Geology of the South-Central Cape Breton Highlands (Parts of NTS Sheets 11K/07 and 11K/10), Inverness and Victoria Counties, Nova Scotia

R.J. Horne

Minerals and Energy Branch
Paper 95-2

Nova Scotia
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Honourable Donald R. Downe
Minister

William D. Hogg, C.A.
Deputy Minister

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GEOLOGY OF THE SOUTH-CENTRAL CAPE BRETON HIGHLANDS (PARTS OF NTS SHEETS 11K/07 AND 11K/10), INVERNESS AND VICTORIA COUNTIES, NOVA SCOTIA

by

R. J. Horne

ABSTRACT

Bedrock mapping (1:10 000 scale) of pre-Carboniferous rocks in the south-central Cape Breton Highlands was undertaken during the 1990 and 1991 field seasons. The mapped area occurs mainly within the Aspy Terrane, which is underlain by low- to high-grade, Ordovician to older, metastratified units and Ordovician to Devonian or younger plutons. A small area included in the Bras d'Or Terrane, occurring in the northeastern part of the mapped area, is underlain by Precambrian diorite. The results of this mapping, including unit subdivisions, structure, metamorphism and economic geology are presented and the preliminary results of new U-Pb (zircon) age dates for three plutonic units are given.

Medium- to coarse-grained diorite in the northeastern corner of the mapped area belongs to the Kathy Road dioritic suite (Ᵽ$_{KR}$; 560±2 Ma, U-Pb, zircon, Dunning et al., 1990). A fault contact is interpreted between this unit and younger rocks of the Aspy Terrane which dominate the mapped area. Aspy Terrane units include: the primarily metasedimentary, low- to medium-grade (garnet-staurolite zone) Jumping Brook metamorphic suite (ꞒO$_{JB}$), and medium- to high-grade (kyanite±sillimanite zone) Middle River metamorphic suite (ꞒO$_{MR}$); gneissic (kyanite±sillimanite zone) Pleasant Bay complex (ꞒO$_{PB}$), including the Late Ordovician Belle Côte Road orthogneiss (O$_{PBbc}$; 442±3 Ma, U-Pb, zircon, G. Dunning, personal communication, 1995); the primarily metavolcanic, low grade (garnet zone) Sarach Brook metamorphic suite (S_{SB}; 433+7/-4 Ma, U-Pb, zircon, Dunning et al., 1990); the foliated Taylors Barren pluton (S_{TB}; 430±2 Ma, U-Pb, zircon, G. Dunning, personal communication, 1995); and unfoliated Devonian to Carboniferous intrusions, including the West Branch North River pluton (D_{NR}; 399.6±4.6 Ma, Rb-Sr whole rock, O'Beirne-Ryan and Jamieson, 1986; 385±5 Ma and 381±5 Ma, $^{40}Ar/^{39}Ar$, biotite, Reynolds et al., 1989), the Bothan Brook pluton (D_{BB}; 376±3 Ma, U-Pb, zircon, G. Dunning, personal communication, 1995), the Boundary Line intrusive suite (DC_{BL}), the Margaree pluton (DC_{MP}; 343±17 Ma, Rb-Sr whole rock, O'Beirne-Ryan et al., 1986; 368 Ma and 375 Ma, $^{40}Ar/^{39}Ar$, biotite, Reynolds et al., 1989) and the Peters Brook pluton (DC_{PB}).

Field relations and geochronology provide constraints on the depositional, structural, metamorphic and plutonic history of the Aspy Terrane in the mapped area. The Belle Côte Road orthogneiss is interpreted to have intruded the Jumping Brook and Middle River units and paragneiss of the Pleasant Bay complex, therefore constraining their age as Ordovician or older. A similar metamorphic, structural history is displayed by the Jumping Brook metamorphic suite, Middle River metamorphic suite and Pleasant Bay complex, with matrix-porphyroblast relations indicating development of two metamorphic fabrics. The Pleasant Bay complex was intruded by the foliated (augen) Taylors Barren

pluton. The principal fabric in the Jumping Brook, Middle River, Pleasant Bay and Taylors Barren units and transposed intrusive contacts between the Belle Côte Road orthogneiss and older units (inferred) and the Taylors Barren pluton and the Pleasant Bay complex are roughly parallel indicating regional deformation overlapped intrusion of the Belle Côte Road orthogneiss and Taylors Barren pluton, i.e. Late Ordovician to Early Silurian. Folding of the principal fabric in these units defines a regional U-shaped map pattern. The age of this deformation is constrained between emplacement of the Taylors Barren pluton and West Branch North River pluton, the latter of which truncated the regional fold pattern, i.e. Early Silurian to Early Devonian. Other Devonian or younger, unfoliated intrusions, including the Bothan Brook, Margaree and Peters Brook plutons intruded earlier, foliated units. The Sarach Brook metamorphic suite does not exhibit evidence of the regional deformation found in the above units and has been juxtaposed adjacent to the Middle River unit by movement on the mylonitic Southern Highlands shear zone (SHSZ). Shear fabrics indicate oblique movement on the north-northeastward-trending, moderately westward dipping SHSZ, however the sense of displacement is unclear. The SHSZ deforms, and may be partly coeval with, the Late Devonian Bothan Brook pluton. The mylonitic, northward-trending, steep Coinneach Brook shear zone (CBSZ) deforms the Jumping Brook metamorphic suite and West Branch North River pluton in the northern part of the area and is probably coeval with the SHSZ. Oblique, dextral/west-sideup movement is indicated for the CBSZ. Late, steep, brittle (cataclastic) faults deform the shear zones and commonly form unit boundaries. Geochronological data indicate progressive regional cooling, from 650°C in the Late Silurian to 300°C in the Late Devonian. Unroofing during this interval is consistent with the change from ductile (foliations) to brittle-ductile (mylonites) to brittle (cataclastic faults) deformation.

Several mineral occurrences and alteration zones occur within the study area. Most mineralization and alteration overprint tectonic fabrics and are probably related to the Devonian-Carboniferous granitoids.

ACKNOWLEDGMENTS

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INTRODUCTION

GENERAL GEOLOGICAL SETTING

The Cape Breton Highlands form an elevated area of pre-Carboniferous plutonic and metamorphic rocks located in northern Cape Breton Island (Fig. 1, p. 6). Early reconnaissance mapping of the Cape Breton Highlands was carried out mainly by the Geological Survey of Canada (e.g. MacLaren, 1956a, 1956b; Kelley, 1957, 1960, 1967; Neale, 1963a, 1963b, 1964a, 1964b; Milligan, 1970; Currie, 1978) a compilation of which was presented by Keppie (1979). Local detailed mapping included Wiebe (1972, 1975) and Smith and Macdonald (1981, 1983). More recently, 1:50 000 scale maps have been presented for the whole of the Cape Breton Highlands (Barr et al., 1987a), resulting in a comprehensive map of the area with correlation of rock units throughout the Cape Breton Highlands (Barr et al., 1992). In spite of the considerable number of studies carried out in the Cape Breton Highlands the protoliths of the metamorphic units, particularly the gneisses, remain a contentious issue (e.g. Jamieson et al., 1991; Keppie et al., 1991).

The Cape Breton Highlands are characterized by north-northeastward-trending belts of gneissic, meta-sedimentary-metavolcanic and igneous rocks (Fig. 1, p. 6). This area has traditionally been ascribed to the Avalon Terrane of the Appalachian Orogen (Williams, 1979). Barr and Raeside (1989) proposed that contrasts in the pre-Carboniferous geology of the Cape Breton Highlands justify its subdivision into three tectono-stratigraphic terranes as follows (Fig. 2, p. 7): (1) the Blair River Complex (Barr et al., 1987b) is characterized by Helikian gneiss and syenite-anorthosite intrusions. U-Pb (zircon) dating of the Blair River Complex has been interpreted to constrain a minimum age of 1217 Ma for the Sailors Brook gneiss and igneous ages of 978+6/-5 Ma and 1035+12/-10 Ma for the Otter Brook orthogneiss and Lowland Brook syenogranite (Miller and Dunning, 1993). The Blair River Complex is interpreted as Grenvillian basement and correlated with the Humber Terrane in Newfoundland. It is separated from the Aspy Terrane by the mylonitic Red River and Wilkie Brook Faults (Fig. 1, p. 6); (2) the Aspy Terrane comprises low- to high-grade, Ordovician-Silurian metavolcanic and metasedimentary rocks intruded by Ordovician to Devonian-Carboniferous granitoids and is correlated with the Exploits and Gander Terrane in Newfoundland and the Miramichi Terrane in New Brunswick; (3) the Bras d'Or Terrane is characterized by low pressure gneiss, Cambrian and older metamorphic units and Precambrian to Cambrian plutons. The Bras d'Or Terrane is correlated with parts of the Exploits and Gander Terrane in Newfoundland and part of the Avalon Terrane in New Brunswick. The Bras d'Or and Aspy Terranes are separated by the Eastern Highlands Shear Zone (Fig. 1, p. 6).

The Terranes proposed by Barr and Raeside (1989) are not completely accepted. Keppie et al. (1990) and Keppie (1990) included the whole of the Cape Breton Highlands within the Avalon Composite Terrane, which is then defined by the presence of a lower Paleozoic overstep sequence containing a distinctive Cambrian-Ordovician, Acado-Baltic fauna and Silurian-Gedinnian, Rhenish-Bohemian fauna. Lynch and Tremblay (1992) interpreted geological contrasts in the Cape Breton Highlands as reflecting a regional unconformity between overlying rocks of the younger Aspy Terrane and older rocks of the Bras d'Or Terrane. Lynch et al. (1993) suggested this unconformity is represented by a paraconformity between basal conglomerate of the Chéticamp Lake metamorphic suite (Aspy Terrane) and McMillan Flowage Formation (Bras d'Or Terrane) (Lin et al., 1991) and an unconformity between basal conglomerate of the Mabou Highlands metamorphic suite and plutonic basement rocks of uncertain age. A similar interpretation was presented by Lin (1993) and is supported by the occurrence of `Bras d'Or Terrane rocks' (Chéticamp pluton, Fig. 1, p. 6) within the Aspy Terrane, and the lack of an identified basement for the Aspy Terrane. More recently, Lynch and Lafrance (1994) proposed the high grade (gneissic) rocks within the Highlands, including rocks of both the Bras d'Or and Aspy Terranes, represent a nappe emplaced over `nongneissic' rocks during the Early Devonian. Later folding of the related thrust and erosion resulted in the current map patterns.

The following paper presents the results of mapping and detailed, follow-up study of an area of the south-central Cape Breton Highlands. The study area is located northeast of Margaree Centre and comprises parts of NTS map sheets 11K/07 and 11K/10 (Fig. 1, p. 6). The area occurs at the eastern margin of the proposed Aspy Terrane and locally includes the Precambrian Kathy Road dioritic suite of the Bras d'Or Terrane. Preliminary results of this study

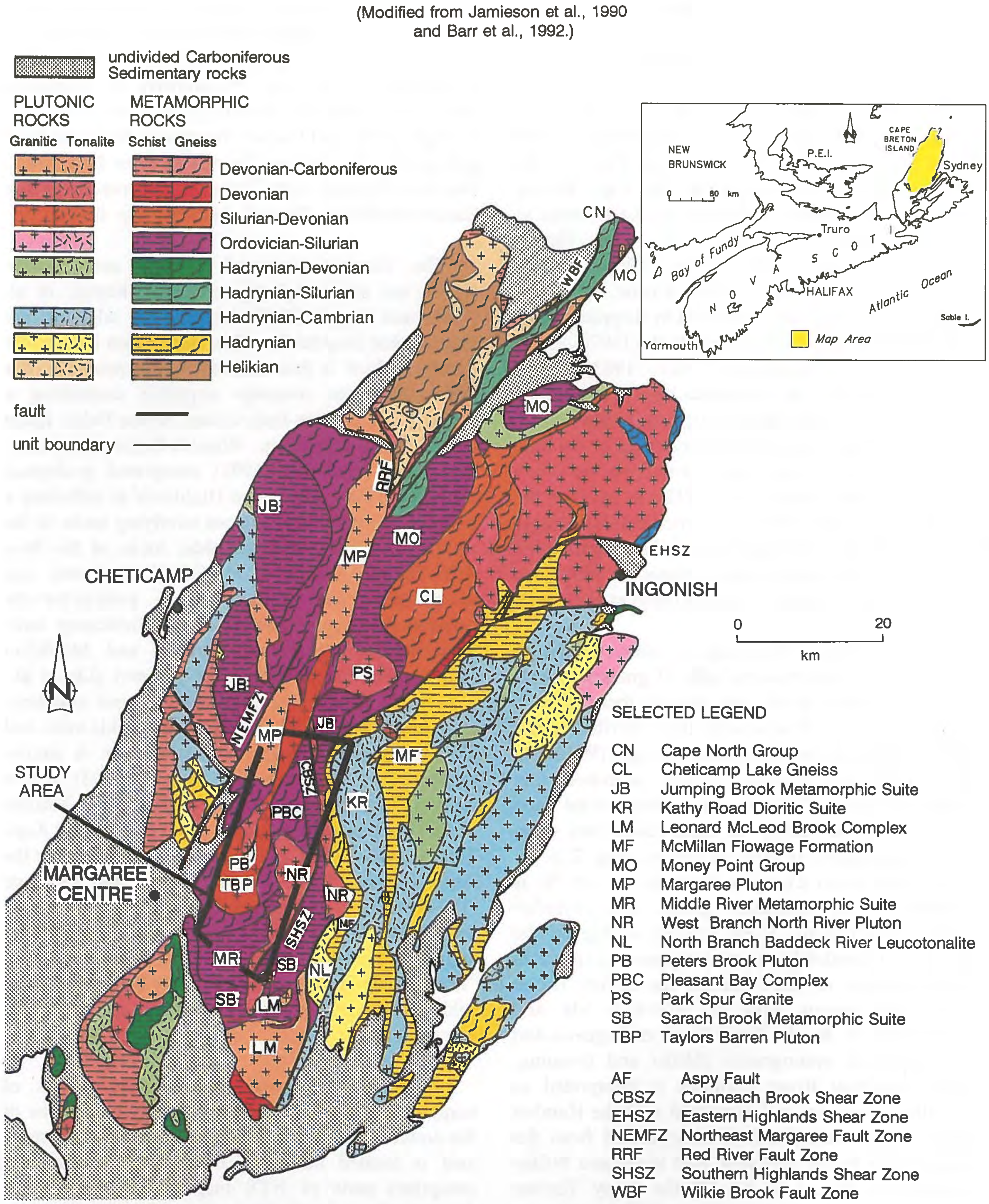


Figure 1. General geological map of the Cape Breton Highlands showing the location of the study area.

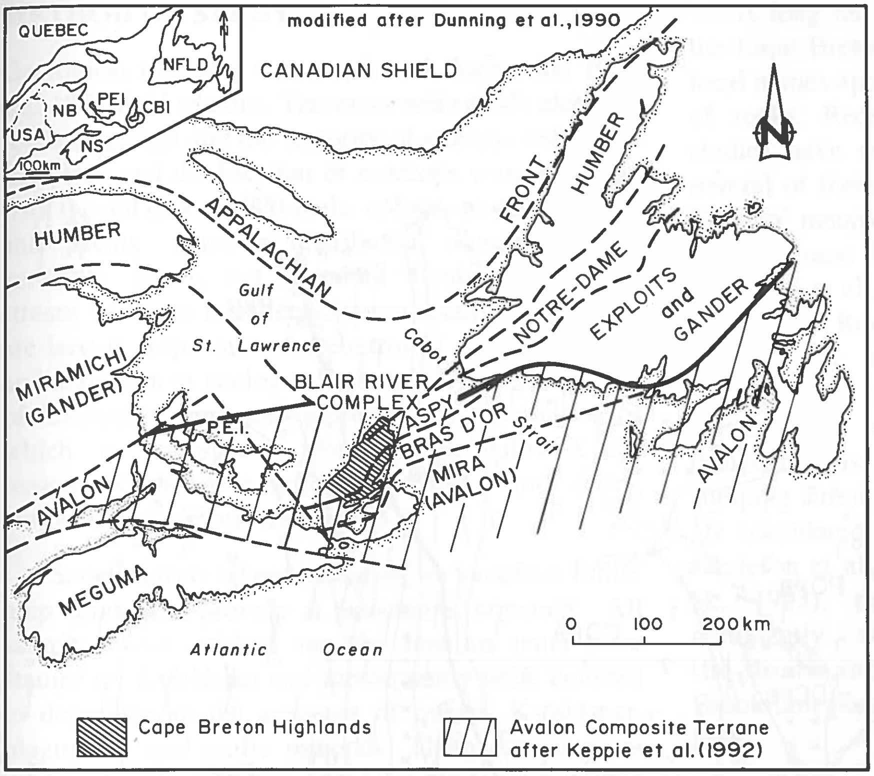


Figure 2. Tectono-stratigraphic map of the northern Appalachian Orogen showing differing interpretations of the Cape Breton Highlands. Barr and Raeside (1989) subdivided the Highlands into three tectono-stratigraphic terranes: Blair River Complex, Aspy Terrane and Bras d'Or Terrane. In contrast, Keppie et al. (1992) included the Highlands in the Avalon Composite Terrane.

were presented in Horne (1991, 1994). Concurrent bedrock mapping east of the study area is presented by Ham (1994) and correlation of units between the two areas has been established (Fig. 3, p. 8).

PREVIOUS WORK

Several previous mapping efforts were carried out within the study area; correlation of previous mapping with the units established here is presented in Table 1 (p. 10-11). General mapping by the Geological Survey of Canada was carried out by Kelley (1960), who produced the first detailed geological map of the area. This work subdivided the area into Precambrian to pre-Mississippian metasedimentary, metavolcanic, gneissic and intrusive units and provided a general geological framework for the area. Milligan (1970) mapped the metamorphic rocks in the southern part of the mapped area which he correlated with the Precambrian George River Group.

More recent, detailed mapping within the area includes that by Jamieson et al. (1987), Jamieson (1981), Jamieson and Doucet (1983) and Jamieson and Craw (1983). The results of this work are compiled in Barr et al. (1987a, 1992) who showed the area to be underlain by the Kathy Road dioritic suite, Pleasant Bay complex, Middle River metamorphic suite, Sarach Brook metamorphic suite, Jumping Brook metamorphic suite, Taylors Barren pluton, West Branch North River pluton, Leonard MacLeod Brook complex and undifferentiated, unfoliated granitoid rock (Fig. 1, p. 6). Several geochronological studies have been carried out within the study area and are discussed within individual lithologic unit descriptions.

PHYSIOGRAPHY AND GLACIATION

The Cape Breton Highlands form an elevated plateau (peneplain) of pre-Carboniferous basement rocks which has been referred to as the Northern Tableland of Cape Breton Island (Goldthwait, 1924). This plateau is incised by numerous rivers and streams which locally produce steep river valleys. The large north-northeastward-trending Northeast Margaree River valley forms the western boundary of the mapped area with several of its tributaries cutting steep-sided valleys through the area. The southern part of the study area is cut by the southward flowing Middle River and its tributaries.

A study of the surficial geology of the mapped area conducted concurrently with this study by Finck (1992) indicated that products of in situ weathering processes predominate over till. The northern part of the area is underlain by approximately 20% till, the maximum thickness of which is <3 m, with the remainder covered by colluvium (approximately 16%), felsenmeer (approximately 41%) and mixed felsenmeer, grus and saprolite (approximately 23%) (Finck, 1992).

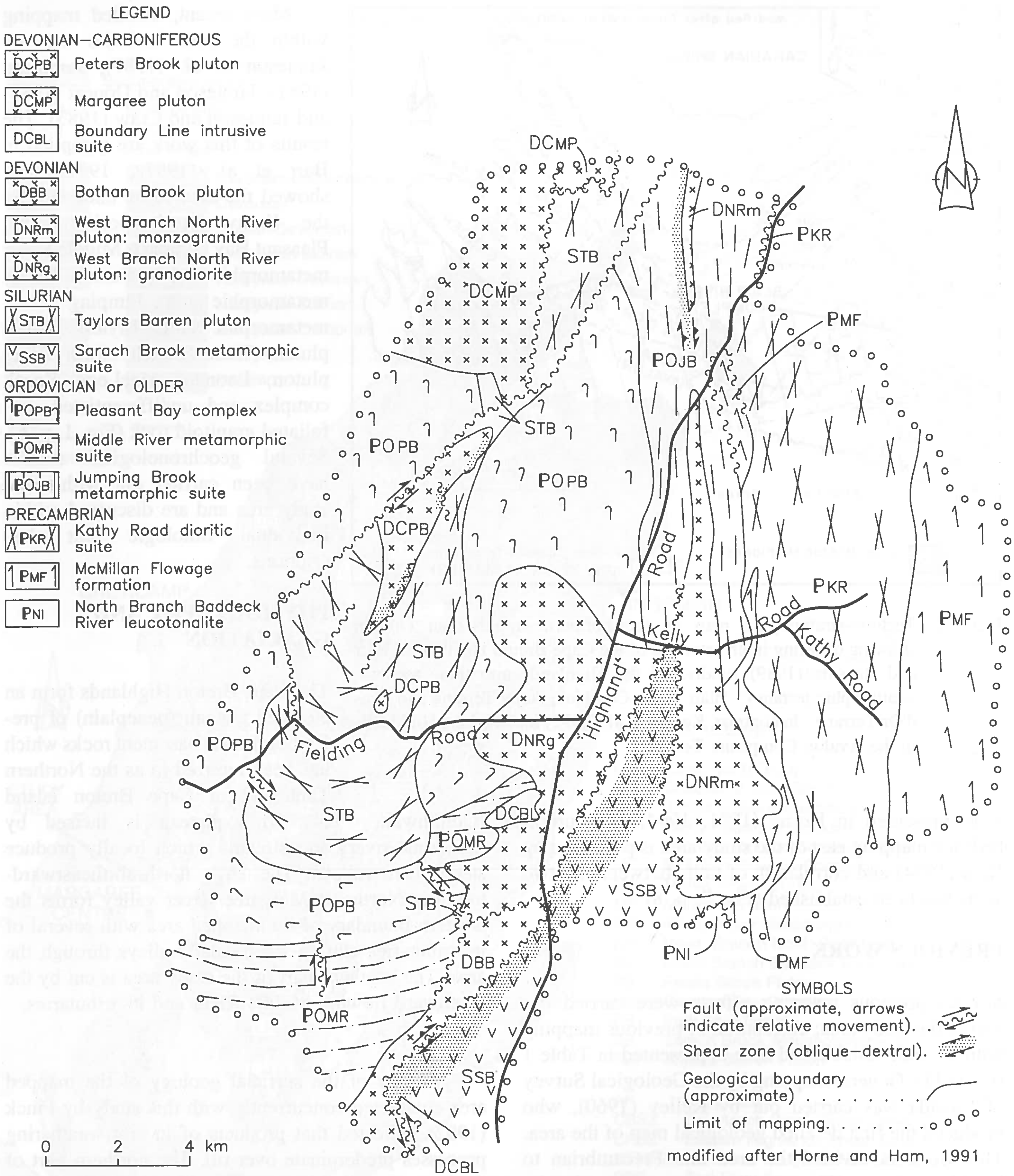


Figure 3. Simplified geology map of the south-central Cape Breton Highlands (includes study area of this paper and the area in Ham (in preparation)).

METHOD OF STUDY

Geological mapping was conducted during the 1990 and 1991 field seasons. Traverses were made along all roads (logging) and the majority of streams within the map area and the location of outcrops were recorded with the aid of 1:10 000 scale, colour, air photographs and pacing. Outcrop distribution along roads is generally spotty, but exposure along streams and stream valleys is excellent. Stream sections, therefore, are largely responsible for control of unit boundaries and definition of geological relationships. Recognition of felsenmeer, grus and saprolite, the distribution of which is widespread along roads, allowed for reasonably confident definition of the overall distribution of the various map units.

Samples were taken to account for variation within map units and provide a reasonable coverage. All samples were slabbed and the igneous units were stained for K-feldspar and subsequently point counted to determine modal amounts of quartz, K-feldspar, plagioclase and mafic minerals. Thin sections were made of representative samples for petrographic assessment. Geochemical analyses were obtained for selected mineralized or altered samples to assess their economic potential. Geochemical analyses were done at the Minerals Engineering Centre, Technical University of Nova Scotia, Halifax. The methods used include colourmetric, atomic absorption, spectrograph, selective ion electrode, Leco induction furnace, and titration.

LITHOLOGY

NOMENCLATURE

As discussed by Jamieson et al. (1987), nomenclature in the Cape Breton Highlands is confusing, particularly in the metamorphic rocks. This resulted, in part, because of the piecemeal approach to mapping with different mappers using different criteria for subdivision. In addition, a general lack of formalization of units has lead to revisions and renaming of units by later workers (Table 1, p. 10-11). Confusion is enhanced by varying interpretations of the status and correlation (grouping) of units (e.g. Barr et al., 1992; Keppie et al., 1992; Lynch et al., 1993; McMullin et al., 1993). Correlation is often obscured by moderate to strong structural and metamorphic modification which inhibits determination of stratigraphy, protolith and age.

A long list of units are currently outlined within the Cape Breton Highlands (Barr et al., 1992), with local names applied to lithologically distinct packages of rocks. Recent geological and geochronological studies have suggested possible age correlation of several of these units, in particular the `Ordovician-Silurian' metavolcanic-metasedimentary rocks of the Aspy Terrane (Fig. 1, p. 6; Barr and Jamieson, 1991; Jamieson et al., 1990; Keppie et al., 1992; Lynch et al., 1993). Regardless of possible age correlation, metamorphic units within the mapped area are distinguished by unique lithologic and structural-metamorphic character and therefore their unit designation is justified. For example, although the Jumping Brook and Sarach Brook metamorphic suites are considered correlative (Barr and Jamieson, 1991; Jamieson et al., 1990; Keppie et al., 1992; Lynch et al., 1993), the lithologic contrast between the dominantly volcanic Sarach Brook unit and the dominantly metasedimentary Jumping Brook unit precludes them being formational equivalents.

Formalization of units within the Highlands should occur on a regional scale, addressing the character of the entire unit. Because none of the units addressed in this study are restricted to the study area, this report has not attempted to make unit names formal. For the most part this report has adopted the unit names presented in Barr et al. (1992), including the Jumping Brook metamorphic suite, Middle River metamorphic suite, Pleasant Bay complex, Sarach Brook metamorphic suite, Taylors Barren pluton, West Branch North River pluton, and Margaree pluton. A paragneiss unit referred to as the First Fork Brook gneiss has been identified within the Pleasant Bay complex. The West Branch North River pluton of Barr et al. (1992) has been subdivided into the West Branch North River pluton and Bothan Brook pluton, similar to the subdivision of Jamieson and Doucet (1983). Recent dating indicates different ages for these units. The Leonard McLeod Brook complex of Barr et al. (1992), within the mapped area, has been renamed the Boundary Line intrusive suite. It comprises fine- to medium-grained monzogranite and diorite. In contrast, the Leonard McLeod Brook complex included screens of metavolcanics (Sarach Brook metamorphic suite) (Raeside and Barr, 1992). The Peters Brook pluton is a new addition.

Table 1. Table of formations with correlation of previous mapping with the units established in the mapped area for this paper for the south-central Cape Breton Highlands.

UNIT (This Paper)	LITHOLOGY	CONTACTS
DEVONIAN-CARBONIFEROUS		
Peters Brook pluton DC$_{PB}$	medium grained, equigranular, pink monzogranite; locally intensely sheared	fault contact with ЄO$_{PB}$; intrusive and fault contact with S$_{TB}$
Margaree pluton DC$_{MP}$	medium- to coarse-grained, megacrystic, biotite (hornblende(?)) rapakivi granite	fault contact with S$_{TB}$; intrusive contact with ЄO$_{PB}$
Boundary Line intrusive suite DC$_{BL}$		intrusive contact with D$_{NR}$; intrusive contact with S$_{SB}$; local fault contact with D$_{BB}$
monzogranite DC$_{BLm}$	fine- to medium-grained, equigranular, pink monzogranite; abundant mafic dykes	
diorite DC$_{BLd}$	medium grained, equigranular, black diorite	
DEVONIAN		
Bothan Brook pluton D$_{BB}$	medium- to coarse-grained, moderately equigranular, pink, biotite±hornblende monzogranite-syenogranite	intrusive contact with ЄO$_{MR}$; fault contact with S$_{SB}$; local fault contacts with ЄO$_{MR}$ and DC$_{BL}$
West Branch North River pluton D$_{NR}$		
monzogranite D$_{NRm}$	medium- to coarse-grained, moderately equigranular, pink, biotite±hornblende monzogranite-syenogranite	fault and intrusive contact with ЄO$_{JB}$
granodiorite D$_{NRg}$	medium- to coarse-grained, light grey, megacrystic, biotite-hornblende granodiorite	intrusive contacts with ЄO$_{PB}$ and S$_{TB}$; local fault contact with S$_{TB}$
SILURIAN		
Taylors Barren pluton S$_{TB}$	variably foliated augen granite	intrusive and local fault contact with ЄO$_{PB}$; fault contact with ЄO$_{JB}$
Sarach Brook metamorphic suite S$_{SB}$	undivided fine- to coarse-grained felsic-intermediate pyroclastics and flows and minor slate; locally mylonitic	fault contacts with D$_{NR}$ and ЄO$_{MR}$
ORDOVICIAN OR OLDER		
Pleasant Bay complex ЄO$_{PB}$		
Belle Côte Road orthogneiss O$_{PBbc}$	light grey, homogeneous, quartz-feldspar-biotite±garnet gneiss and minor amphibolite	intrusive contacts with ЄO$_{MR}$ and ЄO$_{JB}$
First Fork Brook gneiss ЄO$_{PBff}$	variable, banded, mafic quartz-feldspar-biotite-hornblende-garnet gneiss, amphibolite, minor pelitic gneiss	
Middle River metamorphic suite ЄO$_{MR}$	undivided medium- to high-grade metasedimentary rocks; includes psammitic units, biotite-garnet-kyanite schist, amphibolite, marble	intrusive contact with ЄO$_{PB}$ and S$_{TB}$; fault and intrusive contact with D$_{BB}$
Jumping Brook metamorphic suite ЄO$_{JB}$		intrusive and gradational contact with ЄO$_{PB}$, fault contact with S$_{TB}$; fault contact with Ᵽ$_{KR}$
George Brook amphibolite ЄO$_{JBgb}$	fine- to coarse-grained amphibolite	
Corney Brook schist ЄO$_{JBcb}$	medium- to coarse-grained, pelitic mica-garnet-staurolite-kyanite schist	
Dauphinee Brook schist (subunit a) ЄO$_{JBdb-a}$	fine grained, semipelitic, biotite-garnet schist	
Dauphinee Brook schist (subunit b) ЄO$_{JBdb-b}$	psammitic-semipelitic chlorite±garnet±kyanite schist	
PRECAMBRIAN		
Kathy Road dioritic suite Ᵽ$_{KR}$	medium grained, equigranular diorite; locally strongly sheared	fault contact with ЄO$_{JB}$

Table 1. Continued

PREVIOUS ASSIGNMENT	AGE
DEVONIAN-CARBONIFEROUS	
granite, pre-Mississippian (Kelley, 1960)	intruded Taylors Barren pluton
granite and porphyroblastic granite, pre-Mississippian (Kelley, 1960); Margaree granite (Currie, 1978); Margaree pluton (Jamieson et al., 1987; Barr et al., 1987c, 1992)	343±17 Ma, Rb-Sr whole rock (O'Beirne-Ryan et al, 1986); $^{40}Ar/^{39}Ar$ ages of 368 Ma and 375 Ma, biotite (Reynolds et al., 1989)
microgranite-diorite (Jamieson, 1981); Leonard McLeod Brook diorite-microgranite complex, Devonian or earlier (Jamieson and Doucet, 1983); Leonard McLeod Brook complex (Barr et al., 1987a, 1992)	intruded West Branch North River pluton
DEVONIAN	
granite, pre-Mississippian (Kelley, 1960); syenogranite (Jamieson, 1981); Bothan Brook syenogranite, Devonian or older (Jamieson and Doucet, 1983); Bothan Brook pluton (O'Beirne-Ryan and Jamieson, 1986); included with West Branch North River pluton, Devonian (Barr et al., 1992)	376±3 Ma, U-Pb zircon (G. Dunning, personal communication, 1995)
granite, pre-Mississippian (Kelley, 1960); monzogranite-granodiorite (Jamieson, 1981); West Branch North River monzogranite, Devonian (Jamieson and Doucet, 1983); West Branch North River pluton (O'Beirne-Ryan and Jamieson, 1986; Barr et al., 1992)	399.6±4.6 Ma, Rb-Sr whole rock (O'Beirne-Ryan and Jamieson, 1986) $^{40}Ar/^{39}Ar$ age of 385±5 Ma, biotite (Reynolds et al., 1989) $^{40}Ar/^{39}Ar$ age of 381±5 Ma, biotite (Reynolds et al., 1989)
SILURIAN	
granite gneiss, pre-Mississippian (Kelley, 1960); granite, Devonian or earlier (Milligan, 1970); foliated syenogranite (Jamieson, 1981); foliated granitic rocks, late Precambrian (Jamieson and Craw, 1983); Egypt Highland unit, late Precambrian(?) (Jamieson and Doucet,1983; Doucet, 1983); Taylors Barren pluton, Silurian (Barr et al., 1987a, 1992; Jamieson et al., 1987)	419±17 Ma, Rb-Sr whole rock (Gaudette et al., 1985); 430±2 Ma, U-Pb zircon (G. Dunning, personal communication, 1995)
metasedimentary rocks and minor metavolcanic rocks, Precambrian (Kelley, 1960); George River Group, Precambrian (Milligan, 1970); Northern (Crowdis Mountain) volcanic unit, Late Precambrian (Jamieson and Doucet, 1983); Sarach Brook metamorphic suite, Silurian (Barr et al., 1987a, 1992)	433+7/-4 Ma, U-Pb zircon (Dunning et al., 1990)
ORDOVICIAN OR OLDER	
mixed rocks, Precambrian (Kelley, 1960); Pleasant Bay complex, Silurian or older (Jamieson et al., 1987; Barr et al., 1987a, 1992); Pleasant Bay complex (Currie, 1987)	
Belle Côte Road gneiss (Jamieson et al., 1987)	433+20/-10 Ma, U-Pb zircon (Jamieson et al., 1986); 386±3 Ma, U-Pb titanite (Barr and Jamieson, 1991); 442±3 Ma, U-Pb zircon (G. Dunning, personal communication, 1995) 411±2 Ma, U-Pb monazite, 376±4 Ma U-Pb, rutile (Barr and Jamieson, 1991)
mixed rocks, pre-Mississippian (Kelley, 1960); George River Group, Precambrian (Milligan, 1970); Middle River metamorphic complex (Jamieson, 1981); gneiss complex, Late Precambrian (Jamieson and Craw, 1983); Middle River unit, Late Precambrian (Jamieson and Doucet, 1983); Middle River metamorphic suite (Barr et al., 1987a, 1992)	$^{40}Ar/^{39}Ar$ ages of 388 Ma and 390 Ma, hornblende, and 370 Ma, biotite (Reynolds et al., 1989); 386±9 Ma, hornblende and 377±9 Ma, biotite (Doucet, 1983)
mixed rocks, Precambrian (Kelley, 1960); Jumping Brook metamorphic suite, Silurian or older (Jamieson et al., 1987; Barr et al., 1987a, 1992)	U-Pb (zircon) age of 439 ± 7 Ma for dyke interpreted as feeder of basal rhyolite (Currie et al., 1982)
George Brook amphibolite (Jamieson et al., 1987; Barr et al., 1987a, 1992)	$^{40}Ar/^{39}Ar$ ages of 383 Ma and 384 Ma, hornblende, for George Brook amphibolite and 383 Ma, biotite and 390 Ma, hornblende for the Corney Brook schist (Reynolds et al., 1989)
Corney Brook schist (Jamieson et al., 1987; Barr et al., 1987a, 1992)	
Dauphinee Brook schist (Jamieson et al., 1987; Barr et al., 1987a, 1992)	
Dauphinee Brook schist (Jamieson et al., 1987; Barr et al., 1987a, 1992)	
PRECAMBRIAN	
hornblende-biotite-quartz-feldspar gneiss, hornblende-biotite-feldspar gneiss, diorite, quartz diorite, granodiorite, minor granite, pre-Mississippian (Kelley, 1960); Kathy Road dioritic rocks, Ordovician-Devonian (Barr et al., 1987a, 1992)	560±2 Ma, U-Pb, zircon (Dunning et al., 1990)

A summary of lithologic units, contact relations, published and new age determinations and correlation of units with previous mapping is presented in Table 1 (p. 10-11).

PRECAMBRIAN

Kathy Road Dioritic Suite (Ᵽ$_{KR}$)

Definition and Previous Work

The Kathy Road dioritic suite (Ᵽ$_{KR}$) occurs only locally along the eastern margin of the mapped area and is included within the Bras d'Or Terrane of Barr and Raeside (1989). This unit is well exposed west of the Highland Road and the reader is referred to Ham (in preparation) for a detailed account. The Ᵽ$_{KR}$ corresponds to the Kathy Road dioritic rocks of Barr et al. (1987a, 1992) and forms a large, north-south-trending body of massive and variably foliated diorite in the south-central Cape Breton Highlands (Fig. 1, p. 6). Kelley (1960) included this unit within undivided hornblende-biotite-quartz-feldspar gneiss, hornblende-biotite-feldspar gneiss, diorite, granodiorite and minor granite.

Distribution and Field Observations

Within the study area the Ᵽ$_{KR}$ is limited to an area including two short unnamed roads south of Coinneach Brook Road (Fig. 4, in pocket). No outcrops were observed in the area, however the presence and distribution of this unit is confidently established by felsenmeer. The Ᵽ$_{KR}$ in this area is dominated by massive, medium grained, equigranular diorite which locally displays a strong, penetrative foliation, interpreted to reflect ductile shearing.

Contacts

The unexposed contact with the adjacent Jumping Brook metamorphic suite (Dauphinee Brook schist subunit b) is represented by an abrupt lithologic change in felsenmeer over only a few metres. The presence of shear zones in both units near the assumed contact and the relative ages of the two units (the intrusive Ᵽ$_{KR}$ is the older unit) implies a fault contact. A fault is shown in this area by Barr et al. (1992; Devonian mylonite unit) which has been referred to as the Eastern Highlands Shear Zone (EHSZ) and interpreted as the boundary between the Bras d'Or and Aspy Terranes (Barr and Raeside, 1989; Fig. 2, p. 7).

Age

A U-Pb (zircon) age of 560±2 Ma obtained in the southern part the Ᵽ$_{KR}$ indicates this unit is a Late Precambrian to Cambrian intrusion (Dunning et al., 1990).

ORDOVICIAN OR OLDER

Jumping Brook Metamorphic Suite (ЄO$_{JB}$)

Definition and Previous Work

The Jumping Brook metamorphic suite (ЄO$_{JB}$) consists of a north-northwestward-trending sequence of low- to medium-grade pelitic to psammitic schist and amphibolite occurring in the northeastern part of the study area (Figs. 3, p. 8; and 4, in pocket). The ЄO$_{JB}$ is located at the eastern margin of the Aspy Terrane and forms a narrow belt between the Kathy Road dioritic suite to the east and the Pleasant Bay complex and Taylors Barren pluton to the west (Figs. 1, p. 6; and 3, p. 8). The term Jumping Brook metamorphic suite has been adopted from Jamieson et al. (1987), who showed extension of this unit north of the mapped area and proposed correlation with similar rocks in the Chéticamp area (Fig. 1, p. 6). Earlier mapping (Kelley, 1960) included this unit with undivided metamorphic rocks.

Within the mapped area the ЄO$_{JB}$ comprises four distinct map units, including the pelitic and psammitic varieties of the Dauphinee Brook schist, the Corney Brook schist and the George Brook amphibolite, each of which forms narrow north-northwestward-trending belts (Fig. 4, in pocket). Metamorphic grade increases progressively westward, from the biotite-garnet zone of the Dauphinee Brook unit to the staurolite zone of the Corney Brook unit (Fig. 5, p. 13).

Dauphinee Brook Schist (ЄO$_{JBdb}$)

Distribution and Field Observations

The Dauphinee Brook schist consists of two distinct units within the mapped area.

The **psammitic schist** (ЄO$_{JBdb-b}$) is dominated by a distinctive, medium grained, light grey, well foliated

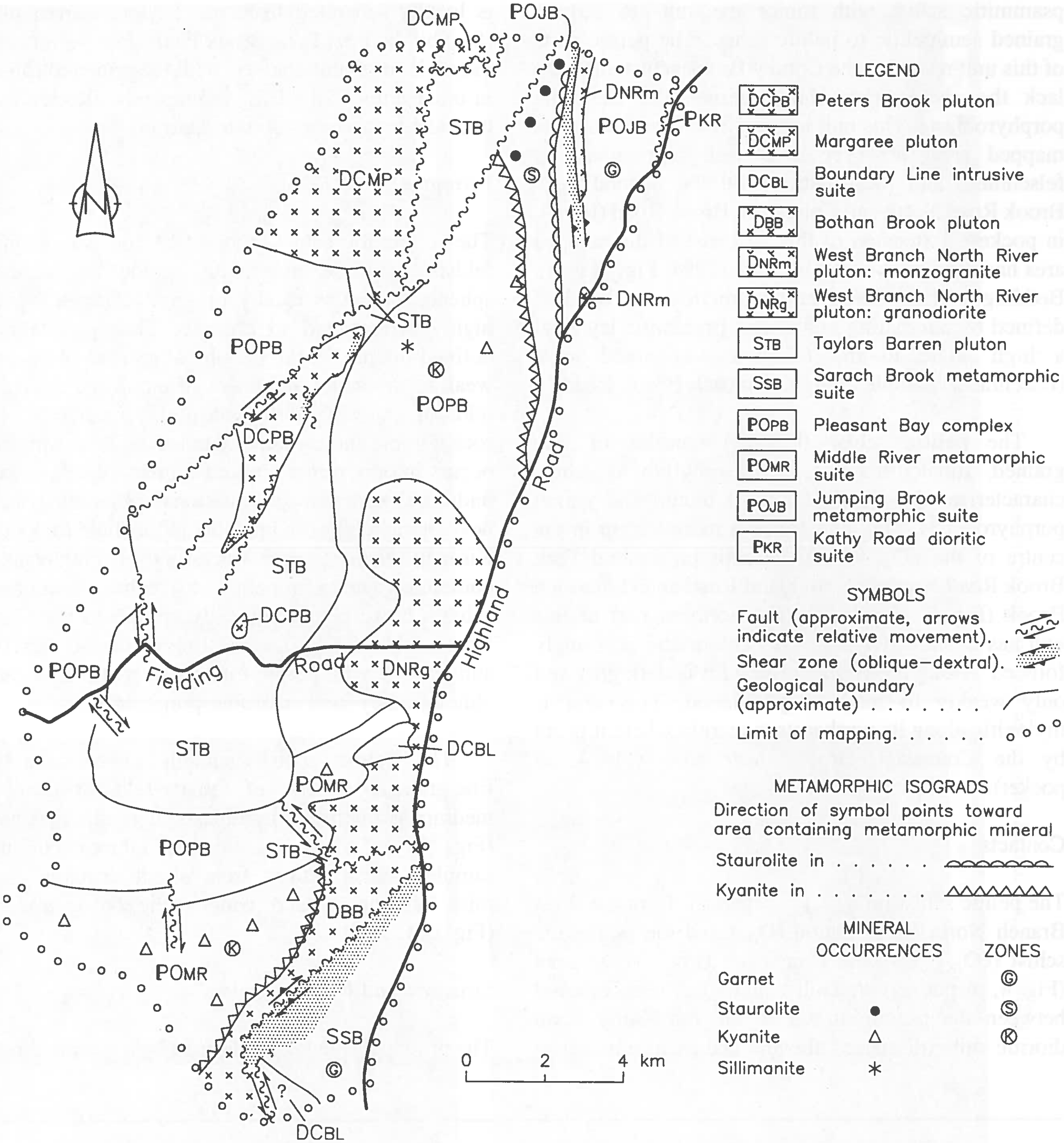


Figure 5. Simplified geology map of the study area showing metamorphic isograds and the distribution of index minerals.

psammitic schist with minor medium- to coarse-grained semipelitic to pelitic schist. The pelitic parts of this unit resemble the Corney Brook schist although lack the characteristic large garnet and staurolite porphyroblasts. This unit is poorly exposed within the mapped area, however it is well represented by felsenmeer and local outcrop on the Second Fork Brook Road North and Coinneach Brook Road (Fig. 4, in pocket). Extension of this unit east of the mapped area has been established by Ham (1994; Fig. 3, p. 8). Bedding is rare, however centimetre-scale bedding defined by alternating pelitic and psammitic layers at a high angle to the foliation was noted in a (felsenmeer) sample along Coinneach Brook Road.

The **pelitic schist** ($\text{ЄO}_{JBdb\text{-}a}$) consists of fine grained, foliated-lineated, pelitic phyllite to schist, characterized by small (1-2 mm) biotite and garnet porphyroblasts. This unit forms a narrow strip in the centre of the ЄO_{JB} which outcrops on Second Fork Brook Road North, the Highland Road and Coinneach Brook (Fig. 4, in pocket). The northern part of this unit has a distinctive blue grey colour and is strongly foliated. Along the Highland Road it is dark grey and only weakly to moderately foliated. This unit is mylonitic along its northeastern margin where it is cut by the Coinneach Brook shear zone (Fig. 4, in pocket).

Contacts

The pelitic schist ($\text{ЄO}_{JBdb\text{-}a}$) is separated from the West Branch North River pluton (D_{NR}) and the psammitic schist ($\text{ЄO}_{JBdb\text{-}b}$) by the Coinneach Brook shear zone (Fig. 4, in pocket). A fault contact has been inferred between the psammitic schist and the Kathy Road dioritic suite (discussed above). The psammitic schist is locally separated from the Taylors Barren pluton (S_{TB}) by the First Fork Brook Fault (Fig. 4, in pocket). Parallelism of unit contacts with the principal foliation in other units of the ЄO_{JB} implies modification of the contacts by a common deformation.

Petrography

The psammitic schist (subunit b) consists of quartz, feldspar, chlorite, muscovite, epidote and accessory sphene. Garnet is locally present, although typically highly retrograded to chlorite. The rock fabric is defined mainly by the parallel alignment of mica and weak to moderate alignment of elongated quartz and feldspar grains. Chlorite constitutes up to 30% of the rock volume and contains abundant epidote. Muscovite occurs in only minor amounts. Quartz displays strong undulose extinction and occasional subgraining, locally developing a fabric subparallel to the main rock fabric. Kinking of mica and fracturing of plagioclase is common. The semipelitic to pelitic sections of subunit b are petrographically similar to the Corney Brook schist (ЄO_{JBcb}), consisting of coarse muscovite and chlorite with porphyroblasts of biotite and garnet, although they lack staurolite porphyroblasts.

The pelitic schist (subunit a) consists of a fine grained matrix of quartz-feldspar-mica and medium grained porphyroblasts of biotite and garnet (Figs. 6a and b). A variable shear fabric occurs in all samples which ranges from slight development of mica fish and pressure fringes (Fig. 6a) to mylonitic (Fig. 6b).

Structure and Metamorphism

The principal foliation is defined by a steeply dipping,

Figure 6. Photomicrographs of the Jumping Brook metamorphic suite. (a) Photomicrograph of the Dauphinee Brook schist subunit a ($\text{ЄO}_{JBdb\text{-}a}$) showing abundant biotite and lesser garnet porphyroblasts. Pressure fringes associated with biotite indicate a dextral component of shear. Section cut perpendicular to foliation and parallel to lineation. (b) Mylonitic Dauphinee Brook schist subunit a ($\text{ЄO}_{JBdb\text{-}a}$) from the Coinneach Brook shear zone. Mica fish and asymmetric pressure shadows around garnet porphyroblast indicate a dextral sense of shear. S_1 foliation is defined by inclusion trails in garnet porphyroblasts. (c) Garnet-staurolite schist from the Corney Brook schist unit (ЄO_{JBcb}). Medium grained inclusions in staurolite are locally continuous with the matrix foliation (S_2) implying syn- to post-S_2 growth of staurolite. Mica fish indicate a dextral component of shear; section cut perpendicular to foliation and parallel to lineation. (d) Enlargement of area outlined in (c). Fine grained inclusion trails in garnet define an early, S_1, metamorphic fabric which is oblique to the matrix foliation. A shear fabric, S_3, which formed the mica fish in (c) truncates the S_2 foliation. (gt = garnet, st = staurolite, f = mica fish, pf = pressure fringe, ps = pressure shadow, mf = mylonitic fabric).

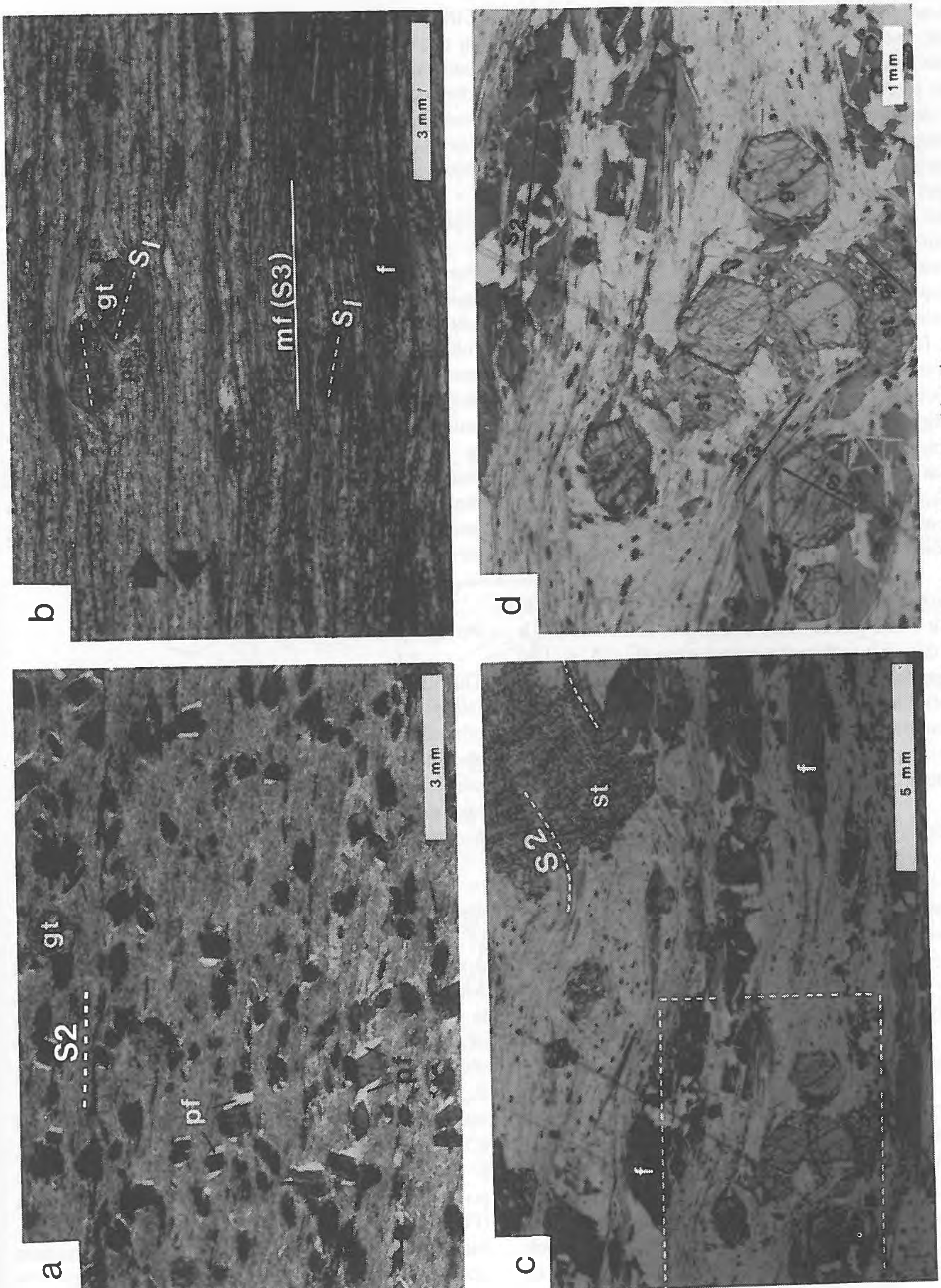


Figure 6. Photomicrographs of the Jumping Brook metamorphic suite.

north-northwestward-trending schistosity (Figs. 4, in pocket; and 7, p. 17) which is phyllitic in the pelitic subunit a and defined by grain alignment and layering in the psammitic subunit b. A south-southeastward/ ≈35° lineation (Fig. 7, p. 17) reflecting development of pressure shadows around porphyroblasts related to shearing is common in the pelite. A complex structural and metamorphic history is recorded within the pelitic subunit and pelitic portions of the psammitic subunit. Inclusion trails in garnet, S_1, are oblique to the matrix foliation, S_2 (Figs. 6a and b, p. 14). A variably developed shear fabric, S_3, which roughly parallels S_2, overprints the earlier fabrics (Fig. 6b, p. 14). The shear fabric varies from weak to moderate in the southern part of the map area to mylonitic adjacent to the Coinneach Brook shear zone. Shear indicators, including pressure fringes, mica fish, C/S fabrics and asymmetric, rotated garnet and biotite porphyroblasts with associated pressure shadows (Figs. 6a and b, p. 14), indicate an oblique shear with dextral horizontal component and west-sideup dip slip component. Minor kinking of S_2 and S_3 occurs locally.

Biotite and garnet porphyroblasts in the pelitic subunit a and pelitic areas of the psammitic subunit b place this unit within the garnet zone (Fig. 5, p. 13). Retrograde metamorphism is exhibited by replacement of biotite and garnet by chlorite, particularly within the psammitic subunit where some thin sections show nearly complete conversion of biotite and garnet to chlorite.

Protolith

Local bedding within the psammitic subunit and the composition of the pelitic subunit suggest a sedimentary protolith.

Corney Brook Schist (ЄO$_{JBcb}$)

Distribution and Field Observations

The Corney Brook schist (ЄO$_{JBcb}$) consists of a distinctive, medium- to coarse-grained, mica schist characterized by coarse porphyroblasts of garnet and staurolite. This unit occurs predominantly west of the George Brook amphibolite, forming a narrow belt along the western margin of the Jumping Brook metamorphic suite. A small area also occurs east of the George Brook amphibolite unit in the area of Coinneach Brook and Coinneach Brook Road (Fig. 4, in pocket). The principal foliation is steep and trends north-northwestward. It is mainly schistose in character, defined by coarse, aligned mica. A south-southeastward/≈40° lineation is locally prominent. Narrow horizons of George Brook amphibolite locally occur within this unit on Coinneach Brook.

Contacts

Parallelism of contacts between this unit and other units of the Jumping Brook metamorphic suite, as well as the Pleasant Bay complex (ЄO$_{PB}$), with the principal foliation within each of these units implies modification of the contacts by a common deformation. The prominence of shear fabrics in this unit (see below) are consistent with a tectonic contact, at least locally, with the Pleasant Bay complex. Jamieson et al. (1987) and Marcotte (1987) interpreted the Belle Côte Road orthogneiss (O_{PBbc}) (Fig. 4, in pocket) to be intrusive into the Jumping Brook metamorphic suite.

Petrography

This unit is dominated by alternating layers of quartz-feldspar and muscovite-biotite in roughly equal proportions. Garnet and staurolite porphyroblasts are abundant. Opaque phases are abundant (up to 5%) and occur along cleavage planes in biotite, and as inclusions in staurolite and garnet. Minor tourmaline occurs within biotite.

Structure and Metamorphism

A complex structural-metamorphic history is recorded within the Corney Brook schist. An early foliation, S_1, is represented by fine inclusion trails within the core of garnet porphyroblasts. This foliation is typically oblique and at a high angle to the principal foliation, S_2, which is defined by aligned biotite-muscovite-opaques of the matrix and enhanced by layering of quartz-rich and mica-rich layers (Figs. 6c and d, p. 14). S_2 trends north-northwestward (Figs. 4, in pocket; and 7, p. 17). Inclusion-free rims on garnet (Fig. 6d, p. 14) record a second stage of growth. Inclusions within staurolite are typically medium grained, similar to the matrix, commonly continuous with the matrix foliation and locally sigmoidal (Figs.

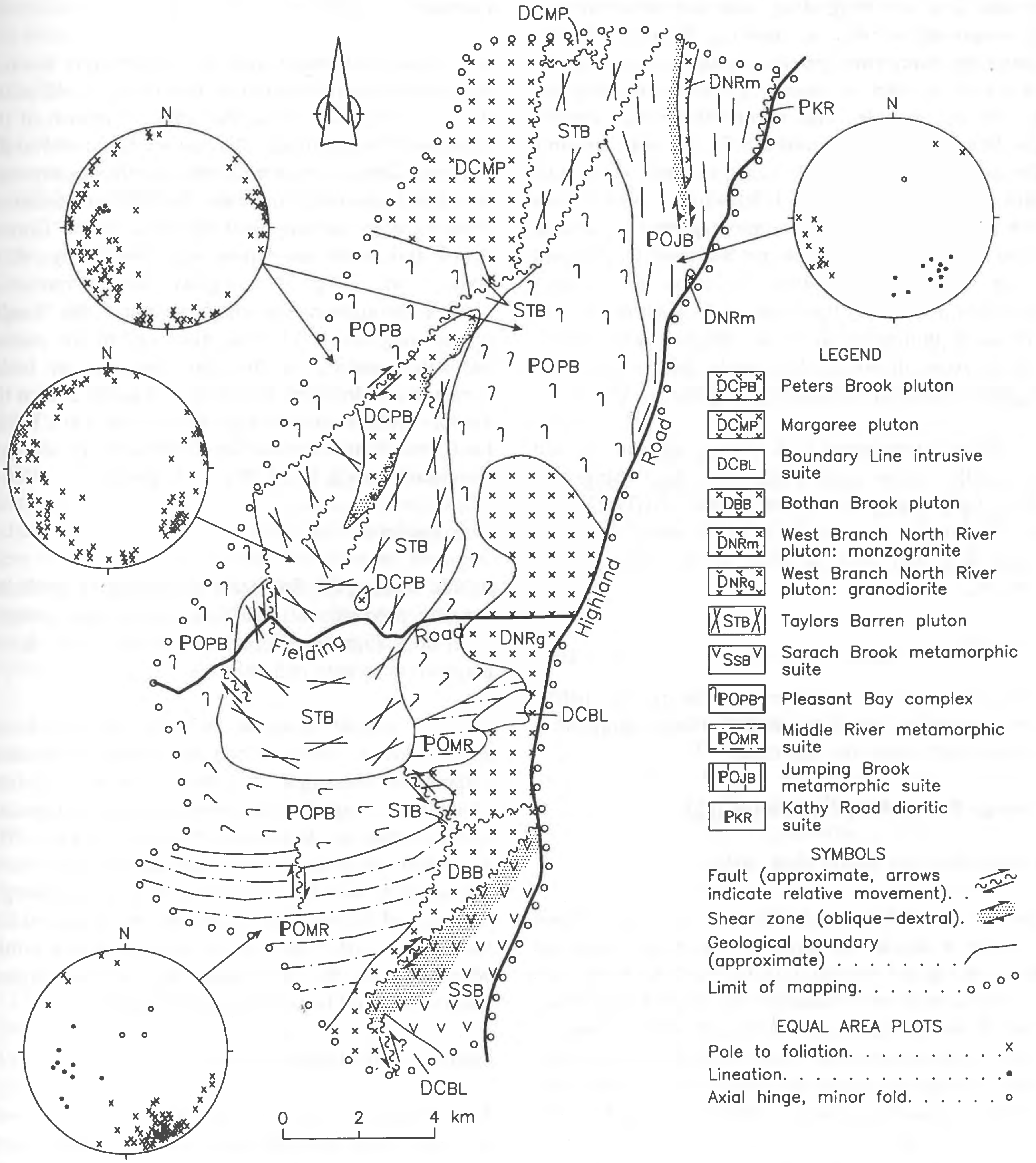


Figure 7. Simplified geology map of the study area showing the trends of foliations (pattern) and equal area stereoplots of principal foliations, lineations and axial hinges of minor folds for the Jumping Brook metamorphic suite, Middle River metamorphic suite, Pleasant Bay complex and Taylors Barren pluton.

6c and d, p. 14), suggesting staurolite growth during development of the S_2 (matrix) foliation. Where staurolite overgrows garnet, inclusion trails in the garnet are oblique to those in the staurolite (Fig. 6d, p. 14). A variable, late shear fabric, S_3, roughly parallels S_2 (i.e., north-northwest/steep) and overprints the metamorphic fabrics (Figs. 6c and d, p. 14). Shearing is defined by C/S fabrics in the matrix, mica fish (biotite porphyroblasts) and asymmetric, rotated garnet and staurolite porphyroblasts and is localized along discrete shear planes. Inclusion trails within staurolite are locally truncated by S_3 (Fig. 6d, p. 14). All shear indicators show an oblique, dextral/west-sideup sense of shear. Retrograde metamorphism is represented by the breakdown of garnet to chlorite.

Minor, asymmetric kink folding affecting S_2 and S_3 locally occurs within this unit. Axial hinges of these folds plunge moderately, ≈60° NNW (Fig. 7, p. 17), roughly perpendicular to the shear lineation, suggesting they may be drag folds related to the shearing.

Protolith

Although primary structures are absent, the pelitic composition reflected by abundant mica suggests a sedimentary origin for this unit.

George Brook Amphibolite (ЄO$_{JBgb}$)

Distribution and Field Observations

The George Brook amphibolite (ЄO$_{JBgb}$) outcrops on Coinneach Brook, the southern branch of Coinneach Brook Road and Second Fork Brook Road North, and is represented by felsenmeer on Cape Clear Road, First Fork Brook Road North and short, unnamed roads north and south of First Fork Brook Road North (Fig. 4, in pocket). The majority of this unit consists of fine- to medium-grained, strongly lineated (south-southeast/≈40°), locally foliated (north-northwest/steep) amphibolite consisting primarily of aligned, needle-like amphibole crystals. Minor unfoliated- to weakly-foliated, medium- to coarse-grained amphibolite locally occurs on a branch of Second Fork Brook Road North and on Coinneach Brook. The latter consists of centimetre-scale amphibole phenocrysts(?) in a groundmass of mainly amphibole and plagioclase and displays an igneous texture.

Contacts

The contact between a small area of strongly lineated amphibolite occurring within the Corney Brook schist (ЄO$_{JBcb}$) is exposed along the southern branch of the Coinneach Brook Road. The contact is parallel to the principal fabric in both units and therefore interpreted as tectonic (sheared?) in nature. General parallelism of contacts with the principal foliation in the Corney Brook and Dauphinee Brook schist units (Figs. 4, in pocket; and 7, p. 17) suggests this interpretation applies throughout the mapped area. The locally preserved igneous(?) texture displayed by the coarse, unfoliated portion of this unit suggests an initial intrusive relationship. This unit is separated from the Taylors Barren pluton (S_{TB}) by the First Fork Brook Fault which is exposed on Coinneach Brook and Coinneach Brook Road (Fig. 4, in pocket).

Petrography

In thin section, the fine grained, lineated amphibolite consists predominantly of fine- to medium-grained, elongate, aligned, amphibole grains and lesser plagioclase, quartz and chlorite.

The coarse grained, weakly to unfoliated amphibolite is characterized by coarse, subgrained amphibole phenocrysts in a fine- to medium-grained groundmass of amphibole, chlorite, plagioclase, quartz, sphene, biotite, K-feldspar(?) and epidote. The amphibole phenocrysts are completely recrystallized, consisting of aligned, elongated subgrains defining a pronounced fabric. This fabric varies in orientation from phenocryst to phenocryst suggesting that it may be related to the crystallography of the original phenocrysts and is not a tectonic feature.

Structure and Metamorphism

The dominant structure in this unit is a well developed, moderately plunging, south-southeastward-trending lineation defined by elongate amphibole grains. Locally, a north-northwestward-trending, steeply dipping (east) foliation is present. Narrow, north-northwestward-trending mylonite zones trending parallel to the foliation were noted on a branch of Second Fork Brook Road North and on a short unnamed road north of First Fork Brook Road (Fig. 4, in pocket). The mylonite is characterized by paper thin foliation bands and elongate mineral aggregates (amphibole and plagioclase(?)) defining a pronounced lineation.

Protolith

The weakly foliated portion of this unit displays an igneous texture, implying it represents a metamorphosed mafic intrusion. By association, the strongly lineated portion of this unit is inferred to represent a highly deformed mafic intrusion.

Age of the Jumping Brook Metamorphic Suite

The depositional age of the Jumping Brook metamorphic suite is not well constrained. Currie et al. (1982) obtained a U-Pb (zircon) age of 439±7 Ma for a salic dyke cutting the Cambrian Chéticamp pluton which they interpreted to be feeding `basal rhyolitic flows of the Jumping Brook (complex) metamorphic suite'. $^{40}Ar/^{39}Ar$ dating in the Chéticamp area gave ages of 383 Ma and 384 Ma (hornblende; total gas) for the George Brook amphibolite (ЄO$_{JBgb}$) and 383 Ma (biotite; total gas) and 390 Ma (hornblende; 90% gas) for the Corney Brook schist (ЄO$_{JBcb}$) (Reynolds et al., 1989).

The Jumping Brook metamorphic suite is widely considered correlative with other metasedimentary-metavolcanic units within the Aspy Terrane (Barr and Jamieson, 1991; Jamieson et al., 1990; Keppie et al., 1992; Lynch et al., 1993) including the Silurian Sarach Brook metamorphic suite (S_{SB}) (433+7/-4 Ma, U-Pb, zircon; Dunning et al., 1990) and Money Point Group (427±2 Ma, U-Pb, zircon; Keppie et al., 1992). However, if the Jumping Brook metamorphic suite was intruded by the Belle Côte Road orthogneiss (442±3 Ma; G. Dunning, personal communication, 1995), as suggested here, and by Jamieson et al. (1987) and Marcotte (1987), an Ordovician or older age is inferred.

Middle River Metamorphic Suite (ЄO$_{MR}$)

Definition and Previous Work

The Middle River metamorphic suite (ЄO$_{MR}$) forms a distinct unit of medium to high grade metasedimentary rocks in the southern part of the study area (Figs. 1, p. 6; 3, p. 8; and 4, in pocket). The term Middle River metamorphic suite has been adopted from Barr et al. (1987a, 1992), and corresponds to the Middle River unit of Jamieson and Doucet (1983) and Doucet (1983). The ЄO$_{MR}$ was included with undivided `mixed rocks' (pre-Mississippian) by Kelley (1960) and considered part of the George River Group by Milligan (1970). Only the northern part of the ЄO$_{MR}$ is exposed within the study area, but its entire distribution, as defined by Barr et al. (1992), is shown on Figure 1 (p. 6). This unit is characterized by psammitic metasedimentary rocks, semipelitic biotite-garnet-kyanite schist, amphibolite and minor marble.

Doucet (1983) and Barr et al. (1992) showed the ЄO$_{MR}$ to be in fault contact with all adjacent units, including the West Branch North River and Bothan Brook plutons to the east, the Pleasant Bay complex to the north and the Sarach Brook metamorphic suite to the south (Fig. 1, p. 6). Peak metamorphic conditions reached kyanite (and local sillimanite) grade (Doucet, 1983). Doucet (1983) and Barr and Jamieson (1991) considered the ЄO$_{MR}$ to be the higher grade equivalent of the Sarach Brook metamorphic suite.

Distribution and Field Observations

The Middle River metamorphic suite (ЄO$_{MR}$) is well exposed on Middle River and its tributaries (Fig. 4, in pocket). The ЄO$_{MR}$ is lithologically variable, comprising psammitic metasedimentary rocks, biotite-garnet-kyanite schist, amphibolite, quartzo-feldspathic gneiss, minor marble and minor foliated granite. Lithological variability occurs at the metre scale making vertical definition and lateral correlation difficult. The marble presents an exception, with one horizon traceable across the mapped area (Fig. 4, in pocket). Primary structures are absent in the ЄO$_{MR}$. However, stratigraphic control, provided by the marble, implies lithologic layering and compositional banding, which parallel the marble (Fig. 8a, p. 20), reflect original bedding.

Psammitic lithologies typically consist of monotonous, fine- to medium-grained, strongly banded (centimetre scale), medium grey, quartz-rich metasedimentary rocks (Fig. 8b, p. 20). This lithology dominates in the area north of the main marble horizon. **Schistose lithologies** are typified by metamorphic layering characterized by felsic lithosomes and biotite±kyanite-rich layers (Fig. 8c, p. 20), the latter defining a schistosity. Garnet

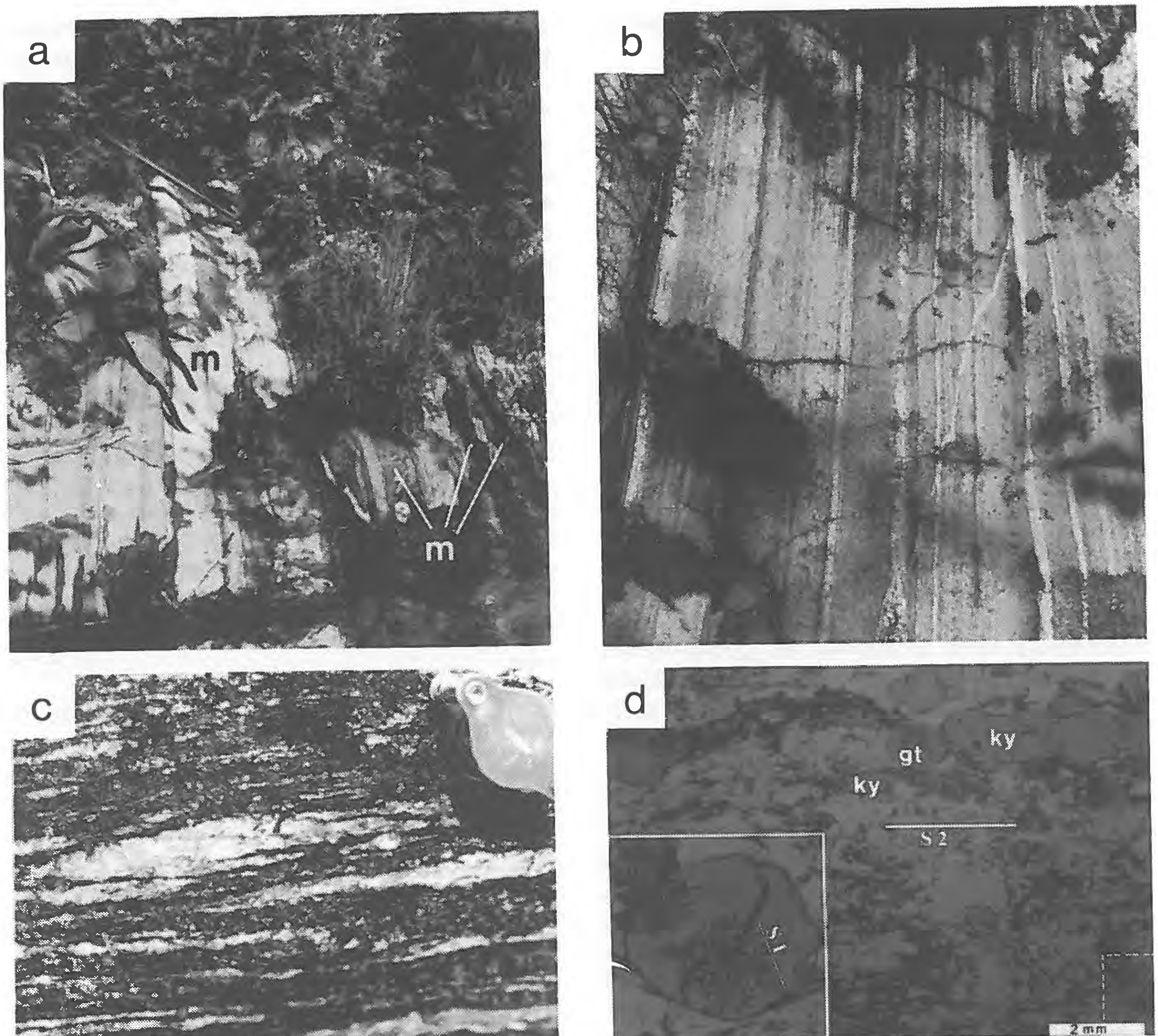


Figure 8. Middle River metamorphic suite (ЄO_{MR}). (a) Photograph of the 'main' marble unit (m) exposed on Middle River. Note several narrow horizons of marble to the right of the wide horizon in the centre of the photograph. (b) Photograph of an outcrop of typical psammitic metasedimentary rock of the Middle River unit. Note the well developed layering, interpreted to represent primary lithologic layering. (c) Photograph of an outcrop of biotite-garnet-kyanite schist of the Middle River unit consisting of felsic lithosomes and biotite-kyanite-garnet-rich layers. (d) Photomicrograph of biotite-garnet-kyanite schist of the Middle River unit. Aligned biotite and kyanite (ky) define the principal foliation (S_2). Inset in bottom left corner, representing enlargement of area outlined in bottom right corner, shows earlier S_1 foliation defined by inclusion trails in garnet porphyroblast (gt). (e) Folded and boudinaged granite dyke in the Middle River unit. Axial planes of folds and planes of boudinage parallel the principal foliation, implying that the dyke intrusion preceded the end of regional deformation. Vertical fold hinges and axes of boudins indicate horizontal extension.

porphyroblasts are ubiquitous and generally abundant, locally up to ≈30%. Biotite-garnet-kyanite schist is common south of the main marble horizon. **Amphibolite** horizons are common throughout the ЄO$_{MR}$ and are typically medium grained and garnetiferous. Amphibolite is frequently associated with marble and may represent metamorphosed dolostone. **Marble** horizons occur throughout the southern part of the ЄO$_{MR}$ within the study area (Fig. 4, in pocket). Correlation of marble horizons is generally difficult, however one horizon can be confidently traced from near the mouth of Fionnar Brook northeastward along Middle River and across to Sarach Brook. This horizon was also extended westward to two small tributaries of the southern branch of Ryan Brook by Milligan (1970). Although not noted in this survey, marble was also indicated in the upper part of Fionnar Brook by Milligan (1970) and Doucet (1983). The marble is typically granular, medium grained and white and locally contains fine grained, disseminated graphite. Marble horizons are typically 1-2 m thick, although the combined thickness of several intercalated horizons locally reaches ≈5 m.

Deformed, discordant granite and pegmatite dykes are abundant and occur in most outcrop of the ЄO$_{MR}$. As noted by Doucet (1983), pegmatite is the dominant lithology in the area of the intersection of Middle River with Sarach and Bothan Brooks, where it constitutes greater than 50% of the outcrop (unit ЄO$_{MRp}$ on Fig. 4, in pocket).

Contacts

The contact between the Middle River metamorphic suite (ЄO$_{MR}$) and the Pleasant Bay complex (Belle Côte Road orthogneiss (O_{PBbc})) to the north is not exposed. Parallelism of the contact with the principal fabric in both units implies the contact has been modified by a common deformation. An original intrusive contact between these units is suggested by the small areas of orthogneiss within the ЄO$_{MR}$ (Fig. 4, in pocket) which may represent deformed plugs of the Belle Côte Road orthogneiss. A local fault contact with the Bothan Brook pluton (D_{BB}) is exposed along the upper part of Sarach Brook. Further south on Sarach Brook an intrusive contact is defined by dykes of D_{BB} cutting the ЄO$_{MR}$. However, the dyking is typically affected by brittle deformation characterized by slickensided shear fractures. A small block of Taylors Barren pluton (S_{TB}) is locally in fault contact with the ЄO$_{MR}$ along the upper part of Middle River (Fig. 4, in pocket).

Structure and Metamorphism

The most conspicuous structure in the Middle River metamorphic suite is a lithological and compositional layering. Metamorphic fabrics, including gneissic banding and schistosity parallel the lithological layering and define an east-west map pattern (Fig. 7, p. 17). Lineations along foliation planes defined by quartz slickenfibres and slickenlines invariably plunge moderately (20°-50°) to the west (Fig. 7, p. 17) and indicate minor, late, foliation parallel shear. The axial hinges of minor folds plunge moderately to steeply to the east (Fig. 7, p. 17), roughly perpendicular to the lineations, suggesting the folds may represent drag folds related to this shearing.

The semipelitic, schistose rocks of the ЄO$_{MR}$ display a complex structural/metamorphic history. The principal foliation, S_2, is defined by biotite-muscovite-kyanite±hornblende within the matrix and metamorphic layering defined by alternating quartz-feldspar and mica-rich layers (Fig. 8d, p. 20). Kyanite shows ambiguous relations with the matrix foliation. Most kyanite parallels the principal foliation, S_2 (Fig. 8d, p. 20), however locally kyanite is wrapped around by the matrix foliation. Inclusion trails in the cores of garnet porphyroblasts are generally oblique to the matrix foliation and represent an early, S_1 fabric (Fig. 8d, p. 20). Inclusion free rims on garnet suggest a second period of growth.

The axial planes and planes of boudinage of deformed granite dykes parallel the principal foliation (Fig. 8e, p. 20) implying their formation preceded the end of regional deformation (i.e. development of S_2). Although difficult to measure on outcrop surfaces, axes of boudins and fold hinges generally appear to be subvertical, suggesting horizontal extension.

Brittle faults, characterized by cataclastic textures, affect the ЄO$_{MR}$ along the upper parts of Fionnar Brook, Sarach Brook and Middle River (Fig. 4, in pocket). Map patterns imply a minor component of dextral offset on the Fionnar Brook fault and ≈2 km of sinistral offset on the Middle River fault (Fig. 4, in pocket).

Peak metamorphism is reflected by the assemblage garnet-kyanite. Minor sillimanite (fibrolite) has also been documented by Doucet (1983), which he considered metastable with kyanite. Doucet (1983) interpreted this assemblage to reflect peak metamorphic conditions of 650°-700°C. Calcite-dolomite and garnet-biotite geothermometry gave equilibrium temperatures in the 500°-600°C range (Doucet, 1983). Similar assemblages and textural relationships occur in comparable rocks throughout this unit implying uniform metamorphic conditions throughout the $ЄO_{MR}$.

Protolith

Primary features within the Middle River metamorphic suite have been obliterated by metamorphism and deformation. However, the $ЄO_{MR}$ is considered primarily metasedimentary with no evidence of volcanic units. Parallelism of the marble units with the compositional layering implies this layering reflects original stratigraphic layering. The rock compositions within the $ЄO_{MR}$ are assumed to reflect original rock types, i.e. psammitic units representing sandstone-wackes, semipelitic schists representing shale and siltstone and marble representing limestone. The spatial association of some amphibolite with marble suggests the former may often represent metamorphosed dolomite.

Age

The depositional age of this unit is unknown. $^{40}Ar/^{39}Ar$ ages of 388 Ma and 390 Ma, hornblende; 370 Ma, biotite (Reynolds et al., 1989); and 386±9 Ma, hornblende; 377±9 Ma, biotite (Doucet, 1983) indicate cooling through respective closure temperatures and provide only a minimum age for the development of the S_2 foliation. If, as suggested above, the Belle Côte Road orthogneiss (O_{PBbc}) intruded the $ЄO_{MR}$ then an Ordovician or earlier age is implied.

Pleasant Bay Complex ($ЄO_{PB}$)

Definition and Previous Work

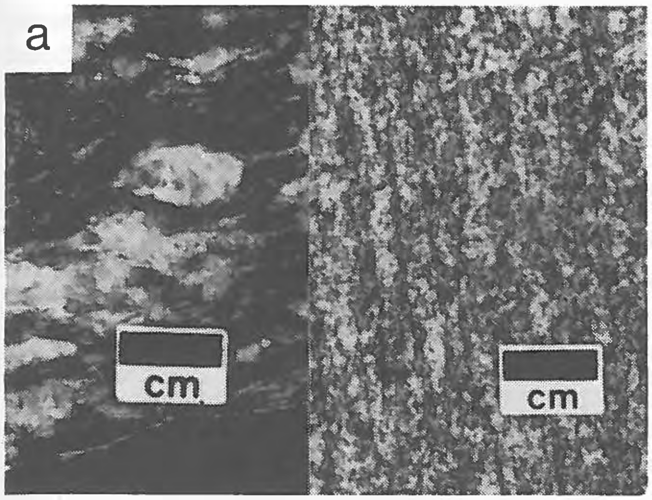
The term Pleasant Bay complex was initially applied by Currie (1987) to a belt of gneissic rocks in the western Cape Breton Highlands. Currie (1987) subdivided this unit into the following four units: (1) biotite gneiss and schist, (2) gneissic to schistose amphibolite, (3) gneissic biotite augen granodiorite, and (4) lit-par-lit and composite granitoid gneiss. Barr et al. (1992) adopted the term Pleasant Bay complex, however they applied it to a more restricted area than that defined by Currie (1987) which they subdivided into the Belle Côte Road gneiss and megacrystic orthogneiss units. Within the mapped area Jamieson et al. (1987) subdivided the Pleasant Bay complex into the Belle Côte Road gneiss and minor amphibolite. Milligan (1970) included the Pleasant Bay complex ($ЄO_{PB}$) in the southern part of the mapped area with the George River Group.

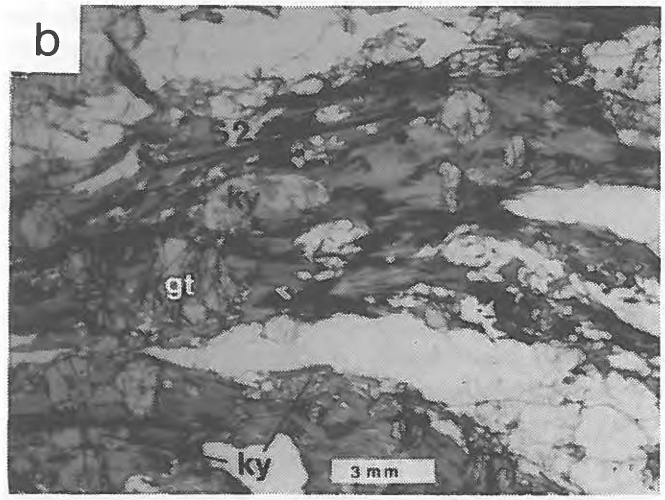
The $ЄO_{PB}$ underlies a large portion of the mapped area and consists mainly of orthogneiss, referred to as the Belle Côte Road orthogneiss (O_{PBbc}), and lesser paragneiss, referred to as the First Fork Brook gneiss ($ЄO_{PBff}$) (Fig. 4, in pocket). Both units occur within many outcrops and the map distribution presented in Figure 4 (in pocket) reflects the predominance of one unit over the other.

Distribution and Field Observations

The **First Fork Brook gneiss** is lithologically variable, consisting mainly of mafic (>15% mafic minerals) quartz-feldspar-biotite gneiss, amphibolite to amphibolitic gneiss and minor coarse grained, pelitic, garnet-staurolite-kyanite±sillimanite gneiss (Fig. 9a (left), p. 23). No systematic distribution of lithologies is apparent except for a narrow band of distinctive pelitic, garnet-kyanite gneiss which has been traced from First Fork Brook to First Fork Brook Road (Fig. 4, in pocket). Foliation is defined by metre-scale lithologic banding and centimetre-scale gneissic banding of felsic and mafic layers. Undeformed pegmatites and granite dykes are common and folded granitoid dykes similar to those in the Middle River metamorphic suite locally occur.

The **Belle Côte Road orthogneiss** consists of light grey, leucocratic (<15% mafic minerals), moderately to strongly foliated quartz-feldspar-biotite±garnet gneiss (Fig. 9a (right), p. 23) with lesser garnet amphibolite and paragneiss. The orthogneiss is typically homogeneous in character, interrupted only by common, foliation-parallel amphibolite bands (10 cm-3 m). Small-scale (millimetre-centimetre) metamorphic banding, defined by segregation of felsic and mafic minerals, defines the principal fabric in this





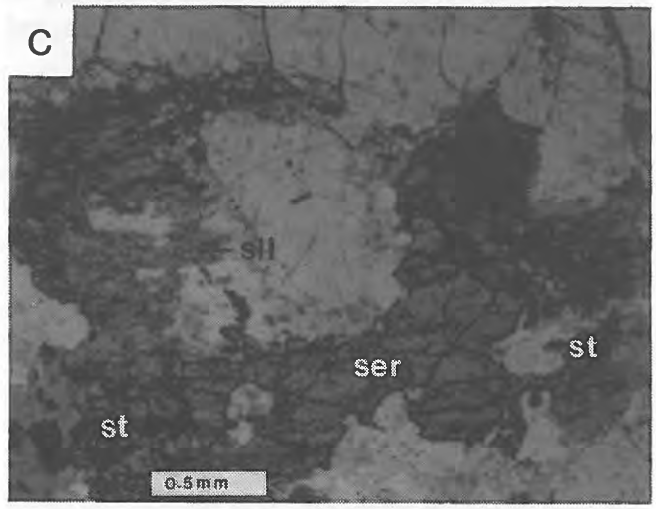


Figure 9. Pleasant Bay complex (ЄO$_{PB}$). (a) Photographs of slabs of pelitic, garnet-kyanite paragneiss of the First Fork Brook gneiss, left, and typical Belle Côte Road orthogneiss, right. (b) Photomicrograph of garnet-kyanite paragneiss shown in (a). Kyanite occurs within biotite-rich layers and helps define the principal foliation, S_2. (c) Photomicrograph showing sillimanite replacing(?) highly retrograded staurolite (sericite) in semipelitic paragneiss of the First Fork Brook gneiss (ky = kyanite, sil = sillimanite, st = staurolite, gt = garnet, ser = sericite).

unit (Fig. 9a). Undeformed pegmatite and granite dykes, associated locally with epidote veins and quartz-muscovite alteration, are abundant.

Contacts

The Pleasant Bay complex was intruded by the Taylors Barren pluton (S_{TB}) (discussed in the section on the Taylors Barren pluton), the West Branch North River pluton (D_{NR}) (Tompkins Spur; inset Fig. 4, in pocket), the Margaree pluton (DC_{MP}), and the Peters Brook pluton (DC_{PB}) (Maggie Ranalds Brook; inset Fig. 4, in pocket). The contact between the Belle Côte Road orthogneiss (O_{PBbc}) and the Taylors Barren and Peters Brook plutons is locally defined by the First Fork Brook Fault (Fig. 4, in pocket). The relationship between the Pleasant Bay complex and the Middle River (ЄO$_{MR}$) and Jumping Brook (ЄO$_{JB}$) metamorphic suites is unclear. Jamieson et al. (1986, 1987) and Plint and Jamieson (1989) interpreted the Belle Côte Road orthogneiss to be intrusive into the Jumping Brook metamorphic suite on the basis of increasing metamorphic grade toward the orthogneiss and the presence of pelitic inclusions (paragneiss) within the orthogneiss. Similar observations were made within the mapped area; metamorphic grade progresses from garnet-zone to staurolite-zone in the Jumping Brook unit toward the kyanite±silliminate zone of the Pleasant Bay complex (Fig. 5, p. 13). As discussed above, an intrusive relationship is interpreted between the Belle Côte Road orthogneiss and the Middle River metamorphic suite.

Structure and Metamorphism

The dominant structure within the Pleasant Bay complex is the well developed gneissic foliation. The orientation of this foliation varies systematically from north-south-trending/steeply westward-dipping in the northern part of the area to east-west-trending/steeply northward-dipping in the southern part of the area to north-south-trending/steeply eastward-dipping along the western side of the area (Fig. 4, in pocket) resulting in a U-shaped map pattern (Fig. 7, p. 17).

The pelitic part of the paragneiss displays a similar structural-metamorphic history to lithological equivalents in the Middle River metamorphic suite. The principal foliation, S_2, is defined by metamorphic layering and aligned biotite-muscovite-kyanite in the matrix (Fig. 9b, p. 23). Kyanite generally occurs with biotite and is locally wrapped around by the matrix foliation. Garnet porphyroblasts commonly have inclusion-rich cores, with inclusion trails defining an early fabric, S_1, oblique to the principal foliation, and inclusion-free rims.

Rare sillimanite, predominantly fibrolite with minor prismatic crystals, occurring on Centre Road, has replaced biotite, staurolite and kyanite (Fig. 9c, p. 23). Retrograde metamorphism is variable within the paragneiss with local intense alteration of garnet to chlorite and garnet and staurolite to sericite (Fig. 9c, p. 23).

Folded and boudinaged granite dykes, similar to those in the Middle River metamorphic suite, occur within the Pleasant Bay complex (Cape Clear Road and Charlie Brook, insets Fig. 4, in pocket); the dykes on Charlie Brook are clearly related to the Taylors Barren pluton. Axial planes and planes of boudinage parallel the gneissic foliation implying, as in the Middle River unit, that their intrusion preceded the end of the formation of foliation. Axes of boudins and fold hinges are generally subvertical, suggesting horizontal extension.

The Pleasant Bay complex is deformed by several late brittle faults which often form the contacts with other units (Fig. 4, in pocket).

Protolith

The homogeneous nature of the Belle Côte Road orthogneiss is consistent with an igneous protolith. This interpretation is also held by Jamieson et al. (1986, 1987, 1990) and Marcotte (1987) who interpreted this unit as orthogneiss of tonalitic to granodioritic composition.

The inhomogeneous nature of the paragneiss, characterized by small and large scale compositional and lithological banding implies a stratified protolith for this unit. The pelitic portions probably reflect a sedimentary origin whereas the amphibolitic portions may represent mafic flows.

Age

U-Pb (zircon) ages of 433 +20/-10 Ma (Jamieson et al., 1986) and 442±3 Ma (G. Dunning, personal communication, 1995) have been determined for the Belle Côte Road orthogneiss. This sample came from an area west of the mapped area on the Belle Côte Road. The 442±3 Ma age is considered to represent an igneous age indicating a Late Ordovician age for this unit. The 433+20/-10 Ma age probably reflects either a component of Proterozoic lead (Lynch and Tremblay, 1992) or lead loss (Keppie et al., 1991). U-Pb ages of 386±3 Ma (titanite) for the Belle Côte Road orthogneiss, and 411±2 Ma (monazite) and 376±4 Ma (rutile) for the First Fork Brook gneiss (Barr and Jamieson, 1991), represent cooling through the respective closure temperatures of monazite, titanite and rutile.

SILURIAN

Sarach Brook Metamorphic Suite (S_{SB})

Definition and Previous Work

The Sarach Brook metamorphic suite (Barr et al., 1987a, 1992) consists of a sequence of low grade metavolcanic and minor metasedimentary rocks occurring east of the Bothan Brook pluton (D_{BB}) and south of the Middle River metamorphic suite ($ЄO_{MR}$) (Figs. 1, p. 6; and 3, p. 8). This unit corresponds to the Northern (Crowdis Mountain) volcanic unit of Jamieson and Doucet (1983). Kelley (1960) included this unit with undivided Precambrian metasedimentary and metavolcanic rocks and Milligan (1970) included these rocks within the Precambrian George River Group (Table 1, p. 10-11). Jamieson and Doucet (1983) indicated several mylonite zones cutting this unit, including the Southern Highlands shear zone (Fig. 1, p. 6) and several east-west trending zones south of the Middle River unit.

Distribution and Field Observations

The Sarach Brook metamorphic suite underlies the southeastern corner of the mapped area and is well exposed on tributaries of Sarach Brook. It is also represented by a few outcrops and widespread, well developed felsenmeer along the Boundary Line Bypass and Mile 12.5 Road (Fig. 4, in pocket).

This unit is lithologically variable, including fine grained volcanic rocks, medium- to coarse-grained felsic pyroclastics (Fig. 10e, p. 26), feldspar porphyry (Fig. 10f, p. 26), crystal tuff and minor black slate. A variable, mylonitic shear foliation related to the Southern Highlands shear zone (Figs. 3, p. 8; and 4, in pocket) obliterates primary layering along the western margin of this unit. Limited exposure and lithologic variability makes stratigraphic subdivision and lateral correlation difficult.

Contacts

The Southern Highlands shear zone separates this unit from the Bothan Brook pluton (Figs. 3, p. 8; and 4, in pocket). The contact with the Boundary Line intrusive suite (Leonard McLeod Brook complex on Fig. 1, p. 6, Barr et al., 1992) is not exposed. However, fine grained granitic dykes (D_{BB}(?) on Fig. 4, in pocket), which may be related to the Boundary Line unit or Bothan Brook pluton, cut deformed rocks of the Sarach Brook unit on Sarach Brook and South Sarach Brook implying an intrusive relationship.

Structure and Metamorphism

Except where affected by the Southern Highlands shear zone, this unit is quite undeformed with little evidence of regional deformation (Figs. 10e and f, p. 26). The western margin of the Sarach Brook metamorphic suite is overprinted by mylonitic textures related to the Southern Highlands shear zone (see section on Shear Zones and Brittle Faults, this paper). Although not noted in this study, metamorphic garnet was described from this unit by Jamieson et al. (1990).

Age

A 433 +7/-4 Ma U-Pb (zircon) crystallization age was determined for a rhyolite sample from this unit east of the mapped area (Dunning et al., 1990).

Taylors Barren Pluton (S_{TB})

Definition and Previous Work

The term Taylors Barren (S_{TB}) was applied by Jamieson et al. (1987) to distinguish a north-northeastward-trending `distinctive belt of variably foliated, pink granitoid rocks' which occur in the central Cape Breton Highlands (Fig. 1, p. 6). The Taylors Barren pluton corresponds to the Egypt Highlands unit of Doucet (1983), Jamieson and Doucet (1983) and Jamieson and Craw (1983). Milligan (1970) referred to this unit in the area south of the Fielding Road as granite and Kelley (1960) referred to this unit as granitic gneiss.

Distribution and Field Observations

The Taylors Barren pluton forms a large, linear body of distinctive, variably foliated, augen granite which bisects the area, extending from Coinneach Brook Road at the northern limit of mapping to south of the Fielding Road (Fig. 4, in pocket). This unit is exposed on several brooks and is represented by scattered outcrops and felsenmeer along logging roads.

The large majority of the Taylors Barren pluton exposed within the area is represented by medium- to coarse-grained, pink-red, variably foliated, augen granite characterized by a high percentage of feldspar augen (Fig. 10a, p. 26). Weakly foliated augen granite (Fig. 10b, p. 26) is common along a branch of Centre Road and Maggie Ranalds Brook. Areas of intensely foliated augen granite displaying well developed shear fabrics (Fig. 10c, p. 26) were noted along Caribou Road and Second Fork Brook Road North. A distinct fine- to medium-grained variety characterized by a strong, planar foliation and only a few augen (Fig. 10d, p. 26), locally occurs near the western margin. The latter is restricted in distribution, occurring near the western margin of the Taylors Barren pluton along Nile, Maggie Ranalds, and First Fork Brooks (Fig. 4, in pocket). This variety is similar in appearance to portions of the Belle Côte Road orthogneiss (O_{PBbc}) and, when in contact, distinction is difficult.

Contacts

The contact between the Taylors Barren pluton (S_{TB}) and Pleasant Bay complex ($ЄO_{PB}$) is well exposed on

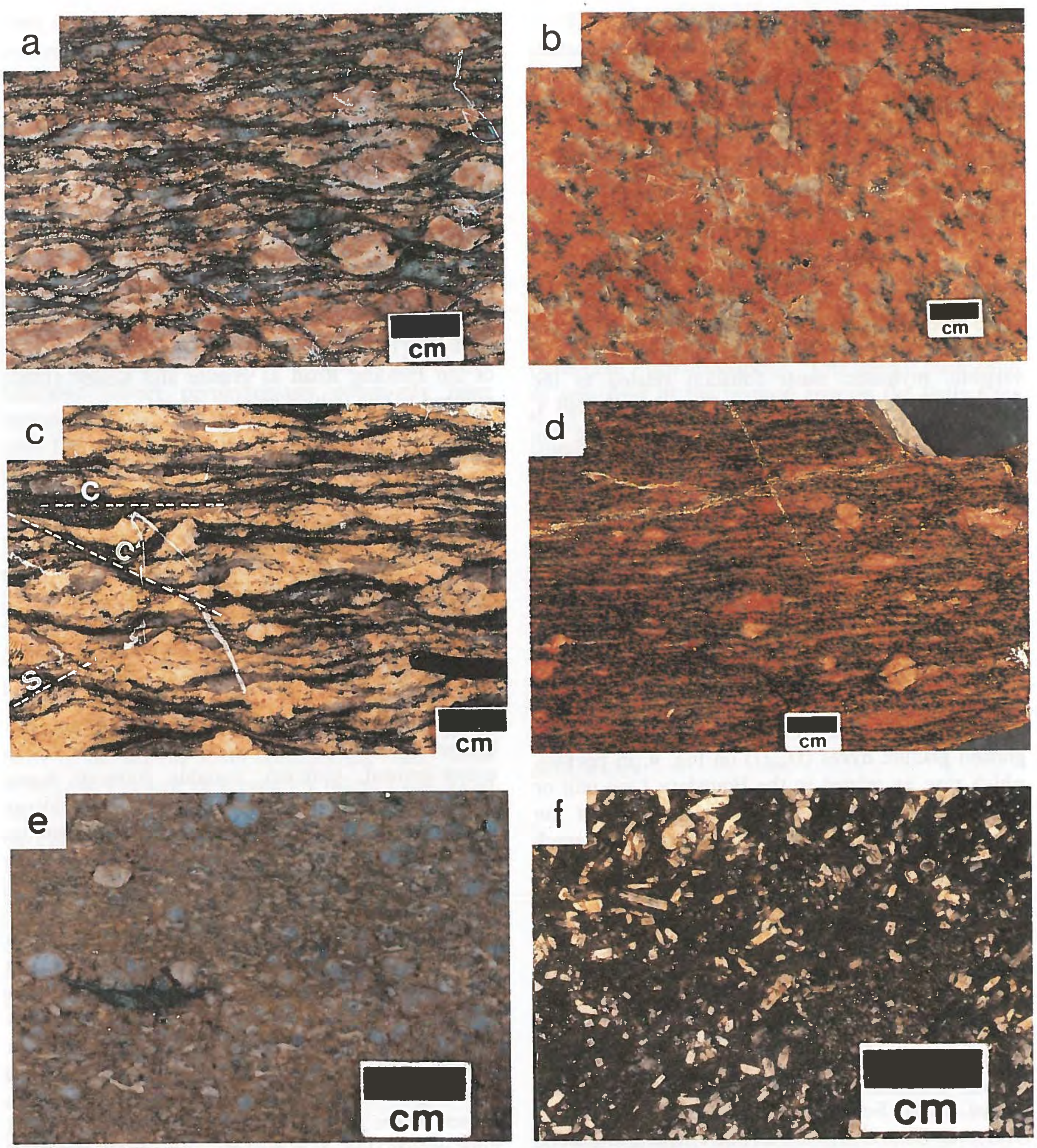


Figure 10. Photographs of slabbed surfaces of samples of the Taylors Barren pluton (S_{TB}; a-d) and the Sarach Brook metamorphic suite (S_{SB}; e, f). (a) Typical, medium- to coarse-grained, strongly foliated augen granite; surface cut perpendicular to foliation and parallel to lineation. (b) Weakly foliated, medium- to coarse-grained augen granite. (c) Protomylonitic, medium- to coarse-grained augen granite with well developed C, S, and C′ (shear bands) planes which indicate a dextral sense of shear; sample cut perpendicular to foliation and parallel to lineation. (d) Fine- to medium-grained, strongly foliated augen-poor granite. (e) Felsic pyroclastic. (f) Feldspar porphyry. Note the undeformed nature of this unit shown by rounded quartz clasts in (e) and the random orientation of feldspar phenocrysts in (f).

Nile Brook, South Nile Brook, Charlie Brook and First Fork Brook. The most revealing exposure occurs along the interval of Nile Brook between South Nile Brook and Marks Shanty Brook (Fig. 4, in pocket) which is characterized by alternating, foliation-parallel bands of Pleasant Bay complex and Taylors Barren pluton. Contacts between the two units are generally sharp and parallel to the foliation, indicating the two units shared a common phase of deformation. Although this deformation often obscures the relationship between the two units, an intrusive relationship is locally defined on Nile Brook by preserved stoping features showing injection of the Taylors Barren pluton along an existing foliation (banding) in the gneiss (Fig. 11a). Similar observations were made on a tributary of First Fork Brook. In addition, folded dykes of distinct Taylors Barren pluton within the Pleasant Bay complex were observed on Charlie Brook (Figs. 4 (inset), in pocket; and 11b). Thus, a primary intrusive relationship is established between these two units.

Fault (cataclastic) contacts locally separate the Taylors Barren pluton (S_{TB}) from the Margaree pluton (DC_{MP}), Jumping Brook metamorphic suite (ꞒO$_{JB}$) and Pleasant Bay complex (ꞒO$_{PB}$) (Figs. 4, in pocket; and 7, p. 17).

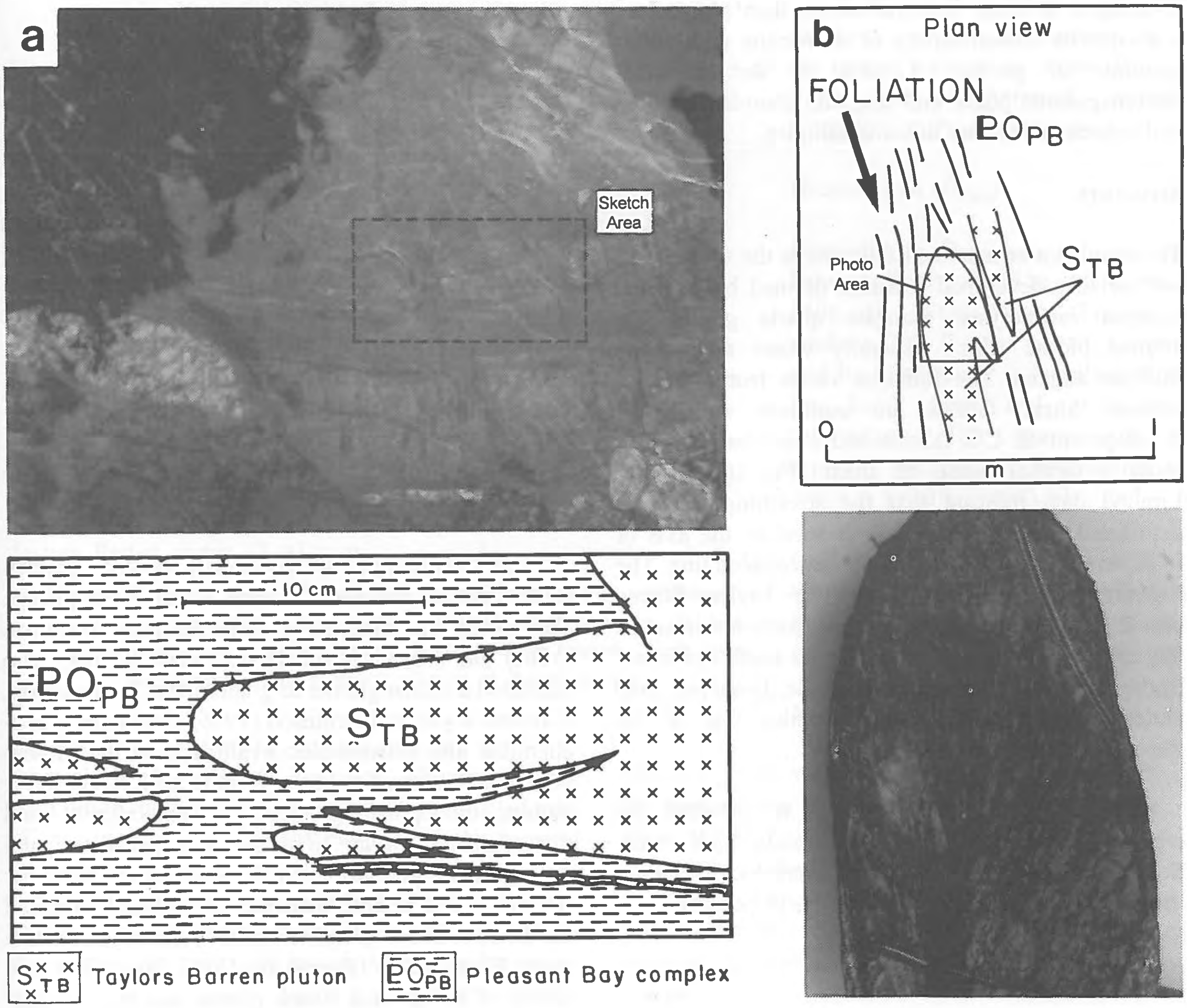


Figure 11. Photographs and sketches of the contact between the Taylors Barren pluton (S_{TB}) and the Pleasant Bay complex (ꞒO$_{PB}$). (a) Photograph and sketch of a stoped contact zone between the Pleasant Bay complex and the Taylors Barren pluton exposed on Nile Brook. (b) Photograph and sketch of a folded dyke of Taylors Barren pluton within the Pleasant Bay complex exposed on Charlie Brook. Note: view of photograph is from bottom.

Petrography

As indicated above this unit is texturally variable. Modal proportions of quartz-K-feldspar-plagioclase determined from point counting of a weakly foliated sample of augen granite plot in the monzogranite field (Fig. 12, p. 29). In thin section this unit is highly variable, displaying intense deformation characterized by subgraining and local shear fabrics. The weakly foliated sample consists predominantly of quartz, feldspar and chlorite with minor muscovite and opaques. Quartz is the dominant phase and is characterized by strong undulose extinction and subgraining, defining a well-developed foliation. K-feldspar is much more abundant than plagioclase and consists predominantly of microcline with minor amounts of perthite. Chlorite is the dominant ferromagnesian phase and contains abundant epidote and sphene inclusions in some samples.

Structure

The dominant structure in this unit is the ubiquitous, yet variably developed foliation defined by augened feldspar megacrysts, elongate quartz grains and aligned biotite which generally wraps around the feldspar augens. The foliation varies from weak to intense. Shear fabrics are common with local development of C/S fabrics and shear bands which show a dextral sense of shear (Fig. 10c, p. 26). Limited data indicate that the stretching lineation associated with this shearing, defined by the axis of feldspar augens, is horizontal to shallow plunging. The foliation in the southern part of the Taylors Barren pluton varies systematically from north-northeast in the east to east-west in the centre to north-northwest in the west, defining a regional-scale, U-shaped map pattern (Fig. 7, p. 17) which mimics that of the Pleasant Bay complex.

The Taylors Barren pluton is affected by numerous metre- and centimetre-scale kink folds. Several brittle faults cut this unit and locally define the contacts with other units (Fig. 4, in pocket).

Age

An Rb-Sr whole rock date of 419±17 Ma (Gaudette et al., 1985) was obtained from the unfoliated portion of this unit. A U-Pb (zircon) age of 430±2 Ma (G. Dunning, personal communication, 1995) has recently been determined which is interpreted as the age of crystallization. This age is consistent with the age constrained by the Late Ordovician (442±3 Ma, U-Pb, zircon, G. Dunning, personal communication, 1995) Belle Côte Road orthogneiss (O_{PBbc}), which the S_{TB} intruded, and the Early Devonian (ca. 400 Ma, O'Beirne-Ryan and Jamieson, 1986) West Branch North River pluton, which intruded the S_{TB} (see below).

DEVONIAN

West Branch North River Pluton (D_{NR})

Definition and Previous Work

The West Branch North River pluton (D_{NR}) is an irregularly shaped granodiorite-monzogranite intrusion located in the south-central Highlands (Figs. 1, p. 6; and 3, p. 8). It is typically unfoliated and intruded surrounding metamorphic units, cutting across regional fabrics. The D_{NR} includes two northward-trending lobes separated by the Southern Highlands shear zone (Fig. 3, p. 8). The western lobe consists predominantly of granodiorite (D_{NRg}) and the eastern lobe consists of monzogranite (D_{NRm}). Most of the western lobe and the northern tip of the eastern lobe of this intrusion occur within the mapped area (Fig. 4, in pocket).

Early mapping by Kelley (1960) showed `granite' in the area of the West Branch North River pluton. The pluton was mapped in more detail by Jamieson (1981) and Jamieson and Doucet (1983, 1984) who indicated a monzogranite to granodiorite composition. O'Beirne-Ryan and Jamieson (1986) conducted a geochemical and petrographic evaluation of the pluton, which they referred to as the West Branch North River pluton, distinguishing areas of granodiorite and monzogranite similar to those indicated above and suggesting a probable genetic association with the Bothan Brook pluton. Regional compilation included the Bothan Brook pluton as part of the West Branch North River pluton (Barr et al., 1992), however recent dating of the Bothan Brook pluton (see below) indicated it is significantly younger than the D_{NR} and therefore considered separately here.

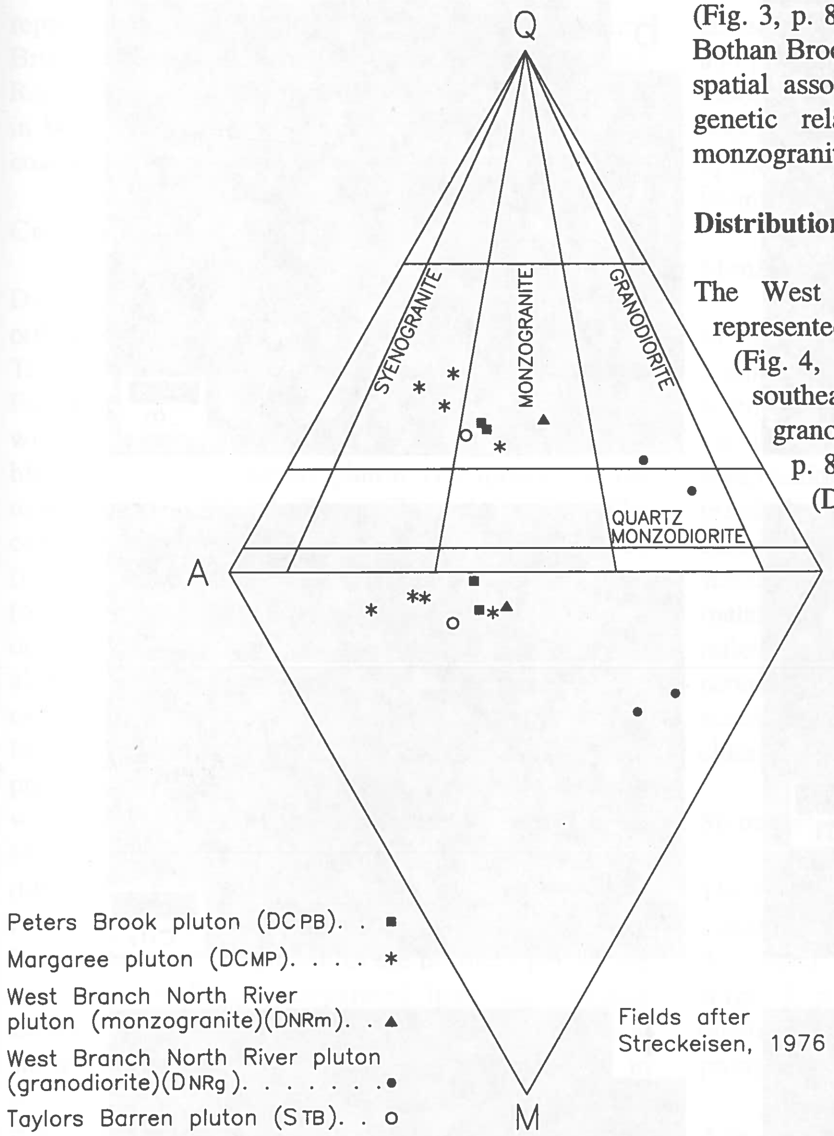


Figure 12. Ternary plot of modal quartz(Q)-potassium feldspar(A)-plagioclase(P) and mafic minerals(M)-potassium feldspar-plagioclase for the Taylors Barren, West Branch North River, Margaree and Peters Brook plutons of the study area.

The limits of the D_{NR} defined here are similar to those shown by O'Beirne-Ryan and Jamieson (1986), with the exception of the inclusion of an isolated area of monzogranite in the northern part of the mapped area (Figs. 3, p. 8; and 4, in pocket) which was previously referred to as undifferentiated, unfoliated granitoid of Devonian age by Jamieson et al. (1987) and Barr et al. (1992) and included with the Park Spur granite (Fig. 1, p. 6) by Slauenwhite (1989). Correlation of this monzogranite with the D_{NRm} is justified on the basis of its occurrence along strike of the linear, northern extension of the main monzogranite body of the West Branch North River pluton (Fig. 3, p. 8). However, as shown in the case of the Bothan Brook pluton, similarity in composition and a spatial association does not in itself demonstrate a genetic relationship, and therefore this area of monzogranite may represent a different intrusion.

Distribution and Field Observations

The West Branch North River pluton (D_{NR}) is represented in two regions of the mapped area (Fig. 4, in pocket). The largest underlies the southeastern part of the area and represents granodiorite (D_{NRg}) of the western lobe (Fig. 3, p. 8). Two small areas of monzogranite (D_{NRm}), occurring in the northeastern part of the area, represent the northern tip of the eastern lobe of the pluton (Fig. 3, p. 8) and an inferred northern extension of the eastern lobe.

Granodiorite (D_{NRg})

Granodiorite (D_{NRg}) occurs in the area between Centre Road to just north of Mile 16 West Road (Fig. 4, in pocket). The D_{NRg} is poorly exposed and its distribution is largely defined by local grus and widespread felsenmeer. The granodiorite is typically medium- to coarse-grained, mafic (≈20% mafics) and is characterized by distinct, pink K-feldspar megacrysts which contrast with the grey groundmass (Fig. 13a, p. 30). Pegmatite-aplite dykes and quartz veining are conspicuously rare.

Monzogranite (D_{NRm})

The monzogranite (D_{NRm}) occurs in two small areas in the northeastern part of the mapped area. One occurs along the Highland Road, north of Cape Clear Road (Fig. 4, in pocket), and represents the northern tip of the eastern lobe of the West Branch North River pluton (Fig. 3, p. 8). No outcrop occurs in this area, however the presence and distribution of this unit here is confidently established by felsenmeer along the Highland Road and to the south along Gillis Road (Ham, 1994). Similar monzogranite forms a narrow, linear body occurring from Second Fork Brook Road North to Coinneach Brook Road. This body is

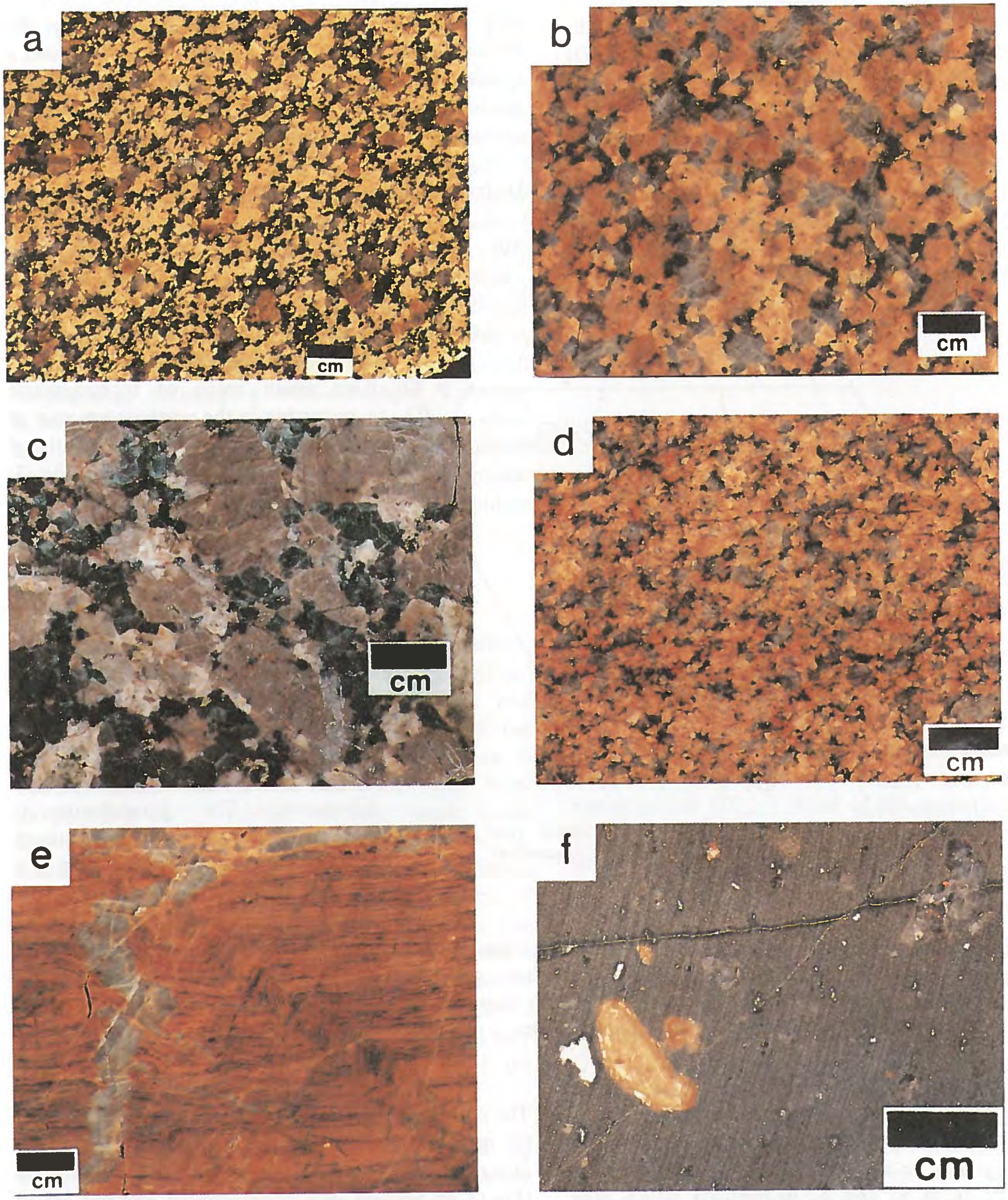


Figure 13. Photographs of slabbed surfaces of samples of selected plutonic rocks in the area. (a) Granodiorite of the West Branch North River pluton (D_{NRg}). Note the distinctive pink K-feldspar megacrysts. (b) Monzogranite of the Bothan Brook pluton (D_{BB}). (c) Megacrystic rapakivi monzogranite of Margaree pluton (DC_{MP}). (d) Medium grained, equigranular monzogranite of the Peters Brook pluton (DC_{PB}). (e) Photograph of slabbed surface of mylonized Bothan Brook pluton (D_{BB}). A strong internal fabric within the quartz vein, which truncates the mylonitic fabric, parallels the mylonitic fabric, suggesting syntectonic emplacement. (f) Mafic dyke with quartz and feldspar phenocrysts which intruded the West Branch North River pluton (D_{NR}).

represented by outcrop and felsenmeer on Coinneach Brook Road and felsenmeer on Second Fork Brook Road North and Coinneach Brook. The monzogranite in both these areas is leucocratic, pink, medium- to coarse-grained and slightly megacrystic.

Contacts

Dykes of distinct D_{NRg} intruded the Belle Côte Road orthogneiss (O_{PBbc}) along Tompkins Spur and the Taylors Barren pluton on Caribou Road (insets on Fig. 4, in pocket) indicating an intrusive relationship with these units. A fault contact with a small faulted block of Taylors Barren pluton is exposed on the upper section of Middle River (Fig. 4, in pocket). The contact between the D_{NRg} and the Bothan Brook pluton (D_{BB}) is not exposed, however it is defined by abrupt (over a few metres) lithologic change which is well defined by a few outcrops and abundant felsenmeer along Mile 16 West Road (Fig. 4, in pocket). No evidence of an intrusive relationship (e.g. dykes) between these units was observed, suggesting a probable fault contact. This interpretation is consistent with the contact between these units intersecting the Middle River fault, although these features have different orientations (Fig. 4, in pocket). The Boundary Line intrusive suite intruded the West Branch North River pluton. In the northern part of the map area the D_{NRm} is separated from the Jumping Brook metamorphic suite by the Coinneach Brook shear zone along its western boundary (Fig. 4, in pocket), however, along its eastern boundary an intrusive relationship is inferred between these units.

Petrography

Granodiorite (D_{NRg})

Modal proportions of quartz-K-feldspar-plagioclase determined from point counting indicate a granodiorite to monzodiorite composition (Fig. 12, p. 29). In thin section the granodiorite is quite fresh, with only minor chloritization of biotite. Distinct green-brown biotite is the dominant ferromagnesian phase and about three times more abundant than hornblende; total mafic mineral content determined from point counting of two slabs is 20-22%. Hornblende is generally green and usually associated with biotite. Plagioclase is abundant and notably fresh, with local myrmekite rims where in contact with K-feldspar. K-feldspar is much less abundant than plagioclase and occurs as microcline and perthite, the latter displaying film and string type exsolution textures. Accessory phases include disseminated epidote, sphene (occurring as subhedral to anhedral grains up to 1.5 mm in length), and apatite (commonly occurring as inclusions within biotite).

Monzogranite (D_{NRm})

In hand sample the D_{NRm} is medium- to coarse-grained, slightly megacrystic, pink and generally resembles the Bothan Brook pluton (Fig. 13b, p. 30). Point counting of one slab indicated a monzogranite composition (Fig. 12, p. 29). In thin section this unit primarily consists of quartz, displaying undulose extinction; plagioclase, generally with hematized and seritized cores; and K-feldspar, including perthite (patch, rod, film) and microcline. Chlorite is common, reflecting alteration of biotite. No hornblende was noted. Sphene, opaques, apatite and epidote constitute accessory phases. Minor muscovite has replaced chlorite and feldspar.

Structure

The West Branch North River pluton (D_{NR}) is typically massive (unfoliated). Mylonitic fabrics are locally developed along the Coinneach Brook shear zone (Figs. 3, p. 8; and 4, in pocket). The D_{NR} generally displays well developed jointing, however no prominent trends are apparent (Fig. 14, p. 32).

Age

Field relations (dykes) indicate the D_{NRg} intruded the Late Ordovician Belle Côte Road orthogneiss (O_{PBbc}) and Early Silurian Taylors Barren pluton (S_{TB}). An Rb-Sr, whole rock, age of 399.6±4.6 Ma (O'Beirne-Ryan and Jamieson, 1986) was determined from samples including both monzogranite and granodiorite and $^{40}Ar/^{39}Ar$ ages (biotite) of 385±5 Ma for the monzogranite and 381±5 Ma for the granodiorite were reported by Reynolds et al. (1989). (Note that although sample 27 of Reynolds et al. (1989) was described as granodiorite in their appendix, its location (their Fig. 3b) lies within the area of D_{NRm} in this report). The $^{40}Ar/^{39}Ar$ dates correspond to $^{40}Ar/^{39}Ar$ dates of biotite in metamorphic units throughout the Aspy Terrane (Reynolds et al., 1989; Keppie et al., 1992), including the adjacent Middle River

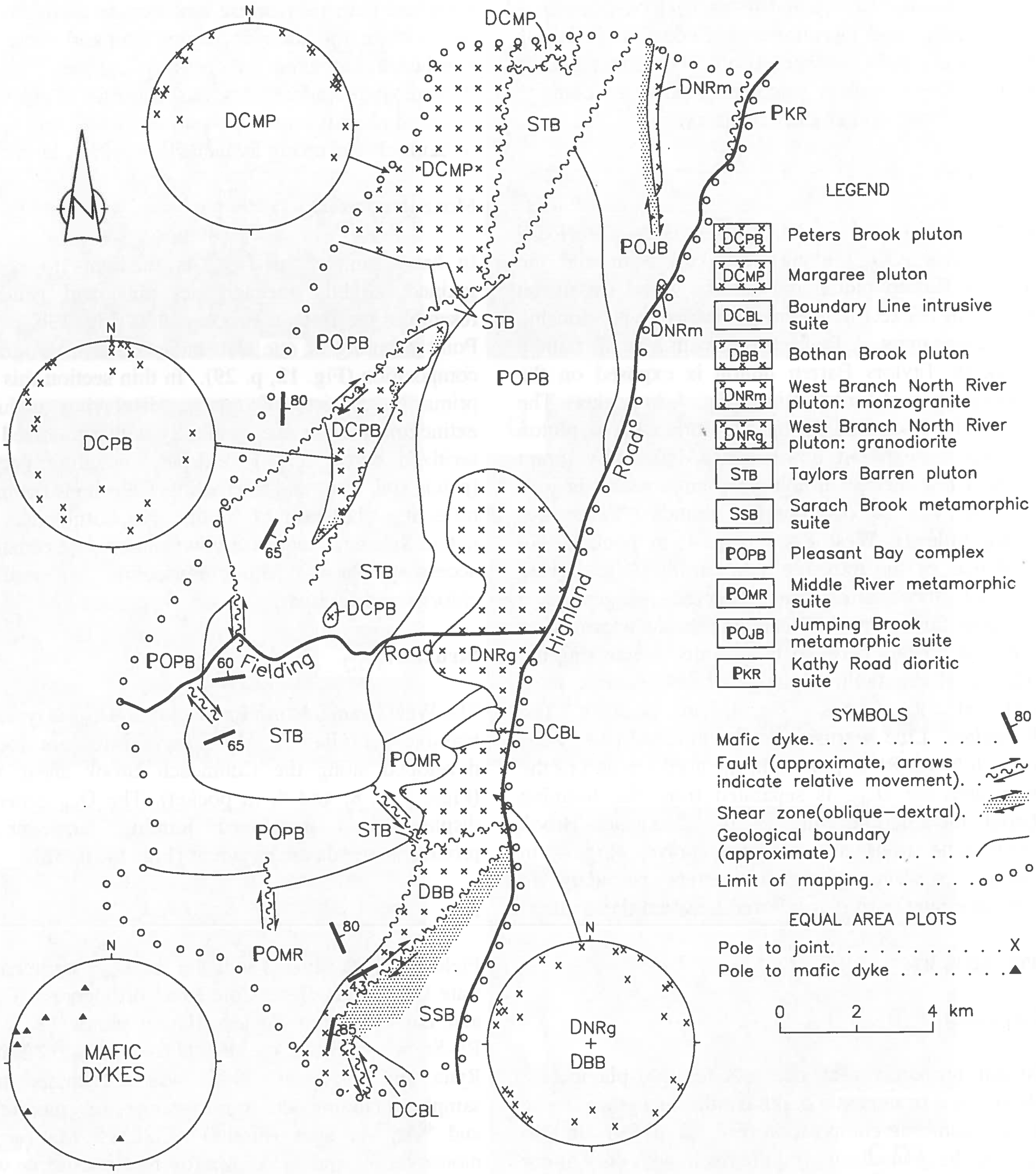


Figure 14. Map showing the distribution of mafic dykes within the mapped area and equal area stereoplots of poles to mafic dykes and joints within the West Branch North River (D_{NR}) and Bothan Brook (D_{BB}), Margaree (DC_{MP}) and Peters Brook (DC_{PB}) plutons.

metamorphic suite (EO_{MR}) (Doucet, 1983) and therefore only constrain a minimum intrusive age. Interpretation of the Rb-Sr date as the age of intrusion is questionable because this method of dating has been shown to be unreliable in the Cape Breton Highlands, giving both younger and older ages when compared to U-Pb and $^{40}Ar/^{39}Ar$ ages (Jamieson et al., 1991). However, the Rb-Sr date is consistent with intrusion of the D_{NR} into the Early Silurian Taylors Barren pluton and the minimum age constrained by the $^{40}Ar/^{39}Ar$ dates.

Bothan Brook Pluton (D_{BB})

Definition and Previous Work

The Bothan Brook pluton is a small, linear monzogranite intrusion occurring south of the West Branch North River pluton (Fig. 3, p. 8). The D_{BB} is contiguous with the D_{NR} (Fig. 3, p. 8) leading to the impression they are one in the same. Kelley (1960) referred to this pluton as granite of pre-Mississippian age, which included the West Branch North River pluton and Milligan (1970) referred to this unit as alaskite of Devonian or earlier age. Jamieson (1981) was the first to subdivide this unit from rocks of the West Branch North River pluton and referred to it as syenogranite. The term Bothan Brook syenogranite was used by Jamieson and Doucet (1983) and the term Bothan Brook pluton (granite) was applied by O'Beirne-Ryan and Jamieson (1986). As mentioned above, regional compilation (Barr et al., 1992) included the Bothan Brook pluton as part of the West Branch North River pluton (Table 1, p. 10-11).

Distribution and Field Observations

The Bothan Brook pluton occurs in the southern part of the mapped area and is well exposed on Bothan, Sarach and South Sarach Brooks and represented by felsenmeer along logging roads (Fig. 4, in pocket). The Bothan Brook pluton (D_{BB}) consists of uniform, medium- to coarse-grained, pink, leucocratic, slightly megacrystic monzogranite (Fig. 13b, p. 30). Pegmatite dykes and quartz veins are conspicuously rare, as are xenoliths. Several mafic dykes cut this unit (Fig. 14, p. 32). Epidote alteration, occurring as veinlets or pervasive replacement, was locally noted within samples of felsenmeer.

Contacts

A fault contact with the Middle River metamorphic suite (EO_{MR}) is exposed on the upper part of Sarach Brook (Fig. 4, in pocket), however further south on this Brook a fault contact is less defined between these units. The Southern Highlands shear zone (Figs. 3, p. 8; and 4, in pocket) separates the D_{BB} from the Sarach Brook metamorphic suite (S_{SB}) and is well exposed on various branches of Sarach Brook. The Boundary Line fault (Fig. 4, in pocket) separates this unit from the Boundary Line intrusive suite (DC_{BL}).

Petrography

In hand sample the Bothan Brook pluton (D_{BB}) is typically medium- to coarse-grained, pink, and moderately equigranular to slightly megacrystic. Quartz generally displays a distinct, milky white colour.

In thin section this unit is characterized by moderately to strongly altered feldspar, quartz, chloritized mafics (biotite?), and minor amounts of muscovite, epidote, sphene and opaques. Plagioclase is generally moderately to strongly sericitized and commonly contains large muscovite flakes. Rare myrmekite rims on plagioclase occur where in contact with K-feldspar. K-feldspar is generally quite fresh and displays both exsolution and replacement perthitic textures. Chlorite is the sole ferromagnesian phase and is interpreted to reflect alteration of biotite. Muscovite is common and occurs as an alteration product of plagioclase and chlorite; some chlorite is nearly completely replaced by muscovite. Epidote is common and almost always associated with chlorite. Sphene is a common accessory phase, often forming euhedral grains up to 1.75 mm in length.

Structure

The Bothan Brook pluton is deformed by the Southern Highlands shear zone with development of a narrow (several metres) zone of mylonite along its eastern margin (Fig. 13e, p. 30). Local well developed cataclastic zones reflecting brittle faulting are common, most notably along the upper part of Sarach Brook and on Boundary Line Bypass (Fig. 4, in pocket). Jointing is generally well developed, although no systematic trends were apparent (Fig. 14, p. 32).

Age

A U-Pb (zircon) crystallization age of 376±3 Ma (G. Dunning, personal communication, 1995) has recently been determined for a sample of this unit from along Bothan Brook.

DEVONIAN-CARBONIFEROUS

Boundary Line Intrusive Suite (DC_{BL})

Definition and Previous Work

The Boundary Line intrusive suite (DC_{BL}) consists of several small intrusions of fine- to medium-grained diorite and monzogranite occurring in the southeastern part of the mapped area (Fig. 4, in pocket). Mafic dykes are common to abundant within the monzogranite. The diorite and monzogranite units exposed in the Boundary Line Bypass area were previously included in the Leonard McLeod Brook complex of Jamieson and Doucet (1983) and Barr et al. (1992) (Fig. 1, p. 6; Table 1, p. 10-11).

Distribution and Field Observations

The DC_{BL} occurs as small intrusions within the West Branch North River granodiorite (D_{NRg}) exposed on a road east of Tompkins Spur on Spring Road, on a northern branch of Mile 16 West Road and the upper section of Middle River, and within the Sarach Brook metamorphic suite (S_{SB}) exposed on the upper part of Bothan Brook and on Boundary Line Bypass (Fig. 4, in pocket). Within the D_{NRg} this unit is characterized by monzogranite (DC_{BLm}) with numerous associated mafic dykes. In the Boundary Line Bypass area distinct regions of monzogranite (DC_{BLm}) and diorite (DC_{BLd}) occur.

The monzogranite is typically fine- to medium-grained, pink and equigranular. Abundant, small miarolitic cavities were noted in a monzogranite outcrop on a tributary of Middle River suggesting a high level of intrusion. Quartz veins and associated quartz-muscovite greisen and epidote stringers are locally abundant within the monzogranite on the Boundary Line Bypass.

Contacts

An intrusive contact between the diorite (dyke) and monzogranite of the Boundary Line unit is exposed on a branch of Mile 16 West Road. The contact between the diorite and Bothan Brook pluton on the Boundary Line Bypass is defined by the cataclastic Boundary Line fault. The relationship between the Boundary Line intrusive suite and the Sarach Brook metamorphic suite is not exposed, although it is inferred to be intrusive.

Petrography

Diorite (DC_{BLd})

In hand sample the diorite (DC_{BLd}) is medium grained, dark, equigranular and characterized by euhedral plagioclase laths in a groundmass of amphibole. In thin section it is seen to consist predominantly of plagioclase, hornblende and epidote with minor quartz, sphene and opaques. Epidote is secondary after plagioclase, which is typically strongly altered.

Monzogranite (DC_{BLm})

In hand sample the monzogranite (DC_{BLm}) is fine- to medium-grained, pink, leucocratic (≈3% mafics) and equigranular. K-feldspar consists predominantly of microcline with lesser perthite displaying film and rod type exsolution. Plagioclase is typically strongly altered, characterized by common, fine grained sericite and muscovite alteration. Quartz generally shows strong undulose extinction and local subgraining. Minor amounts of chlorite and lesser biotite occur throughout. Opaques are common to abundant and generally associated with chlorite. Accessory, euhedral sphene occurs in some samples.

Structure

The DC_{BL} is typically massive and unfoliated within the mapped area. Development of local cataclastic zones associated with the Boundary Line Fault occur along Bothan Brook and the Boundary Line Bypass (Fig. 4, in pocket).

Age

The DC_{BL} locally intruded, and so is younger than, the Devonian(?) West Branch North River pluton (D_{NR}). If the mafic dykes which intruded the Bothan Brook pluton are related to the DC_{BL} then a late Devonian or younger age is implied. No radiometric age dates for this unit have been published.

Margaree Pluton (DC_{MP})

Definition and Previous Work

The area of Margaree pluton (DC_{MP}) discussed here represents the southern extremity of a large, linear, north-northeastward-trending body of coarse grained, megacrystic granite in the western Cape Breton Highlands (Fig. 1, p. 6). This unit was previously referred to as the Margaree granite by Currie (1978) (Table 1, p. 10-11). The Margaree pluton has been examined by Neale (1963a), O'Beirne-Ryan et al. (1986), Barr et al. (1987a), Currie (1987) and Jamieson et al. (1987) and is generally described as a coarse grained, biotite±hornblende, rapakivi granite.

Distribution and Field Observations

The Margaree pluton underlies the northwestern corner of the mapped area (Figs. 3, p. 8; and 4, in pocket). Excellent exposure of this unit is found in cliff sections (i.e. Cape Clear Lookoff) and valley walls along First Fork Brook. Exposure along logging roads is sporadic. Felsenmeer of felsic quartz-feldspar porphyry occurring within the Belle Côte Road orthogneiss unit (O_{PBbc}) near the end of Centre Road (Fig. 4, in pocket) was included with the Margaree pluton by Jamieson et al. (1987),

Within the mapped area the DC_{MP} typically displays a distinctive, medium- to coarse-grained, highly megacrystic texture (Fig. 13c, p. 30). However, a fine- to coarse-grained porphyritic texture (fine- to medium-grained porphyritic groundmass with coarse megacrysts) is common along the southern margin of this unit and may represent a chilled marginal phase against the Pleasant Bay complex ($ЄO_{PB}$).

Contacts

The Second Fork Brook Road fault defines the contact between this unit and the Taylors Barren pluton (S_{TB}) (Fig. 4, in pocket). The contact between the Margaree pluton (DC_{MP}) and the Pleasant Bay complex (O_{PBbc}) is not exposed. However, felsenmeer of felsic porphyry near the end of Centre Road (Fig. 4, in pocket), which is similar to the porphyritic variety of the Margaree pluton, probably represents a dyke of Margaree pluton (Jamieson et al., 1987), implying an intrusive relationship.

Petrography

Modal proportions of quartz-K-feldspar-plagioclase indicate a monzogranite to syenogranite composition (Fig. 12, p. 29). Feldspar megacrysts, predominantly K-feldspar, are abundant (up to 40% of the rock volume) and a distinctive feature of this unit. K-feldspar megacrysts often have plagioclase rims (rapakivi texture) and, although euhedral in form, have irregular edges due to their late development. In thin section the K-feldspar megacrysts are characterized by both exsolution and replacement type perthite textures.

The groundmass consists of quartz, feldspar, chlorite, biotite and accessory epidote, apatite, opaques, hematite, sphene and zircon. Quartz commonly occurs as large aggregates forming coarse, composite grains. Chlorite is an alteration product of biotite and has generally replaced 90-100% of the biotite. Opaques, apatite and zircon are commonly associated with chlorite. Both plagioclase and K-feldspar have a clouded appearance in thin section resulting from the common sericitization of plagioclase and hematization of both feldspars. A small amount of K-feldspar occurs as microcline. Myrmekite rims locally occur on plagioclase at K-feldspar-plagioclase boundaries. Hematite occurs both as narrow fracture fillings and distinct, individual grains.

Structure

The Margaree pluton (DC_{MP}) is typically massive and unfoliated. Fault contacts with the Taylors Barren pluton (S_{TB}) are characterized by well developed cataclastic zones. One such cataclastic zone, exposed on First Fork Brook consists of several metres of microbreccia-cataclasite. Jointing is ubiquitous, locally forming spectacular cliff faces. A stereoplot of limited joint data from this unit (Fig. 14, p. 32) does not reveal any systematic trends.

Age

A six point, whole rock Rb-Sr isochron age of 343±17 Ma (O'Beirne-Ryan et al., 1986) and $^{40}Ar/^{39}Ar$ (total gas, biotite) ages of 368 Ma and 375 Ma (Reynolds et al., 1989) have been published for the Margaree pluton. O'Beirne-Ryan et al. (1986) considered the 343±17 Ma Rb-Sr age as too young for an intrusive age because dykes of the older Salmon Pool granite (365+10/-5 Ma, U-Pb (zircon), Jamieson et al., 1986) cut the Margaree pluton. The $^{40}Ar/^{39}Ar$ age corresponds to $^{40}Ar/^{39}Ar$ ages documented for plutonic and metamorphic units throughout the region (e.g. Reynolds et al., 1989; Doucet, 1983; Keppie et al., 1992) and therefore provide only a minimum age for intrusion. A maximum age is constrained by its intrusion into the Ordovician Belle Côte Road orthogneiss.

Peters Brook Pluton (DC_{PB})

Definition and Previous Work

The term Peters Brook pluton is applied here to a small (3.25 x 0.5 km), linear, north-northeastward-trending granite intrusion occurring in the Centre Road area (Figs. 3, p. 8; and 4, in pocket). The only prior recognition of this unit was by Kelley (1960), who identified several `granite' bodies in the areas of Maggie Ranalds and Peters Brooks, and Covey (1978) who noted medium grained granite on the upper part of Charlie Brook.

Distribution and Field Observations

The Peters Brook pluton occurs in the central part of the mapped area, between Maggie Ranalds and First Fork Brook South (Fig. 4, in pocket). In addition, small satellite intrusions and dykes of similar granite occur on Caribou Road and the headwaters of Maggie Ranalds Brook. The Peters Brook pluton is well exposed on Peters Brook, Black Brook and First Fork Brook South and represented by felsenmeer on Centre Road.

The majority of this pluton consists of massive, medium grained, unfoliated, equigranular, pink-red monzogranite (Fig. 13d, p. 30) although a strong shear foliation, related to the Black Brook shear zone (Figs. 4, in pocket; and 15, p. 37), is locally developed along the eastern margin. The foliation is defined by stretched quartz and feldspar grains. Dykes, veins and xenoliths are conspicuously rare.

Contacts

Dykes of Peters Brook pluton (DC_{PB}) crosscut the Taylors Barren pluton (S_{TB}) on Caribou Road and the First Fork Brook gneiss ($ЄO_{PBff}$) near the headwaters of Maggie Ranalds Brook (insets on Fig. 4, in pocket) indicating an intrusive relationship with these units. A fault contact with the Belle Côte Road orthogneiss (O_{PBbc}) is inferred along the western margin of this unit based on cataclastic textures (microbreccia, cataclasite) in felsenmeer of this unit on Centre Road and a high degree of fracturing near the contact on Peters Brook. The Black Brook shear zone forms the contact with the Taylors Barren pluton (S_{TB}) along the eastern margin of this unit (Fig. 4, in pocket).

Petrography

In outcrop, the unfoliated Peters Brook pluton is typically fine- to medium-grained, equigranular, pinkish-red, leucocratic (<10% mafics) and extremely homogeneous (Fig. 13d, p. 30). Quartz displays a distinct milky white colour and the feldspar is usually pink to dark red. Proportions of quartz-K-feldspar-plagioclase plot in the monzogranite field (Fig. 12, p. 29). The sheared portion of this pluton exhibits a strong penetrative foliation.

In thin section, the Peters Brook pluton is typically moderately to strongly altered with chlorite completely replacing biotite and moderate to strong sericitization and hematization of feldspars. K-feldspar is slightly hematized and both microcline and perthite occur, the latter with film and rod type exsolution. Plagioclase is generally moderately to intensely altered, commonly consisting of fine sericite and muscovite flakes. Chlorite is the sole ferromagnesian silicate. Accessory phases include hematite, epidote and apatite. Hematite occurs as fracture fillings, euhedral grains and fine, disseminated grains in feldspar, the latter resulting in the pervasive pink-red colour of this unit.

Structure

The Peters Brook pluton (DC_{PB}) is typically massive and unfoliated. The Black Brook shear zone deforms the eastern margin of the unit, developing a pronounced shear foliation (see section on Shear

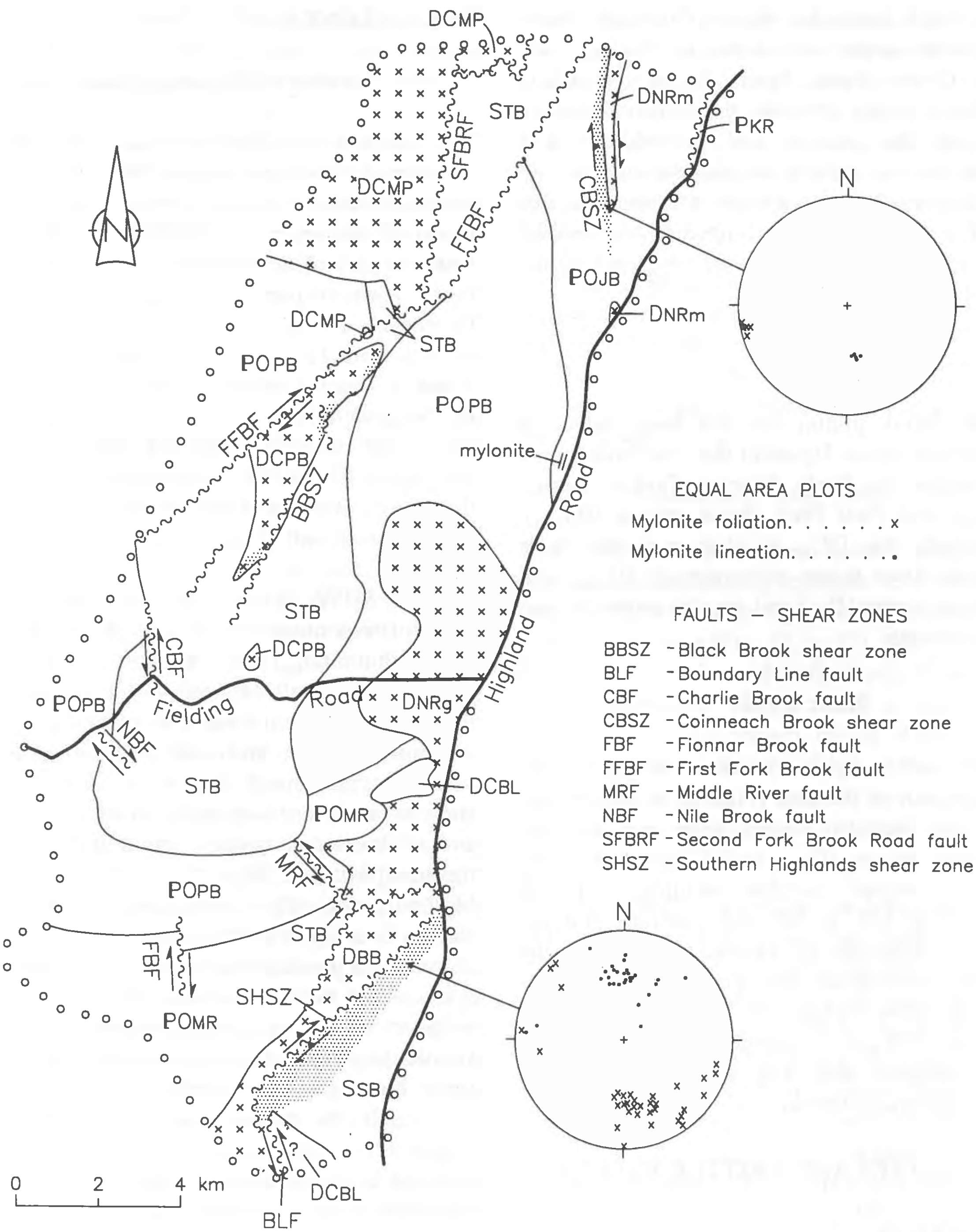


Figure 15. Map showing shear zones and brittle faults in the mapped area and equal area stereoplots of mylonitic fabrics (foliation and lineation) from the Southern Highlands and Coinneach Brook shear zones. See Figure 14, p. 32, for legend.

Zones and Brittle Faults, this paper). Cataclastic zones reflecting brittle faults occur within the Peters Brook pluton on Centre Road, Peters Brook and Black Brook. These faults parallel the sheared eastern boundary of the pluton and probably reflect reactivation of the earlier, ductile deformation. In addition, slickensided fractures occur throughout this unit, which is typically highly fractured. A stereoplot of limited joint data (Fig. 14, p. 32) does not define any systematic trends.

Age

The Peters Brook pluton has not been dated by radiometric techniques. Dykes of this unit crosscut the foliation within the Early Silurian Taylors Barren pluton (S_{TB}) and First Fork Brook gneiss (PO_{PBff}). Petrographically the DC_{PB} is similar to the West Branch North River pluton monzogranite (D_{NRm}) and Bothan Brook pluton (D_{BB}) and may be related to one of these intrusions.

Mafic Dykes

Unfoliated mafic dykes occur throughout the southwestern part of the area (Figs. 4, in pocket; and 14, p. 32) and intruded several units including the Bothan Brook pluton (D_{BB}), indicating a later age. These dykes display variable textures, including porphyritic (Fig. 13f, p. 30) and medium grained, equigranular. Although no evidence exists for the origin of the mafic dykes, they may be related to the diorite (and mafic dykes) of the Boundary Line intrusive suite (DC_{BL}). A stereoplot of mafic dykes within the mapped area (Fig. 14, p. 32) does not define any systematic trends.

SHEAR ZONES AND BRITTLE FAULTS

INTRODUCTION

Several major movement horizons have been identified within the study area and commonly define unit boundaries (Fig. 15, p. 37). These movement horizons vary from ductile to brittle in character; ductile **shear zones** are characterized by wide zones of protomylonite to ultramylonite; **brittle faults** are characterized by narrow zones of fault breccia-microbreccia-cataclasite and slickensides and are typically strongly chloritized and hematized.

SHEAR ZONES

Southern Highlands Shear Zone

The term Southern Highlands shear zone (SHSZ) was introduced by Mengel et al. (1991) who extended this structure from Bothan Brook to Coinneach Brook. In this study, however, the term SHSZ is restricted to the southern part of the mapped area and the shear zone in the northern part of the area is referred to as the Coinneach Brook shear zone (Figs. 3, p. 8; 4, in pocket; and 15, p. 37). Distinction of these shear zones is justified in that similar mylonite zones have not been identified in the intervening area. However, these shear zones are probably related (see Discussion, this paper). The SHSZ, as defined here, corresponds to the Sarach Brook mylonite zone of Jamieson (1981) and Jamieson and Doucet (1983, 1984).

The SHSZ defines the boundary between the Sarach Brook metamorphic suite (S_{SB}) and the Bothan Brook pluton (D_{BB}) (Figs. 4, in pocket; and 15, p. 37). The SHSZ is well exposed within the map area on several tributaries of Sarach Brook and represented by occasional outcrop and widespread felsenmeer along several logging roads (Fig. 4, in pocket). The shear zone has a surface expression of up to 1.25 km wide and is developed mainly within the Sarach Brook metamorphic suite (Figs. 15, p. 37; 16a and b, p. 40). Mylonite is developed along the eastern margin of the Bothan Brook pluton (D_{BB}) (Fig. 13e, p. 30) indicating deformation postdates its intrusion. The SHSZ extends northeast of the mapped area (Fig. 3, p. 8; Ham, in preparation), but is not recognized south of Bothan Brook. Jamieson and Doucet (1983) suggested this shear zone continued further south, possibly being responsible for the widening of the Bothan Brook pluton in this area. However, no evidence of shearing is found in the felsenmeer and rubblecrop along the Boundary Line Spur (Fig. 4, in pocket) to imply extension of the SHSZ into this area. In contrast, felsenmeer of brecciated mylonite (Fig. 16c, p. 40), occurring within the Boundary Line fault southeast of the SHSZ (Fig. 4, in pocket), suggests possible sinistral offset of this shear zone along the Boundary Line fault.

The SHSZ is characterized by low grade, protomylonite to mylonite and chloritic schist developed primarily in volcanic rocks of the Sarach Brook metamorphic suite. The majority of the zone is characterized by dark green mylonite consisting of thin (<1 mm), mylonitic banding and a conspicuous stretching lineation defined by light coloured, elongate mineral aggregates. The latter presumably represent stretched volcanic fragments or phenocrysts and give a characteristic striped appearance to many outcrops (Fig. 16a, p. 40). Chlorite schist is common and is interpreted as strongly sheared, intermediate to mafic volcanic rocks. Local zones of pale, fine grained, felsic mylonite presumably represent sheared felsic volcanic rocks.

The trend of the mylonitic foliation varies systematically in a Z-shaped map pattern; northeast/vertical at the margins of the shear zone and E 45° N in the centre (Figs. 4, in pocket; and 15, p. 37). The stretching lineation plunges moderately (≈45°) northwards in the centre of the shear zone and varies overall from westward- to northeastward-trending with a dominant 45° plunge (Figs. 4, in pocket; and 15, p. 37). Several oriented samples of mylonite investigated for shear sense indicators revealed ambiguous results, with a preponderance of symmetrical pressure shadows suggesting a probable high ratio of pure to simple shear. Mengel et al. (1991), however, stated that shear sense indicators including C-S fabrics, shear bands and asymmetric fish indicate an oblique, dextral/northwest-sidedown sense of shear. Local asymmetric, rotated fragments and associated pressure shadows (Fig. 16b, p. 40) are consistent with this interpretation; however, it should be noted that similar features indicating the opposite sense of shear were noted. As discussed by Mengel et al. (1991), a northwest-sidedown sense of shear implies this fault is either an extensional or reoriented contractional structure. The latter is supported by the occurrence of high grade rocks (Middle River metamorphic suite) in the hanging wall. Reorientation of this fault has been proposed by Jamieson and Doucet (1983) and Lynch and Lafrance (1994).

The Bothan Brook pluton (D_{BB}) is locally affected by the SHSZ (Fig. 13e, p. 30). Granite dykes intruded the shear zone along South Sarach Brook (Fig. 4, in pocket). These dykes are presumably related to the Bothan Brook pluton, implying late syntectonic intrusion. This is consistent with folded, granite-related(?) quartz veins which locally truncate the mylonite fabric in the Bothan Brook pluton (Fig. 13e, p. 30), but also display a strong foliation defined by recrystallized quartz which parallels the mylonitic fabric. Late syntectonic intrusion may explain the pronounced elongation of the Bothan Brook pluton. If this interpretation is correct the age of the shear zone is constrained by the age of the pluton (i.e. 376±3 Ma, U-Pb, zircon, G. Dunning, personal communication, 1995). This is inconsistent with an Rb-Sr whole rock date of 394±28 Ma obtained for the shear zone (Jamieson and Doucet, 1984).

The SHSZ is locally affected by minor kink folds with associated tension gashes (Fig. 16d, p. 40) and is deformed by late cataclastic faults (Fig. 16c, p. 40). Brittle faulting at the contact of the SHSZ and the Bothan Brook pluton probably reflects reactivation of this structure.

Coinneach Brook Shear Zone

The Coinneach Brook shear zone (CBSZ) is a north-northwestward-trending mylonite zone transecting the Jumping Brook metamorphic suite in the northeastern corner of the area (Fig. 15, p. 37). The CBSZ outcrops on a branch of Second Fork Brook Road North and along Coinneach Brook, and is represented by felsenmeer on Coinneach Brook Road and several branch roads of Second Fork Brook Road North (Fig. 4, in pocket). As noted above, the CBSZ was included in the Southern Highland shear zone of Mengel et al. (1991).

The CBSZ is defined by an approximately 100 m wide zone of well developed, homogeneous mylonite mainly within the Dauphinee Brook schist (ЄO$_{JBdb}$). The mylonite is characterized by paper thin (<1 mm) banding and a strong stretching lineation defined by centimetre scale, ovoid mineral aggregates within the foliation. Colour contrasts between the dark, lineated mineral aggregates, which probably reflect stretched porphyroblasts, and the remainder of the rock produces a characteristic striped appearance similar to the mylonite in the Southern Highlands shear zone (i.e. Fig. 16a, p. 40). The exposed western margin of the CBSZ is gradational with the Dauphinee Brook schist (ЄO$_{JBdb}$) and characterized by progressive deformation from well-developed mylonite to sheared Dauphinee Brook schist (ЄO$_{JBdb\text{-}a}$) (e.g. Fig. 6b, p. 14) over approximately 1 m. The eastern margin of the mylonite is not exposed, however felsenmeer of the West Branch North River pluton (D_{NRm}) locally displays a mylonitic fabric similar to that developed in the Bothan Brook pluton along the SHSZ (i.e. Fig. 13e, p. 30).

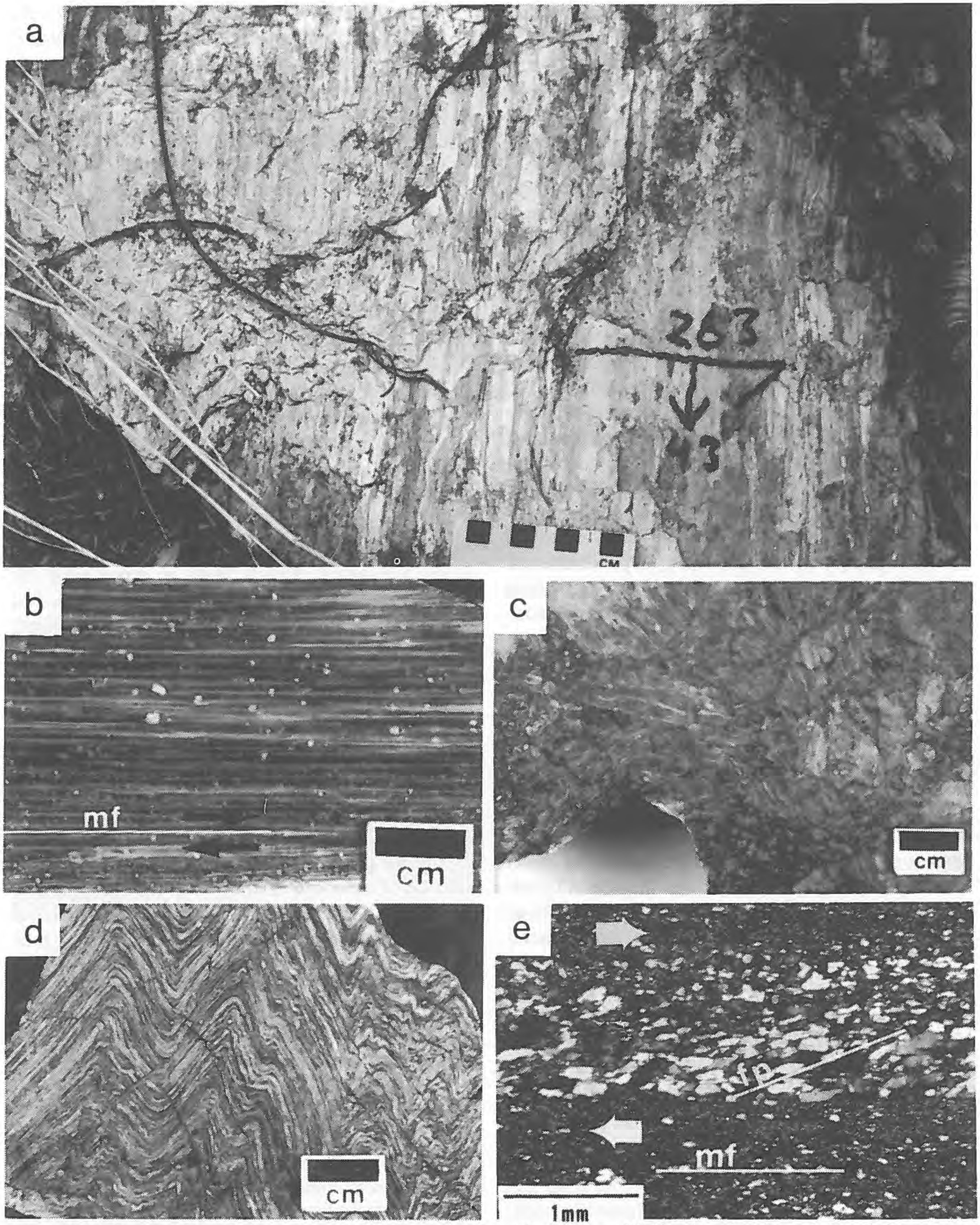


Figure 16. Photographs and photomicrographs of mylonite from the Southern Highlands and Coinneach Brook shear zones and Boundary Line fault.

The mylonitic fabric trends 170°/89°E with a strong lineation plunging ≈39° south. No mesoscopic kinematic indicators were identified within the mylonite. In thin section the mylonite is defined primarily by a shear foliation and asymmetric fabrics are rare and ambiguous. Local ribbons of recrystallized quartz display strain-insensitive fabrics (Hanmer and Passchier, 1991) with flattening planes of subgrains and recrystallized grains oblique to the mylonitic foliation defining a shear sense (Simpson and Schmid, 1983; Hanmer and Passchier, 1991) (Fig. 16e) indicating oblique dextral/west-sideup movement. Rotated, asymmetric garnet porphyroblasts and mica fish within sheared Dauphinee Brook schist ($ЄO_{JBdb-a}$) adjacent to the mylonite (e.g. Fig. 6b, p. 14) indicate a similar sense of shear.

Black Brook Shear Zone

The Black Brook shear zone (BBSZ) is defined by strongly foliated granitoid rocks occurring along the eastern boundary of the Peters Brook pluton (Figs. 4, in pocket; and 15, p. 37). The BBSZ occurs mainly in the Peters Brook pluton (DC_{PB}), however it locally affects the Taylors Barren pluton (S_{TB}). The foliation is north-northeastward-trending, parallel to the shear zone boundary and steeply dipping. In outcrop, the foliation is defined by elongated quartz, feldspar and biotite. In thin section the quartz and feldspar consist of elongated (recrystallized(?)) aggregates with quartz displaying undulose extinction and sutured boundaries.

The BBSZ coincides with a series of air photo lineaments occurring along the eastern margin of the Peters Brook pluton which extend south to the Fielding Road (Fig. 4, in pocket), suggesting it may be part of a larger regional structure. The age of the BBSZ is unknown, however it affects the unfoliated, Devonian-Carboniferous(?) Peters Brook pluton.

Brittle faulting, characterized by fault breccia-cataclasite, coincident with the BBSZ (Fig. 4, in pocket) suggests reactivation of this structure.

BRITTLE FAULTS

Charlie Brook Fault

The Charlie Brook fault (Fig. 15, p. 37) is exposed along Charlie Brook, where it locally defines the contact between the Taylors Barren pluton (S_{TB}) and the Belle Côte Road orthogneiss (O_{PBbc}), and in a gravel pit on the southern side of the Fielding Road (Fig. 4, in pocket). This fault is characterized by slickensided fractures and breccia-cataclasite and is generally chloritized.

Middle River Fault

The Middle River fault is exposed on the upper part of Middle River where it locally defines a contact between a block of the Taylors Barren pluton (S_{TB}) and the Middle River metamorphic suite ($ЄO_{MR}$) (Figs. 4, in pocket; and 15, p. 37). Extrapolation of this fault to the northwest, defining the contact between the Middle River metamorphic suite ($ЄO_{MR}$) and the Pleasant Bay complex (O_{PBbc}), could explain the apparent (sinistral) displacement of the Middle River metamorphic suite.

First Fork Brook Fault

The north-northeastward-trending First Fork Brook fault (Fig. 15, p. 37) is well exposed on several branches of First Fork Brook and in a gravel pit on Second Fork Brook Road North, and defined by felsenmeer along Centre Road (Fig. 4, in pocket). This fault locally defines the contact between the Margaree pluton (DC_{MP}) and Taylors Barren pluton (S_{TB})

Figure 16. Photographs and photomicrographs of mylonitic shear zones. (a) Photograph of mylonite outcrop from the Southern Highlands shear zone showing downdip lineation defined by stretched volcanic fragments producing a 'striped' appearance. (b) Photograph of slab from the Southern Highlands shear zone cut perpendicular to mylonitic foliation and parallel to mylonitic lineation. Asymmetric pressure shadows of feldspar indicate relative dextral (west-sidedown) sense of shear. (c) Photograph of slabbed felsenmeer sample of brecciated mylonite from the Boundary Line fault. (d) Photograph of slabbed felsenmeer sample of tightly folded mylonite from the Southern Highlands shear zone. (e) Photomicrograph of mylonite from the Coinneach Brook shear zone. Section cut perpendicular to the mylonitic foliation and parallel to mylonitic lineation. Quartz ribbons of recrystallized quartz exhibiting 'strain-insensitive' fabrics with flattening plane (fp) oblique to the mylonitic fabric (mf) indicate a dextral sense of shear.

(exposed along the main branch of First Fork Brook); the Margaree pluton (DC_{MP}) and the Pleasant Bay complex ($ЄO_{PB}$) (exposed on First Fork Brook South); and the Taylors Barren pluton (S_{TB}) and the Jumping Brook metamorphic suite ($ЄO_{JB}$) (exposed on Second Fork Brook Road North, Coinneach Brook and Coinneach Brook Road). This fault is inferred to locally define the contact between the Taylors Barren pluton (S_{TB}) and the Pleasant Bay complex ($ЄO_{PB}$); and the Pleasant Bay complex ($ЄO_{PB}$) and Peters Brook pluton (DC_{PB}). This fault is represented by a zone of microbreccia-cataclasite several metres wide exposed on Coinneach Brook. Approximately 1.25 km of (horizontal) dextral offset is indicated along this fault between First Fork Brook and First Fork Brook South by offset of the Margaree pluton (Figs. 4, in pocket; and 15, p. 37).

Second Fork Brook Road Fault

The Second Fork Brook Road fault is a north-south-trending brittle fault which defines the contact between the Margaree (DC_{MP}) and Taylors Barren plutons (S_{TB}) (Fig. 15, p. 37). This fault is observed only in felsenmeer along Second Fork Brook Road North (Fig. 4, in pocket), in which brittle deformation of both the Margaree and Taylors Barren plutons was observed.

Nile Brook Fault

The Nile Brook fault is defined by a 1-2 m wide zone of intense brittle-ductile deformation exposed within the Taylors Barren pluton (S_{TB}) along Nile Brook (Figs. 4, in pocket; and 15, p. 37). Domino structures developed in large clasts within the fault zone indicate a dextral sense of displacement.

Boundary Line Fault

The Boundary Line fault defines the contact between the Boundary Line intrusive suite (DC_{BL}) and the Bothan Brook pluton (D_{BB}) in the southern part of the mapped area (Figs. 4, in pocket; and 15, p. 37). This fault is exposed on the upper part of Bothan Brook and along the Boundary Line Bypass (Fig. 4, in pocket). As indicated above, this fault deforms the Southern Highlands shear zone. Brecciated mylonite occurring in felsenmeer southeast of the SHSZ suggests a sinistral component of offset.

Fionnar Brook Fault

The Fionnar Brook fault (Fig. 15, p. 37) is defined by zones of closely spaced, intensely slickensided, fractures along Fionnar Brook (Fig. 4, in pocket). Minor dextral displacement is inferred from apparent offset of the contact between the Middle River metamorphic suite ($ЄO_{MR}$) and the Belle Côte Road orthogneiss (O_{PBbc}).

ECONOMIC GEOLOGY

INTRODUCTION

Several minor mineral occurrences and zones of hydrothermal alteration occur within the mapped area. Occurrences are listed here by Nova Scotia Department of Natural Resources (NSDNR), Mineral Occurrence Record Numbers and described below. The occurrence records provide further description, analytical data and references on each of the occurrences. In addition, several other occurrences, which have not been given Mineral Occurrence Record Numbers, are described.

NOVA SCOTIA DEPARTMENT OF NATURAL RESOURCES, MINERAL OCCURRENCES

K07-04 Nile Brook Occurrence

Two sulphide occurrences occur along a section of Nile Brook just north of the intersection of Nile Brook and South Nile Brook (Fig. 4, in pocket). The first documentation of these occurrences was made by Kelley (1960) with later descriptions by Cranton (1966), Milligan (1970), MacNabb et al. (1976), Chatterjee (1980), Doucet (1983) and NSDNR, Mineral Occurrence K07-04.

The most northern of the two occurrences consists of a steeply dipping, northwestward-trending mineralized shear zone (≈0.5 m wide) which occurs within an inclusion of a mafic schistose gneiss hosted by augen granite of the Taylors Barren pluton (S_{TB}) (Kelley, 1960). Mineralization consists of chalcopyrite, pyrite, pyrrhotite and minor sphalerite (Chatterjee, 1980). The southern occurrence is hosted by the Pleasant Bay complex and consists of disseminated sulphide (chalcopyrite, pyrite, sphalerite) within a shear zone. In addition, minor disseminated sulphide was noted in the area between the two main occurrences (NSDNR, Mineral Occurrence K07-04). Analytical results from various sources are compiled in NSDNR, Mineral Occurrence K07-04 and indicate anomalous values of Cu (maximum 2.76%), Pb (maximum 1.93%), Zn (maximum 1.86%), Au (maximum 0.0145 oz/ton) and Ag (maximum 34 ppm).

Minor disseminated sulphide was noted in inclusions of First Fork Brook gneiss (ЄO$_{PBff}$) within the Taylors Barren pluton near the upper end of Nile Brook (Fig. 4, in pocket) and, as suggested by Kelley (1960), an investigation of similar inclusions may be warranted.

K07-22 Charlie Brook Occurrence

Minor molybdenite, pyrite and fluorite were documented in the upper part of Charlie Brook (Fig. 4, in pocket) by Covey (1978). Molybdenite was reported to occur as small flakes associated with pyrite and quartz veins within float of fine grained, unfoliated granite. Quartz veining with silicification, sericitization and pyrite mineralization were reported from outcrop of this unit. Fluorite was also reported to occur along `shear planes' in float of `granite gneiss' (Taylors Barren pluton(?)) from this area (Covey, 1978). Recent updating of NSDNR Mineral Occurrence Record K07-22 by G. DeMont indicated that the molybdenite-bearing quartz veins occur within the Taylors Barren pluton (DeMont, in preparation).

K07-34 Cape Clear Road Alteration Zone

A distinctive alteration zone, characterized by quartz, muscovite, pyrite and locally abundant kyanite, occurs in the Belle Côte Road orthogneiss (O$_{PBbc}$) along a branch of Cape Clear Road (Fig. 4, in pocket). The alteration occurs as three distinct zones, each separated by fairly unaltered orthogneiss (Fig. 17). The trend of the altered zones parallels the gneissic fabric. The combined width of alteration is approximately 75 m.

The alteration zone is variable in character, consisting of: (i) northward-trending quartz±feldspar±muscovite±pyrite veins, (ii) quartz-muscovite-pyrite alteration, which comprises most of the alteration zone, and (iii) distinct zones of massive, unfoliated

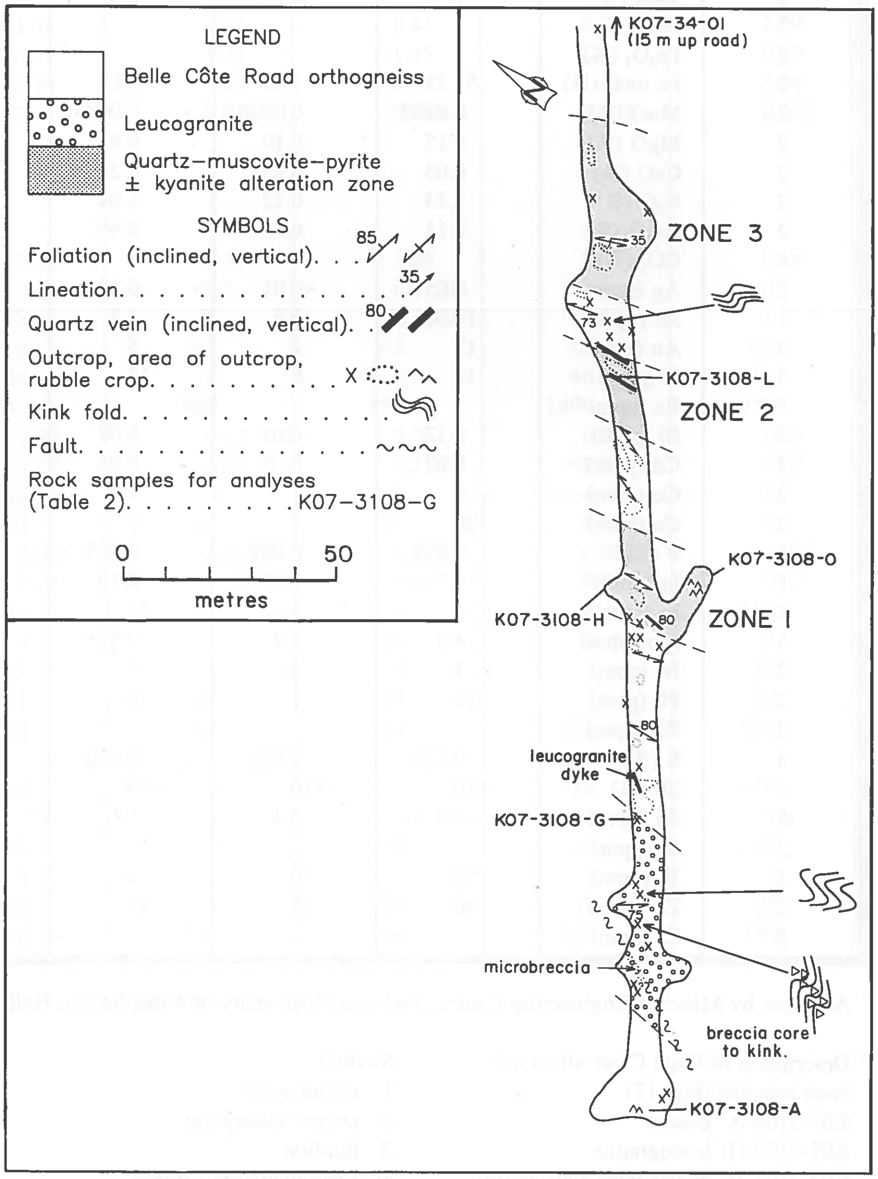


Figure 17. Detailed geological map of the Cape Clear Road alteration zone Nova Scotia Department of Natural Resources, Minerals and Energy Branch, Mineral Occurrence K07-34. See Figure 4, in pocket, for location. See Table 2 for major and trace element analyses for rock samples from this mineral occurrence. Note analyses for sample K07-34-01 are available in NSDNR, Mineral Occurrence Record K07-34.

Table 2. Table of geochemical analyses of selected mineralized or altered samples from the south-central Cape Breton Highlands[1]. See Figure 4 (in pocket) for Mineral Occurrence and Miscellaneous locations and Figure 17 (p. 43) for sample locations from Cape Clear Road alteration zone (Nova Scotia Department of Natural Resources (NSDNR), Mineral Occurrence K07-34).

Cape Clear Road Alteration Zone[2] (NSDNR, Mineral Occurrence K07-34)

Method[3]		K07-3108-A	K07-3108-G	K07-3108-H	K07-3108-L	K07-3108-O	Reference[4]
1	SiO_2 (%)	26.49	78.40	79.29	95.49	74.27	
2	Al_2O_3 (%)	6.84	12.12	11.65	2.38	12.12	
2	TiO_2 (%)	1.90	0.24	0.47	0.02	0.20	
3	FeO (%)						
2	Fe_2O_3 (%)						
2	Fe total (%)	51.25	1.61	3.69	0.76	5.15	
2	MnO (%)	0.0103	0.0066	0.0094	0.0099	0.0081	
2	MgO (%)	0.15	0.10	0.61	0.15	0.44	
2	CaO (%)	0.03	0.83	0.25	0.25	0.40	
2	K_2O (%)	1.13	0.12	1.04	0.01	2.42	
2	Na_2O (%)	0.11	6.17	0.60	0.83	1.35	
4	CO_2 (%)						
2	Ag (ppm)	0.05	<0.05	0.10	<0.05	<0.05	<0.1
1	As (ppm)	10.00	0.8	4.3	0.8	0.5	12
2	Au (ppb)	12	2	5	6	11	
5	B (ppm)	15	6	15	13	7	11
5	Ba (ppm)						
5	Bi (ppm)	0.17	0.04	0.07	0.05	0.07	0.07
2	Cd (ppm)	0.07	0.05	0.03	0.03	0.03	<0.1
2	Co (ppm)	2	1	2	1	2	4
2	Cu (ppm)	120	7	7	5	15	4
6	F (%)	0.021	0.009	0.023	0.009	0.024	0.050
5	In (ppm)	0.7	0.03	0.12	0.05	0.23	0.04
2	Li (ppm)	6	3	25	4	14	168
5	Mo (ppm)	4.8	2.4	3.5	6.3	5.7	4.1
2	Ni (ppm)	4	3	3	2	3	16
2	Pb (ppm)	10	1	6	2	12	18
2	Rb (ppm)						
4	S (%)	0.230	0.006	0.040	0.017	0.021	0.0014
5	Sb (%)	<10	<10	<10	<10	<10	<10
5	Sn (ppm)	6.8	5.4	5.6	5	3.7	8.5
5	Sr (ppm)						
1	W (ppm)	50	50	2	2	2	1
2	Zn (ppm)	40	15	19	10	25	65
5	Zr (ppm)						160

[1] Analyses by Minerals Engineering Centre, Technical University of Nova Scotia, Halifax

[2] Description of Cape Clear alteration zone samples (Fig. 17)
K07-3108-A: gossan
K07-3108-G: leucogranite
K07-3108-H: quartz-muscovite-pyrite alteration
K07-3108-L: quartz vein
K07-3108-O: quartz-muscovite-pyrite-kyanite alteration

[3] Method
1: colourmetric
2: atomic absorption
3: titration
4: Leco induction furnace
5: spectrograph
6: selective ion electrode

[4] Reference sample for K07-3108-A, -G, -H, -L, -O

Table 2. Continued.

		NSDNR Mineral Occurrence K07-37c[6]	Location Misc.-1a[7]	Location Misc.-2[8]	Location Misc.-3[9]	
Method[3]		K07-3270-1	K07-3302	K07-3328	K07-3340-2A	Reference[5]
1	SiO_2 (%)					
2	Al_2O_3 (%)					
2	TiO_2 (%)					
3	FeO (%)	1.98	1.02	0.44	0.54	2.59
2	Fe_2O_3 (%)	10.77	1.24	1.85	1.01	0.19
2	Fe total (%)	13.03	2.40	2.35	1.63	3.14
2	MnO (%)	0.654	0.027	0.018	0.004	0.062
2	MgO (%)					
2	CaO (%)					
2	K_2O (%)					
2	Na_2O (%)					
4	CO_2 (%)	2.12	0.51	1.24	0.48	0.16
2	Ag (ppm)	0.3	<0.1	0.2	0.1	<0.1
1	As (ppm)	3	45	20	3.3	1.8
2	Au (ppb)	<5	<5	<5	<5	<5
5	B (ppm)	38	3	4	46	12
5	Ba (ppm)	740	900	850	1400	530
5	Bi (ppm)	0.09	0.12	0.06	0.07	0.05
2	Cd (ppm)	3.17	0.06	0.11	<0.01	0.02
2	Co (ppm)	142	7	6	4	6
2	Cu (ppm)	92	13	15	6	5
6	F (%)	0.041	0.028	0.017	0.058	0.056
5	In (ppm)	0.03	<0.02	0.04	0.04	0.03
2	Li (ppm)	56	14	4	4	154
5	Mo (ppm)	4	7	10	2	2
2	Ni (ppm)	121	5	3	7	20
2	Pb (ppm)	231	45	18	2	20
2	Rb (ppm)	98	203	127	122	224
4	S (%)					
5	Sb (%)	<10	<10	<10	<10	<10
5	Sn (ppm)	2.6	2.1	2.6	7	7.6
5	Sr (ppm)	170	50	58	27	120
1	W (ppm)	1	1	1	1	3
2	Zn (ppm)	1890	28	27	17	68
5	Zr (ppm)	110	250	300	460	150

[5] Reference Sample for K07-3270-1, K07-3302, K07-3328, K07-3340-2A
[6] Diamictite on Sarach Brook
[7] Mile 16 West Road Occurrence
[8] Bothan Brook Occurrence
[9] Boundary Line Bypass epidote greisen

quartz-muscovite-pyrite±kyanite alteration which occurs sporadically within the quartz-muscovite-pyrite alteration.

The massive kyanite-bearing alteration consists of randomly oriented kyanite blades and euhedral pyrite occurring within a matrix of quartz (Fig. 18a), clearly demonstrating a hydrothermal, as opposed to metamorphic, origin. Gradation of this alteration with unaltered gneiss and the retention of the host foliation within the alteration indicates this zone reflects alteration of the host gneiss. A hydrothermal origin is supported by the absence of kyanite in the host Belle Côte Road orthogneiss. Hydrothermal fluids responsible for the Cape Clear alteration zone are inferred to be related to late intrusive activity, possibly the small leucogranite body exposed in the immediate area (Fig. 17, p. 43). Strike extension of this alteration zone has not been established, however minor quartz-feldspar veins and granite dykes are exposed to the southeast along First Fork Brook and boulders of quartz-muscovite-pyrite occur to the southwest along First Fork Brook (Fig. 4, in pocket). It should be noted that these boulders are well rounded and may be well removed from their source.

Several samples of the various rock types within the alteration zone were analyzed for various major and trace elements (Table 2, p. 44-45). Additional analyses from this zone are presented in NSDNR, Mineral Occurrence K07-34.

K07-37 Sarach Brook Occurrence

Several occurrences of disseminated sulphides associated with quartz veins occur within the Middle River metamorphic suite (EO_{MR}) along the lower part of Sarach Brook (K07-37a, Fig. 4, in pocket). Only pyrite was recognized, however a petrographic assessment has not been done. These zones locally reach widths of 3 m. No geochemical analyses are available.

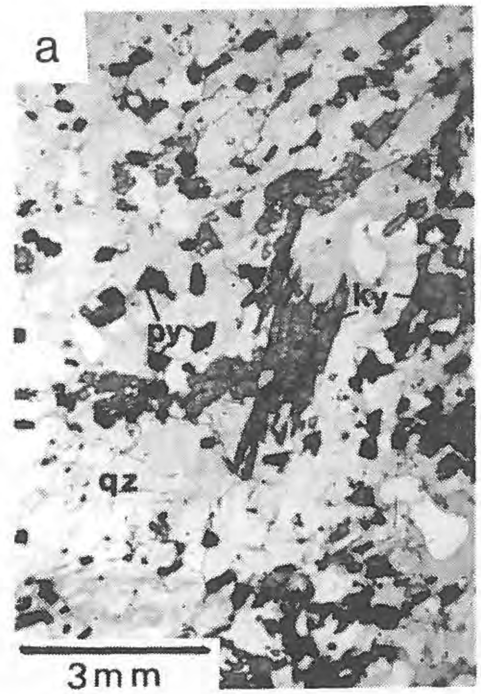


Figure 18. (a) Photomicrograph of quartz-pyrite-kyanite alteration from the Cape Clear Road alteration zone. Note the massive character, with randomly oriented kyanite and euhedral pyrite (qz = quartz, py = pyrite, ky = kyanite). (b) Photograph of a section of poorly sorted diamictite exposed on the upper part of Sarach Brook. See Figure 4, in pocket, for location K07-37c.

Two occurrences of disseminated sulphides occur within the Southern Highlands shear zone (Sarach Brook metamorphic suite (S_{SB})) along South Sarach Brook (K07-37b, Fig. 4, in pocket). The westernmost of these occurrences, situated approximately 100 m east of the Bothan Brook pluton (D_{BB}), consists of local, finely disseminated and stringer sulphides consisting predominantly of pyrite with minor galena. Geochemical analyses from this occurrence, reported in NSDNR, Mineral Occurrence K07-37, reveal moderately elevated values of Cu (up to 95 ppm), Pb (up to 143 ppm), Zn (up to 368 ppm), molybdenum (up to 24 ppm) and silver (up to 0.7 ppm). The other occurrence occurs approximately 500 m further east on South Sarach Brook and consists of pyritiferous `quartz muscovite schist'. Pyrite and associated alteration clearly overprint mylonitic shear fabrics. An undeformed, fine grained, porphyritic granite dyke, lithologically similar to the Bothan Brook pluton, occurs adjacent to the mineralized zone and may be responsible for this alteration-mineralization. Geochemical analyses recorded in NSDNR, Mineral Occurrence K07-37 reveal moderately elevated values of Cu (up to 49 ppm), Pb (up to 91 ppm) and Zn (up to 119 ppm) from this location.

An ≈2 m thick section of diamictite (Fig. 18b, p. 46) is exposed along the upper part of Sarach Brook, occurring at the contact between the Middle River metamorphic suite ($ЄO_{MR}$) and Bothan Brook pluton (D_{BB}) (K07-37c, Fig. 4, in pocket). The diamictite consists of poorly sorted material cemented by iron oxide and is generally very porous. Clasts range from silt up to boulder size, some of which are well rounded and include samples of the Bothan Brook monzogranite (D_{BB}) and Middle River metamorphic suite ($ЄO_{MR}$), indicating a local origin. This unit is similar in character to the Bridgewater Conglomerate unit found in southern Nova Scotia (Ralph Stea, personal communication, 1992) which represents an iron cemented till (Stea, 1978). Geochemical analyses reveal elevated values of Fe total (13.03%), CO_2 (2.12%), Co (142 ppm), Cu (92 ppm), Ni (121 ppm), Pb (231 ppm), and Zn (1890 ppm) (Sample K07-3270-1, Table 2, p. 44-45).

K07-38 Centre Road Quartz-Magnetite Occurrence

Abundant, angular rubble of quartz-magnetite occurs on a branch of Centre Road, east of First Fork Brook South (Fig. 4, in pocket). The abundance and restricted distribution of this quartz-magnetite rubble suggests it represents felsenmeer and, therefore, is of local origin. Outcrop and felsenmeer of gneiss and felsenmeer of unfoliated, fine- to medium-grained, pink monzogranite (dykes(?)), commonly with associated epidote and quartz-muscovite alteration, occur within the immediate area. Magnetite occurs as fine (<1 mm) to coarse (+1 cm) disseminations within quartz-feldspar veins(?). In contrast to the host orthogneiss unit (O_{PBbc}), the quartz-magnetite vein material lacks a foliation, implying it postdates regional deformation, and is probably related to hydrothermal activity associated with late intrusive activity represented by local monzogranite dykes.

A few boulders of quartz-magnetite, similar to those described here, were noted on Wildcat Brook Road approximately 4 km south of K07-38 (Fig. 4, in pocket).

K07-39 Maggie Ranalds Brook Specularite Occurrence

Narrow (1 mm-1 cm) veins of specular hematite occur within a small plug of the Peters Brook pluton (DC_{PB}) and as a stockwork of specularite in several outcrops of paragneiss near the headwaters of Maggie Ranalds Brook (Fig. 4, in pocket). The undeformed nature of the specularite veins and their occurrence in the Peters Brook pluton suggests they may be related to this pluton; hematite is common within the Peters Brook pluton, as well as the Margaree (DC_{MP}), West Branch North River (D_{NR}) and Bothan Brook (D_{BB}) plutons, occurring as narrow (<1 mm) fracture fillings and small disseminated, euhedral grains.

MISCELLANEOUS MINERALIZATION AND ALTERATION

Mile 16 West Road Occurrence

Considerable rubble (felsenmeer) of highly silicified mylonite (SHSZ) with finely disseminated sulphide (pyrite(?)) occurs in a large, bulldozed area on the western side of the Highland Road just north of

Mile 16 West Road (Fig. 4, in pocket, location Misc.-1a). Several angular boulders of similar rock occur on the first southward-trending side road of Mile 16 West Road (Fig. 4, in pocket, location Misc.-1b). Geochemical analyses reveal only slightly elevated values of Pb (45 ppm) (location Misc.-1a, Sample K07-3302, Table 2, p. 44-45).

Bothan Brook Occurrence

Considerable disseminated sulphide (pyrite) occurs within the Southern Highlands shear zone (Bothan Brook pluton (D_{BB})) along Bothan Brook (Fig. 4, in pocket, location Misc.-2). Geochemical analyses did not reveal any elevated metal concentrations (Sample K07-3328, Table 2, p. 44-45).

Boundary Line Bypass Epidote Greisen

Rubble (felsenmeer) of quartz-muscovite-epidote greisen occurs within the monzogranite unit of the Boundary Line intrusive suite (DC_{BLm}) on the Boundary Line Bypass and a branch of the Boundary Line Spur (Fig. 4, in pocket, location Misc.-3). In both areas the alteration is associated with quartz veins (a several metre wide vein occurs on the Boundary Line Bypass). Geochemical analysis of a greisen sample from this area does not indicate any anomalous metal values (Sample K07-3240-2A, Table 2, p. 45-46). However, a panned concentrate of `granite till' in this area was reported to contain beryl and gave a value of 320 ppm Sn (Tilsley, 1981).

Upper Middle River Occurrence

Anomalous values of Cu (up to 154 ppm), Pb (up to 550 ppm) and Zn (up to 510 ppm) were reported from rock samples of the Middle River metamorphic suite ($ЄO_{MR}$) containing disseminated sulphide along the upper part of Middle River in the area north of Mile 16 West Road (Fig. 4, in pocket, location Misc.-4; Sangster, 1980). Comparable values (up to 155 ppm Cu, 2650 ppm Pb and 8500 ppm Zn) were obtained from diamond drill intersections on Mile 16 West Road (DDH-16 and -17, Fig. 4, in pocket; Sangster 1981).

It is interesting to note that similar zones of disseminated sulphide with anomalous base metal values occur within the Middle River metamorphic suite just outside the mapped area. These included samples of outcrop along the upper west branch of Fortune Brook which yielded values up to 1100 ppm Zn and 480 ppm Pb (Hibbins, 1980); and analysis from percussion diamond drilling in the Ryan Brook area (DDH-13 to DDH-15; Fig. 4, in pocket) revealed anomalous values of Cu (up to 164 ppm), Pb (up to 1650 ppm), Zn (up to 6950 ppm) and Ag (up to 3.4 ppm) (Hibbins, 1981).

Quartz-Muscovite±Sulphide Alteration Zones

Several alteration zones characterized by quartz-muscovite±disseminated sulphide which clearly postdate regional deformation were noted within the area (Fig. 4, in pocket). These include:

(i) An ≈2 m wide zone of altered Taylors Barren pluton (S_{TB}) exposed on the Fielding Road at its intersection with the Egypt Highlands Road. This zone consists predominantly of quartz, muscovite and altered feldspar (Fig. 4, in pocket, location Misc.-5a).

(ii) Felsenmeer to subcrop of altered Middle River metamorphic suite ($ЄO_{MR}$) occurring on the Egypt Highlands Road (Fig. 4, in pocket, location Misc.-5b).

(iii) Abundant felsenmeer of altered gneiss, consisting of quartz-muscovite-pyrite, occurring on a branch of Centre Road east of First Fork Brook South, near the quartz-magnetite occurrence (Fig. 4, in pocket, location Misc.-5c).

(iv) Felsenmeer of sulphide-bearing alteration on a southward running branch of Spring Road (Fig. 4, in pocket, location Misc.-5d).

These alteration zones are commonly associated with late, crosscutting granitic dykes and epidote alteration (veining), suggesting they reflect hydrothermal alteration related to one or more of the late, unfoliated, intrusions within the study area (i.e. Peters Brook pluton (DC_{PB}), Margaree pluton (DC_{MP}), West Branch North River pluton (D_{NR})).

DISCUSSION

INTRODUCTION

As discussed in the introductory section, considerable debate exists regarding the tectono-stratigraphic character of the Cape Breton Highlands. The relationship between the high-grade gneisses and low- to medium-grade schists, correlation of map units and the ages of units are central issues to much of this debate (Jamieson et al., 1991; Keppie et al., 1991). This point is emphasized by the following three interpretations of the relationship between the high-grade Pleasant Bay complex (PO_{PB}) and Middle River metamorphic suite (PO_{MR}) and surrounding low- to medium-grade units (e.g. Jumping Brook (PO_{JB}) and Sarach Brook (S_{SB}) metamorphic suites). Barr et al. (1992) and Jamieson et al. (1991) considered the gneissic Pleasant Bay complex and Middle River metamorphic suite to be Ordovician to Silurian in age and the Middle River unit to be a high-grade equivalent of the low- to medium-grade units. Keppie et al. (1990) grouped the Pleasant Bay and Middle River units as Middle-Late Proterozoic gneisses and considered the low- to medium-grade units to be Ordovician to Silurian in age, presumably unconformably overlying the gneissic rocks. Lynch and Lafrance (1994) suggested the Pleasant Bay and Middle River units form part of a regional nappe, consisting of high-grade rocks, separated from underlying low- to medium-grade units by a mylonite zone. Clearly, constraints on the relationships between these units and their depositional or intrusive ages are important for a confident understanding of the tectono-stratigraphic framework of the Cape Breton Highlands. The following discussion focuses on establishing the geological history of the mapped area by synthesizing the constraints established in this report regarding the relationship between map units, the relative and absolute ages of map units and the structural and metamorphic development of the area. The results of this study may help clarify more regional interpretations.

DEFINITION, CONTACT RELATIONS - RELATIVE AGES AND AGES OF UNITS

Definition

The mapped area is underlain by a diverse assortment of units which can be broadly grouped as (meta)stratified or (meta)plutonic (Fig. 19, p. 50). The stratified units include four lithologically distinct map units, namely the Jumping Brook metamorphic suite, Middle River metamorphic suite, First Fork Brook gneiss and Sarach Brook metamorphic suite. The Jumping Brook unit consists mainly of low- to medium-grade semipelitic to pelitic schists and lesser amphibolite. The medium- to high-grade Middle River unit is lithologically variable, including psammite, pelitic schists, amphibolite and marble. The high grade First Fork Brook unit includes banded gneiss, amphibolite and minor pelitic gneiss. The Sarach Brook unit consists of low grade, mainly felsic volcanics with minor slate. Although the relationship between the stratified units is unclear, distinct lithologic character and age data preclude them being formational equivalents.

Plutonic units include the Kathy Road dioritic suite, Belle Côte Road orthogneiss (tonalite-granodiorite), Taylors Barren pluton (monzogranite), West Branch North River pluton (granodiorite-monzogranite), Bothan Brook pluton (monzogranite), Boundary Line intrusive suite (diorite-monzogranite), Margaree pluton (monzogranite), and Peters Brook pluton (monzogranite). Structural, textural and petrographic-lithogeochemical (O'Beirne-Ryan and Jamieson, 1986; O'Beirne-Ryan et al., 1986; Barr and Hegner, 1992) traits and relative and absolute ages support genetic distinction between most of the plutons.

Contact Relations-Relative Ages

Established field relations, discussed in detail within the unit descriptions, provide an understanding of the relationship between units and the relative ages of units within the mapped area. Intrusive contacts provide the best constraints on relative ages. Regional scale faults separate the Kathy Road and Sarach Brook units from the rest of the area, which comprises a geologically coherent block of medium- to high-grade metastratified units and foliated and unfoliated plutonic units. The relationship between these units follows.

The Jumping Brook and Middle River metamorphic suites and the Pleasant Bay complex form a structurally conformable sequence which records a similar, complex, structural and metamorphic history, inhibiting a clear understanding of the relationship between units. The Jumping Brook and Middle River units are geographically separated so that an understanding of their relationship is limited to age constraints. The First Fork Brook unit is considered to represent enclaves of the Jumping Brook and Middle River units within the Belle Côte Road orthogneiss (Fig. 19a, p. 50). No intrusive contacts between these units have been preserved, and this interpretation is

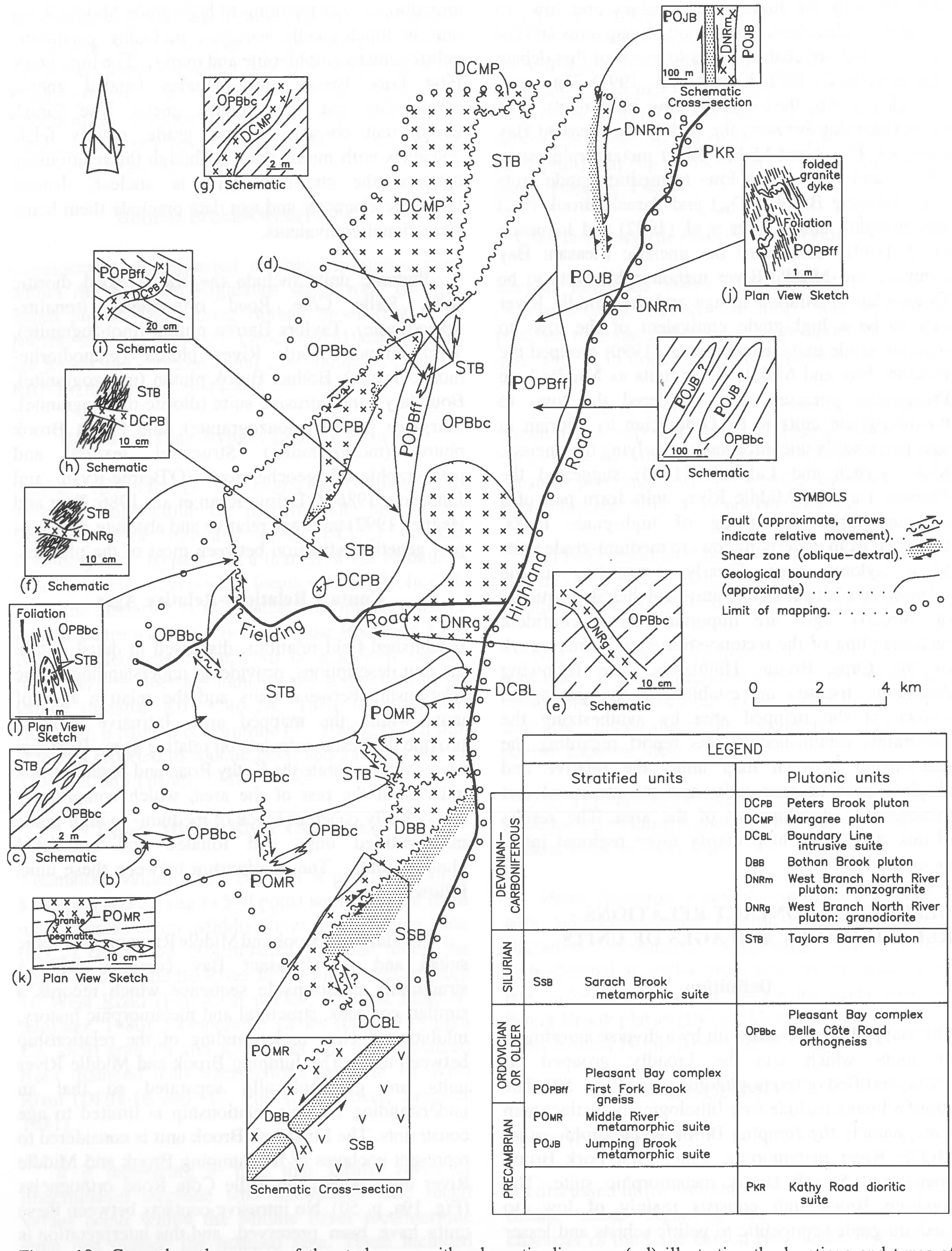


Figure 19. General geology map of the study area with schematic diagrams (a-l) illustrating the locations and types of established contact relationships between units.

based on the following observations: (1) the First Fork Brook gneiss has a similar structural and metamorphic history to that of the Middle River and Jumping Brook units; (2) increasing metamorphic grade within the Jumping Brook unit toward the Pleasant Bay complex (Fig. 5, p. 13); (3) the distribution of the First Fork Brook unit at the margins of the Pleasant Bay complex; and (4) the occurrence of small areas of Belle Côte Road orthogneiss within the Middle River unit which may represent satellite plutons (Fig. 19b, p. 50). The interpretation that the Belle Côte Road orthogneiss intruded the Jumping Brook and Middle River metamorphic suites provides a relative age for these units.

The Taylors Barren pluton clearly intruded, and thus postdates, the Pleasant Bay complex (Figs. 11, p. 27; 19c and d, p. 50). Although not established, the Taylors Barren pluton is assumed to have intruded, or at least postdates, the Middle River and Jumping Brook metamorphic suites, the latter of which it is only in fault contact with in the northern part of the mapped area. Field evidence indicates the unfoliated plutons invariably intruded the foliated units (Figs. 4, in pocket; and 19, p. 50). The West Branch North River pluton intruded the Pleasant Bay complex (Fig. 19e, p. 50) and the Taylors Barren pluton (Fig. 19f, p. 50). The Margaree pluton intruded the Pleasant Bay complex (Fig. 19g, p. 50). The Peters Brook pluton intruded the Taylors Barren pluton (Fig. 19h, p. 50) and the Pleasant Bay complex (Fig. 19i, p. 50). Except for the Boundary Line intrusive suite, which intruded the West Branch North River pluton, the relative ages between the various unfoliated plutons is not established.

Ages of Units

Although the relative ages of many of the units are reasonably well established, depositional and igneous age data are incomplete. This reflects the general lack of fossils within the area and constraints of blocking temperatures of various radiometric dating techniques, which commonly record the timing of regional cooling or thermal overprinting. The influence of regional cooling on age data is clearly demonstrated in Table 3, p. 52, where a direct relationship between age dates and blocking temperatures (of the dated phase) is evident. Abundant $^{40}Ar/^{39}Ar$ data for units within the Aspy Terrane indicate similar ages (Devonian) as do units within the area (e.g. Middle River metamorphic suite, West Branch North River and Margaree plutons), indicating a similar cooling history regionally. Rb/Sr dating is considered suspect within the Highlands because ages determined by this method are both older and younger than those determined by $^{40}Ar/^{39}Ar$ and U-Pb techniques (Jamieson et al., 1991). U-Pb (zircon) ages for igneous units, including three new dates presented here, and relationships between units provide constraints on the ages of units. Data regarding the ages of the various units are presented in the unit descriptions above and summarized in Table 3, p. 52.

Igneous ages have been established for the Kathy Road dioritic suite (560±2 Ma, U-Pb, zircon) and Sarach Brook metamorphic suite (433+7/-4 Ma, U-Pb, zircon) (Dunning et al., 1990). As mentioned above these two units are separated from the rest of the area by regional scale faults and therefore their ages do not help constrain the ages of other units within the area. Field evidence indicates the Jumping Brook, Middle River and First Fork Brook units are the oldest rocks within the geologically coherent block comprising the rest of the area. The Belle Côte Road orthogneiss (442±3 Ma, U-Pb, zircon, G. Dunning, personal communication, 1995), which is interpreted to have intruded these units, constrains a minimum Ordovician or older age for these units. Other interpretations of the age of the Jumping Brook and Middle River units have been previously presented. An Early Silurian (439±7 Ma, U-Pb, zircon) salic dyke cutting the Chéticamp pluton was presumed to represent feeder dykes for rhyolite within the Jumping Brook unit (Currie et al., 1982). However, confident correlation of the dykes and rhyolite was not established. Barr and Jamieson (1991) considered the Jumping Brook and Middle River units to be Ordovician to Silurian in age, correlating these with other units including the Sarach Brook metamorphic suite and Money Point Group, for which Early Silurian crystallization ages of rhyolites have been established. However, until the relationship between these units or depositional ages are established such correlation can only be considered tentative. As discussed above, the stratified units within the area are lithologically distinct and, although they may be correlative at the group or higher level, they are not correlative at the formation level. If the Jumping Brook or Middle River units are Silurian in age, the interpretation that they are intruded by the Belle Côte Road orthogneiss is not correct. Keppie et al. (1990) considered the Middle River units to be Middle Proterozoic in age, correlative with units of the Bras d'Or Terrane, and the Jumping Brook unit to be

Table 3. An interpretation of the geological history of the mapped area in the south-central Cape Breton Highlands and a summary of radiometric dates for units in the area.

Period	Epoch	Radiometric Date (Ma)	Age (Ma)	Blocking Temperature*	Deposition	Deformation	Plutonism	Synthesis
CARBONIFEROUS								
DEVONIAN	Late	U-Pb(Z), D_{BB} 376±3[1] U-Pb (R), $ЄO_{PBff}$ 376±4[2]	370			brittle faulting; ductile shearing	D_{BB}	- brittle faulting - late synintrusive ductile shearing (mylonites); CBSZ, SHSZ, BBSZ - intrusion of D_{BB}
	Middle	$^{40}Ar/^{39}Ar$ (B), D_{NR} 385±5[3], 381±5[3]; $ЄO_{MR}$ 370[3], 377±9[4] U-Pb (T), O_{PBbc} 386±3[2] $^{40}Ar/^{39}Ar$ (H), $ЄO_{MR}$ 388[3], 390[3]; 386±9[4] Rb/Sr SHSZ 394±28[5]	380 390	B (300°C) R (380-430°C) T (500-700°C) H (400-500°C)			? DC_{PB} DC_{MP} DC_{BL} ?	- intrusion of DC_{BL}, DC_{MP}, DC_{PB}
	Early	Rb/Sr (WR) D_{NR} 399.6±4.6[6]	400			regional deformation	D_{NR}	- intrusion of D_{NR} - regional folding of $ЄO_{JB}$, $ЄO_{MR}$, $ЄO_{PB}$, S_{TB} - minimum age of peak metamorphism (700-750°C)[4,9]
SILURIAN	Late	U-Pb (M) $ЄO_{PBff}$ 411±2[2] Rb/Sr (WR) S_{TB} 419±17[7]	410 420	M (650-700°C)		regional deformation; S_2		- regional deformation; foliation in S_{TB}, folded dykes
	Early	U-Pb (Z) S_{TB} 430±2[1] U-Pb (Z) S_{SB} 433+7/-4[8]	430		S_{SB}	regional deformation	S_{TB}	- syntectonic intrusion of S_{TB} and intrusion of dykes into $ЄO_{MR}$ and $ЄO_{PBff}$ - deposition of S_{SB} - regional deformation; gneissic fabric
ORDOVICIAN	Late	U-Pb (Z) O_{PBbc} 442±3[1]	440 450			regional deformation; S_1	O_{PBbc}	- intrusion of O_{PBbc} - regional deformation
	Middle		460		$ЄO_{PBff}$ $ЄO_{MR}$ $ЄO_{JB}$			- minimum age of deposition of $ЄO_{JB}$, $ЄO_{MR}$, and $ЄO_{PBff}$ constrained by inferred intrusive relation of O_{PBbc}

[1]G. Dunning, personal communication, 1995; [2]Barr and Jamieson, 1991; [3]Reynolds et al., 1989; [4]Doucet, 1983; [5]Jamieson and Doucet, 1984; [6]O'Beirne-Ryan and Jamieson, 1986; [7]Gaudette et al., 1985; [8]Dunning et al., 1990; [9]Plint and Jamieson, 1989.

B = biotite, R = rutile, T = titanite, H = hornblende, M = monazite, Z = zircon, WR = whole rock
CBSZ = Coinneach Brook shear zone
SHSZ = Southern Highlands shear zone
BBSZ = Black Brook shear zone

regional deformation .....
ductile shearing ....
brittle faulting ....

* From Mezger et al., 1991.

See Figure 19 legend for definition of geological unit designations.

Ordovician to Silurian in age. There are differing implications regarding the tectono-stratigraphic subdivisions of the Cape Breton Highlands depending on which of the above interpretations regarding the ages of Jumping Brook and Middle River units is correct (as outlined in the Introduction section). However, constraints on the maximum age of the units are not established and as such the debate regarding the age of these units is unresolved.

An Early Silurian (430±2 Ma, U-Pb, zircon, G. Dunning, personal communication, 1995) igneous age has been established for the Taylors Barren pluton. Intrusive relationships constrain the age of many of the unfoliated plutons as younger than the Taylors Barren pluton (Fig. 19, p. 50). $^{40}Ar/^{39}Ar$ dates for the West Branch North River pluton (385±5 Ma, monzogranite; 381±5 Ma, granodiorite) and Margaree pluton (368 Ma; 375 Ma) (Reynolds et al., 1989) provide minimum ages for these units. The Boundary Line intrusive suite intruded the West Branch North River pluton and therefore is younger. The distinct bimodal nature (diorite/monzogranite) of the Boundary Line intrusive suite suggests that this unit may represent an intrusive equivalent of volcanic rocks (basalt/rhyolite) of the Fisset Brook Formation. Recent U-Pb dating (zircon) of rhyolite of the Fisset Brook Formation in the Gillanders Mountain area indicates a crystallization age of 374 Ma (Barr et al., 1995). A Late Devonian (376±3 Ma, U-Pb, zircon, G. Dunning, personal communication, 1995) igneous age has been established for the Bothan Brook pluton. The Peters Brook pluton postdates the Taylors Barren pluton, however a minimum age is not constrained.

Relative and absolute ages for the units provide reasonable constraints on the geological sequence (as presented in the map legend) within the area. The most outstanding questions remain the ages of the Jumping Brook and Middle River units. Further constraints on unit ages will rely on precise dating of the Boundary Line, Margaree and Peters Brook units, which intruded these units, dating detrital phases and correlation of the Jumping Brook, Middle River and First Fork Brook units with units for which ages are better constrained.

STRUCTURE AND METAMORPHISM

General Statement

A protracted and complex deformational history is recorded within the mapped area, including regional deformation (fabric development) and metamorphism, syntectonic intrusion and development of mylonitic shear zones and brittle fault zones. Field relations, including map patterns, crosscutting relations, and established age relations between map units and radiometric age data allow the determination of the deformational-metamorphic history of the area.

The mapped area can be divided into three deformational-metamorphic zones. The Kathy Road dioritic suite (P_{KR}) is separated from the rest of the area by a regional shear zone and because it constitutes only a very minor part of the area it is not discussed here. The Sarach Brook metamorphic suite is separated from the rest of the area by a regional shear zone and displays only a mild deformational-metamorphic character and is not discussed below. The majority of the area defines a distinct structural-metamorphic block which is the subject of the following discussion.

Regional Deformation (S_1 and S_2) and Metamorphism

The earliest structures recorded within the mapped area are found within the stratified units. The Jumping Brook and Middle River metamorphic suites and First Fork Brook gneiss all display a similar metamorphic-deformational history. The majority of the area occurs within the kyanite±sillimanite zone (Fig. 5, p. 13), which encompasses the Middle River metamorphic suite and Pleasant Bay complex. The Jumping Brook metamorphic suite has been divided into a garnet zone (Dauphinee Brook schist (PO_{JBdb})) and a staurolite zone (Corney Brook schist (PO_{JBcb})) (Fig. 4, in pocket). The metamorphic zones defined here correspond to the low, medium and high grade zones of Craw (1984) and Plint and Jamieson (1989). Tectonic juxtaposition of these zones (Craw, 1984; Plint and Jamieson, 1989; Lynch and Tremblay, 1992) is supported in the mapped area by sharp boundaries between the zones and the occurrence of mylonite zones and kinematically related, pervasive shear fabrics throughout the Jumping Brook metamorphic suite.

Microstructural-metamorphic observations described in the unit descriptions indicate two metamorphic fabrics. An early metamorphic fabric, S_1, is defined by fine inclusion trails occurring within garnet and biotite porphyroblasts which, therefore, postdate development of S_1. The principal foliation, S_2, defines the mesoscopic schistose and gneissic fabrics in these units and is defined by alignment of mineral phases formed during fabric development and metamorphic layering. The garnet zone is characterized by a fine grained matrix of mica and porphyroblasts of biotite and garnet. The staurolite zone is characterized by a medium grained foliation, defined by muscovite-biotite-opaques and metamorphic layering of mica and quartzo-feldspathic layers, as well as coarse porphyroblasts of garnet and staurolite. Staurolite is characterized by medium grained, locally sigmoidal inclusion trails implying syntectonic, relative to S_2, growth. The kyanite zone is characterized by a medium- to course-grained matrix, defined by aligned kyanite-biotite±hornblende± opaques and well developed metamorphic layering, and porphyroblasts of garnet, kyanite and local staurolite (relict) and sillimanite.

The microstructural-metamorphic character defined within the area is strikingly similar to that described in the Chéticamp area (Plint and Jamieson, 1989) and Cape North area (Macdonald and Smith, 1980) implying a similar tectonic history throughout this region.

Peak metamorphic conditions have been estimated for the Middle River metamorphic suite at 650°-700°C (Doucet, 1983) and for the high grade rocks of the Jumping Brook metamorphic suite, in the Chéticamp area, at 700°-750°C at 8-10 kbar (Plint and Jamieson, 1989). A minimum age for peak metamorphism is constrained by U-Pb dating of monazite (411±2 Ma, Barr and Jamieson, 1991), which has a blocking temperature of 650°-700°C (Mezger et al., 1991), from pelitic gneiss in the Pleasant Bay complex. Titanite, rutile and $^{40}Ar/^{39}Ar$ dating record progressively younger ages which correspond to decreasing blocking temperatures for the respective phases (Table 3, p. 52) implying rapid cooling related to uplift and denudation of the region from the Late Silurian (≈650°-700°C) to the Middle Devonian (≈300°C).

The principal foliation within the Belle Côte Road orthogneiss is defined by metamorphic layering and alignment of mineral phases and it parallels the principal foliation within the stratified units. In addition, the contacts of these units parallel the regional structural fabric indicating these units experienced a common phase of deformation. Assuming that the Belle Côte Road unit intruded the stratified units, the development of the principal foliation in these units either postdates the Belle Côte Road unit or the Belle Côte Road unit is syntectonic with respect to the principal foliation.

Foliation within the Taylors Barren pluton also parallels that in the stratified units and Belle Côte Road orthogneiss. Widespread shear fabric throughout the Taylors Barren pluton reflects a component of dextral shearing during deformation. The intrusive relationship between the Taylors Barren pluton and the Pleasant Bay complex discussed above demonstrates that the Taylors Barren pluton was intruded along a previously existing gneissic fabric. However, parallel fabrics in both units and the orientation of the axial planes of folded and boudinaged dykes (Figs. 4, in pocket; 11, p. 27; 19j, k, and l, p. 50), some distinctly of Taylors Barren pluton, indicate these units experienced a common deformation. The age of regional deformation in the Taylors Barren pluton is constrained to the interval between its intrusion (Early Silurian) and emplacement of unfoliated plutons (Early Devonian(?), West Branch North River pluton).

The above discussion implies a protracted history for the development of the principal fabric (S_2) within the mapped area, from prior- to syn-emplacement of the Belle Côte Road orthogneiss to postemplacement of the Taylors Barren pluton.

Regional Folding of the Principal Fabric (S_2)

The principal fabric in the area defines a regional, U-shaped fold map pattern (Fig. 7, p. 17); north-northeast in the northeastern part of the mapped area to east-west in the southern part, to north-northwest in the northwestern part of the area. The axial planes of the folded syntectonic granite dykes in the Middle River and First Fork Brook units also define this regional fold structure. No fabric related to this fold was recognized within the mapped area. The age of this regional folding postdates the development of the foliation in the Taylors Barren pluton and related folding of the dykes, but predates the emplacement of the West Branch North River pluton, which clearly truncates the map-scale fold pattern.

Shear Zones and Faults

Mylonitic shearing defines two well developed, low grade shear zones within the map area (Figs. 4, in pocket; and 15, p. 37). The Southern Highlands shear zone (SHSZ) defines a northeastward-trending fault defining the boundary of the Bothan Brook pluton (D_{BB}) and the Sarach Brook unit (S_{SB}). The SHSZ also brings high grade rocks of the Middle River metamorphic suite and low grade rocks of the Sarach Brook metamorphic suite within close proximity of each other. The Coinneach Brook shear zone (CBSZ) defines a north-south fault within the Jumping Brook metamorphic suite ($ЄO_{JB}$) and locally defines the western contact of a small area of the West Branch North River pluton (D_{NRm}). Well defined shear sense indicators in the CBSZ indicate oblique-dextral west-sideup movement, however shear sense indicators in the SHSZ within the mapped area are ambiguous (see above). Mengel et al. (1991) stated shear indicators in the SHSZ demonstrate west-sidedown movement whereas Jamieson and Doucet (1983) suggested shearing involved a sinistral horizontal component which would imply a west-sideup dip-slip component. The latter interpretation is consistent with the occurrence of higher grade rocks in the hanging wall and the apparent displacement of the two lobes of the West Branch North River pluton (Fig. 3, p. 8).

The SHSZ and CBSZ are similar in character and probably reflect the same event. The age of faulting is constrained by the Late Devonian Bothan Brook pluton which is affected by the SHSZ. Shear zones of similar description and age have been described by Lin (1993) within the Eastern Highlands shear zone west of Ingonish (Fig. 1, p. 6). Recently, Lynch and Lafrance (1994) suggested that the SHSZ and CBSZ are part of a regional shear zone (Highland shear zone) which defines the base of a nappe (Cabot nappe). They interpret the current position of the shear zone to reflect Alleghenian folding of the nappe. This model suggests a similar kinematic interpretation for the SHSZ as proposed by Mengel et al. (1991). A schematic diagram of this interpretation for the SHSZ and CBSZ is shown in Figure 20 (p. 56), illustrating how these shear zones may be related.

Numerous brittle, generally steep faults occur within the area and define several unit boundaries (Fig. 20, p. 56). These structures affect all map units and mylonitic shear zones, and have substantially modified the geology of the map area.

Shear Zones and Pluton Emplacement

Plutons in the Cape Breton Highlands are typically elongate, with high aspect ratios, aligned with the general north-northeastern structural grain (Fig. 1, p. 6). Some of this elongation results from regional deformation, however many of these plutons are unfoliated and only slightly modified by late faults and shear zones. These include the West Branch North River, Bothan Brook, Margaree and Peters Brook plutons. The coincidence of the elongate form of these intrusions with regional faults suggests emplacement may have been influenced by these structures.

Syntectonic emplacement of the Taylors Barren pluton is supported by its linear form and the fact that deformation of this pluton is constrained to the short interval between intrusion (Early Silurian) and emplacement of Early Devonian unfoliated plutons. In addition, the prevalence of shear fabrics associated with the principal foliation of this unit implies deformation, and therefore emplacement, in a regional-scale shear zone. The Bothan Brook pluton is deformed by the SHSZ. However, limited evidence, including synkinematic quartz veins and undeformed granitic dykes cutting the shear zone support syntectonic emplacement along this structure. The coincidence of local, ductile deformation of the eastern margin of the Peters Brook pluton (Black Brook shear zone, Fig. 20, p. 56) supports syntectonic emplacement of this pluton.

SUMMARY

The above discussion has outlined the relative geological history of the mapped area, a summary of which is presented in Table 3, p. 52. A combination of field data and age dates has provided constraints on the principal elements regarding the geological evolution of the area, outlined in the synthesis column of Table 3, p. 52. The relative age relations are largely constrained by intrusive relations shown by the various plutons. The absolute ages of events are constrained by radiometric dating, however some ages may substantially change when further age data become available.

The oldest rocks are the Jumping Brook, Middle River and First Fork Brook units, which are inferred to have been deposited prior to intrusion of the Late Ordovician Belle Côte Road orthogneiss. These rocks

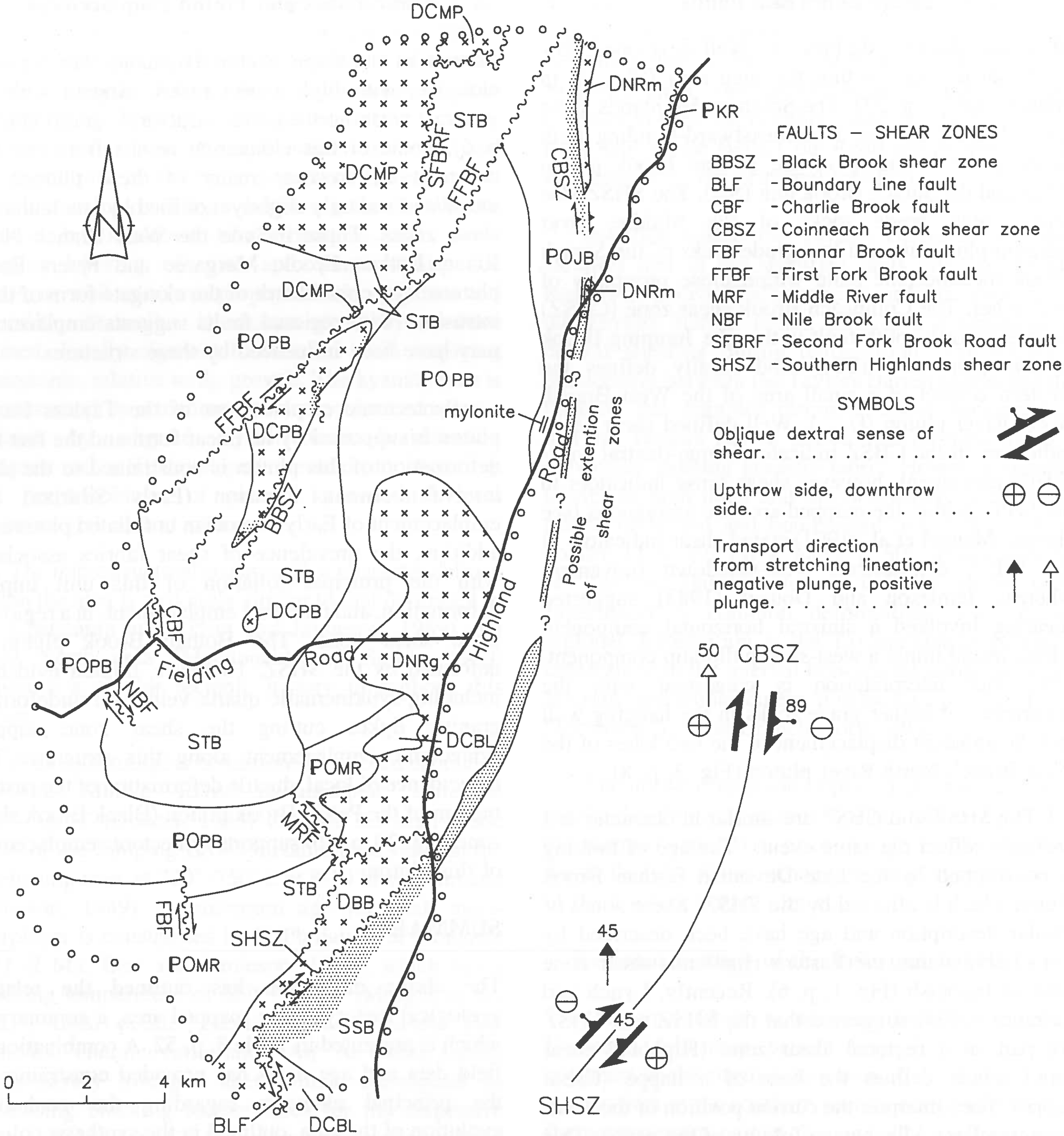


Figure 20. General geology map of the study area showing possible extension of the Southern Highlands and Coinneach Brook shear zones. Inset figure illustrates how these faults are kinematically consistent if the principal movement on the SHSZ was oblique-dextral, northwest-sidedown. See Figure 14, p. 32, for legend.

are characterized by two metamorphic fabrics reflecting a complex structural-metamorphic history. Peak metamorphism reached conditions of 700°-750°C and 8-10 kbars, probably during the Late Silurian. The Late Ordovician Belle Côte Road orthogneiss and Early Silurian Taylors Barren pluton are syntectonic with respect to the principal foliation. Map-scale folding of the principal foliation occurred after emplacement and deformation of the Taylors Barren pluton and prior to the emplacement of the unfoliated plutons. Regional mylonitic shear zones postdate the Bothan Brook pluton and are, in turn, deformed by brittle faults. Radiometric dating by various techniques suggests rapid cooling reflecting uplift and denudation of the area between the Late Silurian and Middle Devonian (Table 3, p. 52). This regional cooling is consistent with the progressive change from ductile deformation (development of metamorphic fabrics) to brittle-ductile deformation (mylonites) to brittle deformation (cataclastic faults) inferred to have occurred during this period, based on the relative age of structures and the inferred ages of the units.

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Figure 4 to accompany Nova Scotia Department of Natural Resources, Minerals and Energy Branch, Paper 95-2