point counting of rock slabs (up to 1500 points depending upon size of slab) and visual modal estimates of hand specimens. The modal amounts of muscovite are mostly based upon point counting of thin sections, which yielded significantly higher values than for rock slabs that were obtained using a binocular microscope. Modal amounts of topaz, which only occurs in leucogranite, were determined by point counting thin sections. Complete petrographic and mineralogical descriptions of each rock type are given in Chapter 4. In the following section the term xenolith refers to inclusions with sedimentary, metamorphic (e.g. porphyroblastic) or granitoid textures that strongly contrast the texture and modal mineralogy of the host unit. Xenoliths have a wide variety of textures and grain sizes and have previously been interpreted as metasedimentary in origin (Jamieson, 1974; Clarke and Halliday, 1980) and as both metasedimentary and granitoid in origin (MacDonald et al., 1992). A more complete description of xenoliths is given below.

3.1.1 Biotite Granodiorite

Biotite granodiorite units are mostly light grey in colour, except for localized alteration zones, which mostly consist of pink to red coloured hematized zones. Rocks are predominantly medium- to coarse-grained and mostly have megacrystic texture, with alkali feldspar, and to a lesser extent plagioclase, megacrysts (Plate 3.1 a). Some granodiorite units have medium- to coarse-grained seriate texture (Plate 3.1b). Several units have medium-grained seriate to equigranular (Plate 3.1e) textures, such as the units that occur along the margins of the Halifax Pluton on map sheet 11D/12 (MacDonald and Horne, 1987), along Highway #101 in Mount Uniacke (Corey, 1987) and the Five Island Pluton on map sheet 21A/16 (Ham and Horne, 1987). These units are denoted by a pattern in Figure 2.3 (in pocket at back). Biotite granodiorite typically contains 15-25% biotite (with accessory apatite, zircon, monazite, xenotime, ilmenite) and trace amounts of muscovite, cordierite and garnet.

Biotite granodiorite units comprise approximately 9.6% of the batholith. Most granodiorite occurs in Stage I plutons, however, some units were noted along the margins of the Stage II Halifax and Davis Lake plutons (MacDonald and Horne (1987) and Ham and MacDonald (1994) respectively). The "type section" for megacrystic granodiorite is along Highway #101 from approximately 0.5 km east of the Lequille intersection, eastward to the Spurr Road overpass (Corey and Horne, 1994b). The "type section" for non-megacrystic to seriate textured granodiorite is along Dunbrack Street, in Halifax, between the St. Margaret's Bay Road and Old Sambro Road (MacDonald and Horne, 1987). Biotite granodiorite is the predominant rock type in the Five Island Lake Stage I pluton. In contrast, it is a subordinate rock type in the Salmontail Lake, Scrag Lake and Cloud Lake Stage I plutons. In these plutons granodiorite mostly occurs

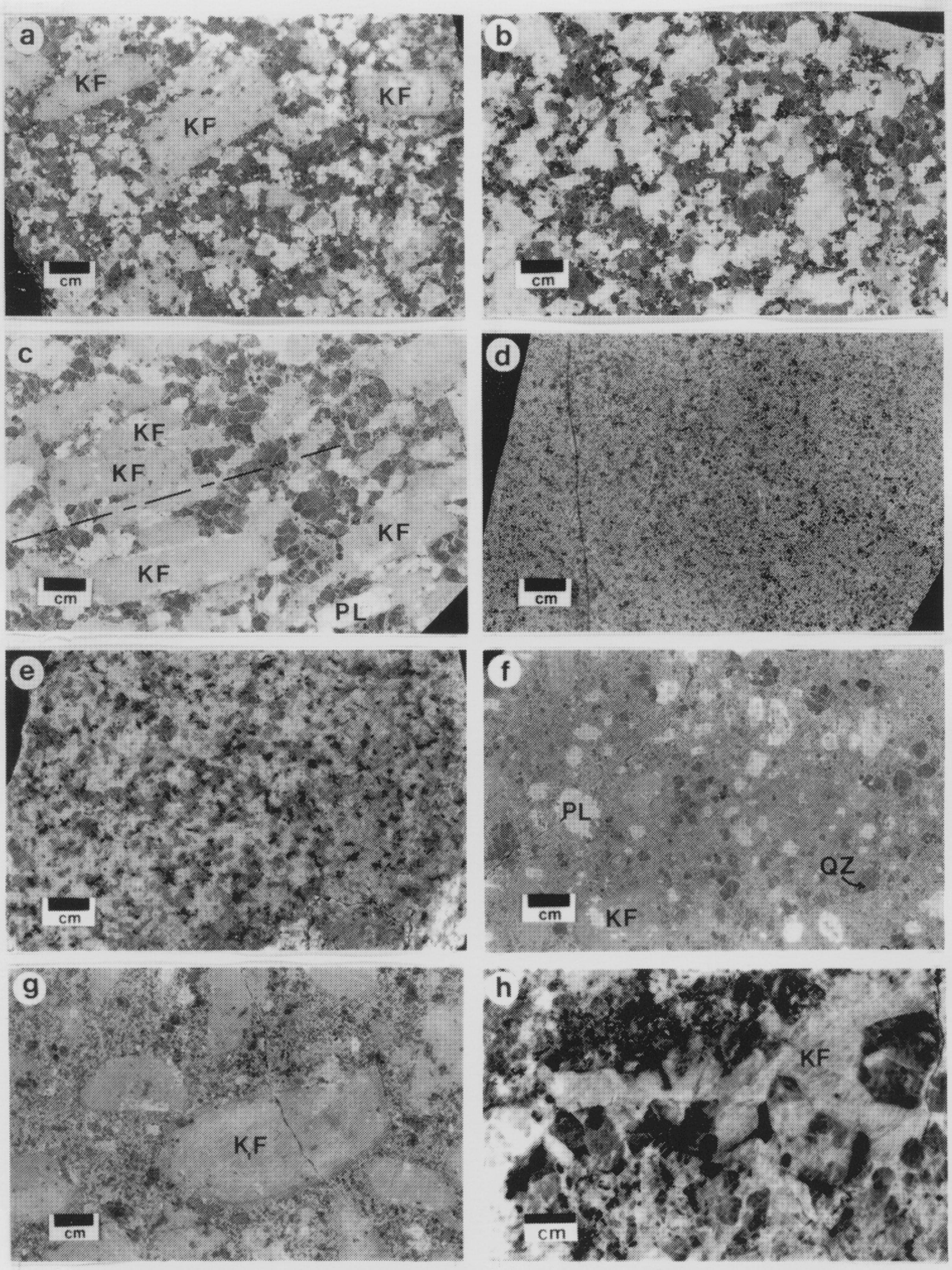

Plate 3.1 Characteristic textural variations for the granitoid rocks of the South Mountain Batholith. (a) medium- to coarse-grained megacrystic; (b) medium- to coarse-grained seriate; (c) medium- to coarse-grained megacrystic with parallel alignment of feldspar megacrysts; (d,e) fine- and medium-grained equigranular; (f,g) fine- to medium-grained and fine- to coarse-grained porphyritic; (h) coarse-grained pegmatitic. Abbreviations include: KF-alkali feldspar; PL-plagioclase; QZ-quartz.

particularly in normally zoned parts of the Scrag Lake and Salmontail Lake plutons. Contacts with metasedimentary and metavolcanic country rocks, where observed, are mostly sharp and intrusive (Plate 3.2). The most notable exception is in the Boot Lake granodiorite (MacDonald and Ham, 1992) where "wispy" zones of mafic porphyry (see below) are developed along the contacts with the Meguma Group metasediments (Plate 3.3). Contacts with biotite monzogranite units in most Stage I plutons and the Stage II Halifax Pluton are gradational. In fact, most of the contacts in Figure 2.3 (in pocket at back) are defined on the basis of point counting of rock slabs and are difficult to detect in the field. In contrast, contacts with the muscovite bearing rocks of both the Stage I and II plutons are ubiquitously sharp and intrusive. Biotite granodiorite units have the highest proportion of xenoliths (Plate 3.4), with the exception of the volumetrically minor mafic porphyry (see below). In general, the highest percentages of xenoliths were noted in areas of granodiorite with the highest percentages of biotite, and locally in close proximity to country rock contacts as along Highway #101 near Mount Uniacke (Jamieson, 1974; Corey, 1987).

Plate 3.2 Sharp intrusive contact between granitoid rocks of the South Mountain Batholith and metasedimentary rocks of the Meguma Group. Note the injection of granitoid rocks along bedding planes and the presence of angular xenoliths of Meguma Group rocks. Width of photograph is approximately 2 metres.

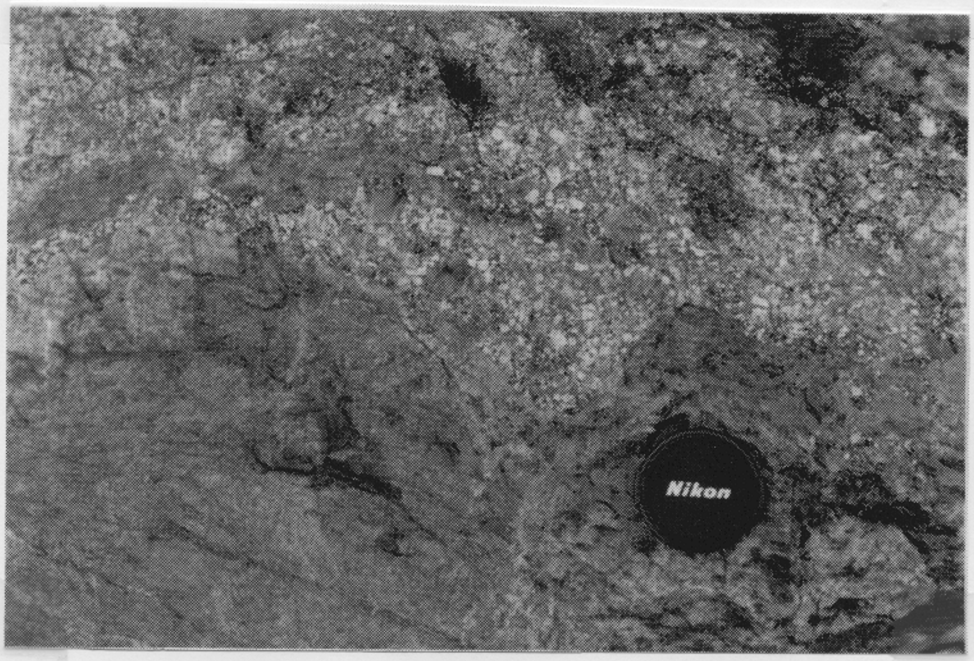

Plate 3.3 "Wispy" bands of biotite-rich mafic porphyry developed along the contact between the Boot Lake granodiorite and metasedimentary rocks of the Meguma Group (MacDonald and Ham, 1992). Note the diffuse nature of the contacts which strongly contrasts the sharp intrusive contacts shown in Plate 3.2.

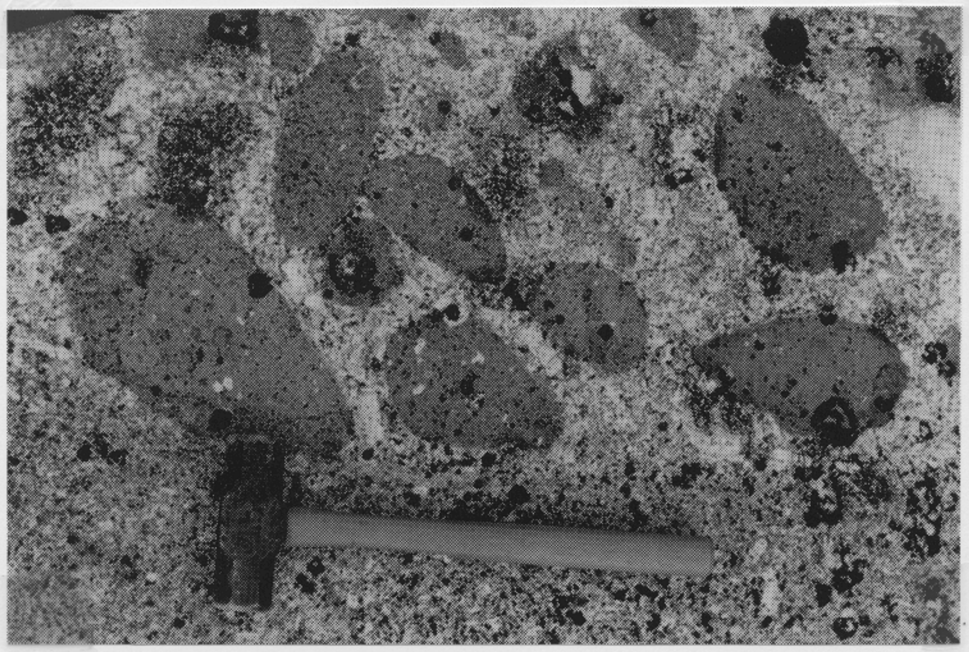

Plate 3.4 Concentration of rounded metasedimentary xenoliths in biotite granodiorite along the northern margin of the Halifax Pluton (MacDonald and Horne, 1987). Note the presence of light grey feldspar porphyroblasts in most xenoliths, and the presence of highly assimilated(?) xenoliths with granitoid textures. Hammer handle is 40 cm long.

3.1.2 Biotite Monzogranite

Biotite monzogranite units are mostly light grey in colour, except for restricted hematized zones that have reddish colouration. Rocks are predominantly medium- to coarse-grained and have megacrystic texture, with alkali feldspar, and to a lesser extent plagioclase, megacrysts. In fact, these rocks strongly resemble biotite granodiorite units. Some monzogranite units display a medium- to coarse-grained seriate texture in part. Several bodies of monzogranite with fine- to coarse-grained porphyritic texture (Plate 3.1f) were noted in parts of the batholith, for example on map sheet 21A/11 (Corey and Horne, 1994b) and map sheet 21A/10 (Horne, 1993) and are denoted by a pattern in Figure 2.3 (in pocket at back). Biotite monzogranite typically contains 10-17% biotite (with accessory apatite, zircon, monazite, xenotime, ilmenite) and trace-1% muscovite and cordierite. These rocks are mostly distinguished from granodiorite on the basis of proportions of quartz-alkali feldspar-plagioclase and, to a lesser degree, lower biotite content.

Biotite monzogranite units comprise approximately 52.2% of the batholith and hence are the predominant rock type. Most biotite monzogranite is restricted to Stage I plutons, however, some units were noted along the margins of the Stage II Halifax and Davis Lake plutons (MacDonald and Horne (1987) and Ham and MacDonald (1994) respectively). Some biotite monzogranite bodies were also noted in the central parts of the New Ross Stage II pluton, although these rocks are interpreted as "roof pendants" of the adjacent Stage I Pluton. There are numerous excellent exposures of biotite monzogranite throughout the entire batholith, however, perhaps the best "type section" for megacrystic monzogranite is along Highway #103 from the Ingram River on map sheet 11D/12 (MacDonald and Horne, 1987) eastward to the intersection with Highway #14, near Chester (Corey, 1990). Note that there are also several small bodies of fine- and coarse-grained leucomonzogranite along this portion of Highway #103. The "type section" for porphyritic textured biotite monzogranite is along a series of secondary roads northeast of Highway #8, in the central part of map sheet 21A/11 (Corey and Horne, 1994b). Biotite monzogranite is the predominant rock type in all Stage I plutons with the exception of the Five Island Lake pluton which is mostly composed of biotite granodiorite. Contacts with metasedimentary and metavolcanic country rocks, where observed, are mostly sharp and intrusive. The most notable exception is in portions of the Cloud Lake monzogranite

(MacDonald and Ham, 1992) where "wispy" zones of mafic porphyry, similar to those in the Boot Lake granodiorite are developed along the contacts with the Meguma Group metasediments (see below for discussion of origin of these rocks). Contacts with biotite granodiorite units in most Stage I plutons and the Stage II Halifax Pluton are gradational. In fact, most of the contacts in Figure 2.3 (in pocket at back) are defined on the basis of point counting of rock slabs and, as noted above, are difficult to detect in the field. In contrast, contacts with the muscovite bearing rocks of both the Stage I and II plutons are ubiquitously sharp and intrusive (Plate 3.5). Biotite monzogranite units have common to abundant xenoliths, the highest percentages being in the rocks with the highest modal amounts of biotite and locally in portions of biotite monzogranite units in close proximity to the country rock contacts.

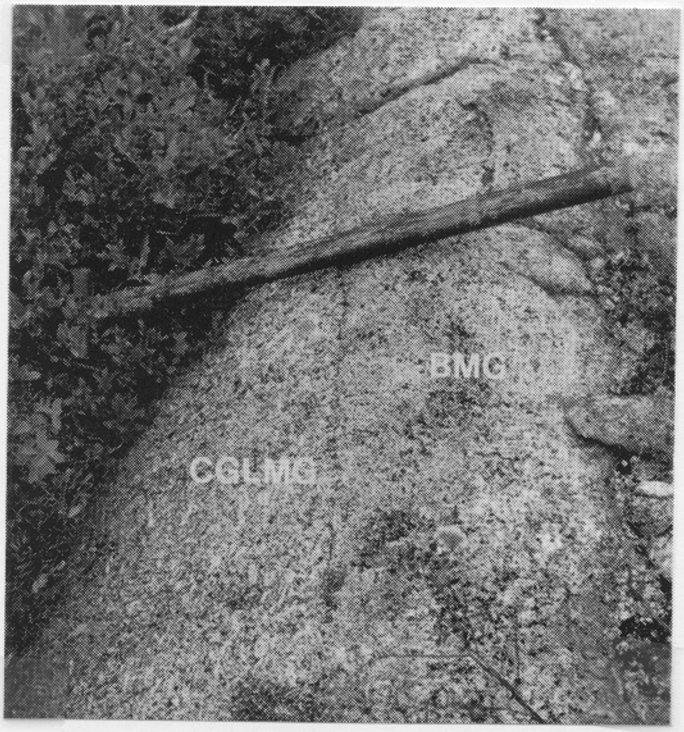

Plate 3.5 Sharp intrusive contact between biotite monzogranite (BMG) of the Stage I Salmontail Lake Pluton and coarse grained leucomonzogranite (CGLMG) of the Stage II New Ross Pluton. Note the lack of contact-related features including the development of chilled margins in both units. Hammer handle is approximately 1 metre long.

3.1.3 Muscovite-Biotite Monzogranite

Muscovite-biotite monzogranite units are mostly light grey in colour, except for restricted hematized zones that have pink to red colouration. The Harrietsfield (MacDonald and Horne, 1987), Sherwood (Ham and Horne, 1987), Whale Lake (Horne, 1993), Kerr Lake (MacDonald and Ham, 1992) and Soloman Lake (Ham and MacDonald, 1994) muscovite-biotite monzogranite units in the Halifax, New Ross, East Dalhousie and Davis Lake Stage II plutons are predominantly medium- to coarse-grained and have moderately megacrystic texture, with 3-20% alkali feldspar megacrysts. Individual megacrysts vary in size from <2.5 to >7 cm in length. The Kejimkujik Lake (Horne and Corey, 1994) and Button Brook (MacDonald and Ham, 1994b) units are texturally similar to the above units but are typified by trace-$\approx$10% small ($\approx$1 x 2-2.5 cm) alkali feldspar megacrysts. The West Dalhousie monzogranite comprises two separate textural types (Corey and Horne, 1989b; MacDonald and Ham, 1992). The first is a very megacrystic phase with 20 to 40% uniformly sized (1 x 3 cm) alkali feldspar megacrysts (Plate 3.6). The second variety is fine- to medium-grained with moderately equigranular or slightly megacrystic texture. This phase is denoted by a pattern in Figure 2.3 (in pocket at back). Rapakivi textures, with albite rims enclosing cores of alkali feldspar (Plate 3.7), are a common feature in muscovite-biotite monzogranite units. Muscovite-biotite monzogranite units typically contain 7-12% biotite (with accessory apatite, zircon, monazite, xenotime, ilmenite), 1-3% muscovite and trace-5% cordierite. These monzogranitic rocks are distinguished from biotite monzogranite units on the basis of significant proportions of muscovite, easily recognizable in hand specimen, and lower proportions of biotite.

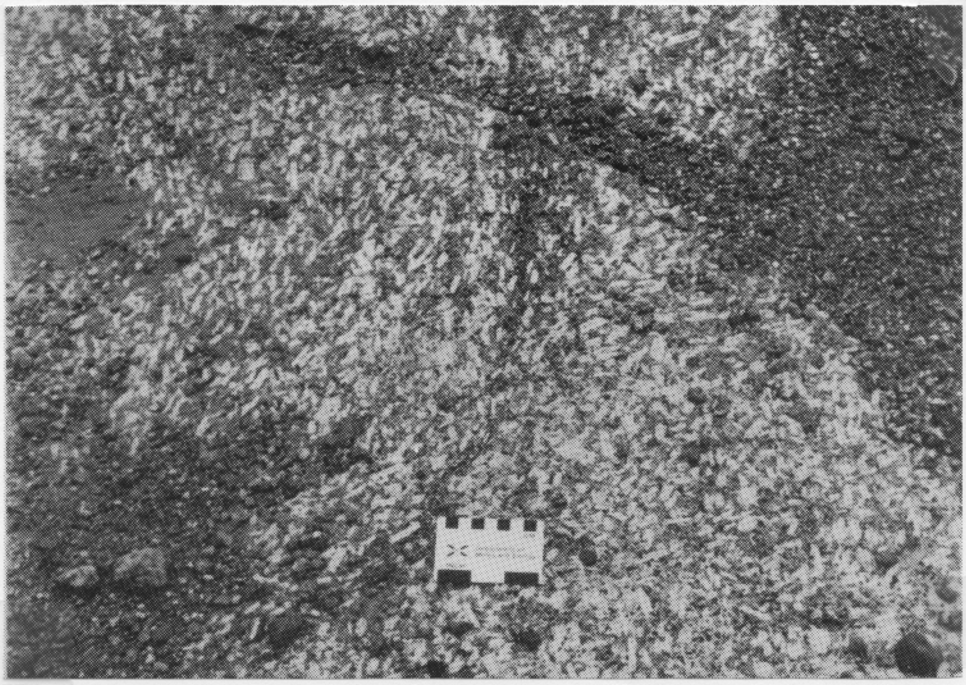

Plate 3.6 Typical outcrop of megacryst-rich West Dalhousie muscovite-biotite monzogranite with abundant (approximately 35%) uniform-sized alkali feldspar megacrysts ($\approx$1 x 2-2.5 cm).

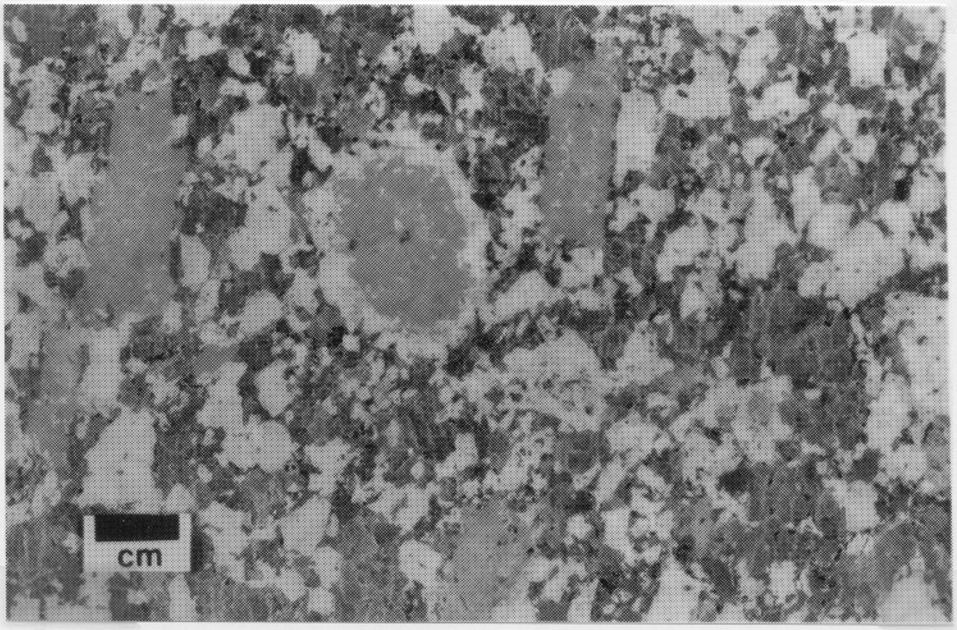

Plate 3.7 Rapakivi texture in the Harrietsfield muscovite-biotite monzogranite with plagioclase (albite?) rim surrounding a ragged-textured alkali feldspar megacryst. The corroded grain boundary indicates that the alkali feldspar was replaced by secondary plagioclase.

Muscovite-biotite monzogranite units comprise approximately 8.9% of the batholith and are restricted to, or form the dominant rock type in, Stage II plutons. Muscovite-biotite monzogranite units occur both in the core regions of reversely zoned parts of the Halifax (MacDonald and Horne, 1988) and New Ross (Ham and Horne, 1987) plutons, and the margins of the normally zoned Morse Road pluton (MacDonald and Ham, 1994b) and normally zoned portions of the New Ross and Davis Lake (Ham and MacDonald, 1994) plutons. The best "type section" for the moderately megacrystic textural variety is along the Old Sambro Road near Harrietsfield, south of Halifax (MacDonald and Horne, 1987). The "type section" for the very megacrystic textural variety is along a series of secondary roads near Squirreltown, east of Highway #10 on map sheets 21A/14 (MacDonald and Ham, 1994b) and 21A/15 (MacDonald and Ham, 1992). The "type section for the equigranular textural type is along the West Dalhousie Road in the north-central portion of 21A/11 (Corey and Horne, 1994b). Contacts with metasedimentary country rocks, where observed (e.g. Whale Lake monzogranite; Horne, 1993), are sharp and intrusive. Contacts between muscovite-biotite monzogranite units and other granitic rock types in the batholith are mostly intrusive, with the exception of the contact with the Harrietsfield monzogranite in the

Halifax Pluton (MacDonald and Horne, 1987) which, in part, is in gradational contact with the adjoining coarse-grained leucomonzogranite unit. Muscovite-biotite monzogranite units have common xenoliths, the highest percentages being in the rocks with the highest modal amounts of biotite.

3.1.4 Coarse-Grained Leucomonzogranite

Coarse-grained leucomonzogranite units show a wide variation in colour with buff, pink and whitish-grey colours predominating. Localized areas with moderate to intense hematization have reddish colouration. Most units are medium- to coarse-grained with megacrystic texture (Plate 3.1c) although fine- to coarse-grained, slightly megacrystic to seriate textures are commonly developed in parts of most units. The Spectacle Lake leucomonzogranite unit, which is exposed in the central portions of map sheet 21A/09 (Corey, 1990), is characterized by a very megacrystic texture (>35%) with uniformly large (i.e. >5 cm) alkali feldspar megacrysts. The Spectacle Lake unit is also denoted by a pattern in Figure 2.3. A body of predominantly equigranular textural variety coarse-grained leucomonzogranite is exposed in the northwestern part of the New Ross Pluton (Ham, 1990) and is denoted by a pattern in Figure 2.3. Rapakivi textures, with albite rims on alkali feldspar, are a common feature. Coarse-grained leucomonzogranite typically contains 2-7% biotite (with accessory apatite, zircon, monazite, xenotime, ilmenite), 4-8% muscovite, trace-5% cordierite and trace amounts of andalusite. Coarse-grained leucomonzogranite is distinguished from other coarse-grained monzogranite and granodiorite rocks on the basis of the low modal biotite and abundant muscovite, commonly as large grains ($\leq$ 1 cm) that are easily recognizable in hand specimen.

Coarse-grained leucomonzogranite units comprise approximately 21.8% of the batholith and are restricted to, and are the dominant rock type in, most Stage II plutons, with the exception of the West Dalhousie and Kejimkujik plutons. The best "type section" for this rock type is along Highway #12 from New Ross, south to Seffernsville on map sheet 21A/09 (Corey, 1990). The "type section" for the very megacrystic textural variety is along a series of secondary roads near Spectacle Lake, between Highways #12 and #14, in the west-central part of map sheet 21A/09 (Corey, 1990). Contacts with metasedimentary country rocks, where observed (e.g. near Upper New Cornwall and Falkland ridge; Horne, 1993), are sharp and intrusive. Contacts between coarse-grained leucomonzogranite units and other granitic rock types in the batholith are mostly intrusive, with the exception of the contact with the Harrietsfield muscovite-biotite monzogranite and the Sandy Lake biotite monzogranite in the Halifax Pluton (MacDonald and Horne, 1987) and several Panuke Lake fine-grained leucomonzogranite bodies in the New Ross pluton (Corey, 1990) which are gradational. Coarse-grained leucomonzogranite units contain few xenoliths, even where units are in direct contact with metasedimentary country rocks. In general, xenoliths in these units have microgranitoid textures, commonly with feldspar porphyroblasts (megacrysts?; Plate 3.8), and do not resemble metasedimentary rocks of the Meguma Group.

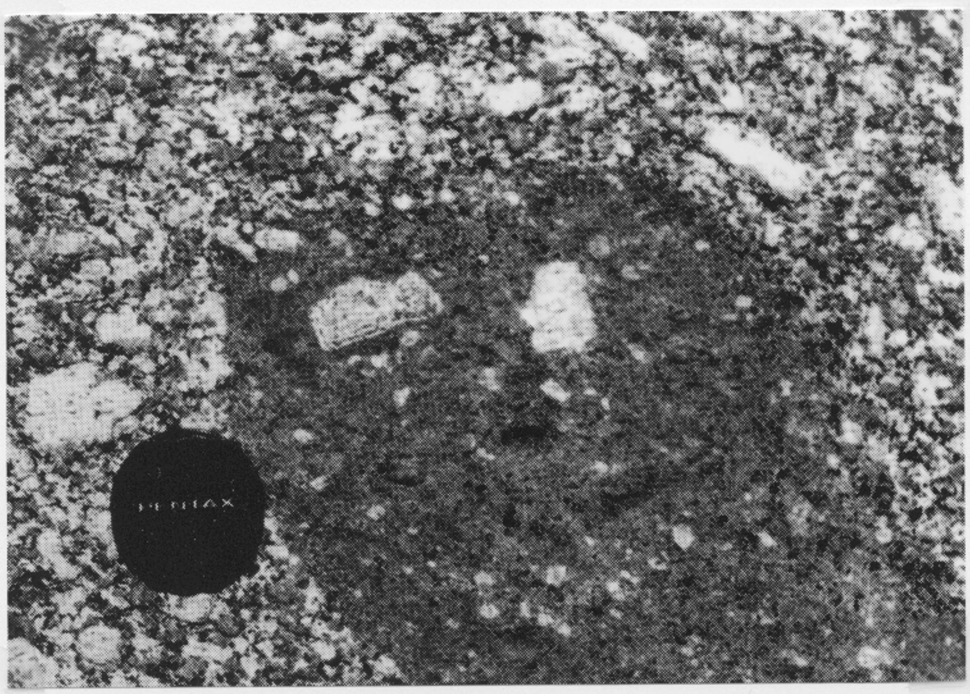

Plate 3.8 Microgranitoid xenolith with alkali feldspar porphyroblasts (megacrysts?) in an outcrop of Halifax Peninsula coarse-grained leucomonzogranite (MacDonald and Horne, 1987).

3.1.5 Fine-Grained Leucomonzogranite

Fine-grained leucomonzogranite units are mostly buff, orange, pink and whitish-grey in colour, which generally reflect the variable degrees of hematization, albitization and K-feldspathization. Localized areas with moderate to intense hematization have intense reddish colouration. Most units are fine- to medium-grained with equigranular (Plate 3.1e) or porphyritic (Plate 3.1f,g) texture. Other common textures include: fine-grained equigranular (Plate 3.1d) or aplitic (i.e. saccharoidal); fine- to medium seriate; and coarse-grained pegmatitic (Plate 3.1h).

Many individual bodies, that range in size from 1-10 km^2, have very uniform equigranular or porphyritic textures and are denoted with separate patterns in Figure 2.3 (in pocket in back). Other fine-grained leucomonzogranite bodies typically have a wide range of textures, many of which may be present within a single outcrop, such as in the Tantallon leucomonzogranite of the Halifax Pluton (MacDonald and Horne, 1987). These bodies are unpatterned in Figure 2.3. Coarse-grained leucomonzogranite typically contains 2-7% biotite (with accessory apatite, zircon, monazite, xenotime, ilmenite), 3-13% muscovite and trace amounts of cordierite and andalusite. Fine-grained leucomonzogranite is distinguished from most other rock types by its finer grain size, and from leucogranite by its high biotite content.

Fine-grained leucomonzogranite units comprise approximately 6.8% of the batholith. The majority of the fine-grained leucomonzogranite units occur in Stage II plutons, particularly the larger bodies (i.e. $>$2-3 km^2), although small ($<$1 km^2) bodies occur in all Stage I plutons. The "type section" for the variable-textured fine-grained leucomonzogranite is along Highways #3 and #103 near Fourteen Mile House and to the west near Upper Tantallon on map sheet 11D/12 (MacDonald and Horne, 1987). The "type section" for equigranular-textured fine-grained leucomonzogranite is along Highway #103, 2-4 km east of the intersection with Highway #14, at the margin if the New Ross pluton on map sheet 21A/09 (Corey, 1990). The "type section" for porphyritic-textured fine-grained leucomonzogranite is along Highway #14, approximately 2 and 4 km south of Upper Vaughan (Ham, 1990). Contacts with metasedimentary country rocks, where observed, are sharp and intrusive (e.g. near Ferguson's Cove, MacDonald and Horne, 1987 Plate 3.9; on Caribou Lake, Horne, 1993; at Inglisville, MacDonald and Ham, 1994b). Contacts between fine-grained leucomonzogranite units and other granitic rock types in the batholith are mostly intrusive (Plate 3.10), with the exception of the contact with several Panuke Lake fine-grained leucomonzogranite bodies in the New Ross pluton which are gradational. Corey (1990) interpreted these bodies as chilled(?) textural equivalents of the adjoining coarse-grained leucomonzogranite. Fine-grained leucomonzogranite units contain few xenoliths, even where units are in direct contact with metasedimentary country rocks.

3.1.6 Muscovite Leucogranite

Leucomonzogranite units are mostly buff, orange, pink and whitish-grey in colour, which

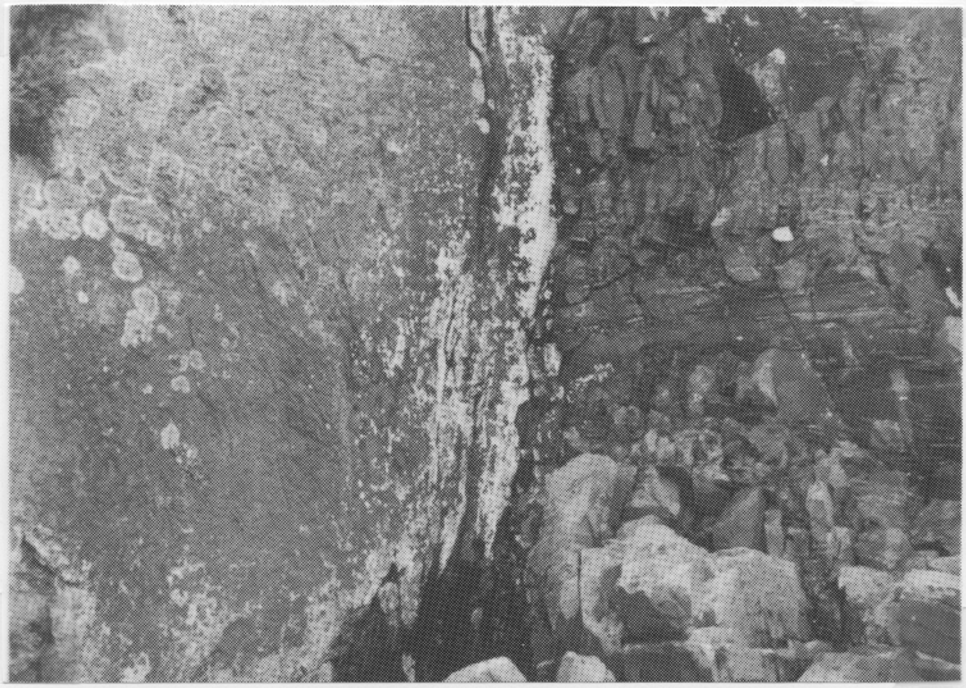

Plate 3.9 Steeply-dipping intrusive contact between the Tantallon fine-grained leucomonzogranite and finely bedded slates of the Halifax Formation near Ferguson's Cove (MacDonald and Horne, 1987). Note the lack of deformation of country rocks and the absence of xenoliths in the leucomonzogranite. Width of photo is approximately 3 metres.

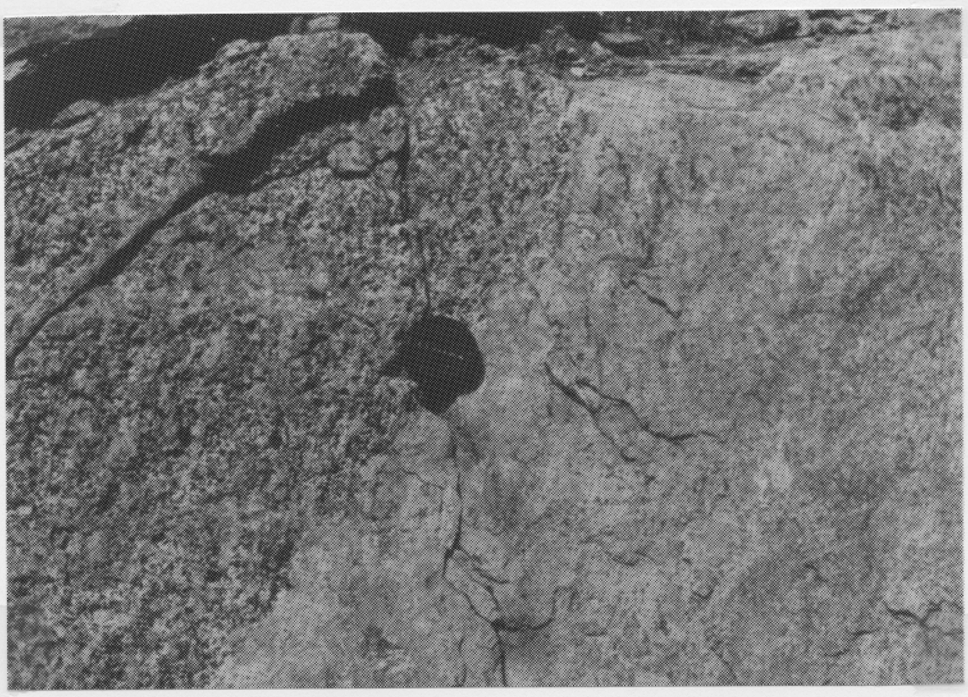

Plate 3.10 Sharp intrusive contact between the Tantallon fine-grained leucomonzogranite and the Sandy Lake biotite monzogranite, Halifax Pluton (MacDonald and Horne, 1987). Field relations elsewhere in the pluton indicate that the Tantallon unit intruded the Sandy Lake unit. Note the lack of a chilled margin in the leucomonzogranite.

generally reflect the variable degrees of hematization, albitization and K-feldspathization. Localized areas with moderate to intense hematization have intense reddish colouration. Most units are fine- to medium-grained with equigranular or porphyritic texture. Other common textures include: fine-grained aplitic (i.e. saccharoidal); fine- to medium-grained seriate; and coarse-grained pegmatitic. Several leucogranite bodies have somewhat uniform textures being mostly equigranular and/or porphyritic. In contrast, the Murphy Lake leucogranite which is exposed in three bodies in the east-central part of map sheet 21A/15, characteristically shows a wide range of textures, many of which may be present within a single outcrop (Plate 3.11; MacDonald and Ham, 1992). Leucogranite units typically contains 0-2% biotite, 3-28% muscovite, 0-8% topaz, 0-2% andalusite and trace amounts of cordierite. Leucogranite is distinguished from most other rock types by its finer grain size, and from leucomonzogranite by its low biotite content.

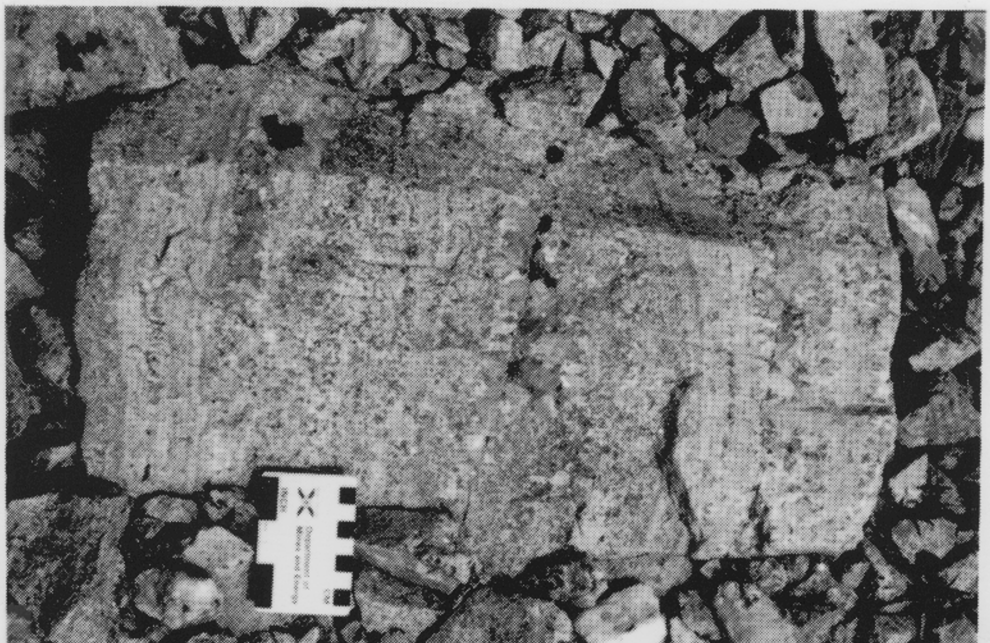

Plate 3.11 Typical boulder of Murphy Lake Leucogranite (MacDonald and Ham, 1992) showing characteristic textural heterogeneity with alternating aplitic and pegmatitic layers.

Leucogranite units comprise approximately 0.7% of the batholith and are restricted to Stage II plutons with the exception of one of the Murphy Lake Leucogranite bodies (MacDonald and Ham, 1992) and the Walsh Brook Leucogranite (Corey, 1987) which are hosted by biotite granodiorite of Stage I plutons. The "type section" for leucogranite is along a series of secondary roads between Lake Lewis and South Canoe Lake and along the adjoining New Ross-Vaughan Road on map sheet 21A/16 (West; Ham, 1990). The "type section" for texturally-variable leucogranite is along a series of secondary roads southeast of Aylesford Lake in the east-central part of map sheet 21A/15 (MacDonald and Ham, 1992). Contacts with metasedimentary country rocks, where observed, are sharp and intrusive (e.g. in the Open Pit Mine at East Kemptville; Ham and MacDonald, 1994). Contacts between leucogranite units and other granitic rock types in the batholith are entirely sharp and intrusive. Leucogranite units are devoid of xenoliths, even where units are in direct contact with metasedimentary country rocks.

3.2 Plutons

The 49 map units in the batholith have been grouped into 13 plutons using the criteria outlined in Chapter 2 (Fig. 3.1). These plutons have been grouped into two stages on the basis of field relations and compositions. Stage I plutons are mainly comprised by biotite granodiorite and biotite monzogranite with minor amounts of fine-grained leucomonzogranite. In contrast, Stage II plutons are primarily made up of muscovite-biotite monzogranite, coarse- and fine-grained leucomonzogranite with minor amounts of muscovite leucogranite and/or biotite granodiorite and biotite monzogranite. Exposed contacts between Stage I and II plutons are rare, however, when observed these contacts were ubiquitously sharp and intrusive with the early Stage I plutons invariably intruded by later Stage II plutons. This general observation is consistent with the observations of McKenzie and Clarke (1975) and Smith (1979). The salient geological features of Stage I and II plutons are given in Table 3.2 and summarized in the following section.

Stage I plutons range in size from 230 to 2460 km^2 whereas Stage II plutons are generally smaller, on average, and range in size from 30 to 1060 km^2. The proportions of rock types in Stage I plutons include: 0-≈100% biotite granodiorite; 0-≈100% biotite monzogranite; and trace-1% fine-grained leucomonzogranite. The proportions of rock types in Stage II plutons include: 0-≈100% muscovite-biotite monzogranite; 0-93% coarse-grained leucomonzogranite; 0-28% fine-grained leucomonzogranite; 0-10% leucogranite. Four out of five Stage I plutons exhibit normal and/or reverse compositional zoning that is manifest by changes in modal mineralogy and major, trace and isotopic geochemistry (see discussions below). The Cloud Lake Stage I pluton does not show obvious evidence of zoning. In contrast, only three of the eight Stage II plutons display normal and/or reverse zoning.

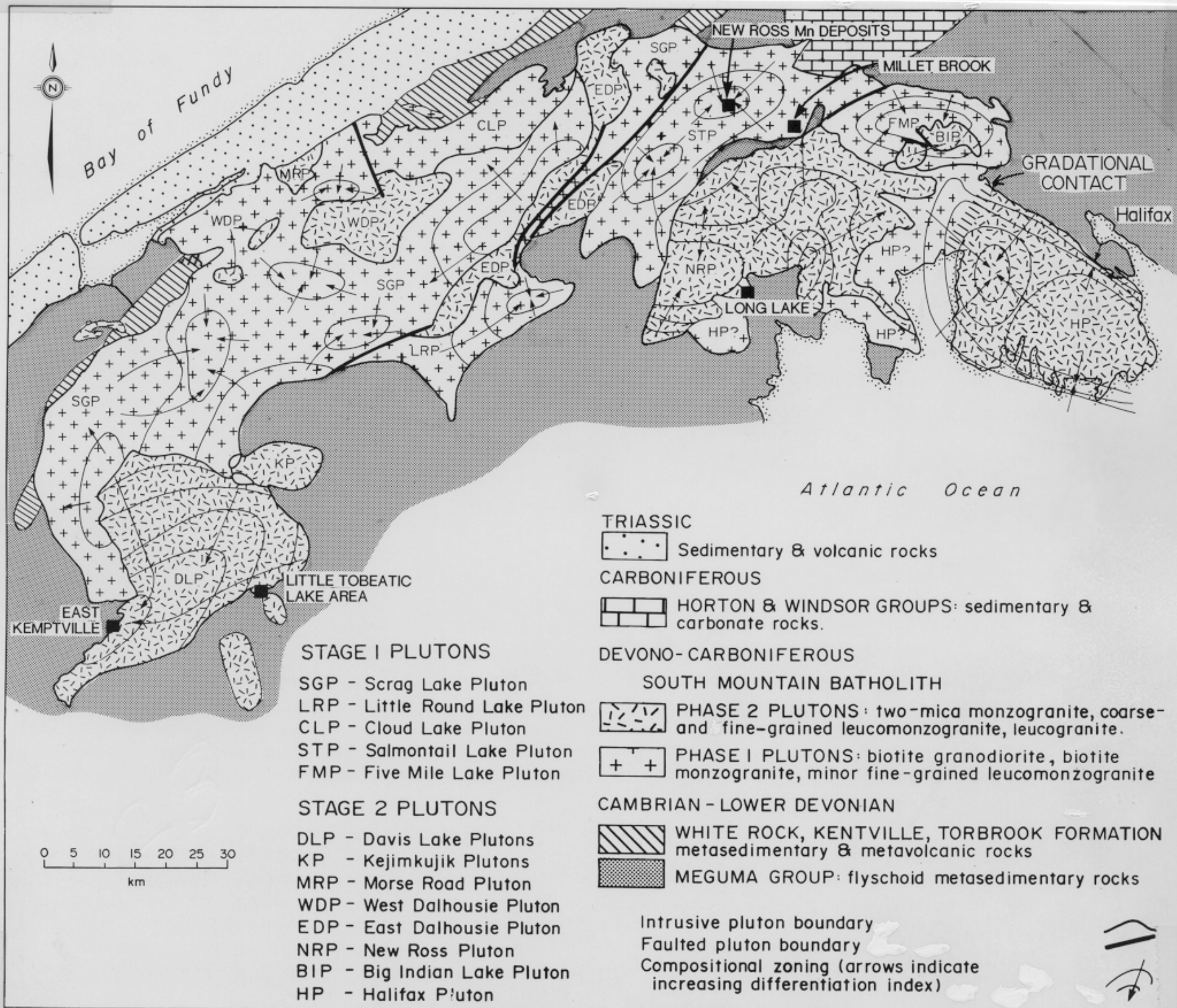

Figure 3.1 Geological map of the South Mountain Batholith showing the location of the five Stage I and eight Stage II plutons. Heavy lines at pluton boundaries indicate faulted contacts whereas thinner lines indicate predominantly intrusive contacts (may be gradational in part). Thin lines within the individual plutons indicate compositional isopleths that were determined from point counting stained rock slabs and/or geochemical data. Arrows indicate increasing differentiation index. Areas of both normal and reverse compositional zoning (differentiation index increases and decreases, respectively, toward the core of the pluton) are evident in some Stage I and II plutons. In fact, several plutons such as the Halifax and New Ross plutons, have both normal and reverse compositional zoning.

Stage I plutons have elliptical shapes with the long axes oriented to the northeast. In contrast, most Stage II plutons are roughly circular or irregular in shape. Both the East Dalhousie and the southwestern part of the Davis Lake Stage II plutons are narrow and somewhat "dyke-like" in shape. All Stage I and five of the eight Stage II plutons are partially bounded by faults.

Table 3.2 Summary of selected features of Stage I and Stage II plutons.

PLUTON NAME	AREA (KM^2)	ROCK TYPES (% of Pluton)	ZONING	SHAPE	ORIEN-TATION	FAULT BOUNDED	PRIMARY FEATURES	COMMENTS
EARLY Stage 1 Plutons - dominantly biotite granodiorite and biotite monzogranite with minor fine-grained leucomonzongranite								
WEST Scrag Lake	2460	BMG(79); BGD(21)	N & R	elongate	NE	partially	well developed N & NE megacryst alignment	several compositional "centres"
Little Round Lake	230	BMG(≈100)	R	elongate	NE	partially	well developed NE megacryst alignment	
Cloud Lake	250	BMG(95); BGD(5)	None	elongate	NE	partially	pervasive NE & E megacryst alignment	locally developed, E-trending biotite foliation
Salmontail Lake	650	BMG(91); BGD(8); FGLMG(1)	N	elongate	NE	partially	weakly developed NE megacryst alignment	two compositional "centres"
Five Mile Lake EAST	270	BGD(≈100)	R	elliptical	E	partially	moderate megacryst alignment - erratic orient.	
LATE Stage 2 Plutons - dominantly muscovite-biotite monzogranite and leucomonzogranite with minor ultra-leucogranite								
WEST Davis Lake	820	CGLMG(93); FGLMG(3); BGD(1); BMG(1); MBMG(1); LG(<1)	N	circular & elongate*	*NE	*partially	well developed N & NE megacryst alignment	*elongate portion partially bounded by intense shearing
Kejimkujik	80	MBMG(≈100)	None	roughly circular	N/A	No	no consistent alignment	
Morse Road	30	CGLMG(85);MBMG(15)	None	roughly circular	N/A	No	no consistent alignment	bands of MBMG along E + W margins suggests normal zoning
West Dalhousie	220	MBMG(≈100)	None	roughly circular	N/A	partially	well developed megacryst alignment - erratic orientation	unique megacryst-rich texture with "bladed" biotite
East Dalhousie	310	CGLMG(52);FGLMG(34); LG(10); MBMG(4)	None	narrow dyke-like	NE	predominantly	locally-developed megacryst alignment - erratic orientation	emplaced along major structure
Big Indian Lake	40	CGLMG(81); FGLMG(17); BMG(2)	None	circular/irregular	N/A	partially	no consistent alignment	ubiquitous metasomatic garnet
New Ross	870	CGLMG(59); FGLMG(28); MBMG(12); LG(2)	N & R	roughly circular	N/A	partially	megacryst alignment defines weakly-developed circular patterns	overall reverse zonation
Halifax EAST	1060	CGLMG(38); MBMG(33); BMG(13); FGLMG(12); BGD(4)	N & R	roughly circular	N/A	no	megacryst alignment defines weakly-developed circular patterns	gradational contact with BMG to west (separate Phase 1 pluton?)

EXPLANATION:
ROCK TYPES - BGD - biotite granodiorite; BMG - biotite monzogranite; MBMG - muscovite-biotite monzogranite; CGLMG - coarse-grained leucomonzogranite; FGLMG - fine-grained leucomonzogranite; ULG - ultra-leucogranite.
ZONING - N - normal; R - reverse
ORIENTATION - refers to direction of long axis of pluton (if applicable); N/A - not applicable

Prominent northeast-trending primary flow features (schlieren, parallel alignment of megacrysts/xenoliths) are common in Stage I plutons whereas they are variably developed (non-existent to strong) with erratic or concentric orientations in Stage II plutons.

Detailed descriptions of the geology of the Scrag Lake and Halifax Plutons which are representative of the Stage I and II plutons respectively. For more complete description of the rocks of the other plutons the reader is referred to the fourteen geological maps with marginal notes that are outlined in Figure 2.1.

3.2.1 Scrag Lake Stage I Pluton

The Scrag Lake Pluton (Fig. 3.1) is the largest Stage I pluton in the batholith (2460 km^2). It forms much of the western end of the batholith and is located on NTS map sheets 21A/04, /05, /06, /10, /11, /12, /14 and /15. It is elliptical in shape with the long pluton axis oriented to the northeast. Field relations are described by several workers (see Table 2.1 for references).

The Scrag Lake Pluton is primarily made up of megacrystic **biotite monzogranite** (79%)

which is distributed throughout the pluton. Contacts with the metasedimentary and metavolcanic country rocks are ubiquitously sharp and intrusive. Modal amounts of biotite range from 10-17% whereas muscovite and cordierite are only present in trace-1%. Most rocks plot in the monzogranite field of Streckeisen (1976), however, some samples plot in the granodiorite field but are not abundant enough to justify separate designation and have been grouped with monzogranitic rocks. The next most abundant rock type in the Scrag Lake Pluton is megacrystic **biotite granodiorite** which comprises approximately 21% of the pluton. Granodiorite occurs mainly along the western margin and the eastern end of the pluton, and between the East Dalhousie and West Dalhousie plutons. Contacts with biotite monzogranite are ubiquitously gradational, in fact, it was not possible to establish contacts in field because of a lack of changes in texture or grain size. Contacts were consequently defined on the basis of proportions of quartz-alkali feldspar-plagioclase, as determined by point counting of rock slabs. Modal amounts of biotite range from 15->25% whereas muscovite and cordierite are only present in trace amounts. Most rocks plot in the granodiorite field of Streckeisen (1976), however, some samples plot in the monzogranite field but were grouped with granodiorite.

Numerous small bodies (<1-2 km^2) of fine-grained leucomonzogranite which constitute <0.1% of the pluton occur throughout the granodiorite and monzogranite units. Contacts are, where observed, sharp and intrusive. Leucomonzogranite rocks vary somewhat in composition but generally are within the description outlined above.

Contacts between the Scrag Lake and other Stage I plutons are both faulted, as for the Little Round Lake, Salmontail Lake and parts of the Cloud Lake Plutons, and intrusive as for part of the Cloud Lake pluton. There was no indication of chilling, for example reduction in grain size, in either the Scrag Lake or Cloud Lake plutons near the intrusive contact. However, schlieren banding in the Cloud Lake pluton near the contact may indicate that it was emplaced and crystallized after the Scrag Lake Pluton. The contacts between Stage I and II plutons, including Davis Lake, Kejimkujik, West Dalhousie, Morse Road and East Dalhousie plutons, were always noted or inferred to be sharp and intrusive. No evidence of chilling, such as reduction of grain size, was noted at any of the intrusive contacts. However, the presence of inclusions of granodiorite and monzogranite in the East Dalhousie Pluton indicates that it post-dates the Scrag

Lake Pluton. Most other Stage II plutons truncate compositional patterns in the Scrag Lake pluton indicating that they were also emplaced subsequent to crystallization of the Scrag Lake Pluton.

The Scrag Lake Pluton displays both normal and reverse compositional zoning (Fig. 3.1) which is readily discernable using modal proportions of biotite and, to a lesser extent, the proportion of quartz-alkali feldspar-plagioclase. Using modal information, Horne et al. (1991) and MacDonald et al. (1992) concluded that there were at least four normally zoned "centres" and one reversely zoned "centre" in the pluton. Normally zoned "centres" are tentatively interpreted as representing in situ fractionation. In general, most of the pluton is normally zoned, with the most highly fractionated rocks in the core regions of the pluton. The origin of the reversely zoned "centre" is not clear at present.

Primary flow features, including parallel alignment of alkali feldspar megacrysts and xenoliths and schlieren banding, are mainly oriented northeast in the central and eastern parts of the pluton and north to north-northeast oriented to the southwest. Interestingly these orientations mirror the structural trends in the country rocks, which will be discussed further in Chapter 4.

3.2.2 Halifax Stage II Pluton

The Halifax Pluton (Fig. 3.1) forms the easternmost part of the batholith and is located on NTS map sheets 11D/05 and 11D/12. It is sub-circular in shape and is the largest Stage II pluton (1060 km^2) in the batholith. MacDonald and Horne (1987) described the field relations for pluton and MacDonald and Horne (1988) reported the results of a detailed petrographic and geochemical study of the Halifax Pluton.

The Halifax Pluton comprises a zoned sequence of megacrystic map units that were intruded by a sequence of fine-grained leucomonzogranite. The zoned sequence consists of: 1) a narrow band (<1-3 km wide) of slightly megacrystic **biotite granodiorite** that extends along the northeastern margin of the pluton and is in sharp intrusive contact with the metasedimentary rocks of the Meguma Group. This unit, which constitutes 4% of the pluton, has 12->15% biotite and trace amounts of muscovite and cordierite; 2) megacrystic **biotite monzogranite** that forms narrow bands (1-3 km wide) along the southern margin of the pluton and adjacent to the granodiorite to the north. Contacts between this unit and the biotite granodiorite are invariably gradational. Biotite monzogranite, which makes up approximately 13% of the pluton, contains 10-

12% biotite and trace-1% muscovite and cordierite; 3) megacrystic **coarse-grained leucomonzogranite** which is the dominant rock type in the pluton (38%) forms a large body in the western part of the pluton and narrow (1-3 km wide) bands along the southern and northern margins of the pluton. Contacts with biotite monzogranite and biotite granodiorite were noted to be both gradational and intrusive. This unit contains 2-6% biotite, 2-5% muscovite. Cordierite or pinite/chlorite/muscovite pseudomorphs, makes up 0-5% of the mode and is most abundant in the narrow bands along the pluton margins and increases toward the adjacent muscovite-biotite monzogranite; 4) megacrystic **muscovite-biotite monzogranite** which is the dominant rock type in the eastern part of the pluton and constitutes 33% of the pluton. Contacts with the adjacent leucomonzogranite are both gradational and intrusive. This unit is in both gradational and intrusive contact with the adjacent coarse-grained leucomonzogranite. This unit has 8-10% biotite 1-2% muscovite. Cordierite constitutes 0-5% of the mode and is most abundant along the southern and northern unit margins. No evidence of chilling, such as reduction of grain size, was noted at any of the intrusive contacts. On the basis of the modal mineralogy the outer part of the sequence (granodiorite to leucomonzogranite) is normally zoned whereas the inner part (leucomonzogranite-muscovite-biotite monzogranite) is reversely zoned.

A second sequence of fine-grained leucomonzogranite which constitutes approximately 12% of the pluton occurs as a body in the northwestern part of the map sheet (approx. 4 x 20 km) and numerous small ($<$1-5 km^2) throughout the pluton. Most rocks are fine- to medium-grained with equigranular or porphyritic textures although some pegmatitic and aplitic textures were also noted. Contacts with the zoned sequence of megacrystic units are ubiquitously sharp and intrusive. Modal mineralogy consists of 2-5% biotite, 2-5% muscovite (locally up to 10%) and trace-2% cordierite. This sequence of rocks cross-cuts the zoned sequence although in general fine-grained leucomonzogranite is most abundant in the most "evolved" part of the coarse-grained leucomonzogranite and may have a genetic relationship.

Primary flow features in the Halifax Pluton define a crude circular pattern that mirrors the margin of the pluton and are in sharp contrast to the northeast orientations for the primary flow features in the Scrag Lake Pluton. The significance of this will be discussed in Chapter 4.

MacDonald and Horne (1988) present a detailed discussion of the possible mechanisms for formation of the compositional zonation in the Halifax Pluton based upon field, mineralogical and geochemical information. They concluded that the zoned sequence of the pluton formed by a combination of sidewall fractional crystallization and vertical stratification caused primarily from a less-dense rising "boundary layer" during fractionation within a single magma chamber (Figure 3.2; see MacDonald and Horne (1987) for more detail). The later-staged fine-grained leucomonzogranites were presumably generated, at least in part, by fractionation of the zoned sequence.

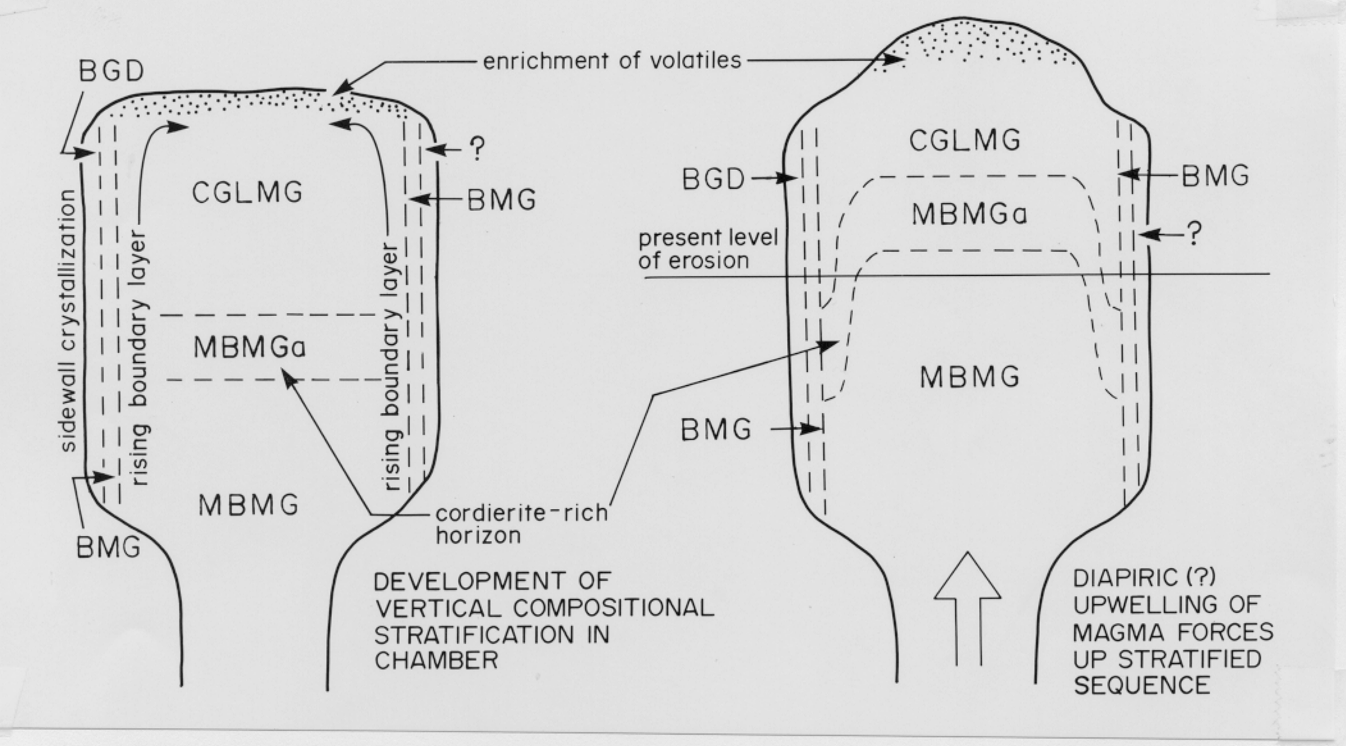

Figure 3.2 A model for the formation of the zonation in the Halifax Pluton (after MacDonald and Horne, 1988). Crystallization commences along the cool metasedimentary walls (sidewall crystallization) followed by the development of a fractionated 'boundary layer' because of slow diffusion rates in the melt. This layer is less dense than adjacent melt and rises to apical portions of the magma chamber causing vertical stratification of the central magma. Cordierite primarily crystallizes in a discrete compositional layer in the sequence. Subsequent influx of magma into lower portions of the chamber 'warps' the stratified sequence which, after erosion to present level, yields the observed outcrop pattern (Fig. 2.3 in pocket at back). Rock units include: BGD - biotite granodiorite; BMG - biotite monzogranite; MBMG - muscovite-biotite monzogranite; MBMGa - cordierite-rich muscovite-biotite monzogranite; CGLMG - coarse-grained leucomonzogranite.

Delineation of the western margin of the Halifax Pluton is somewhat problematic. MacDonald and Horne (1988) focused on the portion of the pluton that occurs north and west from the head of St. Margaret's Bay (Fig. 2.3). However a large area of biotite monzogranite extends from their study area westward to the boundary of the New Ross pluton and northwest to the margin of the Five Island Pluton. There is no clear boundary between this biotite monzogranite and the Sandy Lake unit and subsequently these units have been grouped together. It is possible that the western biotite monzogranite is a separate Stage I pluton. Conversely if this unit is part of the Halifax Pluton, then bodies of Sandy Lake monzogranite in the New Ross Pluton indicates that the Halifax Pluton predated the New Ross Pluton.

3.3 Mafic Porphyry

Mafic porphyry is a volumetrically small (approx 0.07%) rock type in the batholith. However, some mafic porphyry bodies are among the most "primitive" in composition in the batholith, have several features that are unlike the above major rock types and thus merit investigation. Individual bodies display a wide range of textures and modal mineralogy which are summarized in Table 3.3. Mafic porphyry are mainly medium- to dark grey to brownish-grey in colour. Rocks are primarily fine- to coarse-grained and have porphyritic texture with phenocrysts of quartz, plagioclase and alkali feldspar. Mafic porphyry bodies mainly range from granodiorite to monzogranite in composition although some bodies plot in the tonalite compositional field of Streckeisen (1976). As a group, mafic porphyry rocks contain a wide range of biotite (10-32%). However it should be stressed that individual bodies may have either narrow modal ranges, such as at Cloud Lake (15-20%) or wide ranges, as noted in the Boot Lake body (19-32%; Table 3.4) which are both exposed on map sheet 21A/15 (MacDonald and Ham, 1992). Biotite characteristically contains poikilitic inclusions of apatite, zircon, monazite and ilmenite. Several mafic porphyry bodies contain trace-2% reddish coloured (almandine?) garnet. Muscovite is only present in trace amounts. The Boot Lake mafic porphyry contains trace-2% andalusite.

Mafic porphyry bodies were noted in both Stage I and II plutons. Several bodies are restricted to marginal regions of biotite granodiorite and biotite monzogranite of Stage I plutons, such as near Saturday Lake on map sheet 21A/10 (Horne, 1993) and in the Boot Lake unit on map sheet 21A/15 (MacDonald and Ham, 1992). These units have sharp intrusive contacts with the country rocks and both gradational and intrusive contacts with the adjoining granitoid rocks. Other mafic porphyry units are situated away from country rock contacts, such as at Lequille on map sheet 21A/11 (Corey and Horne, 1994b). Contacts with the adjacent granitoid units are sharp and intrusive. It is difficult to give a "type section" for a rock type that has such variation, however,

Table 3.3. Description of mafic porphyries from the South Mountain Batholith.

Map Sheet	Name/Location	Rock Type	Biotite	Garnet	Comments
11D/05	Sambro	BMG/BGD	>15%	-	"Sinuous" contact with CGLMG - magma mixing (?)
21A/10	Saturday Lake	BGD	15-20%	-	Marginal (chilled?) phase of BMG; Mo-bearing quartz veins
21A/11	Leguille	BGD	>20%	trace - 1%	Intrusive contact with BGD
21A/15	Boot Lake	BGD/BTN	19-32%	trace - 2%	Marginal phase of BGD; partial melting of metasediments(?); "wispy" bands in country rocks
21A/15	Cloud Lake	BGD	15-20%	-	Isolated bodies in BMG
21A/15	Burnt Dam Flowage	BGD	15-20%	trace	Marginal phase of BMG at country rock contact
21A/16	Big St. Margaret's Bay Lake	BMG	10-18%	-	"Sinuous" contact with FGLMG - magma mixing(?)
21A/16	Powerline	BMG	12-20%	-	Isolated plugs in BGD

Explanation:

Rock Type: BMG - biotite monzogranite; BGD - biotite granodiorite; BTN - biotite tonalite; CGLMG - coarse-grained leucomonzogranite; FGLMG - fine-grained leucomonzogranite

the excellent exposures at the Lequille intersection of the #103 highway has most of the features found in most bodies. This body is granodiorite in composition, has very high biotite content (>20%) and contains up to 1% garnet crystals. In addition, a sharp intrusive contact with the adjacent Lequille granodiorite unit is exposed in the road cut. Mafic porphyry rocks have the highest proportion of xenoliths of any rocks in the batholith, with the exception of limited areas of granodiorite, chiefly near country rock contacts. The majority of xenoliths are similar, at least macroscopically, to metasedimentary rocks of the Meguma Group.

In addition to the mappable bodies denoted on Figure 2.3 (in pocket at back), numerous "xenoliths" of mafic porphyry were noted throughout the batholith. These are most common in granodiorite but were also noted in biotite and biotite-muscovite monzogranite units. The "xenoliths" also contain metasedimentary xenoliths, despite the fact that they were commonly observed in central regions of the batholith, such as shown in Plate 3.2. The author favours an explanation whereby the mafic porphyry xenolith represents a marginal phase of the Halifax Pluton, perhaps from apical portions of the Sandy Lake unit, that: 1) incorporated abundant metasedimentary xenoliths; 2) crystallized at the pluton margin, thus trapping the metasedimentary xenoliths; 3) was "spalled off" of the marginal zone and "sank" because of higher specific gravity (Miller and MacDonald, 1992); and 4) was trapped in its present location in the Sandy Lake monzogranite during crystallization.

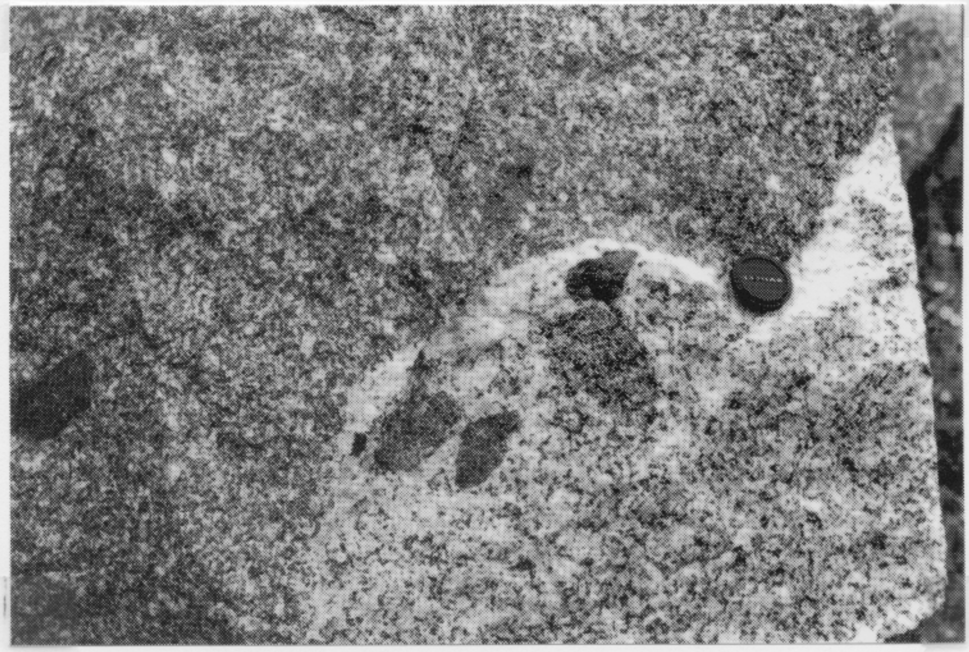

Plate 3.12 Mafic porphyry "xenolith" in an outcrop of Sandy Lake biotite monzogranite from near the margin the Halifax Pluton. Note that 'fresh' metasedimentary xenoliths from the Meguma Group country rocks occur in the mafic porphyry xenolith and are concentrated, along with alkali feldspar megacrysts, in the biotite monzogranite. This is interpreted as concentration of solid components at the bottom of the mafic porphyry xenolith as it sank in the biotite monzogranite melt. The mafic porphyry presumably formed as an early, mafic-rich, marginal phase to the Halifax Pluton that was subsequently incorporated as an autolith by the biotite monzogranite melt.

The contacts between mafic porphyry bodies at Sambro (MacDonald and Horne, 1987) and Big St. Margaret's Bay Lake (Ham and Horne, 1987; Dewolfe, 1994), and the adjoining coarse- and fine-grained leucomonzogranite units respectively, are sharp and intrusive. However, contacts are commonly sinuous or ragged and lack any chilled contacts (Plate 3.2). The morphology of these contacts are markedly different from the angular granite/granite contacts commonly noted throughout the batholith. Dewolfe (1994) noted lobate contacts which he interpreted to reflect mingling of mafic porphyry and leucomonzogranite melts in the Big St. Margaret's Bay Lake area. Similarly, the curving shape of contacts in the Sambro area would not be predicted if one of the units were completely crystalline and therefore these features are tentatively interpreted as representing mingling of two compositionally dissimilar granitoid melts.

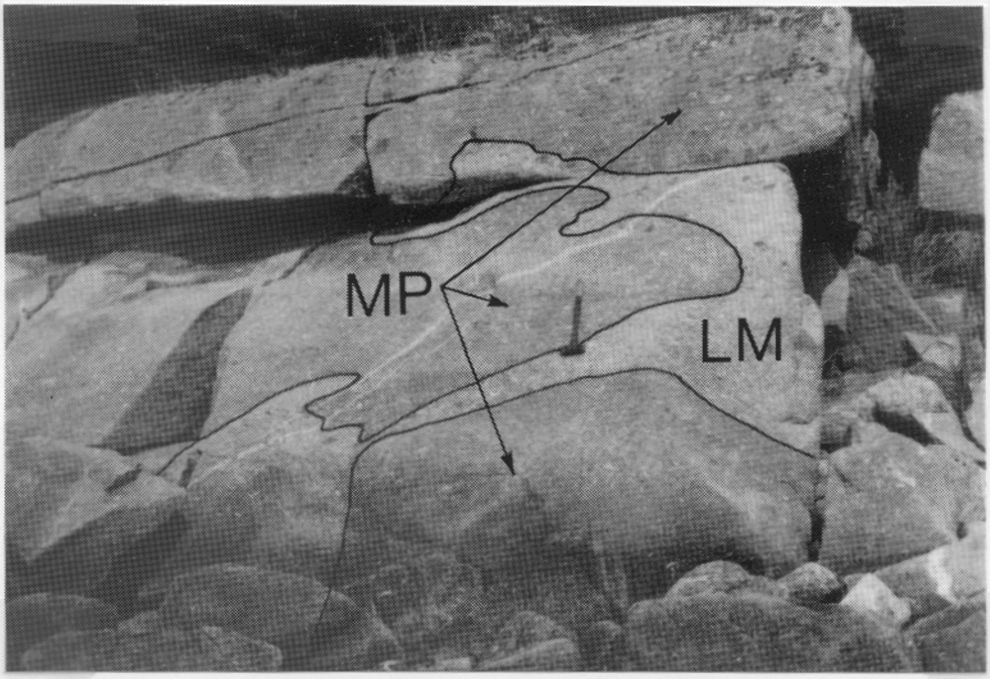

Plate 3.13 Geological contact between mafic porphyry and coarse grained leucomonzogranite at Sambro on map sheet 11D/05 (MacDonald and Horne, 1987). The sinuous morphology and lack of chilling in either unit is consistent with mixing of compositionally dissimilar granitoid melts.

The contacts between the Boot Lake mafic porphyry and the adjoining Halifax Formation slates are very irregular and "wispy" as shown in Plate 3.3. Based entirely on field evidence it is difficult to determine whether the development of mafic porphyry along this contact results from partial melting of metasediments or chilling of the host granodiorite unit with a high degree of country rock assimilation. This will be further discussed in Chapter 6, in light of geochemical information.

3.4 Dyke Rocks

Dyke rocks consist of, in decreasing order, aplite, pegmatite, composite aplite/pegmatite and minor amounts of granitoid units. Aplite dykes, by definition, are fine grained and have sugary (i.e. saccharoidal) texture whereas pegmatite dykes have very coarse grain size with some crystals to 20-30 cm, and commonly have graphic texture. The majority of the other dykes are fine grained with equigranular texture although minor medium- or coarse-grained phenocrysts (mostly quartz and feldspar) may occur. Composite dykes have both "aplite" and pegmatite arranged in alternating bands that are mostly parallel or subparallel to the dyke margins (Plate 3.14).

The late-staged dykes in the batholith have a wide compositional range which is manifest as highly variable mineralogy. The essential mineralogy of dyke rocks consists of quartz, alkali feldspar, albitic plagioclase, muscovite (3-25%) and biotite (trace-10%). Dyke rocks may also contain spessartine-rich garnet (up to 5%), tourmaline (mostly in pegmatite or pegmatite segregations in composite dykes), fluorite and andalusite (up to 5% in some equigranular leucogranite dykes). In addition, some pegmatite dykes reportedly contain columbite, tantalite, tapiolite, cassiterite, wolframite and beryl (Farley, 1979; O'Reilly et al., 1982).

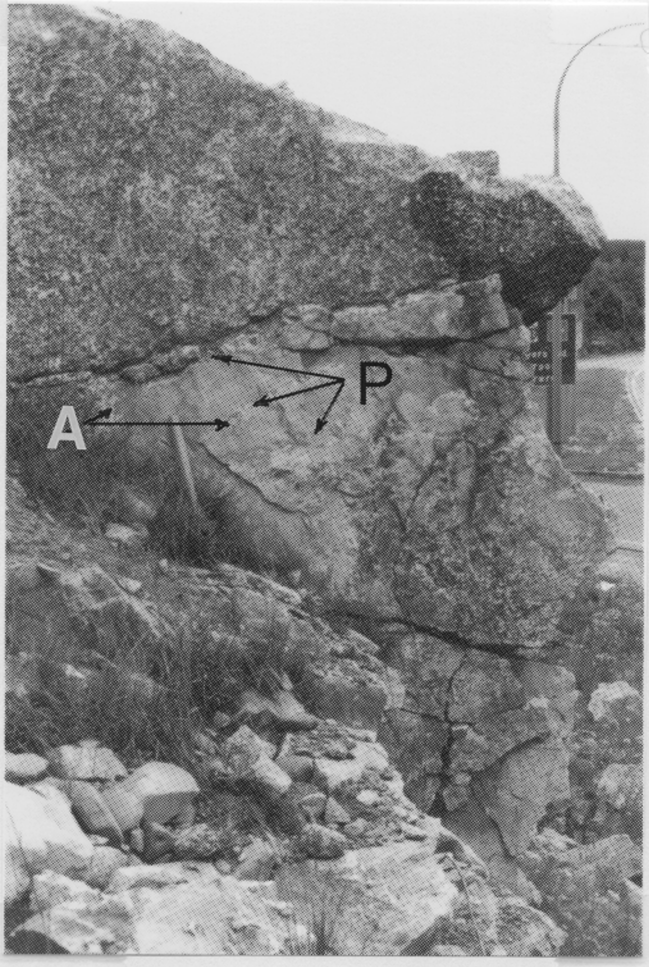

Plate 3.14 Composite aplite/pegmatite dyke in an outcrop of Sandy Lake biotite monzogranite along the northern margin of the Halifax Pluton. Note the alternating layers of aplite and pegmatite that are parallel to the margin of the dyke. Hammer handle is 40 cm long.

Dykes occur in all rock types, in both Stage I and II plutons, from the least evolved biotite granodiorite and mafic porphyry to the most evolved leucogranite. No attempt was made to quantify the exact proportion of dyke rocks in each rock type as part of the mapping project.

However, empirical evidence suggests that dykes are somewhat evenly distributed throughout the entire batholith. It should be stressed that local dyke concentrations were noted within some units, such as in parts of the New Ross Pluton on map sheet 21A/16 (Ham and Horne, 1987). Dyke rocks, by their nature, have sharp intrusive contacts and post-date the crystallization of the host rocks. In several locations throughout the batholith dyke rocks were observed to cross-cut metasedimentary and granitoid xenoliths (Plate 3.15) and primary flow features, such as schlieren bands and megacrysts-rich pods. Most dykes have linear contacts, however, many have curved contacts and sinuous orientations, particularly the flat-lying and shallow-dipping varieties. Dyke thicknesses range from a few centimetres to several metres. Most dykes can only be traced for several metres across individual outcrop, however, a few dykes could be traced for several hundred metres. In fact, there may be a complete continuum from large dykes to small plugs of fine grained leucomonzogranite. Information pertaining to dykes, that was collected during geological mapping, included: dyke rock type; grain size and texture; modal mineralogy; dyke thickness and orientation; and the presence of internal structure such as textural and mineralogical banding. This information is graphically displayed on each of the fourteen 1:50,000 scale geological maps.

Horne et al. (1988, 1992) compiled the orientation data for dykes as part of a structural study of the entire batholith. It should be noted that the vast majority of outcrop inspected during mapping were smooth "glacial pavement" along road sides or rounded (i.e. "roche-montane") and hence did not provide good 3-dimensional data. Therefore, the orientation data used in the studies of Horne et al. (1988; 1992) may be skewed toward steeply-dipping dykes that intersected the outcrop surface. Horne et al. (1988; 1992) noted that the dykes, unlike the quartz veins and fractures/joints, did not show "clustered" orientations. Rather the dykes had random steeply-dipping orientations (Figure 3.3). However, there were slight "maxima" that corresponded to those of the veins and joints. He interpreted this to reflect the relative timing of the vein formation. Early or co-magmatic dykes were more randomly intruded early in the crystallization sequence while the host rocks were relatively plastic, whereas the latter veins are intruded synchronously with the formation of the brittle joints. In several locations in the batholith, dykes were mostly northwest-oriented, that is parallel to the quartz veins, whereas in other areas the dykes orientations approximated the granite/country rock contacts.

Plate 3.15 Narrow aplite dyke cross-cutting an igneous xenolith and host biotite monzogranite (pencil and clipboard for scale).

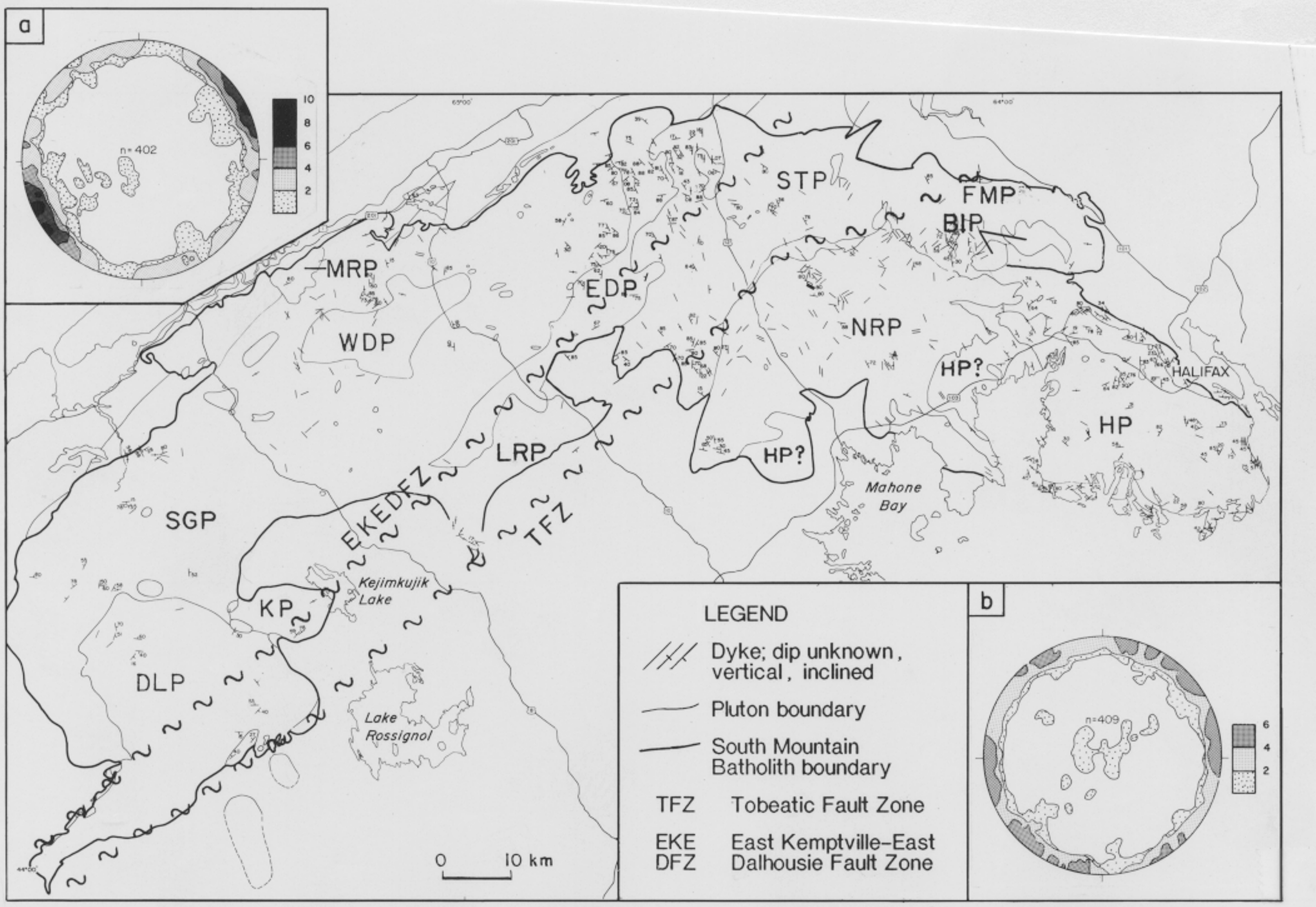

Figure 3.3 Map showing the distribution and orientation of dykes in the South Mountain Batholith. Poles to dykes have been plotted on stereonet density plots (in 1% area) for the portion of the batholith: a) west and b) east of the Tobeatic Fault Zone (after Horne et al., 1992).

Most pegmatite dykes were noted in the New Ross Pluton and include Morley's Pegmatite, Sefferensville Pegmatite, Long Lake pegmatite, Walker Moly (O'Reilly et al., 1982; Ham and Horne, 1987; Ham, 1990). Several pegmatites have also been reported from numerous isolated locales throughout the batholith, mainly within Stage II plutons (reported on virtually all of the 1:50,000 maps). However, compared to other granitic plutons, in particular in the southern parts of the Meguma Zone such as the Port Mouton and Shelburne plutons, the South Mountain Batholith contains volumetrically very minor pegmatite. The implications of this, in terms of the crystallization of the batholith, will be discussed later.

The wide compositional range for dykes is evident within an outcrop of Sandy Lake biotite monzogranite at the intersection of the #103 highway and St. Margaret's Bay Road near Halifax (Figure 3.4a,b). MacDonald (1993) described a series of aplite, aplite/pegmatite and pegmatite dykes form this outcrop that have varying orientation, from subhorizontal to steeply-dipping. Dyke thicknesses range from 5-10 cm to >1m. MacDonald (1993) noted a wide range in modal mineralogy in the aplite dykes and aplitic portions of composite dykes from this outcrop. Variations in modal mineralogy for these dykes (Table 3.4) includes 0.08-4.3% biotite, 0.1-3.5% muscovite, 0.2-2.6% cordierite, 0-1.6% garnet in addition to substantial variations in quartz (21.6-37.2%), K-feldspar (21.2-51.1%), calcic plagioclase (5.4-15.1%) and albite (12.7-19.1%). A complete discussion of the mineralogy and geochemistry of these dykes, and the implication for generation of "late-staged" dykes in the batholith, will be presented in following sections.

3.5 Xenoliths

Information pertaining to xenoliths that was gathered during geological mapping included approximate abundance, size, shape, grain size, texture, and the presence of porphyroblasts and/or megacrysts. To date this information has not been collated and no systematic petrographic studies of xenoliths have been conducted as part of follow-up studies. Therefore, unless stated otherwise, most of the following section is based upon empirical field observations.

Xenoliths in the batholith can be broadly grouped into six main types that include:
1) "fresh" metasedimentary xenoliths Plate 3.16a), commonly with primary sedimentary features. Pelitic xenoliths (Plate 3.16b) may contain porphyroblasts of andalusite (chiastolite variety) and cordierite; 2) fine-grained equigranular xenoliths frequently exhibiting "gneissic" banding (Plate

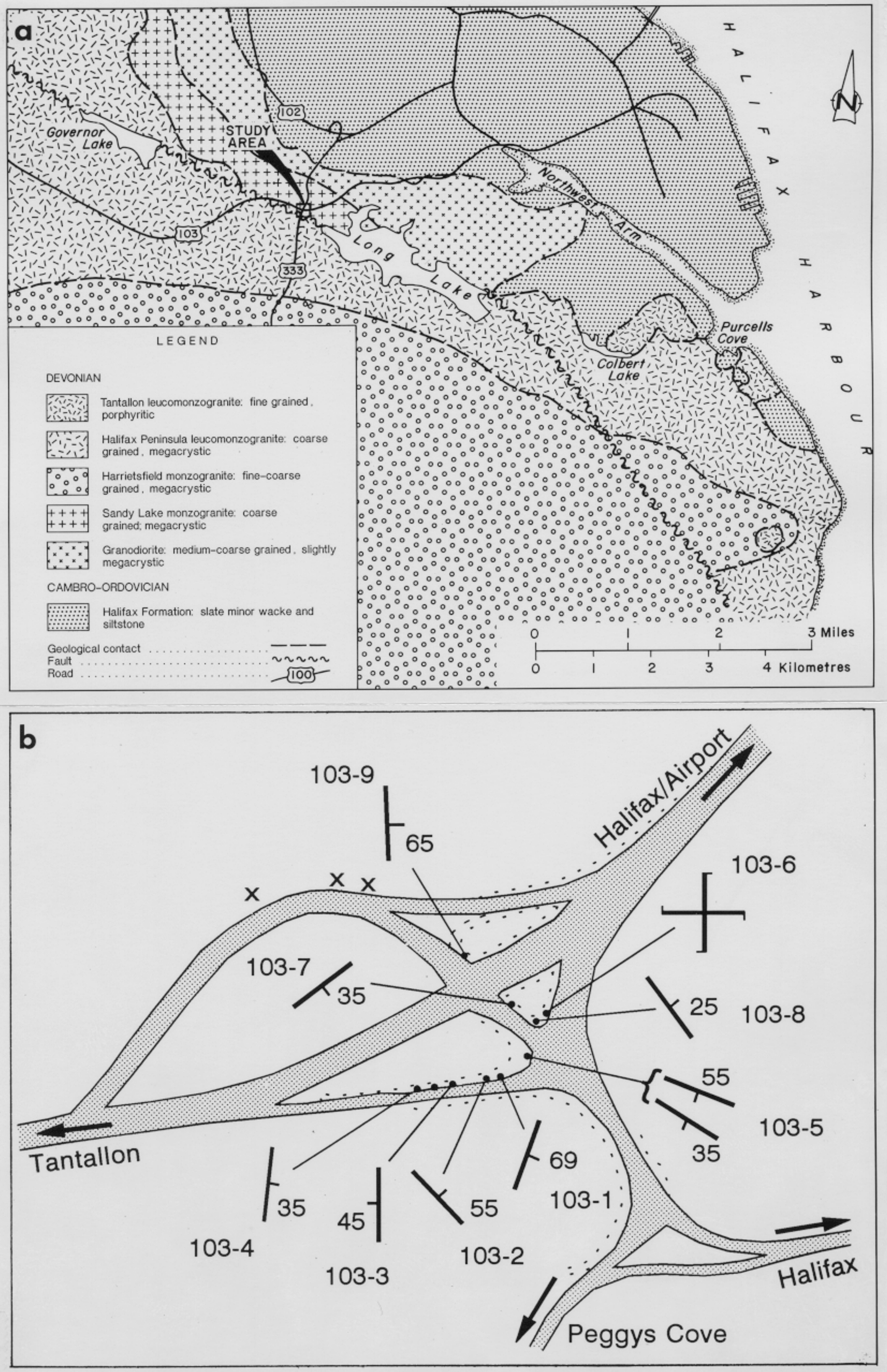

Figure 3.2 Geology map showing the location of aplite, aplite/pegmatite and pegmatite dykes in an outcrop of Sandy Lake biotite monzogranite from the Halifax Pluton. a) general geology of the northeastern part of the Halifax Pluton; b) detailed location map showing the distribution, sample numbers and orientation of dykes.

Table 3.4. Image analysis - derived modal mineralogy of aplite dykes (1000-2000 points).

	A1-A	A1-B	A1-B2	A3	A4	A5-A	A5-B	A5-C	A5-D	A8	A9
Quartz	31.7	30.6	32.4	30.0	34.4	34.0	21.6	22.2	21.8	32.5	37.2
K-feldspar	35.3	34.4	32.1	37.6	23.5	21.2	50.0	51.1	53.4	27.6	30.9
Plagioclase ($An_{>5}$)	9.2	9.6	9.9	6.4	8.6	15.1	5.4	5.5	5.4	9.0	10.8
Albite ($An_{>5}$)*	14.4	12.7	14.2	15.4	17.8	16.8	17.0	15.5	14.4	19.1	13.8
Muscovite**	1.5	2.1	2.1	3.2	2.7	2.5	0.1	0.1	0.4	3.5	2.0
Biotite	3.5	3.1	2.8	2.8	4.3	0.9	0.08	0.08	0.1	1.8	0.1
Garnet	-	-	-	-	0.1	1.6	0.2	0.04	0.2	-	-
Cordierite	0.3	0.5	0.08	0.1	0.6	0.2	0.04	0.04	0.2	0.2	0.1
Pinite***	0.3	0.1	0.2	0.1	2.0	2.1	1.0	1.1	0.9	0.6	0.1
Chlorite****	0.09	0.3	0.4	0.4	0.3	0.4	-	0.04	0.04	0.6	0.04
Apatite	0.4	0.2	0.1	0.3	0.2	-	-	-	-	0.8	-
Opaque (oxides)	-	-	-	-	-	0.05	-	0.04	-	0.03	-
Unclassified*****	3.2	6.5	5.8	4.7	5.4	4.8	4.4	4.1	3.5	4.4	4.8

* Albite - as exsolution lamellae in K-feldspar, rims on zoned plagioclase, and discrete grains
** Muscovite - alteration of K-feldspar, biotite, cordierite and plagioclase
*** Pinite - alteration of cordierite
**** Chlorite - alteration of cordierite and/or biotite
***** Includes analysis at grain boundaries and balsam (i.e. "holes" in slides)

3.16d); 3) fine- to medium-grained xenoliths with abundant medium- to coarse-grained megacrysts of quartz, alkali feldspar and plagioclase (Plate 3.16c). These may also contain metasedimentary xenoliths; 4) medium- to coarse-grained xenoliths with a "ghost-like" appearance (i.e., granitic rocks with a slightly higher biotite content); 5) fine- to medium-grained equigranular leucomonzogranite xenoliths with granitic texture (Plate 3.16e); and 6) granitoid xenoliths from other rock units (Plate 3.16f) of the batholith (e.g. mafic porphyry). Only group #1 can conclusively be assigned to metasedimentary rocks of the Meguma Group. Groups #2 to #4 are tentatively interpreted as partially to extensively assimilated metasedimentary country rocks, in accord with the conclusions of Jamieson (1974). Group #5 has well-developed granitic textures but do not obviously resemble other granitic rock units from the batholith. These xenoliths have low mafic mineral contents and generally are primarily found in biotite-rich monzogranite and granodiorite which were emplaced and crystallized prior to crystallization of Stage II pluton leucomonzogranites. One explanation for this discrepancy is that group #5, and in fact some of groups #2 to #4 xenoliths, may be high-grade metamorphic rocks from deeper crustal levels, possibly from the zone of partial melting. However, detailed petrographic investigations are

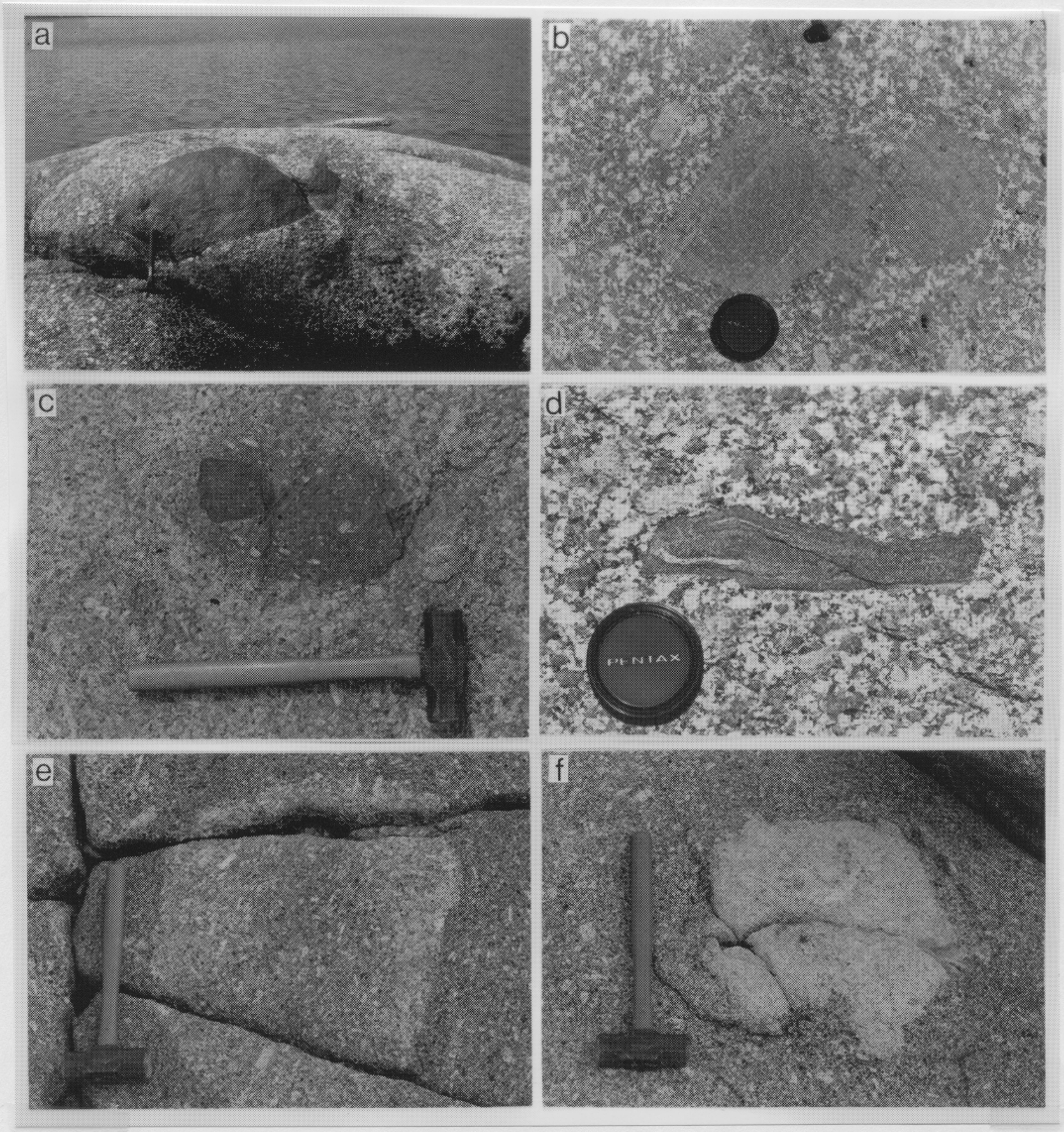

Plate 3.16(a to e) Typical variations in xenoliths in the South Mountain Batholith (see text for description).

required to successfully resolve this issue. Group #6 xenoliths can generally be assigned to other rock units and, unlike group #5, follow the general crystallization sequence of the batholith. That is, xenoliths are more mafic than their host rocks.

Perhaps the most important observation about xenoliths pertains to the distribution. The abundance of xenoliths in any rock unit is directly proportional to the modal proportions of biotite$\pm$cordierite. The highest xenolith abundance is the least evolved, biotite-rich, mafic porphyry and granodiorite units. The abundance of xenoliths decreases in muscovite-biotite monzogranite and only rare xenoliths were noted in some portions of coarse-grained leucomonzogranite. Xenoliths are rare to absent in fine-grained leucomonzogranite and leucogranite, even when in direct contact with country rocks. In general the proportion of xenoliths within map units in granodiorite and monzogranite units is evenly distributed with the exception of several areas close to country rock contacts, such as at Palmer Lake (MacDonald and Ham, 1992) and Mount Uniacke (Jamieson, 1974). Also, a few xenolith "dykes" were noted in granodiorite and biotite monzogranite units in the batholith. The origin of these "dykes" is unclear.

To date, the only documented "exotic" xenolith consists of a single enclave that was intersected in drill core in the Big Indian Lake Pluton (Corey and Chatterjee, 1992). This xenolith contains garnet + clinopyroxene + plagioclase + titanite and was noted to be 'remarkably similar' to lower crustal granulite xenoliths with the same essential mineralogy that were reported in the Tangier lamprphyre dyke (Fig. 1.2; Chatterjee and Giles, 1988). The Big Indian Lake 'exotic' xenolith is tentatively interpreted as a refractory inclusion from the zone of partial melting and/or a high-grade metamorphic rock that was incorporated into the Big Indian Lake Pluton during ascent to the present emplacement level (M.C. Corey, pers. comm., 1993).