Chapter 1

OVERVIEW

1.1 Introduction

The South Mountain Batholith is an arcuate composite granitoid batholith that outcrops in southwestern Nova Scotia. The batholith, which extends from the city of Halifax to near Yarmouth, occupies an area of approximately 7300 km^2 and is the largest granitoid body in the entire Appalachian Orogen of eastern North America. The batholith is bounded by Latitudes 44°00' and 45°00' and Longitudes 63°30' and 66°00' and outcrops in portions of Halifax, Hants, Lunenburg, Kings, Queens, Annapolis, Digby, Yarmouth and Shelburne Counties (Fig. 1.1).

The batholith was the target of sporadic mineral exploration activity from the late 1800's to present. The largest exploration "boom", which occurred between the middle 1970's and the early 1980's, led to the discovery of the East Kemptville Mine (Sn-Zn-Cu-Ag; Richardson et al., 1982) northeast of Yarmouth, and the Millet Brook deposit (U-Cu-Ag; Chatterjee et al., 1985), south of Windsor (Fig. 1.1). The chief catalyst for this exploration "pulse" was the recognition that the batholith and, in fact, most of the granitoid bodies of the Meguma Zone are similar in composition to the granitoid bodies of worldwide "tin belts". In particular the batholith closely resembles Hercynian-aged granites in the Cornwall district of England and the Massif Central area of France. These areas are host to numerous "gregarious" Sn-W-U-Mo deposits and subsequently the discovery of the East Kemptville and Millet Brook deposits was considered to be merely the "tip of the iceberg" (Giles and Chatterjee, 1984).

In spite of the extensive exploration activity, the geological map of the batholith, prior to the commencement of this project (Keppie, 1979), was principally based on reconnaissance mapping by McKenzie (1974) and Smith (1974). Therefore, the South Mountain Batholith project was initiated by the Nova Scotia Department Natural Resources as part of the 1984-1989 Canada-Nova Scotia Mineral Development Agreement. The primary objectives of the project were to produce detailed (1:50,000 scale) geological maps for the entire batholith and surrounding country rock/cover rock sequences and to conduct follow-up petrographic, geochemical and mineral deposit studies of specific aspects of the granitoid rocks where deemed necessary. This information would subsequently be used to evaluate the overall

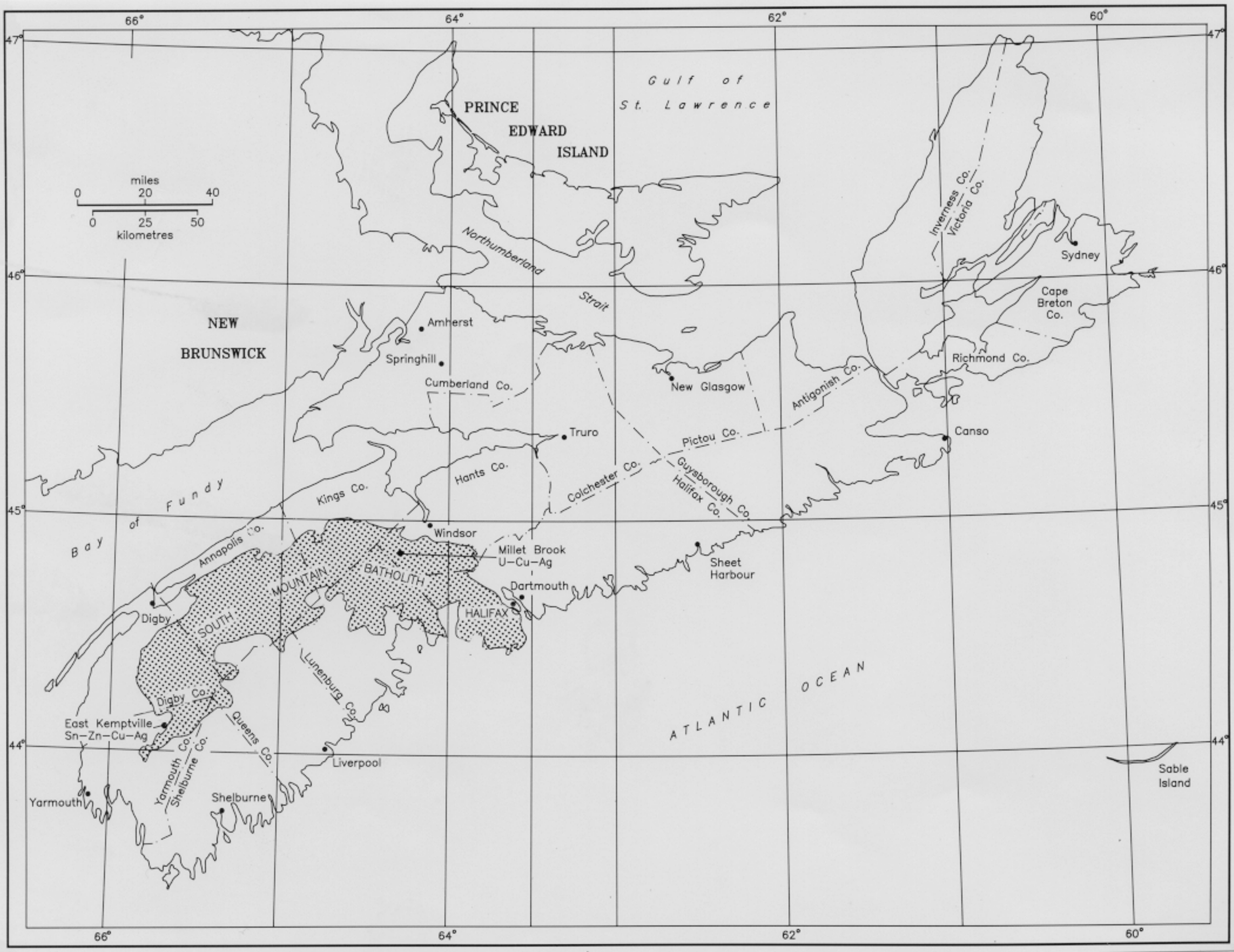

Figure 1.1 Location map for the South Mountain Batholith showing the county boundaries for southwestern Nova Scotia and the location of the East Kemptville and Millet Brook deposits.

economic potential of the batholith. Geological mapping began in 1984 with a detailed investigation of the textural diversity of rocks along a section of highway between Halifax and Chester (MacDonald, 1985). Detailed mapping of the entire batholith commenced in 1985 and was completed in 1988.

The purpose of this report is to present a comprehensive summary of the mapping methodology, petrographic nomenclature and the organization of rock units and results of field mapping from the South Mountain Batholith project. The report also presents summaries of new and published information pertaining to various geological aspects of the batholith including: petrology, geochemistry, structural geology, mode of emplacement, time of emplacement and crystallization, economic geology and exploration methodologies. In addition, a 1:250,000 scale coloured compilation map outlining the geology of the batholith is included (NSDNR Map 94-01, in pocket in back).

1.2 Regional Geological Setting

The South Mountain Batholith is located within the Meguma Terrane (Fig. 1.2), a suspect terrane of the Appalachian Orogen (Williams and Hatcher, 1983). Pre-granitic rocks in the Meguma Terrane include the Cambro-Ordovician Meguma Group and overlying Siluro-Devonian (Emsian) White Rock and Torbrook Formations (Taylor, 1969). The former is comprised of Goldenville Formation psammites and conformably overlying Halifax Formation pelites, whereas the latter comprises mixed volcanic rocks, volcaniclastic and metasedimentary rocks. These rocks were regionally metamorphosed and deformed during the Mid- to Late Devonian Acadian Orogeny (Keppie and Dallmeyer, 1987; Muecke et al., 1988). Following the regional deformation and metamorphism, numerous meta- and peraluminous granitic intrusions, including the South Mountain Batholith, were emplaced ca. 370 Ma (Fairbairn et al., 1964; Clarke and Halliday, 1980; Reynolds et al., 1981, 1987). The batholith is overlain by coarse clastic terrestrial sedimentary rocks of the Horton Group of Tournaisian age (Bell and Blenkinsop, 1960; Howie and Barss, 1975; Utting et al., 1989) to Late Devonian age (Boehner and Giles, 1993). Thus, the times of intrusion, crystallization and unroofing are restricted to a very narrow interval between the Emsian and early Tournaisian periods.

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 orthogneiss and paragneiss complex with associated gabbroic 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) concluded, on the basis of detailed petrographic and geochemical studies, that the Liscomb gneisses are chemically distinct from the Meguma Group rocks and represent a sample of the lower crust.

Ruffman and Greenough (1990) reported 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)

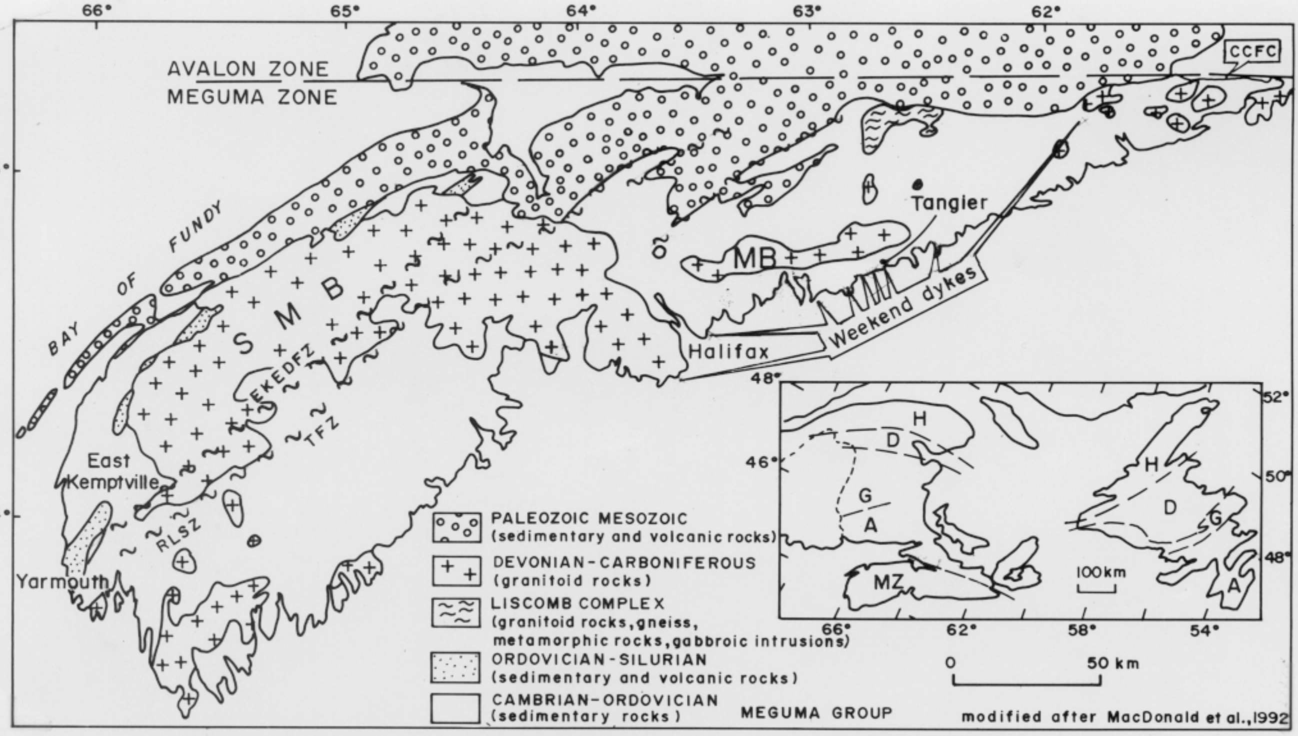

Figure 1.2 Geological map of the Meguma Terrane showing the location of the South Mountain Batholith (SMB) and the Musquodoboit Batholith (MB). The boundary between the Meguma and Avalon Terranes is marked by the Cobequid Chedabucto fault system (CCFS). The location of the "Weekend dykes" of Ruffman and Greenough (1990), including the Tangier dyke of Chatterjee and Giles (1988), and the Liscomb Complex (Giles and Chatterjee, 1986, 1987; Clarke et al., 1993), are given. The locations of the Tobeatic fault zone (TFZ; Giles, 1985), East Kemptville-East Dalhousie fault zone (EKEDFZ; Horne et al., 1988) and Rushmere Lake shear zone (RLSZ; Smith, 1985) are given.

reported $^{40}Ar/^{39}Ar$ ages of 370 ± 2 and 367 ± 2 Ma for two of the Weekend dykes in the vicinity of Tangier (Fig. 1.2) suggesting that the dykes may have been emplaced synchronously with the Liscomb gneisses. 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 and concluded that these xenoliths represent upper crustal material from the Avalon terrane that was rapidly subducted beneath the Liscomb gneisses to lower crustal P-T conditions during the mid- to late-Devonian.

1.3 Previous Work

Several geological mapping projects have been conducted in the South Mountain Batholith and a list of previous workers with their respective subdivision criteria is presented in Table 1.1. Early mapping projects (e.g. Faribault, 1908) delineated the boundaries of the batholith, but no attempt was made to divide the granitic rocks into lithotypes. Faribault (1924) first delineated

Table 1.1 Review of criteria for subdivision of granitic rocks of the South Mountain Batholith.

Author(s)	CRITERIA										COMMENTS
	QAP	GR SIZE	TEX	MODAL MINERALOGY					PLAG COMP	XEN ABUND	
				BIOT	MUSC	CORD	GARN	MEGA			
Faribault (1924)				x	x						2 divisions: biot granite and musc granite
Taylor (1969)			x	x	x					x	2 divisions: biot granite and musc granite with "porphyritic" (i.e. megacrystic) and "xenolith" qualifiers
Smitheringale (1973)	x	x	x							x	7 divisions: (e.g. medium grained non-porphyritic quartz monozonite)
Cormier and Smith (1973); Smith (1974, 1979)	x		x	x	x				x		4 divisions: granodiorite; porphyritic quartz monzonite; muscovite-biotite granite; and alaskite
McKenzie (1974); McKenzie and Clarke (1975)	x		x	x	x				x		3 divisions: granodiorite; adamellite (i.e. monzogranite); and minor intrusives (further subdivided into porphyry, alaskite and leucoadamellite)
Charest (1976)	x		x	x	x				x		5 divisions: granodiorite; adamellite (i.e. monzogranite); porphyry; leucoadamellite; and mica aplite
Present study	x	x	x	x	x	x	x	x			6 main divisions (descriptions in text)

Abbreviations: QAP-modal proportions of quartz-alkali feldspar-plagioclase; GR SIZE-grain size; TEX-texture; BIOT-biotite; MUSC-muscovite; CORD-cordierite; GARN-garnet; MEGA-feldspar megacrysts; PLAG COMP-An content of plagioclase; XEN ABUND-abundance of xenoliths.

different types of granite in the vicinity of Mahone Bay based on the dominance of biotite over muscovite. Taylor (1969) reported the texture (i.e. porphyritic [megacrystic in this report] or non-porphyritic), dominant mica type (i.e. biotite versus muscovite) and the presence or absence of metasedimentary xenoliths for outcrop in the western part of the batholith (west of Longitude 64°00'). However, he did not subdivide the granitic rocks into mappable units on the basis of this information. Subsequent mapping programmes employed various textural and mineralogical criteria to separate the rocks (Table 1.1).

Smitheringale (1973) mapped parts of N.T.S. map sheets 21A/12(east half), 21A/14(east half) and 21A/15(west half). He subdivided the granitic rocks of the South Mountain Batholith and the satellite plutons that intruded Cambrian to Silurian aged metasedimentary and metavolcanic rocks north of the batholith. Granitoid rocks were classified according to the relative proportions of quartz, alkali feldspars and plagioclase and subsequently designated as granodiorite and monzonite (i.e. monzogranite in this study). Rocks were further subdivided on the basis of grain size and texture (e.g. porphyritic [megacrystic in this study], equigranular, seriate). He also noted the presence of metasedimentary xenoliths, although this feature was not used as a criteria for classification. Smitheringale (1973) delineated seven granite map units using the above criteria.

McKenzie (1974) conducted reconnaissance geological mapping of the central portion of the batholith extending from Highway #8 eastward to Highway #14. Granitoid rocks were first divided on the basis of the proportions of quartz, alkali feldspar and plagioclase and termed granodiorite and adamellite (i.e. monzogranite in this study). The modal proportions of biotite and muscovite were also noted for each map unit. McKenzie (1974) observed that the granodiorite was predominantly porphyritic (i.e.megacrystic) in texture but also delineated a band of "augen"-textured granodiorite in the north-central part of his study area. Four adamellite bodies were described, including the Lake George, Springfield Lake and West Dalhousie Adamellites and the New Ross-Vaughan Complex. These bodies were further subdivided into textural and compositional sub-types (e.g. porphyritic, medium grained equigranular). In addition, numerous small bodies ($<$1-5 km^2) of "minor intrusive", including alaskite and leucoadamellite, were outlined. These late-staged rocks were defined on the basis of the modal amounts of biotite and muscovite and the anorthite content of plagioclase feldspars.

Smith (1974) conducted reconnaissance geological mapping of the eastern portion of the batholith from the city of Halifax to St. Margaret's Bay. He divided the granitoid rocks, on the basis of the proportions of quartz, alkali feldspar and plagioclase, into granodiorite, monzonite (i.e. monzogranite in this study), muscovite-biotite granite (i.e. monzogranite/syenogranite in this study). The texture and modal amounts of biotite and muscovite were also noted for each rock type. Smith (1974) also outlined a series of late-staged alaskite bodies that intruded the above rocks. Alaskite was defined on the basis of low biotite content and anorthite content of plagioclase (i.e. $An_{<5}$).

Charest (1976) applied the same rock classification scheme as McKenzie (1974) for a detailed mapping project in the New Ross area of the batholith. He divided the granitoid rocks into granodiorite, porphyritic adamellite, porphyry and leucoadamellite (i.e. megacrystic monzogranite, porphyritic leucomonzogranite and leucogranite in this study). Charest (1976) also introduced the term "mica aplite" for adamellite with fine grained equigranular matrix and coarse grained muscovite$\pm$biotite rosettes.

Dwyer (1976) mapped the part of the batholith between the study areas of McKenzie (1974) and Smith (1974). He divided the granitic rocks into adamellite (i.e. monzogranite) and granodiorite and noted that the monzogranitic rocks of the New Ross-Vaughan Complex

(McKenzie, 1974) extended to the east, and were continuous with the monzonite (i.e. monzogranite) rocks of the Halifax Pluton (Smith, 1974). Similarly Dwyer (1976) concluded that the granodiorite body from the New Ross-Vaughan Complex could be extended to a thin wedge of granodiorite along the margin of the Halifax Pluton.

Keppie (1979) compiled the results of McKenzie (1974), Smith (1974) and Dwyer (1976) and produced a general geology map for the batholith (Figure 1.3) consisting of a three-fold classification scheme that included granodiorite, monzogranite and alaskite.

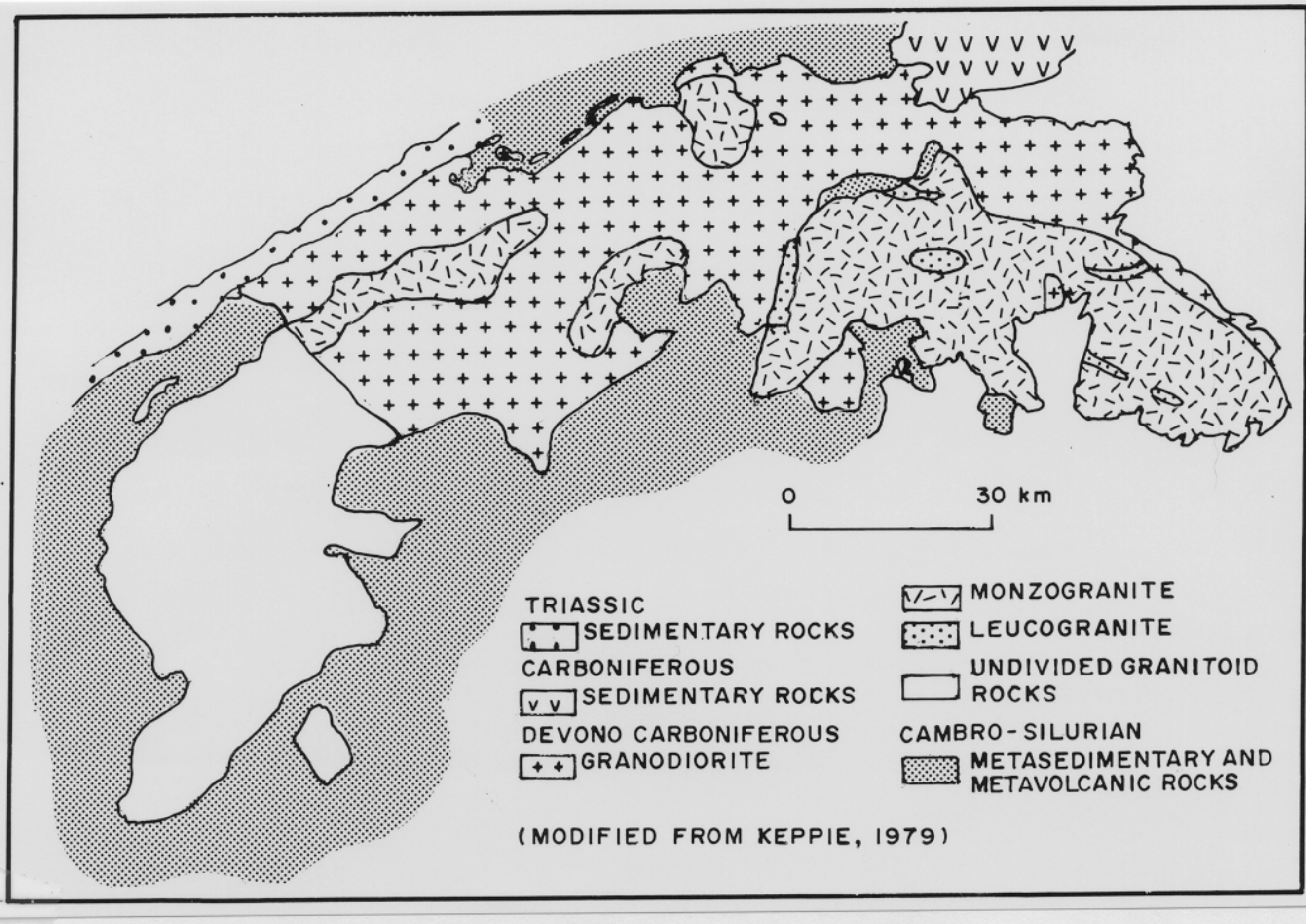

Figure 1.3 General geological map of the South Mountain Batholith, surrounding Cambro-Silurian country rocks and overlying Carboniferous and Triassic sedimentary rocks (modified after Keppie, 1979). This map was compiled from the results of McKenzie (1974), Smith (1974) and Dwyer (1976).