Chapter 7

GEOCHRONOLOGY

7.1 Field and Paleontological Evidence

Stage I and II plutons of the South Mountain Batholith intrude the conformable sequence of Cambro-Ordovician Meguma Group metasedimentary rocks and overlying Ordovician to Lower Devonian White Rock, Kentville, New Canaan and Torbrook formations (Taylor, 1969; Smitheringale, 1973). It should be noted that youngest Torbrook Formation is intruded by the Scrag Lake and Cloud Lake Stage I plutons which are interpreted as being among the first plutons to be emplaced. Since Boucot (1960) identified Lower Emsian fauna in the marine Torbrook Formation and the Early Devonian (Emsian) - Middle Devonian boundary has recently been defined at ca. 385 Ma by Cowie and Bassett (1989), this indicates the batholith has a maximum post Emsian age.

Despite the late, or residual, Acadian structural influence, outlined in Chapter 6, the batholith cross-cuts regional structural trends and has been interpreted as post-dating regional metamorphism and deformation of the Cambrian to Devonian country rocks (McKenzie and Clarke, 1975; MacDonald et al., 1992, and references therein). Reynolds et al. (1973) calculated K-Ar "metamorphic" ages for 15 whole-rock slates (biotite- and chlorite-zone of greenschist facies) from the Meguma Group rocks. They reported apparent ages of 332-405 Ma but concluded that the minimum age for the regional metamorphism was ca 390 Ma. Reynolds and Muecke (1978) concluded the regional metamorphism and deformation of the Meguma Group rocks occurred at least 400-415 Ma, based upon $^{40}Ar/^{39}Ar$ ages for greenschist facies slates. They also noted that the $^{40}Ar/^{39}Ar$ age spectra from several hornfels and slate samples were completely reset by thermal effects from the South Mountain Batholith. Muecke et al. (1988) reported $^{40}Ar/^{39}Ar$ age determinations for micas, hornblendes and six whole-rock slate and siltstone samples from metamorphic rocks of the Meguma Zone. They noted a convergence of whole-rock and hornblende and biotite ages at circa 405-390 Ma and interpreted this intersection to represent the timing of the regional metamorphism. Similarly, Dallmeyer and Keppie (1987) reported "younger" ages ranging from 366.9 ± 5.6 Ma and 385.1 ± 2.6 Ma for amphiboles from calc-silicate horizons from granite contact aureoles. Keppie and Dallmeyer (1987) reported $^{40}Ar/^{39}Ar$ age plateaus ranging from 375-400 for whole-rock slate samples from high temperature contact aureoles in the eastern Meguma Terrane. These "younger" ages were concluded to reflect partial resetting from granite emplacement rather than regional metamorphism.

Several Stage I plutons (e.g. Salmontail Lake) and the Stage II Halifax Pluton are overlain by the coarse, subaerial clastic sediments and marine carbonates of the Horton and Windsor groups. Bell and Blenkinsop (1960) and Howie and Barss (1975) concluded that the Horton Group was deposited during the Early Carboniferous (Tournaisian). Utting et al. (1989) also proposed an Early Carboniferous (Tournaisian) age for this formation based upon their identification of miospore assemblages. Martel et al. (1993) have recently identified Early Tournaisian (Courceyan) and Upper Devonian (Late Famennian) miospores in the lowermost 7.3 m of Horton Bluff sediments in the type area. The Devonian - Carboniferous boundary has recently been placed at 355 Ma by Cowie and Bassett (1989) which firmly constrains the age of deposition for the basal strata of the Horton Group.

Field and paleontological evidence indicates that the batholith must have been emplaced, crystallized, uplifted and unroofed during a narrow time interval. Paleontological evidence suggests this event occurred between the post-Emsian (i.e. Early Devonian; ca. 385 Ma) and late Famennian (i.e. Late Devonian; ca. 355 Ma) ages. Geochronological studies of regional metamorphism and deformation have yielded conflicting dates which reflect both regional metamorphism/deformation and subsequent resetting of ages either from thermal effect associated with granite intrusion or from thermotectonic deformation of the Meguma Terrane. However, the tightly-constrained paleontological data restricts regional deformation/metamorphism to post 385 Ma.

7.2 Summary of Geochronological Studies

There have been numerous radiogenic isotope studies (Rb-Sr, K-Ar, $^{40}Ar/^{39}Ar$, U-Pb, Pb-Pb) of the batholith during the past three decades. The salient aspects of these investigations are summarized in the following section.

The first systematic geochronological studies of the batholith and other Meguma Zone granites were done by Fairbairn et al. (1960, 1964), Lowden (1960, 1961), Lowden et al. (1963), Leech et al. (1963) and Reynolds et al. (1973). These authors employed Rb-Sr or K-Ar methods for whole-rock and/or mineral separates from samples collected throughout the batholith but, in general, did not attempt to differentiate among its various granitic phases. Reynolds et al. (1981) noted that these studies yielded apparent ages ranging from circa 240 to 420 Ma. Cormier and Smith (1973) analysed granitic rocks from the eastern half of the batholith including the Halifax Pluton using the whole-rock Rb-Sr dating method. They concluded that two separate rock sequences with differing ages were present. These include: 1) 417$\pm$38 and 387$\pm$25 Ma for rocks corresponding to granodiorite-biotite monzogranite-muscovite-biotite monzogranite-coarse-grained leucomonzogranite of this study; and 2) 357$\pm$10 and 350$\pm$7 Ma for late-staged "alaskites" (i.e. fine-grained leucomonzogranite of this study) from the Halifax-St. Margaret's Bay and New Ross areas respectively. The ages reported by Cormier and Smith (1973) have recently been recalculated using revised half-life values (1.42 x 10^{-11} vs. 1.39 x 10^{-11}; R.F. Cormier, personal communication, 1994)) resulting in "younger" ages (e.g. ca. 395 compared with 417 Ma), however, the circa 60 Ma. difference in ages between the two granite suites persisted.

The wide range of ages from the above studies are contradictory to the field evidence outlined above. In particular, ages exceeding 400 Ma. would imply that the granitic rocks were intruded and crystallized through Rb-Sr and K-Ar "blocking temperatures" prior to deposition of the intruded country rocks. Similarly, young ages (i.e. 240-300 Ma) would dictate that some granitic rocks were intruded after the deposition of Carboniferous sediments that onlap over parts of the batholith.

Reynolds et al., (1980, 1981) determined the ages of granitoid rocks from the Meguma Zone using K-Ar and $^{40}Ar/^{39}Ar$ methods on biotite, muscovite and feldspar separates. With the exception of one discordant age spectrum, samples from the batholith ranged from 351 to 380 Ma with a mean age of 366.7 $\pm$1.3 Ma (N=23). Reynolds et al. (1981) concluded that the age of the biotite granodiorite (366.6 Ma) was indistinguishable from the age of the "younger" adamellites and late intrusions (366.8 Ma). They concluded that temperatures throughout the batholith must have remained above the "argon retention temperatures" (ca. 300-350°C for biotite; ca. 350°C for muscovite; McDougall and Harrison, 1988) until the intrusion of the late intrusive bodies. Clarke and Halliday (1980) calculated Rb-Sr isochrons for whole-rock samples and mineral separates (plagioclase, alkali feldspar, biotite and muscovite). Their samples were collected during the mapping of McKenzie (1974) and Charest (1976) and included 'granodiorite, adamellite and porphyry" which correspond to: granodiorite and biotite monzogranite;

muscovite-biotite monzogranite and coarse-grained leucomonzogranite; and fine-grained leucomonzogranite and leucogranite of this study. They noted systematic variations in both age and initial ratios for the three rock phases including: granodiorite - 371.8$\pm$ 2.2 Ma, $(Sr^{87}/Sr^{86})_i$ 0.7076$\pm$0.0003 to 0.7090$\pm$0.0003, avg. 0.7081; adamellite - 364.3$\pm$ 1.3 Ma, $(Sr^{87}/Sr^{86})_i$ 0.70942$\pm$35; and porphyry - 361.2$\pm$ 1.4 Ma, $(Sr^{87}/Sr^{86})_i$ 0.71021$\pm$119. They concluded that the age difference between the granodiorite and late-stage porphyries confirmed the intrusive sequence and represented emplacement of early granodiorite, adamellites and late-staged intrusive bodies over a 10 My time interval.

Harper (1988) determined ages for part of the same suite of samples used in the study of Clarke and Halliday (1980) using both Rb-Sr and U/Pb techniques. He reproduced the same apparent age of the monzogranite (i.e. adamellite) but suggested a primary crystallization age of 371$\pm$5 Ma for muscovite separates. He also was able to reproduce their 361$\pm$2 Ma age for leucomonzogranite (i.e. porphyry) but, once again, indicated a primary crystallization age of 369.6$\pm$6 Ma for muscovite separates. Harper determined U-Pb ages of 374.3$\pm$1.9 and 372.8$\pm$2.1 Ma for monazite separates from monzogranite and leucomonzogranite respectively. Harper's (1988) work established that all phases of the batholith crystallized circa 370 Ma and, consequently, the circa 10 My gap in Rb-Sr isochron ages may reflect disruptions in this isotopic system.

O'Reilly et al. (1985) calculated Rb-Sr whole-rock and muscovite ages for leucomonzogranite and leucogranite rocks associated with polymetallic deposits in the eastern part of the batholith. They reported "young" whole-rock ages of 332$\pm$10 Ma (MSWD = 1.53, N=6) and 270$\pm$14 Ma (MSWD = 1.21, N=5) for the Long Lake and Westfield deposits respectively and 281$\pm$5 Ma for the Lake Darling deposit. They suggested that these ages, which strongly contrasted the older (ca. 370 Ma) ages for much of the batholith, constituted evidence for Carboniferous-aged magmatism and mineralization.

Zentilli and Reynolds (1985) reported $^{40}Ar/^{39}Ar$ ages for muscovite and biotite separates from the East Kemptville Sn deposit and its host Davis Lake Pluton. They noted that ages in, and immediately adjacent to, the deposit ranged from 295-350 which contrasted with ages ranging from 317-372 in other portions of the Davis Lake Pluton. They concluded that the circa 300 Ma plateau ages for muscovite greisen from the East Kemptville deposit represented the age of mineralization and attending hydrothermal alteration.

Reynolds et al. (1987) measured $^{40}Ar/^{39}Ar$ ages for micas, K-feldspars and hornblendes from several plutons in the southern part of the Meguma Zone. They concluded that most of the plutons were intruded at 370 Ma, along with the batholith. In addition they reported several "younger" ages that were interpreted as representing a later thermal event at circa 300-320. They also reported an episode of argon loss between 220 and 230 Ma in K-feldspars from the southern plutons that was also interpreted as a "thermal pulse".

Richardson et al. (1989) presented Rb-Sr geochronological and geochemical evidence to suggest that the Davis Lake Pluton was of Carboniferous age and unrelated to the remainder of the Devonian-aged South Mountain Batholith. They reported a whole-rock Rb-Sr "scatterchron" age of 336 ± 14 Ma (MSWD = 24) for eight samples of biotite monzogranite and biotite-chlorite-muscovite monzogranite (i.e. Davis Lake Leucomonzogranite of this study). They also calculated a Rb-Sr isochron for five samples, collected away from the granite/metasediment contact, which yielded a 330 ± 7 Ma age (MSWD = 2.8). They concluded that Sr from assimilated metasedimentary rocks was responsible for the three samples near the contact having isotopic heterogeneities resulting in large MSWD values. Richardson et al. (1989) interpreted the five point Rb/Sr isochron age of 330 ±7 Ma to represent the time of intrusion and crystallization of the Davis Lake pluton, despite the previously published $^{40}Ar/^{39}Ar$ mica dates of ca. 370 Ma (Reynolds et al., 1981; Zentilli and Reynolds, 1985). The data of Richardson et al. (1989) have recently been recalculated and subsequently yield an isochron age of circa 370 Ma (D.J. Kontak, personal communication, 1994). The discrepancy between these ages is tentatively interpreted as stemming from mathematical errors in the calculations of Richardson et al. (1989).

Kontak et al. (1989) and Kontak and Cormier (1991) determined Rb-Sr isochrons for whole-rock and mineral separate (muscovite, plagioclase, K-feldspar) and $^{40}Ar/^{39}Ar$ age determinations on muscovite separates for 11 samples of the East Kemptville leucogranite. They reported an 11 point Rb-Sr isochron of 344 ± 5 Ma that was consistent with some age spectra of 338 ± 2 Ma for muscovite separates. Kontak and Cormier (1991) concluded that internal re-equilibration of Sr among mineral separates and whole-rock had occurred. They reported Rb-Sr isochron ages of 361-311 Ma (average age 330 Ma) for seven whole-rock - muscovite pairs and 276-240 Ma (average age 254 Ma) for seven whole-rock - plagioclase - K-feldspar groups. An

Rb-Sr isochron age of 320±4 Ma was determined for seven muscovite separates. They also noted wide ranges in $^{40}Ar/^{39}Ar$ age spectra with strong discordance of age spectra, particularly in low temperature "steps". Kontak and Cormier (1991) explained the wide ranges of ages, re-equilibration for Sr and discordant $^{40}Ar/^{39}Ar$ spectra as representing episodic thermotectonism along the East Kemptville shear zone.

Clarke et al. (1993) determined $^{40}Ar/^{39}Ar$ age spectra for high purity (>99%) muscovite separates from 12 leucogranite and leucomonzogranite bodies from the eastern portion of the batholith (Figure 7.1). They concluded that the step-wise release spectra yielded excellent

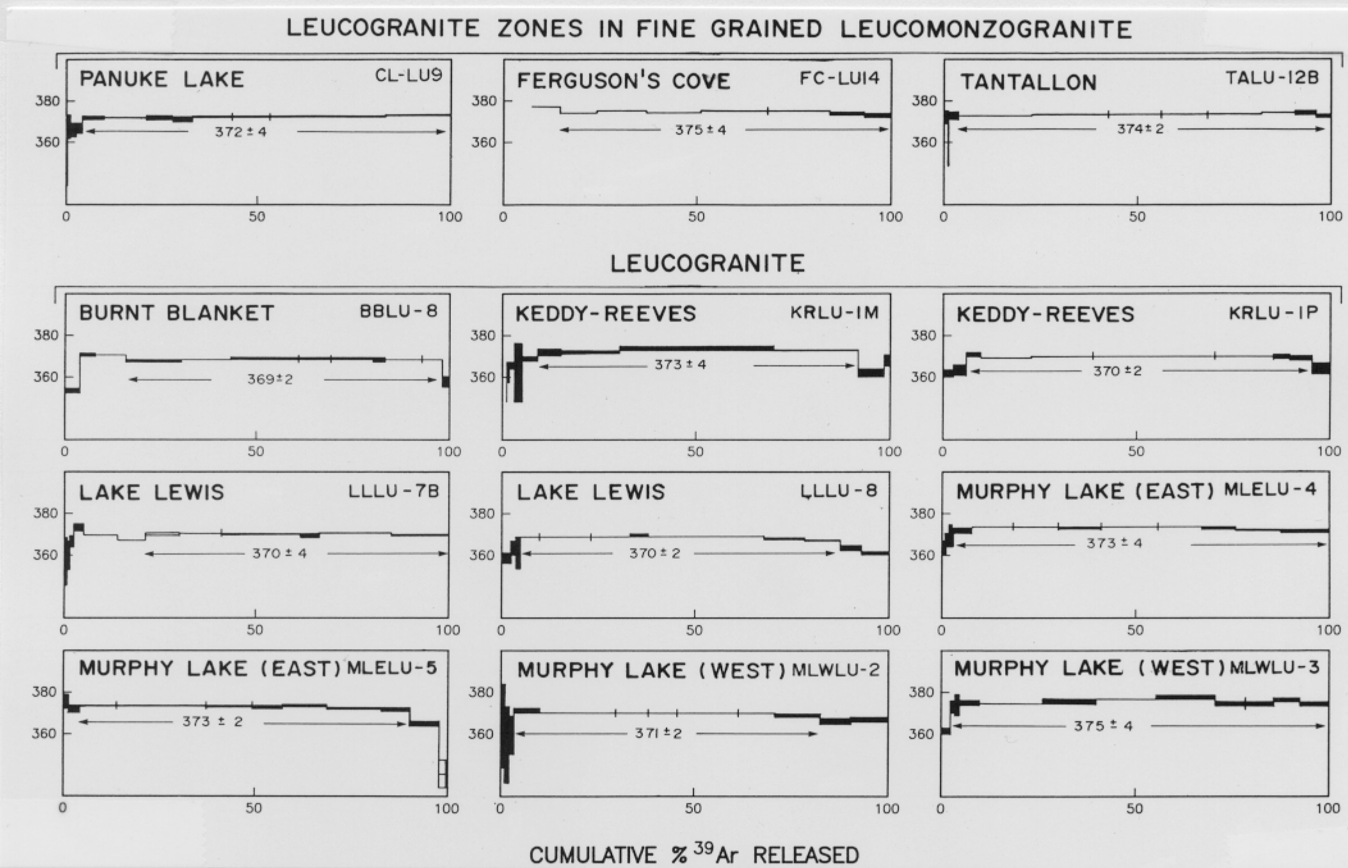

Figure 7.1 $^{40}Ar/^{39}Ar$ age spectra for twelve muscovite separates from leucogranite samples from the eastern portion of the South Mountain Batholith (modified after Clarke et al., 1993). The three spectra at top are from leucogranite zones within fine grained leucomonzogranite bodies whereas the nine spectra at the bottom are from discrete leucogranite bodies.

plateaus for all samples. They noted slight lowering of the apparent age of some samples over the first few percent of gas released. The plateau ages from their study ranged from 369±2 Ma to 375±4 Ma with a mean plateau age of 371.5±2.5 Ma for the entire data set. Their data confirms that the ages of the late-stage leucogranites are remarkably similar to early granodiorite units. Clarke et al. (1993) noted that the consistency of published ages derived using the K-Ar, $^{40}Ar/^{39}Ar$, Rb-Sr, U-Pb and Pb-Pb isotopic systems necessitates rapid crystallization and cooling of the batholith.

Keppie et al. (1993) determined ages for sample suites from the Millet Brook (U-Cu-Ag) and Westfield (W-Sn-Cu-Pb-Zn-Au-Ag) deposits. They used $^{40}Ar/^{39}Ar$ techniques for muscovite separates and U-Pb methods for monazite and zircon separates. The granodiorite from the Millet Brook area yielded a 377+5/-3 Ma age (concordant U-Pb monazite date). They also calculated ages of 377-373 Ma, based on $^{40}Ar/^{39}Ar$ plateau ages for muscovite, for the late leucomonzogranite intrusions in drill core from the Millet Brook deposit and nearby New Ross Pluton. They noted that these dates were significantly older that the Rb-Sr dates reported by Clarke and Halliday (1980). A U-Pb age of 385±2 Ma was obtained for a zircon sample (intercept age) from the fine-grained leucomonzogranite porphyry at Westfield. This age was in sharp contrast to previously Rb-Sr age of 270±15 Ma (O'Reilly et al., 1985). Keppie et al. (1993) concluded that the age discrepancies between their study and previous works represented fluid-related isotopic resetting of Rb-Sr whole-rock and mineral systems. Conversely, their U-Pb dates could also be explained by a component of inheritance.

Chatterjee and Ham (1991) reported U, Th, Pb and Pb isotopic compositions for 34 samples from stage I and II plutons from throughout the batholith. They calculated whole-rock - mineral separate Pb-Pb isochron ages for biotite granodiorite from a Stage I pluton (373.3±3.6 Ma; MSWD = 2.85) and leucogranite from a Stage II pluton (365.2±5.4 Ma; MSWD = 2.57). Chatterjee and MacDonald (1991) reported a Pb-Pb isochron age of 365.7±2.7 Ma; MSWD = 1.95) for two chemically distinct suites of mineralized greisens from the East Kemptville Sn deposit and elsewhere in the Davis Lake Pluton. They also reported a Pb-Pb isochron age of 366.0±5.6 Ma (MSWD = 1.79) for these same greisens and their host leucogranite bodies which approximates a Pb-Pb age of 367.4±4.70 Ma (MSWD = 3.18) for a suite of 24 samples of greisen, leucogranite and coarse-grained leucomonzogranite from the southwestern portion of the Davis Lake Pluton (Figure 7.2a,b; unpublished data, A.K. Chatterjee, 1994). The above results indicate mineralization and crystallization of leucogranite at the East Kemptville deposit were coeval with crystallization of the rest of the Davis Lake Pluton and indeed the entire batholith (cf. Richardson et al., 1989).

Kontak and Chatterjee (1992) conducted a Pb isotopic study of twelve leucogranite samples representing the entire compositional range of the East Kemptville leucogranite and for four galena separates from mineralized greisens at the East Kemptville deposit. They interpreted the close spatial association of galena and black, cassiterite-bearing greisen to represent overlapping paragenesis. In addition to whole-rock analysis, these authors carried out sequential leachate determinations on a mineralized topaz greisen (23% Sn) and on K-feldspar and muscovite separates from one leucogranite sample. The entire Pb-Pb data set, including barren and mineralized leucogranite and greisen, indicated an age of 366±4 Ma (MSWD = 2.63), thus confirming the coeval nature of crystallization of leucogranite and mineralization in the East Kemptville deposit.

7.3 Summary and Discussion

Paleontological data from country rocks and unconformably overlying strata, coupled with geochronological data for deformation and metamorphism in country rocks, constrains the age of intrusion of the batholith to between circa 385 and 355 Ma. The geochronological studies of the granitic rocks of the batholith, outlined above, indicate that all Stage I and II plutons were emplaced, crystallized and generated mineralization within a very narrow time interval, say ≤ 5 Ma at ca. 370 Ma. The concordancy of all the radiometric dating techniques (i.e. K-Ar, $^{40}Ar/^{39}Ar$, Rb-Sr, U-Pb and Pb-Pb) which collectively have a large range in terms of blocking temperatures (i.e. near the solidus to ca. 250°C) implies rapid post-crystallization cooling. Therefore, exhumation must have initiated soon after, or indeed synchronously with, crystallization of the batholith.

Results from Rb-Sr geochronological studies have yielded ages ranging from circa 240-380 Ma although many of the dates cluster around 370 Ma. Some of the variation in the results from early studies (e.g. Fairbairn et al., 1960, 1964) may have arisen from poor analytical apparatus, poor quality standards (i.e. "spikes") or from the use of different half-life constants. However, the diversity of ages from more recent studies have been interpreted as reflecting geological processes in the batholith. A plot of age-corrected (372 Ma) initial ratios for 110 published Rb-Sr isotopic analyses, along with sample locations, is given in Figure 7.3a (unpublished information, A.K. Chatterjee, 1993). Initial $^{87}Sr/^{86}Sr$ ratios range from 0.680 to 0.724 for the entire data set, which has a K/Rb range of 33-250. Two sub-sets of data were selected for study including

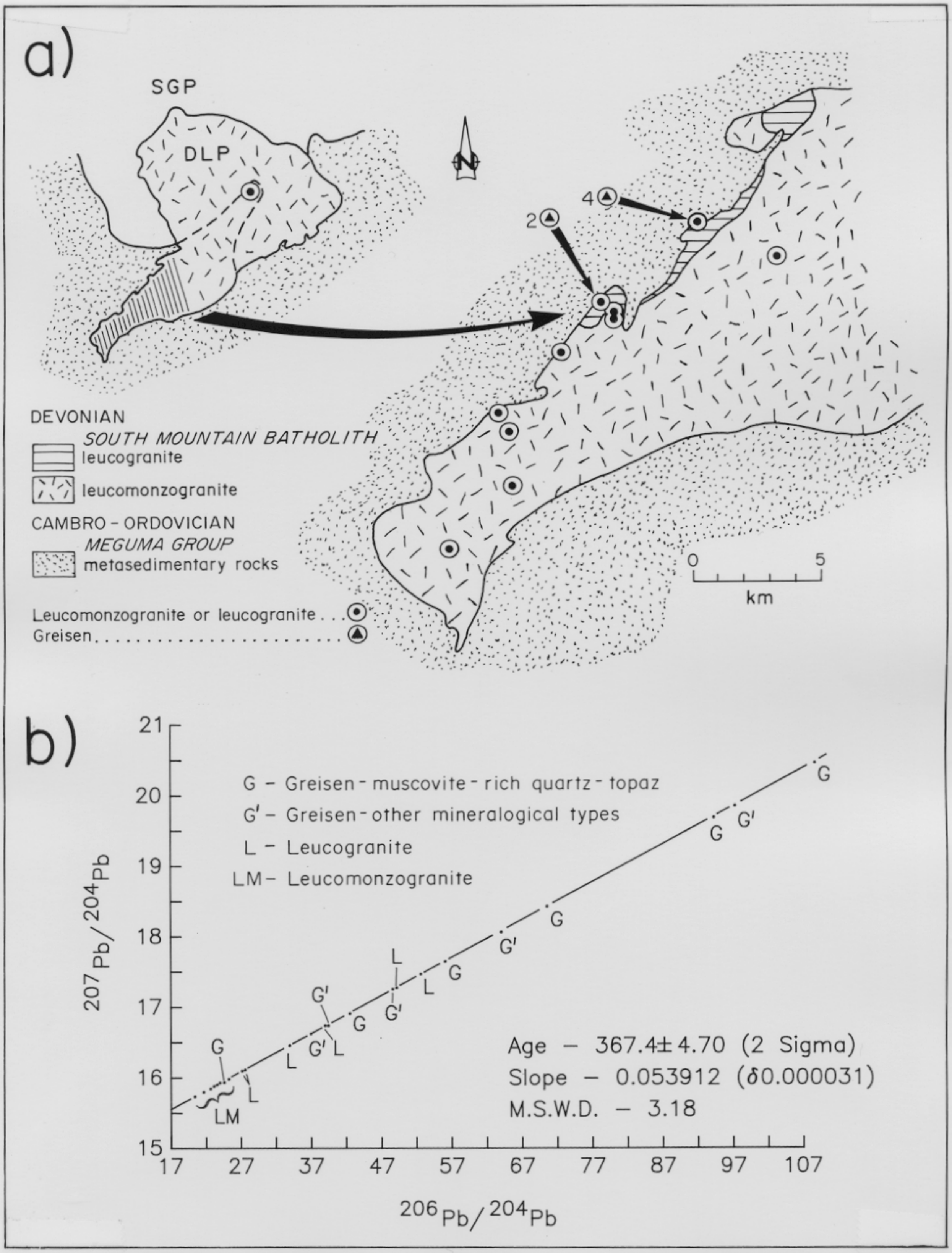

Figure 7.2 Pb-Pb isotopic analyses for a suite of 24 samples of greisen, leucogranite and coarse-grained leucomonzogranite from the southwestern portion of the Davis Lake Pluton (unpublished data, A.K. Chatterjee, 1994): a) sample location map; b) $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ plot for the entire data set (N=24).

samples with K/Rb values of 100-250 and 150-250 and are plotted in Figures 7.3b and c. Clearly, as samples with increasing K/Rb are selected, the initial $^{87}Sr/^{86}Sr$ ratios become more tightly constrained (0.704-0.710 for K/Rb = 100-250; 0.706-0.708 for K/Rb = 150-250). In Chapter 5 it was demonstrated that K/Rb is an effective measure of the degree of fluid/rock or fluid/melt interaction and that rocks with K/Rb$\geq \approx$ 150 have largely been unaffected by fluids. Therefore the data presented in Figure 7.3 suggests that the Sr isotopic system has been disrupted by fluid-related interaction. Clearly this disturbance may be localized along structural features where episodic thermotectonism has been documented, such as along the East Kemptville Shear Zone (Kontak and Cormier, 1991). However, it should be noted that this isotopic disruption may also explain younger Rb-Sr ages, such as those reported by Clarke and Halliday (1980), in regions of the batholith with no pronounced structural deformation.

The majority of ages for the granitic rocks of the batholith, derived using K-Ar and $^{40}Ar/^{39}Ar$ methods, cluster around circa 370 Ma (e.g Reynolds et al., 1980, 1981; Clarke et al., 1993). However, like the data for the Rb/Sr isotopic system, there is a wide spectrum of reported K-Rb and $^{40}Ar/^{39}Ar$ ages for the batholith ranging from circa 250-370 Ma. Some workers have ascribed these 'young' ages to resetting from 'thermal pulse(s)' (Reynolds et al., 1987) whereas other workers concluded that thermotectonic effects along major structures were responsible for Ar loss and subsequent resetting of dates (Kontak et al., 1989; Kontak and Cormier, 1991). In general, K-Ar and $^{40}Ar/^{39}Ar$ geochronological data indicates the batholith cooled through temperatures of approximately 300-350°C at circa 370 Ma with later post-crystallization resetting in several areas throughout the batholith.

Age determinations obtained using U-Pb methods for zircon or monazite separates (Harper, 1980; Keppie at al., 1993) mainly yield circa 370$\pm$5 Ma ages for the various phases of the batholith, although it should be noted that the number of determinations is somewhat limited. An exception is the 385$\pm$2 Ma intercept U-Pb age for zircon from the Westfield deposit. Keppie et al. (1993) calculated a $^{40}Ar/^{39}Ar$ plateau age of 368.2$\pm$6 Ma for a muscovite separate from fine-grained leucomonzogranite at the Westfield deposit. They concluded that the U-Pb zircon age represented time of crystallization ("closure temperature" >750-650°C) whereas the $^{40}Ar/^{39}Ar$ muscovite age represented cooling through $\approx$375-400°C (350°C if data from McDougall and Harrison (1988) are used). However, the circa 20 My gap between crystallization and cooling

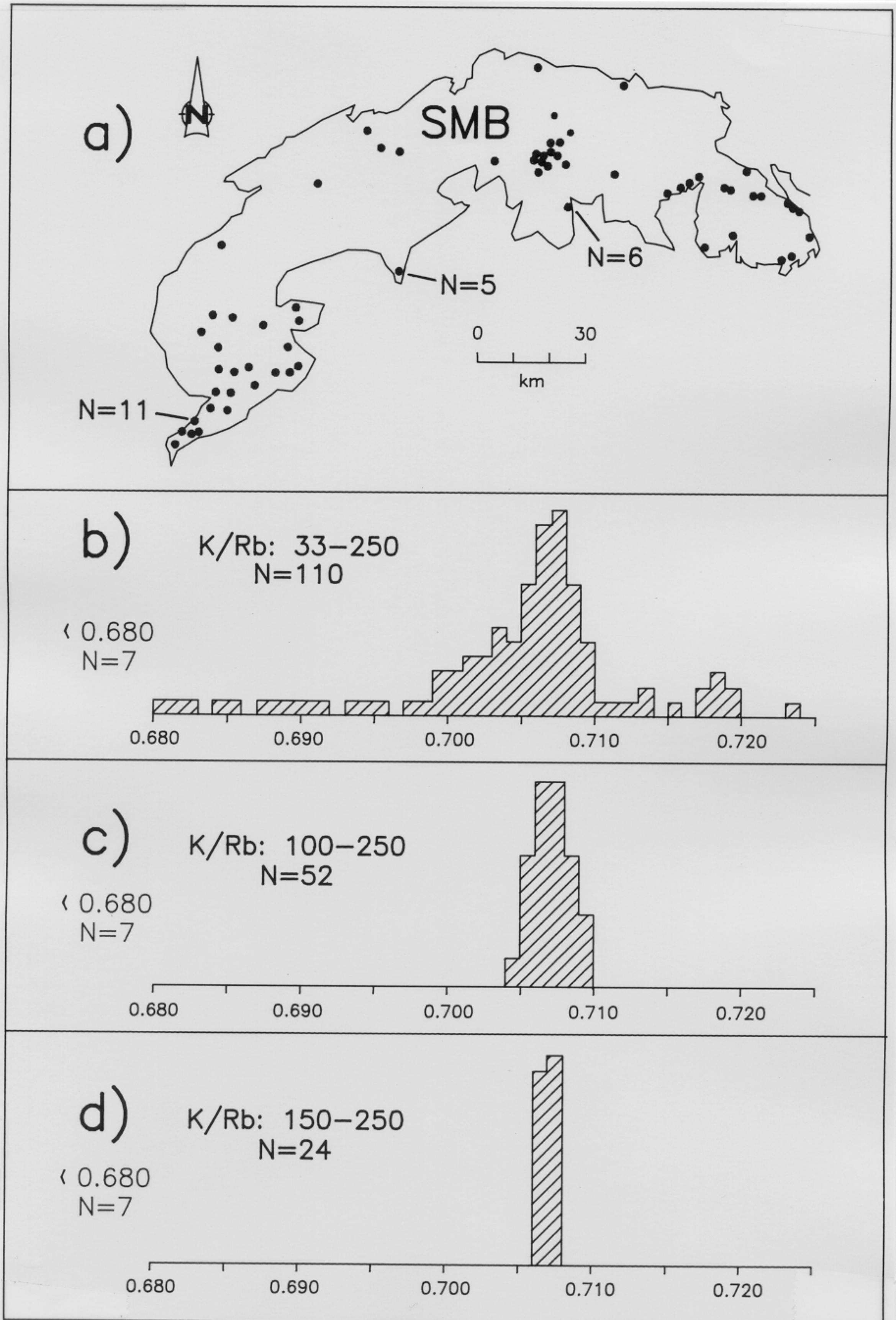

Figure 7.3 Decay corrected initial $^{87}Sr/^{86}Sr$ ratios (time = 372 Ma) for 110 published analyses from the South Mountain Batholith (unpublished information. A.K. Chatterjee, 1993): a) sample location map; b) initial $^{87}Sr/^{86}Sr$ ratios for total data set (N=110) with K/Rb range from 33 to 250; c) initial $^{87}Sr/^{86}Sr$ ratios for samples with K/Rb ranging from 100-250 (N=52); d) initial $^{87}Sr/^{86}Sr$ ratios for samples with K/Rb ranging from 150 to 250 (N=24).

is considered to be somewhat unrealistic, particularly in light of the concordancy of all radiometric dates at circa 370 Ma. It is possible that the zircon age may represent incorporation of previously crystallized zircon during emplacement.

All of the reported Pb-Pb data denotes emplacement, crystallization and post-crystallization alteration/mineralization circa 370±5 Ma. Kontak and Chatterjee (1992) suggested their data recorded a mild overprinting of the Pb-Pb data circa 300 Ma but noted that their data were less conclusive than previous Rb-Sr and $^{40}Ar/^{39}Ar$ studies. Hence, with the exception of the 385±2 Ma age from Westfield, all U-Pb and Pb-Pb derived ages are in accord. Therefore, the Pb isotopic system, unlike the Rb-Sr, K-Ar and $^{40}Ar/^{39}Ar$ systems, was largely unaffected by resetting from either thermotectonism or fluid-driven isotopic re-equilibration.

Despite the restricted time of emplacement and crystallization, a systematic sequence of emplacement is evident throughout. First, Stage I plutons were emplaced. Chilled margins and other definitive contact relations among Stage I plutons are generally absent, although exposed contacts are rare. Stage II plutons were emplaced subsequent to Stage I intrusion. Several Stage I - Stage II pluton contacts were observed. With the exception of a gradational contact at the margin of the Halifax Pluton, all Stage I and II contacts appear to be intrusive in nature. None of the Stage II plutons has chilled margins, with the exception of a narrow zone (<200 m) along the northern contact of the East Dalhousie pluton and surrounding country rocks. The coarse-grained megacrystic units of the Stage II plutons were the first to crystallize. Contacts between these units were noted to be both intrusive and gradational. The emplacement of the fine-grained leucomonzogranite and leucogranite bodies appear to represent the final magmatic event, with the exception of a few fine-grained leucomonzogranite bodies that are in gradational contact with host megacrystic rocks (textural equivalents). The paucity of chilled margins indicates contemporaneous cooling of the various plutons, thus supporting the geochronological data. This factor, coupled with the lack of definitive contact relations at the major pluton boundaries, inhibits any further refinement of the overall emplacement history for the thirteen plutons.

It should be noted that although the arithmetic mean of most ages for the batholith cluster around 370 Ma, there are age discrepancies of several million years within most studies. For example the $^{40}Ar/^{39}Ar$ ages for muscovite separates from leucogranites reported by Clarke et al.

(1993) actually range from 369±2 to 375±4 Ma. These ages may represent subtle differences in emplacement age, both within and between, individual Stage I and II plutons. In fact, it is possible that there are subtle variations in ages throughout the batholith that indicate its exact emplacement and/or cooling history. However, further geochronological studies, involving several isotopic systems, are required to fully unravel this sequence.