Chapter 8

NATURE AND ORIGIN OF THE BATHOLITH

8.1 Introduction

The determination of the origin of granites is perhaps one of the most challenging problems faced by igneous petrologists, principally because granitic bodies, which commonly are formed by partial melting, are rarely at the same crustal level as their protoliths. Therefore, the establishment of source rock compositions for granitic bodies is mainly based upon a plethora of mineralogical, geochemical and isotopic evidence. A full and comprehensive treatment of the origin of the South Mountain Batholith is beyond the scope of this report and therefore brief summaries of the various lines of evidence for the origin of the batholith are presented in the following sections.

8.2 Field Evidence

In previous Chapters it was noted that the batholith is in sharp intrusive contact with Paleozoic metasedimentary and metavolcanic country rocks. In most locations the associated thermal effects of these country rocks is minimal, the exception being the regular development of a narrow thermal aureole (ca. 100m to 1km wide) manifested by porphyroblastic growth of chiastolitic andalusite and cordierite. Other contact-related effects include the obliteration of slaty cleavage and silicification of country rocks. Development of migmatite zones is rare, being restricted to large roof pendants such as along the margin of the Kejimkujik Pluton (Horne, 1994) and near Boot Lake (MacDonald and Ham, 1992). These factors, coupled with the overall lack of deformation of country rocks and abundance of metasedimentary xenoliths in the biotite-rich units, indicate that the batholith was emplaced as a melt, magma or 'crystal mush' and principally intruded via a mechanism of stoping, at least at the present level of exposure. Therefore, based solely on field evidence, it is reasonable to disregard *in situ* melting or granitization of country rocks as a plausible mechanism of formation of the batholith. Accordingly, the plutons of the batholith must have originated by partial melting of a deeper protolith, followed by upward movement of magma to its level of emplacement.

One method of determining the composition of potential source rocks for the batholith

entails the examination of xenoliths, assuming that some may have originated from, or near, the zone of partial melting, and that these can be distinguished from assimilated country rocks. The abundance, morphology and macroscopic mineralogy of xenoliths were noted during field mapping. Some xenoliths have fine- to medium-grained equigranular or fine- to coarse-grained megacrystic igneous textures. Some 'igneous' xenoliths contain xenoliths of possible metasedimentary origin. Results from a petrographic study of xenoliths from throughout the batholith (Tate, 1994) indicated these microgranular igneous xenoliths have the same essential mineralogy as the main rock types of the batholith. Therefore they are tentatively interpreted as 'autoliths' from early-crystallized portions of the batholith that became incorporated into later melts. Tate (1994) also investigated surmicaceous enclaves in the batholith that might represent true restites, although the possibility that these xenoliths represented partial melting of included metasedimentary enclaves could not be ruled out based on available information.

The only 'exotic' xenolith (i.e., not from the country rock at present level of erosion) reported to date was observed in diamond drill core from the Big Indian Lake Pluton (Corey and Chatterjee, 1992). This xenolith contains garnet, clinopyroxene, plagioclase and titanite, and is remarkably similar to lower crustal granulite xenoliths encountered in the Tangier lamprophyre dyke in the eastern Meguma Zone (Giles and Chatterjee, 1987; Eberz et al., 1991). Measurements of X_{Fe} and X_{Mg} of titanite from this xenolith (M.C. Corey, personal communication, 1994) yield similar P-T estimates (approximately 15 kbar and 1100-1400°C) to those for the lower crustal Tangier xenoliths. The relevance of this 'exotic' xenolith, in terms of the origin of the entire batholith, will be discussed at the end of this chapter.

8.3 Mineralogical Evidence

The essential mineralogy of the major rock types of the South Mountain Batholith consists of quartz, alkali feldspar, plagioclase, biotite and muscovite with variable modal amounts of cordierite (0->5%), andalusite (0-2%), garnet (0-5%) and topaz (0-8%), as outlined in Chapter 4. This mineral assemblage is consistent with the S-type class of granites, as proposed by Chappell and White (1974). In particular, the significant modal amounts of cordierite in many monzogranite and leucomonzogranite units satisfies an important mineralogical requirement for S-type granites. Chappell and White (1974) concluded that S-type granites were formed via the melting of predominantly metasedimentary rocks, hence the 'S' denotation, in contrast to I-type granites that originated either from the partial melting of dominantly igneous rocks or from fractionation of

mantle melts. Clarke (1992; and references therein) concluded that the 'alphabet classification of igneous rocks' is fraught with problems and inconsistencies and should be treated with some degree of trepidation. In particular he noted that the letters I and S may only indicate the dominant source material and do not eliminate the possibility of composite source regions, possibly with a mantle input.

The mineralogy of the batholith is consistent with the 'characteristic mineralogy' of peraluminous granites, as outlined by Clarke (1981). However, peraluminous granites can be generated by several processes including fractional crystallization of metaluminous or I-type granites (Clarke, 1981; Zen, 1986), although resulting granites are rarely the size of the South Mountain Batholith. Therefore, conclusions about source rock composition based solely upon the peraluminous nature of the batholith would be suspect.

Ilmenite is the common opaque oxide phase in the batholith. In fact, the only magnetite identified in the entire batholith consists of an occurrence of albite-magnetite breccia in a drill hole in the Davis Lake Pluton (Richardson, 1988), which is interpreted to result from deformation and hydrothermal alteration of coarse-grained leucomonzogranite (MacDonald et al., 1992). The ubiquitous occurrence of ilmenite throughout the batholith, coupled with the presence of muscovite and low Mg/Fe biotite, is consistent with the ilmenite-series of granitic rocks as defined by Ishihara (1977). These rocks were interpreted as originating from partial melting in the middle to lower regions of the continental crust, with possible interaction with C-bearing metasedimentary rocks during generation and/or emplacement (Ishihara, 1977).

In summary, the mineralogical evidence indicates that the South Mountain Batholith was generated by the melting of predominantly metasedimentary source rocks, although the possibility of interaction with, or contribution from, other crustal rocks or possibly mantle-derived magma cannot be dismissed on mineralogical evidence alone.

8.4 Geochemical Evidence

As noted in Chapter 5, all rocks of the batholith are peraluminous (molar Al_2O_3 / (CaO + Na_2O + K_2O) > 1, i.e. A/CNK, > 1). In fact, average compositions for the major rock types in both Stage I and II plutons have A/CNK values in excess of 1.1 and, therefore, satisfy the basic chemical prerequisite for S-type granites (Chappell and White, 1974).
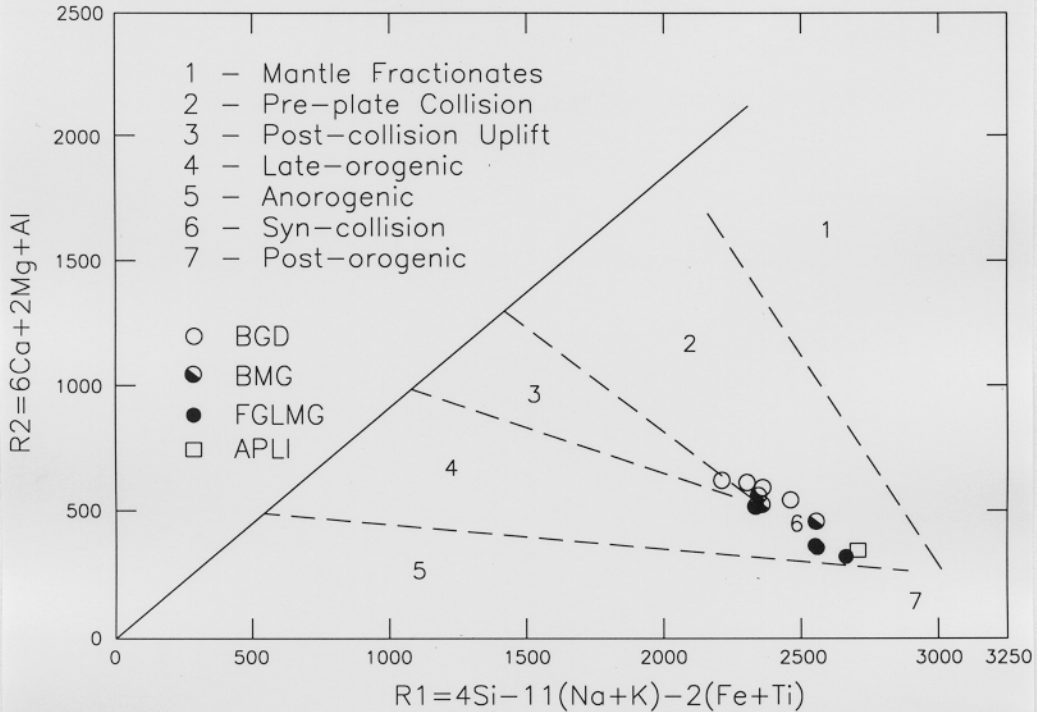
Average major and trace element data for Stage I and Stage II plutons were plotted on several tectonic discriminating diagrams (e.g. Pearce et al., 1984; Whalen et al., 1987; Batchelor and Bowden, 1985). The large variation in trace element content from biotite granodiorite to leucogranite results in the rock types from the batholith plotting in several tectonic environments including volcanic arc, syn-collisional and within plate granites (Pearce et al., 1984) fractionated felsic and orogenic granites (Whalen et al., 1987). Biotite granodiorite and biotite monzogranite mainly plot in the orogenic and syn-collisional tectonic environments on the above diagrams. Data from Stage I and II plutons were plotted on the descriminating diagram of Batchelor and Bowden (1985) and are given in Figure 8.1. With the exception of the highly fractionated leucomonzogranites and leucogranites, all rocks plot in the syn-collisional field of their diagram. In short, the batholith is interpreted to have been generated in a syn- or late-collisional tectonic environment.

In a general sense, the high concentration of large ion lithophile elements (LILE, e.g. Rb, U, F, Li) and the low levels of Ni, Co, Cr and many other high field strength elements (HFSE) elements is consistent with a predominantly crustal source for the batholith. However, this observation is somewhat simplistic in light of the wide range of factors governing the solubilities of these elements in peraluminous melts, and the myriad of conditions (e.g. P, T, aH_2O, fO_2) that could effect the distribution of these elements.

8.5 Stable Isotope (δO^{18}, $\delta^{34}S$) Evidence

There have been several **oxygen isotopic** studies of the batholith during the past two decades. Longstaffe et al. (1980) reported δO^{18} values for 127 whole-rock samples and coexisting minerals from the granitoid and metasedimentary rocks of the Meguma Zone. In determining δO^{18} values for representative compositions from the central and eastern portions of the batholith, Longstaffe et al. (1980) noted that the whole-rock δO^{18} values for the batholith generally ranged from +10.1 to +12.0‰ and noted the coexisting mineral phases were in equilibrium, indicating the whole-rock values were representative of "the magma". They concluded that the batholith was
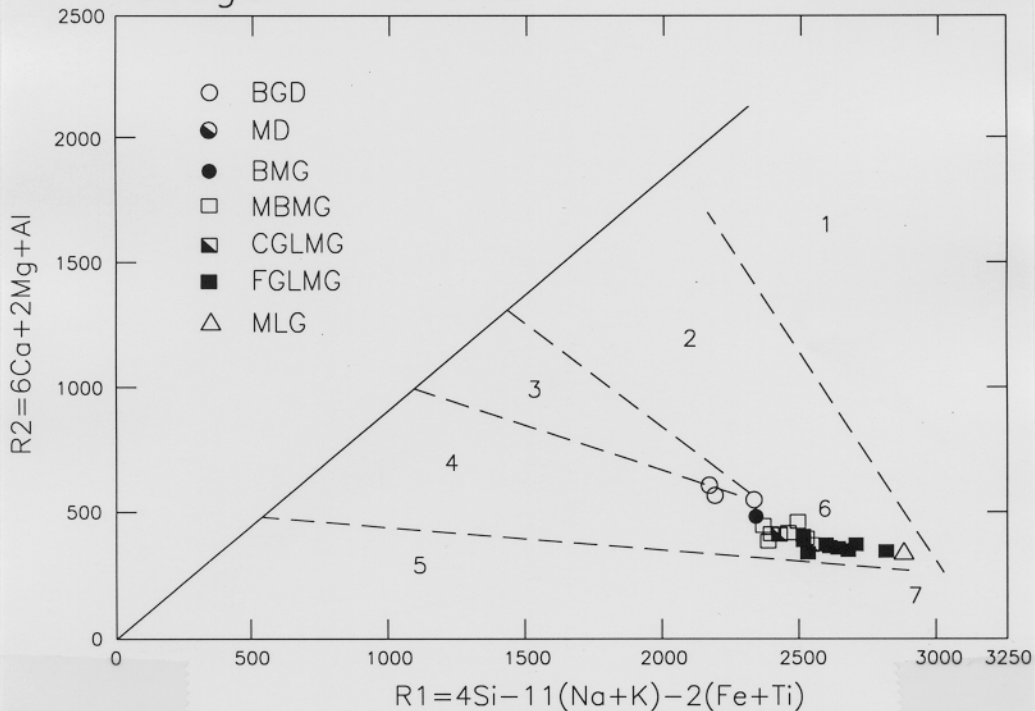
Figure 8.1 Average rock compositions from Stage I and II plutons, plotted on the tectonic descriminating digram from Batchelor and Bowden (1985). See text for discussion.

generated by melting of δO^{18}-rich metasedimentary rocks. Two whole-rock samples from the East Dalhousie-New Ross area of the batholith had δO^{18} values of $+7.8$ and $+9.6‰$. The exact explanation for these low values was not elucidated, however, similar δO^{18} results in the Brenton Pluton were interpreted as being caused by exchange with low δO^{18} fluids during shearing.

Chatterjee and Strong (1985) reported δO^{18} analyses for several unmineralized suites that primarily returned values of ca. $+10$ to $+12‰$, in agreement with the results of Longstaffe et al. (1980). They also analysed sample from the Millet Brook and East Dalhousie U deposits and polymetallic Sn mineralization from the East Kemptville Mine and other occurrences in the Southern Nova Scotia Tin Domain. They noted very high δO^{18} values for mineralized samples from U deposits (ca. $+12$ to $+15‰$) which they interpreted to represent mixing of magmatic and metamorphic (calcareous?) fluids. They also documented low δO^{18} values (ca. $+6.5$ to $+10.0‰$) for two suites of samples from intra- and peri-batholithic greisen suites in southwestern Nova Scotia that were interpreted to represent interaction between meteoric and magmatic fluids.

Kontak et al. (1988) measured the δO^{18} compositions for a suite of fourteen samples of leucomonzogranite and leucogranite samples from the eastern portion of the batholith. They noted that most samples had uniform δO^{18} concentrations of $+10.6\pm0.5‰$ with no systematic variation with proximity to metasediment contacts. They concluded that deviations in mineral separates reflected re-equilibration of feldspars with late-magmatic, low-temperature fluids. One sample of quartz-muscovite greisen from the contact zone of the Halifax Pluton ($+11.5$ to $+14.0‰$ for $300°$-$400°C$) was interpreted as reflecting interaction with a 'heavy' metamorphic fluid. In contrast, a sample from near the East Dalhousie Fault Zone with $\delta O^{18} = +3.6‰$ was interpreted as reflecting interaction with meteoric fluids. Interestingly, this sample was collected proximal to samples from Longstaffe et al. (1980) with the lowest concentrations of δO^{18}. Kontak et al. (1991) presented more δO^{18} data for the same sample suite and confirmed the initial results of Kontak et al. (1988).

Kontak (1990a) reported δO^{18} data for six whole-rock samples from the East Kemptville leucogranite. The entire sample suite had whole-rock δO^{18} values that ranged from $+8.2$ to $+12.2‰$ with an average value ($N=5$) of $8.96\pm0.71‰$. The high whole-rock δO^{18} value in one sample of dyke rock was interpreted as reflecting non- fractional crystallization processes. Kontak

(1990) concluded that the δO^{18} data were consistent with other published data from the batholith and supported the generation of the East Kemptville leucogranite via partial melting of crustal rocks including sedimentary and/or modified plutonic/volcanic rocks that once resided at the earth's surface.

Poulson et al. (1991) reported δO^{18} values for quartz and feldspar separates from a suite of 21 samples of granodiorite from the contact zone at Mt. Uniacke (Corey, 1987). They noted that δO^{18}_{Quartz} values (av +12.24‰, range +11.93‰ to + 12.54‰) were comparable to previously published values (e.g. Longstaffe et al., 1980) for other parts of the batholith. They noted that disequilibrium occurred between δO^{18} results for quartz and feldspar in a few samples and concluded that this probably represented isotopic exchange, mainly between feldspar from these samples and a fluid phase, possibly a low temperature meteoric water.

Clarke et al. (1993) measured whole-rock δO^{18} values for a suite of 47 leucogranite samples from the eastern portion of the batholith. The entire data set ranged from +7.71 to +15.04‰ with an average composition of +11.4±1.01‰ (1 sigma); 42 of the 47 samples lay between +10.1 and +12.7‰. They noted that these results were very similar to the previous studies and reflected the dominance of δO^{18}-rich supracrustal protolith(s). Interestingly, the lowest δO^{18} concentration (+7.71‰) was for a sample from near the East Dalhousie Fault Zone, whereas the highest value (15.0‰) was for a sample from near the Millet Brook U deposit. In both cases these results resemble previously reported δO^{18} values from these same general areas of the batholith studies.

Taylor (1988) concluded that granitic rocks with high δO^{18} values ($\delta O^{18} > +8.0‰$) **require** "...the involvement of some precursor parent material that at some time in the past resided on or near the Earth's surface, either as sedimentary rocks or as weathered or hydrothermally altered rocks". These rocks could represent either the dominant protolith composition or a chemical/isotopic reservoir encountered by the granitic rocks *en route* to the level of emplacement. Therefore, the δO^{18} data for the batholith indicate it was generated by melting of δO^{18}-rich supracrustal rocks. Relatively higher and lower δO^{18} values (i.e. < ca. +9‰ and > ca. +13‰, respectively) indicate interaction with δO^{18}-rich (e.g., metamorphic) and δO^{18}-depleted (e.g., meteoric) fluids during, or subsequent to, crystallization.

Kontak (1990b) determined the **sulphur isotopic** compositions of a suite of 31 sulphide samples (pyrite, pyrrhotite, sphalerite, chalcopyrite, arsenopyrite, galena) from the tin- and base-metal stages of mineralization at the East Kemptville deposit. He noted a very restricted range of $\delta^{34}S$ from +3.6 to +6.6‰ and concluded that these sulphide phases originated from a common magma-derived fluid with a $\delta^{34}S$ value of +5.0±0.5‰. Kontak (1990b) concluded that there was "…negligible contribution of heavy sulphur from the Meguma Group". However, Kontak (1993) concluded that mobilization of sulphur from the Meguma Group could explain extreme variation in $\delta^{34}S$ (-8.8 to +55‰) in a suite of samples from the late-stage zeolite-bearing mineralization at East Kemptville. This conclusion is in accord with the results of an earlier study by Kubilius (1983) where isotopic equilibration between the batholith and Meguma Group country rocks was postulated to explain observed variations in $\delta^{34}S$. Kontak (1990b) concluded that isotopic data indicated the sulphur in the East Kemptville deposit was dominantly of crustal derivation, although the possibility of sulphur contribution from mantle magma(s) or fluid(s) could not be ruled out.

Poulson et al. (1991) conducted a sulphur isotopic study of a suite of samples from the entire batholith and surrounding country rocks, and also for a suite of samples from the granite/metasediment contact zone at Mt. Uniacke. They noted that $\delta^{34}S$ values for the Meguma Group metasedimentary rocks ranged from -3.7 to 26.3‰. They concluded that approximately 30-60% of the sulphur (av. ≈20 ppm for Stage I plutons; ≈300 ppm for Stage II plutons) was present in pyrrhotite, whereas the remainder occurred as substitutions in biotite structure. $\delta^{34}S$ values were noted to range from +5.4 to +8.4‰ for Stage I plutons and +1.6 to +15.0‰ for Stage II plutons. Most samples from the contact zone at Mt. Uniacke had higher $\delta^{34}S$ values (+6.6 to +12.3‰) than 'regional' granodiorite samples of other Stage I plutons. Conversely, some hydrothermally altered granodiorite samples were noted to have much lower $\delta^{34}S$ values (+0.45 to +0.67‰). Poulson et al. (1991) concluded that fractional crystallization combined with assimilation (AFC) of isotopically variable Meguma Group metasedimentary rocks best explained their $\delta^{34}S$ results. Furthermore, they suggested that the AFC processes may have involved either bulk assimilation of Meguma Group rocks or selective desulphidation of country rocks and enclaves.

8.6 Radiogenic Isotope (Sr, Nd, Pb) Evidence

A summary of published **strontium isotopic** studies was presented in Chapter 7. The results from these investigations indicated a wide range of initial $^{87}Sr/^{86}Sr$ ratios from low and intermediate values (ca. 0.680, A.K. Chatterjee, unpublished data, 1994; 0.7076-0.71021, Clarke and Halliday, 1980) in most of the batholith to higher values (0.727, Richardson et al., 1989; 0.729 Kontak and Cormier, 1991) in the Davis Lake Pluton. However, as noted in Chapter 7, the wide variation in initial $^{87}Sr/^{86}Sr$ ratios only persists when "altered" samples with K/Rb < 150 are included. The range of initial $^{87}Sr/^{86}Sr$ for a suite of "unaltered" samples (K/Rb > 150) was noted to be 0.706 to 0.708. Richardson et al. (1990) documented extreme variation in initial $^{87}Sr/^{86}Sr$ ratios (0.7135 to 0.8284) for hydrothermal fluorite and phosphate minerals from the East Kemptville tin deposit. Their data clearly signified the presence of a fluid with high initial $^{87}Sr/^{86}Sr$ ratios, thus supporting the thesis that the Rb-Sr isotopic system was influenced by late- to post-magmatic fluids.

Taylor (1988) noted that granites with initial $^{87}Sr/^{86}Sr$ ratios in excess of 0.706 were generated from the melting of supracrustal metasedimentary rocks, eugeosynclinal volcanogenic sediments or altered volcanic rocks. Chappell and White (1974) stated that S-type granites characteristically have initial $^{87}Sr/^{86}Sr$ ratios greater that 0.708, in contrast to I-type granites with values of 0.704-0.706. The initial $^{87}Sr/^{86}Sr$ ratios for rocks with K/Rb > 150 all lie in the gap between the S- and I-type granites of Chappell and White (1974).

Clarke et al. (1988) conducted a **neodymium isotopic** study of the granitoid rocks of the batholith. They analysed a suite of granodiorite, fine- and coarse-grained leucomonzogranite from the central part of the batholith, along with metasedimentary xenoliths and host granodiorite from the contact zone near Mt. Uniacke. They compared their results with earlier Sm-Nd and Rb-Sr isotopic studies of the country rocks and the South Mountain Batholith respectively (Clarke and Halliday, 1980; 1985) to ascertain the possible genetic links between them. They noted that the batholith had εNd^t (t=372 Ma) values ranging from -5.2 to -1.4 that were significantly higher that those of the Meguma Group rocks (-11.2 to -8.7). Hence, they concluded that the protolith for the batholith was not the Meguma Group, although they documented isotopic re-equilibration between the xenoliths and host granodiorite. Furthermore, based upon the εNd^t and $^{87}Sr/^{86}Sr$ data, Clarke et el. (1988) proposed that the South Mountain Batholith was generated by melting of a

deeper crustal source than the Meguma Group, possibly accompanied by (i.e., mixing with) input from mantle-derived magma.

Chatterjee and Ham (1991) reported **lead isotopic** concentrations for a suite of samples from the entire South Mountain Batholith. They concluded that the batholith was derived from melting of granulite rocks with possible contamination from Liscomb gneisses and overlying Meguma Group rocks prior to final emplacement and crystallization.

Kontak and Chatterjee (1992) conducted a Pb isotopic study of a suite of samples from the East Kemptville leucogranite and associated polymetallic greisens. They reported a μ value of 9.75 for these samples and concluded that this was evidence for an evolved upper crustal source region for the batholith, as opposed to a lower crustal granulite source.

8.7 Summary and Discussion

It is apparent from the field evidence that the South Mountain Batholith was emplaced as a melt or, more likely, as a partially solidified crystal mush by stoping, which had only minimal contact-related effects on the country rocks. Mineralogical, chemical and isotopic constraints dictate that the protolith(s) for the batholith was of supracrustal origin with a significant metasedimentary rock component. However, the possible mixing or interaction with mantle-derived mafic magma and or assimilation of country rocks cannot be ruled out.

Recent work in the eastern Meguma Terrane now provides insight into its crustal stratigraphy at ca. 370 Ma. Giles and Chatterjee (1986, 1987) reported an ortho- and paragneiss complex with associated quartz gabbro, granite and leucogranite intrusions that pierced the Meguma Group metasedimentary rocks near Liscomb. Geochronological studies ($^{40}Ar/^{39}Ar$) of the gneissic rocks (Kontak et al., 1990) indicate that they were emplaced in the waning stages of the Acadian Orogeny (ca. 370 Ma) along with the major granitoid plutons. Clarke et al. (1993) reported T-P estimates for the gneissic rocks that ranged from 760°C and 6.4 kbar to 980°C and 8.2 kbar. They also noted that some petrological disequilibrium features (e.g., mineral zoning and corona structures) were indicative of fluctuating P-T conditions that reflected the rapid emplacement of the gneiss dome ca. 370 Ma. Clarke et al. (1993) concluded that the mafic intrusions in the Liscomb Complex were of within-plate or volcanic arc origin and were derived from slightly depleted mantle source(s).

Ruffman and Greenough (1990) reported on the occurrence of a mafic dyke swarm, termed the "Weekend dykes", that outcrop in the eastern Meguma Terrane (Fig. 1.2). They noted that approximately half of the dykes contained exotic gneissic and (meta)plutonic xenoliths. Kempster et al. (1989) reported $^{40}Ar/^{39}Ar$ ages of 370 ± 2 and 367 ± 2 Ma for two of the Weekend dykes in the vicinity of Tangier which suggested that the dykes may have been emplaced synchronously with the mafic magmas of the Liscomb Complex. Chatterjee and Giles (1988), Eberz et al. (1988) and Eberz et al. (1991) conducted detailed petrological and geochemical studies of a suite of granulite xenoliths from one of these dykes near Tangier, with lamprophyric composition. These workers reported several types of xenoliths with varying modal proportions of sapphirine, garnet, spinel, orthopyroxene, clinopyroxene and amphibole. Chatterjee and Giles (1988) reported maximum P-T estimates for the Tangier xenoliths of 14.2-14.8 kbar and 1030-1066°C and noted that other P-T estimates from the xenolith suite recorded rapid decompression and heating after incorporation into the ascending Tangier dyke. Eberz et al. (1991) concluded that the Tangier xenoliths represent average to upper crustal model compositions and were tentatively interpreted as subducted Avalon Terrane.

The recent documentation of high metamorphic grade rocks in both the Liscomb Complex and Tangier dyke, provides two "windows" to deeper crustal regions of the Meguma Zone ca. 370 Ma, and hence provides the opportunity to evaluate deep crustal source regions for Meguma Zone granitoid rocks.

The crustal stratigraphy ca. 370 Ma consisted of Meguma Group upper crustal rocks overlying Liscomb Terrane which, in turn, was underlain by Tangier (Avalon?) Terrane. Eberz et al. (1991) and Clarke et al. (1993) presented Nd-Sm isotopic data for xenoliths from the Tangier dyke and gneisses from the Liscomb Complex, respectively, and compared their data with published results for the Meguma Group rocks (Clarke and Halliday, 1985). These workers proposed that the crustal stratigraphy in the Meguma Zone ca. 370 Ma was "inverted" with "crustal residence ages" decreasing from the "oldest" Meguma Group (1170-1450 Ma) to the "younger" Liscomb gneisses (403-627 Ma) and Tangier xenoliths (ca. 600 Ma).

All three proposed terranes are possible source regions for the generation of the South Mountain Batholith. Each of these terranes will now be evaluated individually:

1) Meguma Group

Longstaffe et al. (1980) concluded that the batholith could be generated from anatexis of the Meguma Group metasediments, based on δO^{18} data. Conversely, Clarke and Halliday (1980) compared the strontium isotopic compositions of the batholith and the Meguma Group rocks and concluded that the initial $(^{87}Sr/^{86}Sr)_{372}$ ratios of early-crystallized granodiorite (0.7081) were distinctly lower than any of the analysed metasedimentary rocks and consequently the granodiorite, and presumably the batholith as a whole, was not formed by partial melting of these rocks alone. Clarke et al. (1988) measured the neodymium isotopic composition of the batholith and compared the results with data from the Meguma Group rocks (Clarke and Halliday, 1985). They noted that the batholith had epsilon Nd^t values (-5.2 to -1.4) that were considerably higher than values in the Meguma Group (-11.2 to -8.7) and subsequently proposed that the Meguma Group was not a suitable protolith for the batholith.

Isotopic (i.e., Sr, Nd, S) and, presumably, bulk chemical contamination of the batholith by Meguma Group rocks has been documented by Clarke and Halliday (1980), Kubilius (1983) and Clarke et al. (1988), although quantification of the amount of isotopic exchange remains unknown. These factors could influence the determination of source rock composition, however, the removal of these effects would not change the conclusion that the Meguma Group rocks are not suitable protoliths for the batholith.

2) Liscomb Gneisses

Clarke et al. (1993) concluded, on the basis of geochemical and isotopic information that the granites from the Liscomb Complex are similar to other granite bodies in the Meguma Zone. In fact, they noted that these granites isotopically overlap both the South Mountain Batholith and the intermediate gneisses of the Liscomb Complex. They subsequently proposed that other Meguma Zone granitoids could be generated by similar processes as evoked for the Liscomb Complex, that is underplating and partial melting of Liscomb gneisses to form the granitic rocks. In this scenario, slight compositional differences between the plutons of batholith and the Liscomb granites would represent compositional variations in the actual protoliths. Clarke et al. (1988) indicated that the source rocks for the batholith must have "younger" crustal residence ages, as defined by neodymium isotopes, than the Meguma Group rocks. As noted above, the Liscomb

gneisses satisfy this criteria and must be considered a possible source for the batholith.

3) Tangier granulites

As stated above, mineralogical, geochemical and isotopic studies (Chatterjee and Giles, 1988; Eberz et al., 1988; Eberz et al., 1991) indicate that the exotic xenoliths from the Tangier lamprophyre dyke have compositions consistent with upper crustal rocks and, therefore, are potential protoliths for the batholith. Eberz et al. (1991) noted that the neodymium and strontium isotopic compositions of the granulite xenoliths qualified them as potential sources for the batholith. Clarke and Chatterjee (1992) concluded that the granulite facies metasedimentary xenoliths from the Tangier dyke are the most suitable protolith for most peraluminous granites of the Meguma Zone including the South Mountain Batholith, but not the Liscomb granites as outlined above.

In summary, the plutons of the batholith are interpreted as resulting from partial melting of either the Tangier or Liscomb "terranes", or possibly a combination of the two, beneath the Meguma Terrane. Underplating of either terrane by mantle-derived magma may have contributed to the generation large volumes of granite magma ca. 370 Ma. However, unlike the Liscomb Complex, significant amounts of gabbro and diorite intrusions are absent in the South Mountain Batholith and much of the Meguma Zone. Slight mineralogical and geochemical differences between the various plutons may simply reflect compositional variation within these terranes.