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PAPER 89-14

GEOLOGY OF THE NORTHERN AND EASTERN CAPE BRETON HIGHLANDS, NOVA SCOTIA

R.P. Raeside
S.M. Barr

1992

Energy, Mines and Resources Canada
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Authors' address

R.P. Raeside
S.M. Barr
Department of Geology
Acadia University
Wolfville, Nova Socita
B0P 1X0

Cover description

Amphibolite gneiss of the Devonian Neils Harbour Gneiss extensively intruded by granite, pegmatite, and aplite of the three hundred and seventy-three million year old Black Brook Granitic Suite, Cape Egmont area, eastern Cape Breton Highlands.

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GEOLOGY OF THE NORTHERN AND EASTERN CAPE BRETON HIGHLANDS, NOVA SCOTIA

Abstract

The northern and eastern Cape Breton Highlands lie within the Appalachian orogenic belt, in northern Nova Scotia, and include portions of three major contrasting crustal segments. The Blair River Complex in the northwestern Cape Breton Highlands consists of metasedimentary gneisses, metamorphosed to upper amphibolite to granulite facies, and intruded by anorthosite, monzodiorite, and syenite. These Helikian rocks are probably correlative with Grenvillian rocks in western Newfoundland. The complex is bounded by blastomylonitic shear zones. The Aspy Terrane to the south includes Ordovician to Devonian sedimentary and volcanic units, generally metamorphosed to the middle to upper amphibolite facies, and intruded by Silurian granitic to granodioritic orthogneisses and many Devonian to Carboniferous granitic plutons. This terrane is separated from the Bras d'Or Terrane to the southeast by blastomylonitic shear zones which have undergone chlorite grade metamorphism. The Bras d'Or Terrane includes Hadrynian sedimentary, volcanic, and volcaniclastic lithologies, intruded by mainly late Hadrynian to Cambrian diorite, tonalite, granodiorite, and granite. Early Ordovician and Siluro-Devonian granite, granodiorite, and rhyolite are present locally in the Bras d'Or Terrane. Devono-Carboniferous volcanic and sedimentary rocks occur in the northwestern and southern highlands, and all zones are overlain by Early Mississippian clastic, carbonate, and evaporite lithologies.

Résumé

Les parties nord et est des hautes terres du Cap-Breton font partie de la zone orogénique des Appalaches, dans le nord de la Nouvelle-Écosse, et renferment des sections de trois grands segments de croûte présentant des contrastes. Le complexe de Blair River, situé dans le nord-ouest des hautes terres du Cap-Breton, est constitué de gneiss métasédimentaires, dont le degré métamorphique va du faciès des amphibolites supérieur au faciès des granulites; ces gneiss ont été pénétrés par de l'anorthosite, de la diorite monzonitique et de la syénite. Ces roches de l'Hélikien sont probablement en corrélation avec les roches du Grenvillien, dans l'ouest de Terre-Neuve. Le complexe est limité par des zones de cisaillement blastomylonitiques. Le terrane d'Aspy, au sud, se compose de roches sédimentaires et volcaniques, dont l'âge varie de l'Ordovicien au Silurien et le degré métamorphique, du faciès des amphibolites intermédiaire à supérieur; il est en outre pénétré par des orthogneiss granitiques et granodioritiques ainsi que par de nombreux plutons granitiques mis en place au Dévonien et au Carbonifère. Des zones de cisaillement blastomylonitiques qui ont atteint le degré de métamorphisme de faciès des chlorites séparent ce terrane du terrane du Bras d'Or, au sud-est. Ce dernier comprend des lithologies sédimentaire, volcanique et volcanoclastique, et est pénétré par des diorites, des tonalites, des granodiorites et des granites allant surtout de l'Hadrynien supérieur au Cambrien. On trouve, en outre, par endroits, dans le terrane de Bras d'Or, des granites, des granodiorites et des rhyolites d'âge ordovicien à silurien et dévonien. Des roches volcaniques et sédimentaires du Dévonien et du Carbonifère se manifestent dans les secteurs nord-ouest et sud des hautes terres, et toutes les zones sont recouvertes de sédiments détritiques, carbonatés et évaporitiques du Mississippien inférieur.

INTRODUCTION

Location and access

The area studied in this paper lies in northern Cape Breton Island, Nova Scotia, and includes all upland parts of Victoria County and part of Inverness County north of the Grande Anse River (Fig. 1 and 2, Map 1752A). It includes part or all of the onland portions of NTS sheets 11K/02, 11K/07, 11K/08, 11K/09, 11K/10, 11K/15, 11K/16, 11N/01, and 11N/02. Mapping has been confined mainly to the igneous and metamorphic rocks which underlie about 85 percent of the area. Approximately 30 percent of the area is part of the Cape Breton Highlands National Park.

The northern Cape Breton Highlands are readily accessible by paved highway. The Cabot Trail extends across the highlands and along the east coast (Map 1752A). Other paved and gravel roads extend north to Meat Cove and Money Point on the northeastern coast and to Red River on the northwestern coast. Logging roads and Nova Scotia Power Corporation roads provide access to the southern part

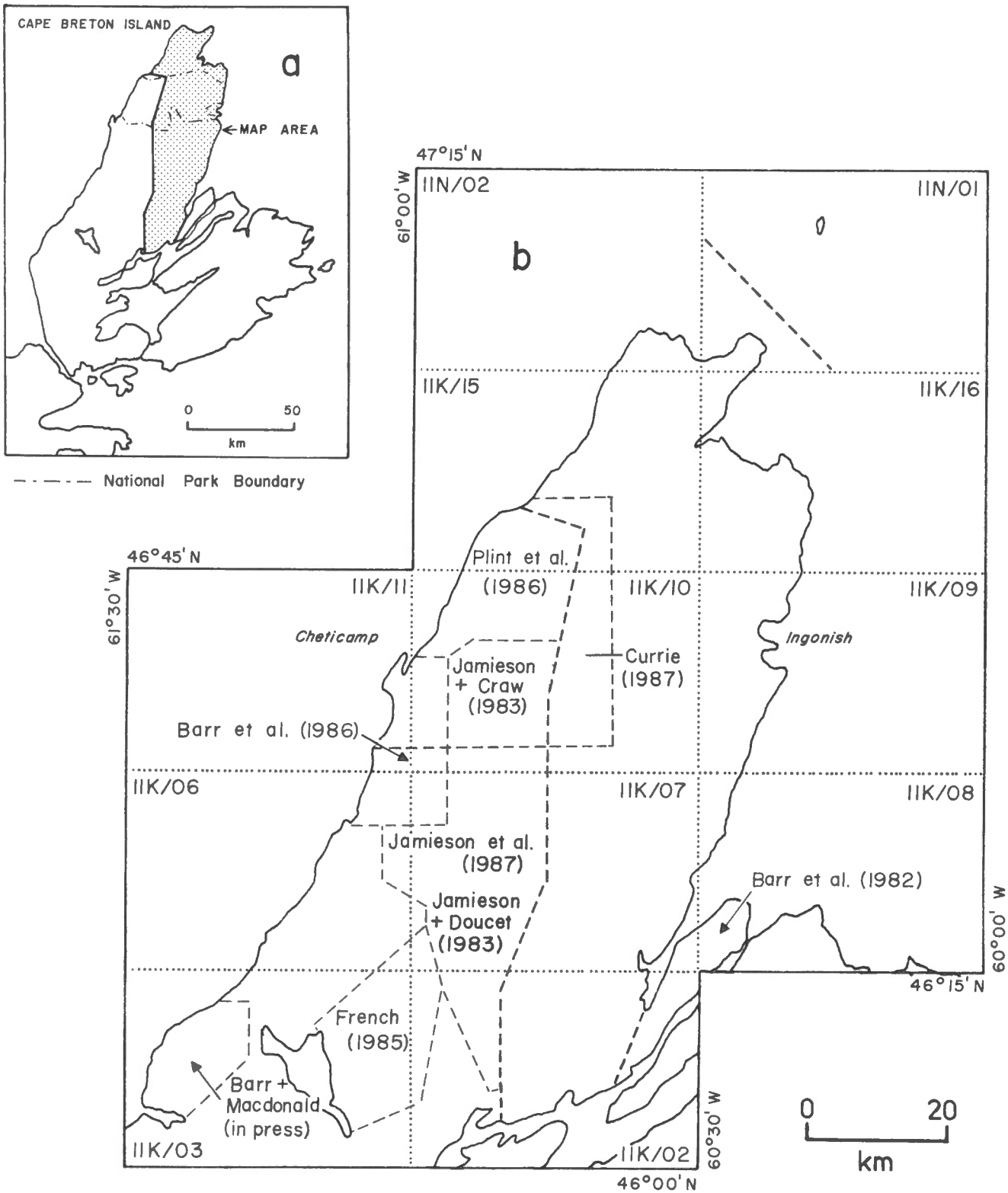

Figure 1. a) Location of the northern and eastern Cape Breton Highlands; b) NTS map sheets for the northern and eastern Cape Breton Highlands area (heavy outline and dotted) and most recent work done in surrounding areas (dashed).

of the area. Within the Cape Breton Highlands National Park there is a maintained network of hiking trails, and numerous fire access trails. Outside the national park, a limited number of trails give access to the highland areas. Although no part of the area is more than 15 km from a road, many of the interior portions are best reached by helicopter.

Settlements are largely confined to coastal fishing communities, and to some of the areas underlain by Carboniferous sedimentary rocks (Aspy Valley, and the east coast). In addition, the Ingonish area is a tourist centre and headquarters of the Cape Breton Highlands National Park operations.

Previous work

The earliest geological map of northern Cape Breton Island (Fletcher, 1884, scale 1:63 360) gives very little geological information about the present area, but shows the distribution of unmetamorphosed sedimentary rocks. The igneous and metamorphic lithologies were not mapped, and were assumed to be Precambrian in age. A second geological investigation was conducted in the area by the Geological Survey of Canada in the 1950s (McLaren, 1956a, 1956b; Kelley, 1957, 1960; Neale, 1963a, 1963b, 1964a, 1964b). These maps are of a reconnaissance nature and provide an outline of the distribution of the major rock types. These workers distinguished unmetamorphosed sedimentary, granitoid plutonic, gneiss, and schist units, but did not attempt correlation of the metamorphosed stratified units. Neale and Kelley (1960) described the stratigraphy and structure of the unmetamorphosed Mississippian sedimentary units of northern Cape Breton Island.

More detailed mapping in the present map area has been of limited extent. Wiebe (1972, 1975) investigated the plutonic and tectonic history of the eastern part of the area. Macdonald and Smith (1980) defined the Cape North and Money Point groups in the Cape North peninsula (Fig. 2) and described the structural and intrusive history of that area. The eruptive and sedimentary rocks of the Fisset Brook Formation at Lowland Cove and the anorthosite and surrounding rocks in the Red River area were mapped by Smith and Macdonald (1981 and 1983, respectively). Much of the mapping by Macdonald and Smith (1980) and Smith and Macdonald (1981, 1983) has been incorporated into this paper. The Carboniferous rocks and the sub-Carboniferous unconformity were investigated by Bradley (1984) and Bradley and Bradley (1984). Areas adjacent to this study area have been described by Barr *et al.* (1982, 1986), Jamieson and Craw (1983), Jamieson and Doucet (1983), French (1985), Plint *et al.* (1986), Currie (1987), Jamieson *et al.* (1987), and Barr and Macdonald (in press). (Fig. 1b).

Airborne magnetic surveys of the area were conducted in 1978 and 1979 by Terra Surveys Ltd. The results of these surveys were published as high resolution aeromagnetic total field and calculated vertical magnetic gradient maps at a 1:25 000 scale (Nova Scotia Department of Mines and Energy, 1980a, 1980b). Regional geochemical survey results are also available (Nova Scotia Department of Mines and Energy, 1984).

Petrologic, isotopic, tectonic, and/or stratigraphic studies have been conducted on some units in the map area. The granitic rocks of the Black Brook Granitic Suite were investigated by Wiebe (1972, 1975), Barr *et al.* (1982), and Barr and Pride (1986). The petrology of the Red River Anorthosite has been investigated by Jenness (1966) and Dupuy *et al.* (1986), and the Cameron Brook and Margaree plutons have been studied by O'Beirne-Ryan *et al.* (1986). Radiometric ages of several units have been published and are incorporated into this report (Margaree Granite — O'Beirne-Ryan *et al.*, 1986; plutons of the Money Point area — Keppie and Halliday, 1986; Lowland Cove Syenite — Barr *et al.*, 1987b; U-Pb dating of plutonic and orthogneissic units across the highlands — Barr *et al.*, 1988, and Dunning *et al.*, in press; $^{40}Ar/^{39}Ar$ dating of stratified and plutonic units — Reynolds *et al.*, in press). Neale and Kennedy (1975) suggested tectonic subdivisions in northern Cape Breton Island and proposed correlations with Newfoundland. Preliminary tectonic and stratigraphic analyses of the area have been presented by Raeside *et al.* (1984, 1986) and Barr *et al.* (1985, 1987c), and a tectonostratigraphic frameworks for the basement rocks of Cape Breton Island including the present area have been proposed by Barr and Raeside (1986, 1989). Possible correlation of the area with Newfoundland based on aeromagnetic and marine seismic reflection data has been discussed by Loncarevic *et al.* (in press).

Present investigation

The Cape Breton Highlands provide one of the largest sectors of pre-Carboniferous crystalline rocks in the Maritime Provinces, and occupy a critical position in the Appalachian orogenic system between the areas of more detailed study in Newfoundland and New England. The main objective of the present investigation was to complete geological mapping of the Cape Breton Highlands at 1:50 000 scale and thus permit a regional synthesis of this portion of the Appalachian system, and an analysis of its role in the development of the orogen (e.g. Barr and Raeside, 1986).

Mapping with some helicopter support was conducted in the northern and eastern highlands by the authors and assistants during May to July 1983, 1984, and 1985 and June to July 1986. Most of the mapping involved following brooks, but outcrops were also located on roads, trails, and in traverses between brooks. The southwestern part of the Cape Breton Highlands has been remapped in recent years by a number of workers (Fig. 1b). The compilation map of the geology of the entire Cape Breton Highlands at 1:100 000 scale which accompanies this report (Map 1752A, in pocket) includes data from the present study and from French (1985), Jamieson *et al.* (1987), Jamieson and Craw (1983), Jamieson and Doucet (1983), Plint *et al.* (1986), and unpublished material from the Inco Gold Company.

The purpose of this report is to provide basic descriptions of the field relations and lithologies of the geological units in the map area, and an overview of the structural, metamorphic, and economic features of the area. More

detailed follow-up studies including geochemistry, petrogenesis, age, and tectonic implications have been or will be published elsewhere.

Physiography

The Cape Breton Highlands form an uplifted peneplain, with a maximum altitude of 531 m. The drainage pattern is generally radial with low gradient stream profiles in the middle of the plateau. Near the margins of the plateau, streams are deeply incised with many gorges and extensive waterfall sections. The area of the present study includes the northern and eastern portions of the highlands, and can be divided physiographically into two upland areas (the North Mountain and the eastern highlands) and four lowland areas (the Salmon River sedimentary area, the Pleasant Bay Lowlands, the Aspy Lowlands, and the Coastal Plain (Fig. 2).

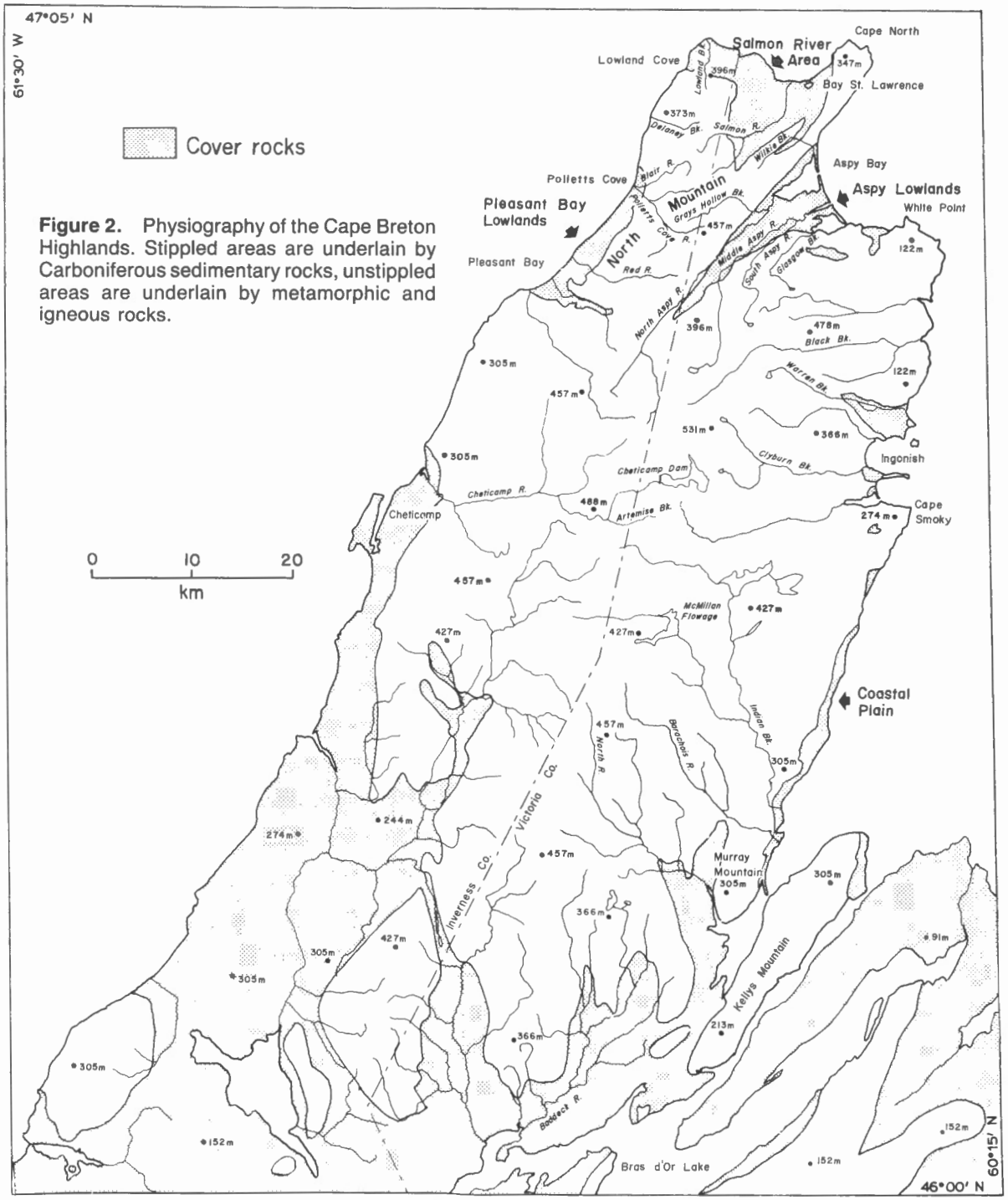

Figure 2. Physiography of the Cape Breton Highlands. Stippled areas are underlain by Carboniferous sedimentary rocks, unstippled areas are underlain by metamorphic and igneous rocks.

The Salmon River area in the northernmost part of the map area between Lowland Cove and Bay St. Lawrence is underlain by sedimentary rocks of the Horton and Windsor groups (Bradley and Bradley, 1984) and is characterized by a series of westerly-facing escarpments. The gently easterly-dipping back slopes of these escarpments conform to the orientation of the underlying units. Post-Carboniferous faulting has also produced a number of fault blocks, some of which form conspicuous summits. The coastline of this area is predominantly cliff, with narrow beaches in coves.

The North Mountain includes the area northwest of the Aspy Lowlands (Fig. 2) and is underlain predominantly by metamorphic and igneous rocks. The eastern margin is the Aspy Fault, a major Carboniferous (or younger) normal fault which extends 60 km into the Cape Breton Highlands and is probably correlative with the Margaree Fault system in the southwestern highlands. Slopes on the eastern margin are mainly cliff or scree, and streams draining toward the Aspy Lowlands are deeply incised. The west coast of the North Mountain is particularly rugged with 400 m cliffs and very deeply incised streams. The summit of the North Mountain is a plateau, average altitude 450 m, with extensive areas of blanket bog and lakes.

The Pleasant Bay Lowlands extend along the west coast of the Cape Breton Highlands from Pleasant Bay to Polletts Cove. This area includes rounded hills and terraced slopes underlain by Devonian and Carboniferous unmetamorphosed sedimentary rocks. The coastline here ranges from low bluffs to 250 m cliffs.

The Aspy Lowlands form a triangular area southeast of the Aspy Fault. They consist of a series of low ridges between northeasterly-flowing streams which are underlain by rocks of the Carboniferous Horton and Windsor groups. A series of lagoons and "barachois" at the head of Aspy Bay are probably mainly underlain by evaporitic rocks of the Windsor Group.

The Coastal Plain extends along the eastern margin of the highlands from Cape Smokey to Murray Mountain. It forms a low platform, 10 to 30 m above sealevel, and displays karst topography in areas underlain by gypsum.

The remainder of the eastern highlands includes a gently easterly-dipping paleoplain, ranging in altitude from 530 m in the central highlands to near sea-level between Ingonish and White Point. This area is underlain mainly by igneous and metamorphic rocks, although a small area of Carboniferous sedimentary rocks is exposed on Cape Smokey. Drainage in the northern part of this area is mainly to the east, with many near-parallel linear streams which are moderately incised. In the southern part of the area drainage is to the southeast. In the central highlands, extensive areas of blanket bog are developed on the plateau.

Acknowledgments

We gratefully acknowledge financial support from the Geological Survey of Canada and the Natural Sciences and Engineering Research Council of Canada. We appreciate the co-operation and assistance we received from Parks Canada and the wardens at Ingonish Beach, Neils Harbour, and Big Intervale. We thank Alan Macdonald, Chris White, Winai Yaowanoiyothin, and Frank Dennis for assistance in the field, Becky Jamieson, Heather Plint, Catharine Farrow, and staff of Inco Gold Company for helpful discussions, and Ken Currie for reviewing the manuscript. We also thank our helicopter pilots Nelson Cornell, Tim Crowley, and Glenn MacDonald. We are especially grateful to Wendy Raeside for logistical support.

REGIONAL SETTING

Within the Appalachian system of Cape Breton Island, four tectonostratigraphic zones were recognized by Barr and Raeside (1986). Three of these zones, the Northwestern Highlands (referred to as the Blair River Complex in this paper), the Highlands and the Bras d'Or zones, extend into the present map area. Additional radiometric dating has shown that the Highlands zone has two components — the western part has been termed the Aspy Terrane and is characterized by mid-Paleozoic deformation and plutonism, and the eastern part is similar to, and is now included with, the Bras d'Or Terrane (Fig. 3).

The Blair River Complex (the Northwestern Highlands zone of Barr and Raeside, 1986, redefined as the Blair River Complex in Barr *et al.*, 1987b), which lies north of the Wilkie Brook and Red River faults (Fig. 3), includes a variety of orthogneissic and paragneissic lithologies, amphibolites, and schists intruded by anorthosite, monzodiorite, and syenite of late Helikian age. These bear many similarities to rocks of the Steel Mountain Anorthosite, the Indian Head Range Complex, and the Long Range Inlier of Newfoundland, and have been assigned a Grenvillian age on the basis of these similarities and a 1040 Ma U-Pb radiometric age from zircon in syenite (Barr *et al.*, 1987b).

The Aspy Terrane encompasses a large portion of the central part of the map area and includes a variety of moderately to highly metamorphosed Paleozoic stratified rocks and granitic to tonalitic plutonic units. It is bounded in the north by the Wilkie Brook and Red River fault zones and to the southeast by the Eastern Highlands shear zone. The Aspy Terrane includes the western part of the Highlands zone of Barr and Raeside (1986).

The remainder of the map area, southeast of the Eastern Highlands shear zone (Fig. 3), lies in the Bras d'Or Terrane, and includes predominantly low to medium grade Precambrian metamorphic units and a wide range of tonalitic and dioritic to granitic plutonic rock types. The Bras d'Or Terrane includes all of the area shown as the Bras d'Or zone and the eastern part of the Highlands zone of Barr and Raeside (1986). Correlations of the Aspy and Bras d'Or terranes to other portions of the Appalachian system are not fully resolved, although many similarities exist to rocks in southwestern Newfoundland (Williams *et al.*, 1988; Loncarevic *et al.*, in press).

BLAIR RIVER COMPLEX

Introduction

The Blair River Complex (Barr *et al.*, 1987b) consists predominantly of a series of quartzofeldspathic gneisses and amphibolites (Polletts Cove River Group) which have been intruded by anorthosite, monzodiorite, syenite, gabbro, and granitic rocks (Fig. 4). All units have undergone deformation and metamorphism during the late Precambrian or early Paleozoic and the complex is overlain by Devono-Carboniferous volcanic and sedimentary rocks of the Fisset Brook Formation and younger Carboniferous sedimentary units of the Horton and Windsor groups.

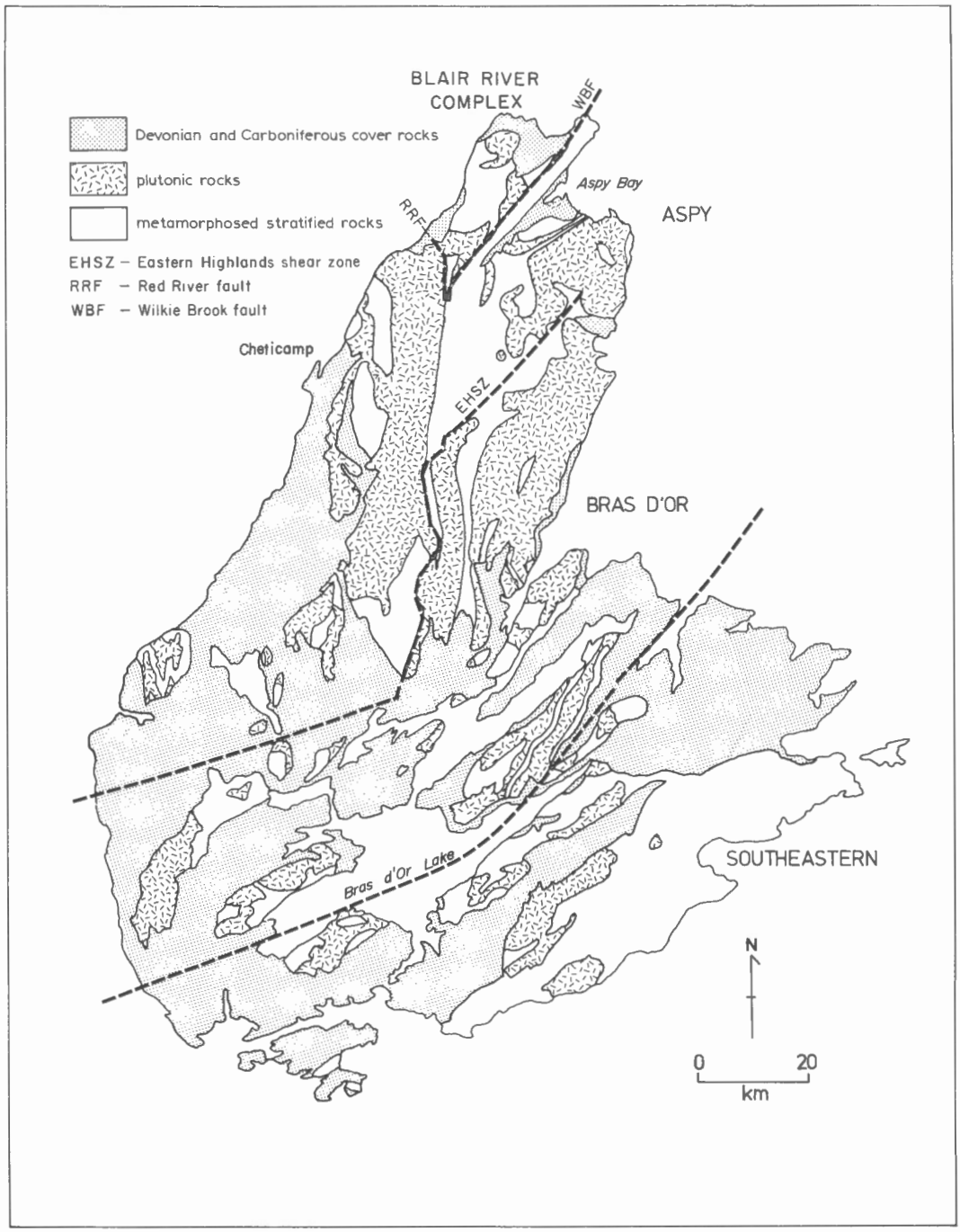

Figure 3. Tectonostratigraphic terranes of northern Cape Breton Island (simplified and modified from Barr and Raeside, 1986).

Precambrian stratified units

Polletts Cove River Group

The Polletts Cove River Group includes all the stratified rocks of the Blair River Complex. It is well exposed along the valleys of Blair River and Polletts Cove River, and their tributaries. The main components are quartzofeldspathic gneiss, amphibolite and amphibolite gneiss, and metagabbro, although there are also minor amounts of calc-silicate rocks and granulites. Quartzofeldspathic gneisses and amphibolites are typically intimately mixed in the Polletts Cove River Group, and are commonly interleaved on individual outcrops, with gradational boundaries in some cases. It is therefore not possible to subdivide the unit on a 1:100 000 scale based on the distribution of these rock types. The distribution of the three most abundant lithologies is not uniform across the area — quartzofeldspathic rocks make up the bulk of the Polletts Cove River Group in the south, whereas amphibolitic rocks are almost equally as abundant as quartzofeldspathic rocks in the central and northern parts. Metagabbros are more restricted, being found only in the central and western parts of the area. These may form larger units, but were not mapped as separate units because of the lack of demonstrable continuity as a result of poor outcrop on the North Mountain plateau.

Quartzofeldspathic gneisses of the Polletts Cove River Group represent a variety of protoliths including at least semipelitic, psammitic, and quartzitic sedimentary rocks, and granitoid plutonic rocks and dykes. Pelitic lithologies appear to be lacking. Psammitic compositions are most abundant: only three samples devoid of mica or chlorite were sectioned, and no sample contains more than 10 percent micas and chlorite. Approximately half of the samples collected contain potassium feldspar (up to 40 percent microcline or microcline-perthite), and plagioclase (An_{22-38}) is ubiquitous. Apatite is a particularly common accessory mineral, ranging up to 5 percent in some gneisses, and titanite is also a common phase. Other isolated samples contain garnet, clinopyroxene, orthopyroxene, cummingtonite, or anthophyllite in small quantities.

Layering is apparent in most quartzofeldspathic gneisses in outcrop. In some cases the layering may represent relict bedding, but in most cases it is defined by subtle variations in the amount of mafic minerals and is probably metamorphic in origin. Throughout the western and central parts of the outcrop area of the Polletts Cove River Group many of the more prominently layered rocks are mylonites. Typically these are severely granulated quartzofeldspathic rocks with few porphyroclasts larger than 2 mm. In the west, especially along the coast, the mylonitized quartzofeldspathic rocks preserve many primary mylonitic textures, including granulated feldspars, lattice defect boundaries, and zones of cryptocrystalline grain size. Farther to the east these textures are less prevalent, and in the narrow zone of Polletts Cove River Group rocks west of Wilkie Brook, mylonites which are recognizable in hand specimen display almost completely recrystallized blastomylonitic textures in thin section. These observations indicate that metamorphism postdating the mylonitization was more extensive in the east.

Most of the quartzofeldspathic rocks display moderate to severe retrograde metamorphism or alteration effects. These range from chloritization of biotite and pervasive sericitization of feldspars (especially in the central parts of the area) to the development of coarse flakes of retrograde muscovite (near the eastern margin). This is consistent with a late mild metamorphic overprinting which was more extensive in the east.

Many of the quartzofeldspathic lithologies may represent metamorphosed granitoid lithologies. Only where primary igneous textures are well preserved can the igneous origin of these rocks be recognized. Examples of relict graphic granite, microcline phenocrysts, and xenolithic textures were noted, although no area of the Polletts Cove River Group appears to have an abundance of such rocks.

Mafic lithologies in the Polletts Cove River Group include amphibolite and amphibolite gneiss, and a variety of metagabbros. Amphibolite and amphibolite gneiss are typically interleaved with the quartzofeldspathic gneiss, and presumably represent metamorphosed thin sills, flows, or volcaniclastic layers. Individual layers commonly range from a few centimetres to a few metres in thickness, although extensive amphibolite sections exist in the Blair River area and along the northwestern coast. Many of the amphibolites are granoblastic or foliated massive rocks, consisting of approximately equal amounts of green hornblende and plagioclase (An_{28-56}) and lesser amounts of opaque minerals and apatite. Quartz is present in most samples; less commonly biotite is also found. A wide range in concentrations of hornblende, plagioclase, and quartz in a few samples indicates that the amphibolites probably represent a variety of protoliths, from basaltic dykes or flows to more intermediate rock types. Amphibolites that display pronounced compositional layering are referred to as amphibolite gneisses. In most cases the layering appears to be metamorphic in origin, with mafic layers depleted in plagioclase.

In the central and northwestern parts of the outcrop area of the Polletts Cove River Group, massive amphibolite layers have preserved a gabbroic texture. Typically these are coarse grained augite-hornblende-plagioclase rocks, in which the hornblende occurs as epitaxial overgrowths on the clinopyroxene and in some rocks has completely replaced it. The hornblende is strongly colour-zoned, with the most intensely green zones on the outer rims. Relict ophitic or subophitic texture, which is commonly best observed in hand specimen, is well preserved in rocks from the northwestern part of the area. The extent of these gabbroic layers was not determined due to limited exposure on the plateaux between the streams, but significant concentrations were noted in the Delaney Brook and Otter Brook areas. There is a general association between the gabbroic layers and the occurrence of anorthosite bodies.

Retrograde metamorphism has affected most of the amphibolites to varying degrees. Along the northwest coast, retrograde metamorphism has been minor resulting in partial chloritization of amphiboles and pyroxenes and sericitization of feldspar. In the central part of the area, pyroxenes have been extensively chloritized and in the east both amphi-

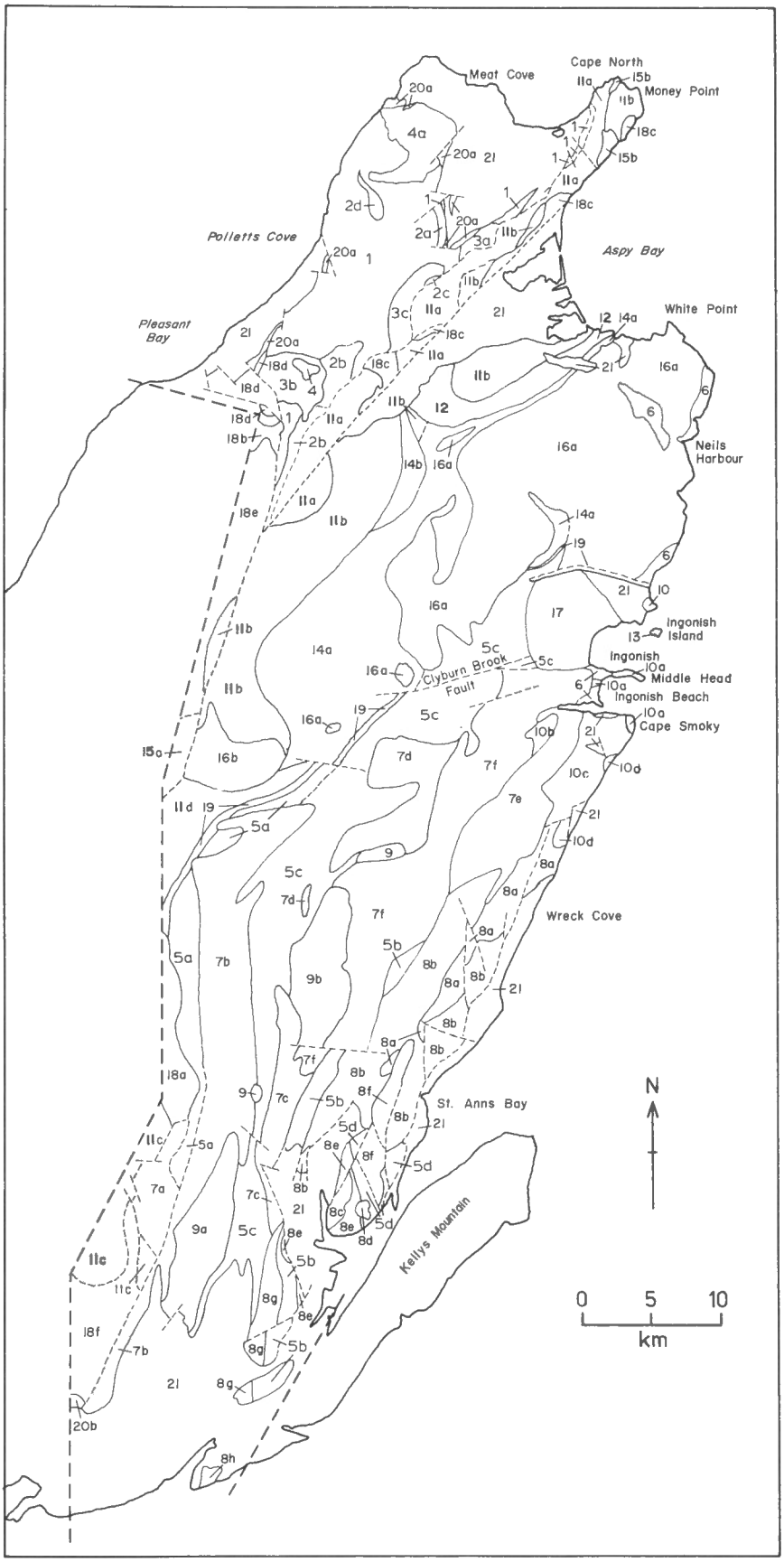

Figure 4. Simplified geological map of the northern and eastern Cape Breton Highlands (modified from Barr *et al.*, 1987a, 1987c and Raeside *et al.*, 1986)

Blair River Complex

Carboniferous
21 Horton and Windsor groups

Devonian to Carboniferous

20a Fisset Brook Formation
19 mylonite

Helikian
4a Lowland Brook Syenite
4 unnamed syenite bodies
3c Grays Hollow monzodiorite
3b Red River monzodiorite
3a Wilkie Brook monzodiorite
2d Delaney Brook anorthosite
2c Grays Hollow anorthosite
2b Red River Anorthosite
2a Salmon River anorthosite
1 Polletts Cove Brook Group

Aspy Terrane

Carboniferous
21 Horton and Windsor groups

Devonian to Carboniferous
20b MacMillan Mountain volcanics
20a Fisset Brook Formation
19 mylonite
18f Leonard MacLeod Brook Complex
18e Margaree Pluton
18d Andrews Mountain Granite
18c Wilkie Sugarloaf plutons
18b Grande Anse Granite
18a West Branch North River Granite
16b Park Spur Granite
16a Black Brook Granitic Suite

Siluro-Devonian
15b Gulch Brook Granite
15a Taylors Barren Pluton
14b Middle Aspy River Orthogneiss
14a Cheticamp Lake Gneiss

Ordovician to Devonian
12 Glasgow Brook Orthogneiss
11d Jumping Brook Metamorphic Suite
11c Sarach Brook Metamorphic Suite
11b Money Point Group
11a Cape North Group

Bras d´Or Terrane

Carboniferous
21 Horton and Windsor groups

Devonian to Carboniferous

19 mylonite

17 Cameron Brook Granodiorite

Silurian
13 Ingonish Island rhyolite

Ordovician to Silurian
10d Morrison Brook Quartz Monzonite

Ordovician
10c Cape Smokey Granite

Hadrynian to Devonian
10b Ski Hill Granodiorite
10a Middle Head Leucodiorite
9b Cross Mountain Suite
9a Bell Lakes Suite
9 unnamed granitoid rocks

Hadrynian to Cambrian
8h Beinn Bhreagh Suite
8g Goose Cove Brook Granodiorite
8f Murray Mountain Quartz Monzodiorite
8e St. Anns Leucogranite
8d Murray Brook Granodiorite
8c Kerrs Brook Granite/Granodiorite
8b Indian Brook Granodiorite
8a Birch Plain Granite
7f Ingonish River Tonalite
7e Wreck Cove Dioritic Suite
7d Gisborne Flowage Quartz Diorite
7c Timber Lake Dioritic Suite
7b Kathy Road Dioritic Suite
7a North Br. Baddeck River Leucotonalite
6 Neils Harbour Gneiss
5d Price Point Formation
5c McMillan Flowage Formation
5b Barachois River Metamorphic Suite
5a Bateman Brook Metamorphic Suite

boles and pyroxenes display extensive chloritization. A number of samples display moderate shearing effects, but pronounced cataclasis appears to be restricted to the quartzofeldspathic lithologies.

In addition to the quartzofeldspathic gneisses and metabasites, rare calcareous rocks were also noted in the Polletts Cove River Group. In the valley of Polletts Cove River, an outcrop of a diopside-tremolite-phlogopite rock was observed. This rock is a medium to coarse grained massive calc-silicate and occurs in association with a thin quartzite layer. A number of xenoliths with calcareous skarn margins which occur in the Lowland Brook Syenite south of Meat Cove may be derived from a calcareous horizon in the Polletts Cove River Group. Assemblages in these xenoliths include partly serpentinized forsterite, forsterite-humite and forsterite-brucite marbles, diopside-phlogopite $\pm$ grossular, idocrase, brucite, tremolite, and sphalerite calc-silicates, and massive phlogopite-sphalerite rocks. No similar rocks were noted in the Polletts Cove River Group, and correlation with the group is speculative.

The Polletts Cove River Group has been intruded by the Lowland Brook Syenite, which has yielded a U-Pb (zircon) age of 1040 +10/-30 Ma. This age was considered by Barr *et al.* (1987b) to represent the age of upper amphibolite to granulite facies metamorphism. The depositional age of the group is therefore Helikian or older.

Precambrian plutons

Anorthosite

Anorthosite in the northern Cape Breton Highlands was recognized by previous workers (Neale, 1963a; Jenness, 1966) and the largest body has been termed the Red River Anorthosite Complex (Macdonald and Smith, 1979; Smith and Macdonald, 1983). Our mapping has better defined the distribution and field relations of anorthosite in the region, including the identification of a major previously unmapped pluton (Delaney Brook anorthosite) in the west-central part of the area. Other mappable anorthosite bodies occur in Grays Hollow Brook and Salmon River. In addition, sheets or dykes of anorthosite occur widely throughout the Polletts Cove River Group.

The anorthosite has a clearly intrusive relationship with gneisses of the Polletts Cove River Group. For example, at its well exposed margins just north of the brook, the Delaney Brook anorthosite occurs as thin sheets in the adjacent mafic gneiss, and gneissic xenoliths occur within the anorthosite. Similar relationships were observed adjacent to other anorthosite bodies.

The anorthosites occur in close association with monzodioritic rocks, which have been previously interpreted to intrude them (Smith and Macdonald, 1983) and not to be genetically related (Dupuy *et al.*, 1986). However, direct evidence for the relative ages of these units was not observed during the present study, and the close association in the field implies a genetic relationship.

The anorthosites are white to buff-coloured rocks, with an abundance of streaky mafic clots representing chloritized mafic minerals. With increasing abundance of these mafic streaks, the rocks grade to anorthositic diorite. Locally, macroscopic mafic and felsic layering is present, representing the transition from anorthosite to anorthositic diorite. The Red River and Grays Hollow anorthosites are generally strongly sheared, probably because of their close proximity to the major mylonitic zones which separate the Blair River Complex from the Aspy Terrane to the south. However, the Delaney Brook and Salmon River anorthosites are mainly unsheared. In all areas the anorthosites are hard massive rocks which form spectacular waterfalls.

The anorthosite consists of unzoned or weakly zoned plagioclase of composition approximately An_{50}. The texture is medium to coarse grained allotriomorphic granular, although many samples are modified by shearing and cataclasis. The plagioclase shows minor to intense alteration to saussurite and sericite. Mafic minerals have been completely replaced by chlorite, epidote, and titanite, although Smith and Macdonald (1983) reported the presence of relict amphibole and pyroxene. Accessory minerals include apatite and opaque minerals, the latter showing partial alteration to leucoxene. Most samples are pervasively cut by irregular veins of chlorite, sericite, and epidote. The anorthositic diorites are generally less altered, and consist mainly of andesine and hornblende.

Monzodiorite and related rocks

Large bodies of monzodioritic rocks occur adjacent to the Red River Anorthosite Complex and farther northeast in the headwaters of Grays Hollow Brook and in the Wilkie Brook area. The Red River body was previously identified by Smith and Macdonald (1983). Although heterogeneous in detail, these bodies have significant features in common and hence are grouped as a single map unit. Similar rocks occur as sheets and dykes throughout the Polletts Cove River Group, where they are difficult to distinguish from amphibolites and metagabbros.

The predominantly monzodioritic bodies range from diorite through quartz monzodiorite to granodiorite, many with black to greenish mafic minerals and red felsic minerals, giving a distinctive appearance in outcrop. Locally they appear to grade to more mafic (gabbroic) and more leucocratic units. The latter include syenite and more quartz-rich rocks (leucotonalite and granodiorite). Typically the rocks are medium to coarse grained, equigranular, and unfoliated, although shearing is widespread, especially in proximity to the Wilkie Brook and Red River fault zones.

Thin section study confirms the heterogeneous nature of these rocks. Most typical, especially in the Red River area, is medium grained quartz monzodiorite, consisting of perthite, oligoclase-andesine, clinopyroxene, and amphibole, with variable amounts of interstitial quartz, and accessory zircon, apatite, titanite, and opaque minerals. With increasing perthite abundance, the quartz monzonite grades to quartz syenite. Similarity of the perthite component indicates a genetic relationship with syenites in the area (although no monzodioritic rocks appear to occur in association with the main Lowland Brook Syenite pluton), and

quartz syenite and syenite dykes and minor intrusions occur widely within the monzodiorite. Some rocks in the monzodioritic unit are similar to anorthositic diorite layers within the anorthosite bodies, and a genetic relationship is possible. Smith and Macdonald (1983) inferred that the monzodiorite is younger than the Red River Anorthosite Complex, and Dupuy *et al.* (1986) suggested on petrological grounds that the two are not genetically related. However, the observations from the present study suggest that the anorthosite, the monzodioritic unit, and the syenite may be similar in age and perhaps genetically linked, an association which has also been described in the Grenville Province (Gower and Ryan, 1986).

Syenite

Syenite forms a large intrusion, named the Lowland Brook Syenite (Barr *et al.*, 1987b), in the northwestern part of the map area. The most extensive exposures are in the upper reaches of Lowland Brook. It also occurs commonly as small bodies and dykes within the monzodioritic bodies and the gneisses of the Polletts Cove River Group.

The syenites vary from massive to gneissic. They are generally red and medium to coarse grained, but some syenitic dykes in the Polletts Cove River Group are fine grained. Syenite consists mainly of strongly perthitic and antiperthitic alkali feldspar, with minor interstitial sodic plagioclase, amphibole, and clinopyroxene. Apatite, zircon, and opaque oxides (mainly ilmenite) are abundant accessory minerals. Textures are typically recrystallized and granoblastic or gneissic. Some syenitic dykes contain interstitial quartz and grade to quartz syenite.

The Lowland Brook Syenite is the only dated unit in the Blair River Complex. Zircon from the syenite has indicated an age of 1040 +10/-30 Ma, which has been interpreted to be a metamorphic age but relatively close to the actual age of crystallization (Barr *et al.*, 1987b). This date, in combination with the distinctive lithological assemblage including quartzofeldspathic gneiss and anorthosite, implies the Polletts Cove River Group and associated intrusive rocks represent Grenvillian basement, probably correlative with Grenvillian rocks in the Long Range Inlier and Indian Head Range Complex of western Newfoundland (Barr *et al.*, 1987b).

Granitoid rocks

Abundant granitic sheets and dykes occur within the units of the Blair River Complex, especially within the Polletts Cove River Group. Many are alkali feldspar granites, ranging in grain size from very fine to pegmatoid, and consisting dominantly of perthitic alkali feldspar and quartz. Mafic minerals are minor and include variably chloritized biotite and amphibole. Cataclastic textures are typically present. Some granitic to syenitic sheets have been deformed and metamorphosed to granitic to syenitic gneisses, and are difficult to distinguish from quartzofeldspathic layers within the gneisses.

ASPY TERRANE

Introduction

Three stratified units have been identified in the Aspy Terrane of the study area (Fig. 4). These represent a wide variety of rock types ranging from highly aluminous schists to metabasites and calc-silicate rocks, although overall semipelitic schists, quartzofeldspathic gneisses, and amphibolites are the most common. In the central highlands, a sequence of gneisses (some of which are orthogneisses) and schists constitutes the Cheticamp Lake Gneiss, and forms the core of the Aspy Terrane. The Cheticamp Lake Gneiss was previously included with the Pleasant Bay Complex by Currie (1987). This gneiss is flanked on its northwestern margin by the Cape North and Money Point groups, both of which are of lower metamorphic grade, ranging in lithology from greenschists to sillimanite-muscovite schists and gneisses and garnet amphibolites.

In adjacent areas to the west, Currie (1982, 1987) has described the Jumping Brook complex in which he included all stratified rocks with strong foliation and/or lineation, except gneisses. Jamieson *et al.* (1987) redefined the Jumping Brook Metamorphic Suite as a belt of low, medium, and high grade metasedimentary, metavolcanic, and metaplutonic rocks. Other stratified units (e.g. the Sarach Brook Metamorphic Suite and the Middle River Metamorphic Suite) have also been identified in the inferred extension of the Aspy Terrane in the southwestern highlands by Jamieson and Craw (1983) and Jamieson and Doucet (1983). These units are all interpreted to be correlative and of Ordovician to Silurian age, based on a U-Pb (zircon) age of 433 +7/-4 Ma for rhyolite near the top of the Sarach Brook Metamorphic Suite (Dunning *et al.*, in press). A similar age of 438 $\pm$ 8 Ma was reported by Currie *et al.* (1982) for rhyolite dykes in the Cheticamp area.

In addition to the stratified units, granitoid plutons are very abundant in the Aspy Terrane. They include orthogneisses (Glasgow Brook and Middle Aspy River) and a variety of granitic plutons and related dykes. Radiometric dating of these later granitic rocks provides minimum ages for the metamorphic units of the Aspy Terrane, and is described subsequently.

Ordovician to Devonian stratified units

Cape North Group

Rocks assigned to the Cape North Group outcrop in an almost continuous belt between the Wilkie Brook and Aspy faults and east of the Aspy Fault in the Big Southwest Brook area. Although there is no lithological continuity across the Aspy Fault, distinctive sequences on either side of the fault imply correlation of the group across it. The Cape North Group was first introduced by Macdonald and Smith (1980) for high grade metamorphic rocks in the Cape North Peninsula. Although they found the boundary between the Cape North Group and the adjacent Money Point Group difficult to define, they noted that the two groups display significant differences in both rock type and metamorphism. In the area

to the south, the metamorphic distinction is less obvious, but the lithological diversity persists, indicating that the two groups can be considered as separate stratigraphic units.

Stratigraphic relationships within the Cape North Group are obscure because of polyphase folding, high grade metamorphism, and limited outcrop, especially in the area to the south. In particular, the complexity of multiple foliation development prohibits stratigraphic analysis throughout the Cape North Group.

The major lithologies in the Cape North Group are semipelitic, pelitic, and calc-silicate gneisses, with minor amounts of amphibolite and marble. In places these have been abundantly intruded by granitic dykes, many of which are probably derived from Devonian plutons (e.g. Wilkie Sugarloaf Granite), but some of which may represent *in situ* melting of pelitic lithologies.

Semipelitic gneisses compose approximately 80 percent of the Cape North Group, although they appear to be more abundant in the Cape North Peninsula (Macdonald and Smith, 1980) and in the area south of the Aspy Fault. Typically these are medium grained equigranular quartz-plagioclase-biotite leucogneisses, only rarely containing muscovite, kyanite, or potassium feldspar. A particularly prominent variety contains 5 to 10 percent hornblende (or chlorite after hornblende) displaying a strongly acicular to bladed form. This hornblende leucogneiss is readily distinguished in the field and appears to be distributed throughout the Cape North Group. In some outcrops, hornblende ranges up to 40 percent, and biotite up to 20 percent. In all semipelitic lithologies, including these more melanocratic varieties, the plagioclase is oligoclase-andesine (An_{22-37}). Some samples have been severely affected by retrograde metamorphism, resulting in moderate saussuritization, and the development of chlorite, epidote, and sericite.

A few layers of pelitic gneiss appear to be restricted to horizons east of a marble unit (described below) in the Cape North Peninsula area (Macdonald and Smith, 1980), and on both sides of it in the MacGregor Brook area (Smith and Macdonald, 1983). Outside these areas of detailed mapping, the exact position of the pelitic layers have not been defined, although they all appear to be within 1 km of the marble unit. They occur as migmatitic medium to coarse grained porphyroblastic mica schists, with abundant kyanite and garnet metacrysts. Sillimanite has also been reported from the Cape North Peninsula (Macdonald and Smith, 1980).

A single marble layer has been traced throughout the extent of the Cape North Group, west of the Aspy Fault; no marble was found in the area to the east. It ranges up to 100 m in thickness, the thickest being on the coast east of Bay St. Lawrence (Macdonald and Smith, 1980), but is typically 2 to 5 m thick. It consists of a medium to coarse grained calcite marble in all areas, and it was noted to be slightly dolomitic in the Cape North Peninsula (Macdonald and Smith, 1980). Calc-silicate rocks are commonly developed in association with the marble and also in isolated layers in the semipelitic gneisses. They consist of hornblende, diopside, clinozoisite, calcic plagioclase (An_{56-83}), phlogopite or pale biotite, microcline, titanite, and calcite. Idocrase and grossular garnet were also reported by Macdonald and Smith (1980).

Amphibolitic lithologies are also represented in the outcrop area of the Cape North Group. The amphibolites are medium grained, relatively massive rocks, and some contain abundant garnet. In many places they can be seen to be crosscutting with respect to the layering in the gneisses, and are assumed in all cases to be intrusive rocks. Individual sheets range up to 25 m across.

The oldest dated rock that has intruded the Cape North Group is the Gulch Brook Granite, which has yielded a Rb-Sr whole-rock isochron age of 413 $\pm$ 10 Ma (Keppie and Halliday, 1986).

Money Point Group

Rocks assigned to the Money Point Group outcrop in a belt extending on the west side of the Aspy Fault from Money Point to Grays Hollow Brook, and on the east side of the fault from Aspy Bay to Cheticamp River. The outcrop areas are not continuous, but are separated by the Aspy Fault and by orthogneiss bodies. As in the Cape North Group, stratigraphic continuity has not been demonstrated between the various outcrop areas of the Money Point Group. However, certain lithologies that are diagnostic of the Money Point Group occur in each of these outcrop areas and permit tentative correlation of scattered blocks.

The Money Point Group was first introduced by Macdonald and Smith (1980) for relatively low grade metamorphosed rocks of the Cape North Peninsula, which are well exposed at Money Point. The outcrop area of the group was subsequently expanded by Raeside *et al.* (1986) to include rocks exposed in Grays Hollow Brook. Macdonald and Smith (1980) and Raeside *et al.* (1986) were unable to discern the nature of the contact between the Money Point and Cape North groups, beyond noting a rapid increase in metamorphic grade which accompanies a change in lithological types. In the area south of the Aspy Fault, the Money Point Group, although compositionally similar to that north of the fault, has been metamorphosed entirely at medium to high grades.

Detailed stratigraphic relations have not been determined in the Money Point Group. In general, the moderate to high metamorphic grade, and the effects of polydeformation prohibit fine-scale analysis of the stratigraphy. The major lithologies which constitute the Money Point Group are mafic (amphibolite and hornblende-biotite schists) but there are also significant proportions of less mafic semipelites, pelites, and calc-silicates and rare marbles. Near the margins of the Black Brook Granitic Suite and the Park Spur Granite, these lithologies have been abundantly intruded by granitic dykes, sheets, and pegmatites.

Mafic lithologies make up about 60 percent of the Money Point Group. These include amphibolites and hornblende-mica schists. The amphibolites are less abundant, and are restricted mainly to the southern part of the outcrop areas, where they make up about 40 percent of the section exposed in Artemise Brook and Cheticamp River. Elsewhere amphibolites compose less than 5 percent of the outcrops and are scattered throughout the area. In some cases they occur as sheets or dykes, up to 20 m thick, which

cut across the stratified units. Typically they are massive medium grained rocks containing green hornblende, andesine or labradorite plagioclase, and abundant accessory titanite, ilmenite, and apatite. Rarely, some amphibolites also contain garnet or clinopyroxene. Macdonald and Smith (1980) postulated that in the Money Point area, where metamorphic grade is lower, the amphibolite sheets were formed as gabbroic sills which were comagmatic with mafic volcanism.

Hornblende-mica schists are more abundant than amphibolite throughout most of the Money Point Group. They are distributed throughout the higher metamorphic grade portions of the Money Point Group and are particularly diagnostic of the group. In the Cape North Peninsula, Macdonald and Smith (1980) reported metabasalt, mafic and intermediate metatuff, and metarhyolite which have been preserved at relatively low metamorphic grade. In many cases they were able to examine the primary depositional characteristics of these volcanic and volcaniclastic rocks. It is likely that the hornblende-mica schists of the higher metamorphic grade areas to the south are the metamorphosed equivalents of these rocks.

The hornblende-mica schists typically are leucocratic to mesocratic medium grained schists with total amounts of hornblende and biotite ranging from 15 to 60 percent of the rock. The relative proportion of hornblende and biotite also varies, from biotite schists with less than 10 percent scattered hornblende clusters to amphibolites with 10 percent or more biotite distributed throughout. Most samples have approximately equal quantities of hornblende and biotite, and in many rocks the hornblende and biotite are segregated into 2 to 5 mm wide layers which may represent original compositional layering in the volcaniclastic pile. The hornblende in most of the hornblende-biotite schists is unusually pale coloured, in contrast to the hornblende in the amphibolites which exhibits pleochroic colours in the mid to deep green range. The biotite is green-brown in most samples, which contrasts with the brown or red-brown biotites in hornblende-free mica schists. Garnets are present in many of the hornblende mica schists: in some cases these are metacrystic and display complex internal textures implying growth in actively deforming rocks. In general, recrystallization has proceeded to such an extent that no correlation can be made between the internal schistosity of the garnet metacrysts and the enveloping foliation.

Less mafic metasedimentary lithologies constitute the remaining 40 percent of the Money Point Group. These include, in approximately equal quantities, pelites, semipelites, and calc-silicate rocks, and rare marbles. These lithologies are distributed throughout the outcrop area of the Money Point Group, and are commonly interbedded with the mafic hornblende-mica schists on a centimetre to decimetre scale.

Pelites are found throughout the unit, ranging from low grade phyllitic schists in the Money Point area to biotite or muscovite-biotite schists in the area south of the Aspy Fault. The more abundant schistose pelites typically consist of quartz, biotite, muscovite, minor plagioclase, and ilmenite. Many samples contain garnet, and some of the more aluminous layers also contain large amounts of aluminosilicate minerals (sillimanite, kyanite, chloritoid, or staurolite). Corundum was also reported from the Money Point area (Macdonald and Smith, 1980).

Semipelitic schists are particularly abundant in the Grays Hollow and Cheticamp River sections of the Money Point Group, but also occur as interstratified layers with pelitic schists, hornblende-mica schists, and calc-silicate gneisses throughout the unit. Typically they are medium grained, moderately schistose rocks, made up of quartz, plagioclase, biotite, and ilmenite. Some samples also contain garnet, muscovite, microcline, or small amounts of aluminosilicate minerals (stable kyanite with enclosed relict staurolite). Psammitic lithologies are associated with the semipelitic schists. These contain less than 5 percent micas, and in some cases no mica. They probably represent metamorphosed impure quartzitic or arkosic layers. Quartzites were also noted by Macdonald and Smith (1980) on the Cape North Peninsula, where they occur as thin graded beds, some with cyclic repetitions. Metaconglomerates were also recorded by Macdonald and Smith (1980), but were not noted in the areas to the south, possibly because the metamorphism has destroyed the primary texture.

Calc-silicate rocks are especially abundant near the Carboniferous unconformity in the North, Middle, and South Aspy rivers, but are distributed throughout the Money Point Group. Their compositions are variable, ranging from marble to calcareous semipelitic and pelitic lithologies. They occur as layers ranging in thickness from 10 cm to 5 m, interbedded with the pelitic, semipelitic, and hornblende-mica schists. Macdonald and Smith (1980) reported low metamorphic grade varieties from the Cape North Peninsula which range from quartz-biotite-calcite schists through amphibole-clinozoisite-epidote-calcite schists to almost pure calcite marble. In the remaining outcrop areas of the Money Point Group they range from mica schists with abundant clinozoisite and calcite through a more common quartz-biotite-scapolite-clinozoisite-calcite rock to phlogopite-tremolite marble. Other minerals noted in various calc-silicate rocks include actinolite, idocrase, grossular, diopside, dolomite, and microcline. Apatite, titanite, and opaque phases are almost ubiquitous accessory minerals in all calcareous rocks.

Marble has been recorded from three areas in the Money Point Group, in the beds of Glasgow Brook and South Aspy River, and from an unspecified location in the Money Point area (Macdonald and Smith, 1980). The samples from Glasgow Brook and South Aspy River are relatively pure marbles, 1 to 1.5 m wide and sandwiched between impure marble and hornblende-mica schist layers.

As for the Cape North Group, the oldest dated intrusion into the Money Point Group is the Gulch Brook Granite (Rb-Sr whole-rock isochron age of 413 $\pm$ 10 Ma — Keppie and Halliday, 1986). Reynolds *et al.* (in press) have reported an $^{40}Ar/^{39}Ar$ age of 380 $\pm$ 5 Ma from biotite and less reliable age of 413 $\pm$ 5 Ma from hornblende from metabasite in the Money Point Group.

Cheticamp Lake Gneiss

The Cheticamp Lake Gneiss occurs in the central part of the Cape Breton Highlands plateau. It was first recognized by Raeside *et al.* (1984), where it was informally referred to as the central Cape Breton Highlands gneiss. It has also been described by Raeside and Barr (1986) and Barr *et al.* (1987c). Typical outcrops include the quarries at Cheticamp Dam and south of Cheticamp Lake. The most common lithologies in the unit are semipelitic gneiss, biotite schist, and massive quartzofeldspathic gneiss. Dykes and other small bodies of weakly foliated to unfoliated biotite granite, muscovite-biotite granite, and pegmatite-aplite related to the Black Brook Granitic Suite are also abundant. Compositionally banded semipelitic gneisses are the most abundant gneissic lithology, although they are generally poorly exposed, their main outcrop extent being limited to the headwaters of a number of streams on the plateau in the Cheticamp Lake area. Typically these rocks are medium grained, poorly foliated, granoblastic biotite gneisses; some also contain significant quantities of garnet and retrograde muscovite and epidote. Throughout the gneiss are scattered occurrences of thin lenses of biotite (or biotite-muscovite) rock, up to 10 cm thick and 3 m long. These are probably the product of desilication of more pelitic layers, possibly accompanying migmatization during metamorphism. Such highly aluminous lenses attest to the sedimentary origin of the semipelitic gneiss.

Incorporated into the semipelitic gneisses are extensive belts of more pelitic material. In the Cheticamp Lake area, a single 2 km wide belt extends for at least 5 km along strike of foliation. Other pelitic gneisses were noted between the headwaters of Middle Aspy River and Black Brook. In addition, a narrow zone of mica schist between the Glasgow Brook Orthogneiss and the Black Brook Granitic Suite is inferred to be a northeasterly continuation of pelitic rocks of the Cheticamp Lake Gneiss. With the exception of this northeasterly belt in which muscovite + quartz is a stable assemblage, the pelitic gneisses commonly contain biotite, garnet, and large poikiloblasts of retrograde muscovite. In some cases retrograde muscovite composes up to 30 percent of the rock. Sillimanite and potassium feldspar are less common. No examples of sillimanite and muscovite in textural equilibrium were noted, indicating the main body of the Cheticamp Lake Gneiss has been entirely metamorphosed to grades higher than the sillimanite-potassium feldspar isograd. Two samples were noted with relict kyanite — one enclosed in garnet, the other in plagioclase — implying an earlier higher pressure or lower temperature history, in common with other units of the Aspy Terrane in the western Cape Breton Highlands (Plint and Jamieson, 1989). The subsequent sillimanite-potassium feldspar grade metamorphism appears to have obliterated earlier textural features, except for these kyanite relicts.

The third prominent lithology in the Cheticamp Lake Gneiss is a massive quartzofeldspathic orthogneiss. Approximately 20 percent of the outcrops of the Cheticamp Lake Gneiss include this lithology, with the freshest and most extensive outcrops located in the quarries near Cheticamp Dam. Typically it lacks compositional layering, but displays a moderate foliation based on the parallel alignment of biotite grains. The orthogneiss is monzogranitic to granodioritic in composition, and occurs as sheets parallel to the layering in the enclosing metasedimentary rocks. Xenoliths of biotite-rich gneiss in the orthogneiss are stretched in the direction of the biotite foliation. In thin section, the orthogneiss is very similar to the semipelitic paragneisses described above, and they can only readily be distinguished in outcrop.

In addition to the three main lithologies described above, the Cheticamp Lake Gneiss also includes a variety of less abundant rock types. Amphibolites and hornblende leucogneisses occur in small quantities throughout the gneiss — these typically occur as thin sheets, and probably represent original mafic layers in the sedimentary pile. They appear to be particularly abundant in the poorly exposed areas of the central Cape Breton Highlands. They display a wide range in mineral abundances, some having approximately equal concentrations of hornblende and plagioclase, others with scattered hornblende poikiloblasts in a biotite gneiss matrix, and yet others occurring as epidote amphibolites in rocks with a calc-silicate affinity. Calcareous rocks are rare in the Cheticamp Lake Gneiss, being restricted to epidote- and diopside-bearing hornblende leucogneisses. One sample of a diopside-microcline gneiss with calcite and only epitaxial hornblende was noted in the Cheticamp Lake area.

Rock types similar to those described also occur in numerous xenoliths and screens in the Black Brook Granitic Suite (Yaowanoiyothin, 1988). These range up to a few kilometres in length and provide outcrops of presumed Cheticamp Lake Gneiss lithologies over a large part of the pluton. No significant variation in the relative abundance of the various lithologies is evident in the xenolith and screen assemblages.

The margins of the Cheticamp Lake Gneiss with other metamorphosed stratified units appear to be faulted in all cases. The southeastern margin, against the Bras d'Or Terrane, is the Eastern Highlands shear zone, which has undergone recrystallization to chlorite schists and blastomylonites. The northwestern margin is less well displayed; along much of the margin the gneiss has been intruded by various granitoid plutons, some of which themselves have been deformed to orthogneisses. A faulted contact was observed in a tributary to Middle Aspy River between the Cheticamp Lake Gneiss and Money Point Group rocks, but it is not known if this fault is of only local importance or of regional extent. In the central highlands, south of Artemise Brook, the Cheticamp Lake Gneiss is inferred to be in contact with the Money Point Group, but the nature of the boundary is unknown because of the extensive blanket bog and overburden. Other margins have been intruded by the Devonian Black Brook Granitic Suite, which therefore sets a minimum age for the metamorphism of the gneiss. The ages of deposition and metamorphism are not known. The gneiss bears many similarities to the Belle Côte Road Orthogneiss described by Jamieson *et al.* (1987) which has been interpreted to have a Late Ordovician to Silurian emplacement age (433 +20/-10 Ma, U/Pb (zircon), Jamieson *et al.*, 1986) and a Late Silurian to Devonian metamorphic age (423 to 385 Ma, U/Pb (zircon) and

Rb/Sr (muscovite)). U-Pb dating of a zircon fraction from the Cheticamp Lake Gneiss has yielded an age of 396 ± 2 Ma (Dunning, in press), which is interpreted to be the age of the high grade metamorphism and migmatization.

Ordovician to Siluro-Devonian plutons

Glasgow Brook Orthogneiss

The Glasgow Brook Orthogneiss is an elongate intrusion, well exposed in Glasgow Brook, which was mapped and named by Wiebe (1972). The extent of the pluton as defined by Wiebe was essentially confirmed by our mapping. On its northern margin the pluton intruded schists of the Money Point Group, in which it occurs as sheets adjacent to contacts. A narrow band of mica schist, interpreted to be part of the Cheticamp Lake Gneiss, separates the orthogneiss from the Black Brook Granitic Suite. Dioritic and semipelitic xenoliths are locally abundant within the orthogneiss, and together with its relative homogeneity, are further evidence for its igneous origin.

The pluton consists of strongly foliated medium to coarse grained hornblende-biotite tonalite to granodiorite. The rock is gneissic in appearance, with mafic minerals concentrated on foliation planes, separated by quartzofeldspathic layers with augen of feldspar and quartz. The relative proportions of hornblende and biotite vary from dominantly hornblende to exclusively biotite. More biotite-rich rocks contain abundant myrmekite. Feldspars are oligoclase-andesine and microcline. Apatite, titanite, and zircon are variably abundant accessory minerals, together with minor opaque minerals. Garnet is present rarely. Epidote is an abundant secondary mineral.

Middle Aspy River Orthogneiss

The Middle Aspy River Orthogneiss is an elongate body which separates the Money Point Group and the Cheticamp Lake Gneiss and is well exposed in the valley of the Middle Aspy River. Contact relations and extent of the body, however, are poorly defined due to limited exposure away from the valley. The Middle Aspy River Orthogneiss contrasts in appearance with the Glasgow Brook Orthogneiss, as it is much finer grained and lacks hornblende. It is a strongly foliated, fine to medium grained biotite granodiorite, and is similar in appearance to the Belle Côte Road Orthogneiss (R.A. Jamieson, pers. comm., 1986) which occurs in the Aspy Terrane to the southwest of the map area and which has yielded a U-Pb (zircon) age of 433 ± 20 Ma (Jamieson *et al.*, 1986). It is also similar to the orthogneissic component of the Cheticamp Lake Gneiss, which has yielded a U-Pb (zircon) age of 396 ± 2 Ma (Dunning *et al.*, in press).

Taylors Barren Pluton

The Taylors Barren Pluton, as described by Jamieson *et al.* (1987) is a belt of variably foliated pink granitoid rocks extending through the central highlands, along the western margin of the map area. Rb-Sr dating has suggested an age of 419 ± 17 Ma (Gaudette *et al.*, 1985). It consists typically of well foliated augen granite, and is locally strongly cataclased. These rocks were not included in the present study.

Gulch Brook Granite

The Gulch Brook Granite (Macdonald and Smith, 1980) has intruded the Money Point Group and Cape North Group north of Aspy Bay. It consists of fine to medium grained foliated muscovite-biotite granite. A smaller unnamed pluton of similar composition was also mapped in the same area by Macdonald and Smith (1980), and compositionally similar sheets and dykes were reported in the Money Point and Cape North groups. Rare examples were observed to the southwest in these same units during the present study.

Macdonald and Smith (1980) interpreted these distinctive foliated granites to be possibly late Precambrian to Cambrian in age; mica ages of 347 to 361 Ma were interpreted to represent thermal updating by the Acadian Orogeny, and a Rb-Sr two-point isochron age of about 458 Ma was not considered reliable. Keppie and Halliday (1986) obtained a Rb-Sr isochron age of 413 ± 10 Ma, which was also considered to represent thermal updating rather than the age of emplacement. However, geographical proximity and petrological similarity to the Black Brook Granitic Suite suggests that a Devonian age may be correct.

Devonian to Carboniferous plutons

Black Brook Granitic Suite

The northeastern part of the map area is dominated by a large granodioritic to granitic intrusion, lobes of which Wiebe (1972, 1975) named (from north to south) the White Point, Black Brook, and Warren Brook plutons. Our mapping has indicated that the Clyburn Brook Pluton of Wiebe (1972, 1975) is also contiguous with this large intrusion, which we refer to as the Black Brook Granitic Suite. Dykes, sheets, and small plutons of similar granitic and granodioritic composition are common in other map units in the Aspy Terrane; the absence of these distinctive intrusions in the Bras d'Or Terrane is one of the main differences between the two terranes. Because of the abundance of granite and granodiorite in the adjacent gneissic and schistose units, as well as abundant schist and gneiss xenoliths in the pluton, the locations of the margins of the pluton are rather arbitrary. The Park Spur Granite (see below) as well as smaller unnamed granites (included in map unit DgrU of Barr *et al.*, 1987a) are also correlated with this plutonic suite.

The White Point, Black Brook, and Warren Brook plutons, as well as associated pegmatite dykes, were originally dated by Cormier (1972 — cited by Barr *et al.*, 1982; pers. comm., 1981) who obtained Devonian ages. These were confirmed subsequently by a U-Pb (monazite) age of 373 ± 2 Ma (Dunning *et al.*, in press). An age of 364 ± 35 Ma was also reported (Cormier, 1972; recalculated by Keppie and Smith, 1978) for a similar granite south of Pleasant Bay and west of the present map area, providing evidence for the wide distribution of Devonian granitic plutonism in the Aspy Terrane.

The Black Brook Granitic Suite and related intrusions consist of pale pink to grey biotite granite gradational to granodiorite. Locally the rocks contain muscovite and rarely garnet. Associated dykes of pegmatite and aplite are abundant, both within the plutons and in the adjacent metamorphic units. Foliation varies from moderate to absent, and locally, especially in the Warren Brook lobe, the granites are strongly sheared. A detailed study of the petrography, geochemistry, and petrogenesis of the Black Brook Granitic Suite and its host rocks was done by Yaowanoiyothin (1988).

Park Spur Granite

The Park Spur Granite (Jamieson *et al.*, 1987) lies in the western part of the present map area, and is generally poorly exposed, although a small lobe appears to extend to the Cheticamp River (Fig. 4). Typical outcrops occur along the Park Spur road, where the granite consists of medium to fine grained, foliated muscovite-biotite granite, similar in appearance to the Black Brook Granitic Suite with which it is here correlated. Muscovite from the pluton has yielded a cooling age of 370 Ma, consistent with this correlation.

West Branch North River Granite

The West Branch North River Granite is located in the south-central highlands, mainly outside the map area covered in this report. It has intruded the Bateman Brook Metamorphic Suite and the Eastern Highlands shear zone, although it is cut by major faults probably related to the Aspy Fault system. Rb-Sr dating indicated an age of 400 $\pm$ 5 Ma (O'Beirne-Ryan and Jamieson, 1986).

The pluton consists of distinctive medium grained red granite of syenogranitic composition. The petrology was described in detail by O'Beirne-Ryan *et al.* (1986).

Grande Anse Granite

The Grande Anse Granite (Grande Anse "granitoid" of Plint *et al.*, 1986) is exposed in the Grande Anse River north of the Margaree Pluton, which appears to have intruded it. According to Plint *et al.* (1986), the pluton consists of fine to medium grained, foliated pink biotite granite. It was not mapped as part of the present study.

Wilkie Sugarloaf Granite and related intrusions

The Wilkie Sugarloaf Granite (termed the Sugarloaf pluton by Macdonald and Smith, 1980) forms the bulk of Wilkie Sugarloaf and is the largest of several distinctive granite plutons that occur north of, but adjacent to, the Aspy Fault. All are composed mainly of distinctive coarse grained pink to red monzogranite consisting of oligoclase, microcline, quartz, and variably chloritized biotite in an allotriomorphic granular texture. Euhedral to subhedral sphene is a characteristic accessory phase. Most samples are strongly sheared and cataclased, probably as a result of movement along the Aspy Fault. Also present in this area are abundant fine grained to aplitic granite dykes which appear to be spatially associated with the Wilkie Sugarloaf and associated coarse grained granites.

The exact ages of these granites are not known; however, their lack of foliation and their crosscutting relation with the Gulch Brook-type foliated granite (Macdonald and Smith, 1980) suggest that they are relatively young. This is supported by radiometric age data. Macdonald and Smith (1980) reported a poorly constrained Early Carboniferous Rb-Sr isochron age for the Relay Station pluton northeast of Wilkie Sugarloaf, and Keppie and Halliday (1986) reported a better isochron for the Wilkie Sugarloaf Granite which gave an age of 330 $\pm$ 23 Ma. We interpret these plutons to be similar in age to the Margaree Pluton (described below), to which they have petrological similarity, and hence they are probably Late Devonian. Radiometric ages may be somewhat too young as a result of shear deformation associated with movement on the Aspy Fault.

Andrews Mountain Granite

The Andrews Mountain Granite is located east of the village of Pleasant Bay and is well exposed on the eastern side of Andrews Mountain. At its northern margin it is sheared by the Red River mylonite zone; however, a lobe of granite extending north of Red River adjacent to Fisset Brook Formation rocks appears also to be part of the Andrews Mountain Granite, indicating that movement on the mylonite zone has been minor since the granite was emplaced. The age of the granite is not known because shearing and deformation within the pluton appear to have disturbed the Rb-Sr system so that no isochron was obtained (R.F. Cormier, pers. comm., 1986). However, petrographical similarity to the Margaree Pluton (described below) suggests a Late Devonian age. The Andrews Mountain Granite is overlain unconformably on the west and south by arkosic sandstones and conglomerates of the Horton Group (Neale, 1963a) and Fisset Brook Formation (Raeside *et al.*, 1986).

The Andrews Mountain Granite is a homogeneous coarse grained red syenogranite, consisting of perthite and quartz with only rare crystals of sodic plagioclase. Essentially no mafic minerals are present except for minor chlorite and more abundant hematite, the latter occurring as interstitial masses, fracture fillings, and coatings on perthite grains.

The granite has been intruded by red granite porphyry dykes consisting of a fine grained groundmass of quartz and alkali feldspar with phenocrysts of quartz, plagioclase, and alkali feldspar. These dykes are up to several metres in width, and may be related to rhyolites within the Fisset Brook Formation exposed to the north and west of the granite. Locally, the granite contains schistose xenoliths, consisting mainly of quartz and biotite.

Margaree Pluton

The Margaree Pluton forms the western margin of the central part of the present map area, extending from the Red River fault zone in the north across the Cheticamp River in the south. It continues farther to the south (Barr *et al.*,

1987a) as a major map unit in the western highlands. The southern and western parts of the pluton were described by O'Beirne-Ryan *et al.* (1986) and Currie (1987). In the present map area it is generally strongly sheared along its northeastern margin, probably by late movement along the Red River fault zone, and along its eastern margin by the Aspy Fault. However, an intrusive contact with the metasedimentary rocks of the Aspy Terrane is exposed in the Cheticamp River where the Aspy Fault apparently lies farther east within the Money Point Group. To the south of the map area the Aspy Fault crosses and displaces the pluton by about 5 km (Barr *et al.*, 1987a). On its western margin, the Margaree Pluton has an intrusive relationship with the Belle Côte Road Orthogneiss (Plint *et al.*, 1986, Barr *et al.*, 1987a).

The Margaree Pluton consists mainly of coarse grained megacrystic biotite-hornblende monzogranite. In places, the texture grades to coarse grained and equigranular, and megacrysts are absent. The pluton is cut by fine grained syenogranite dykes, similar in composition to the Salmon Pool syenogranite to the west (Barr *et al.*, 1987a). However, none of the Black Brook Granitic Suite dykes were observed in the Margaree Pluton, consistent with the younger age suggested for the latter unit by radiometric dating.

O'Beirne-Ryan *et al.* (1986) investigated the petrology of the pluton in the west-central highlands, south of the present study area. Samples from that area gave a whole-rock Rb-Sr age of 343 ± 17 Ma, but this may be somewhat too young, the actual age being similar to the age of the Salmon Pool Granite (about 365 Ma) as discussed by O'Beirne-Ryan *et al.* (1986).

Leonard MacLeod Brook Complex

The Leonard MacLeod Brook Complex (Jamieson *et al.*, 1987) occurs in the south-central highlands southwest of the North Branch Baddeck River Leucotonalite, with which it is in faulted contact. The complex was not mapped as part of the present study, but has been described by Jamieson *et al.* (1987). It consists of metamorphic rocks (probably of the Sarach Brook Metamorphic Suite) intruded by abundant fine grained syenogranite, probably of Devono-Carboniferous age (R.A. Jamieson, pers. comm., 1988).

Other granitoid rocks

In addition to the named granitoid units described above, smaller granitoid bodies occur throughout the Aspy Terrane. The majority are medium grained equigranular biotite (or more rarely muscovite-biotite) granodiorite or granite which are considered to be related to the Black Brook Granitic Suite. As noted previously, one of these intrusions (Pleasant Bay Granite) in the Pleasant Bay gneiss west of the present map area, was dated by Cormier (1972), giving a Rb-Sr isochron age of 364 ± 35 Ma (as recalculated by Keppie and Smith, 1978). This age is consistent with the inferred comagmatic relationship to the Black Brook Granitic Suite.

Pegmatite and aplite bodies are also abundant in the Aspy Terrane and are inferred to be mainly Devonian in age and related to the Black Brook Granitic Suite.

BRAS D'OR TERRANE

Introduction

The Bras d'Or Terrane underlies the southeastern part of the study area (Fig. 3), and extends beyond the southern margin of the Cape Breton Highlands to central and southwestern Cape Breton Island (Barr and Raeside, 1986, 1989). The major lithologies of the Bras d'Or Terrane are low pressure gneisses, low grade metasedimentary rocks, and plutonic rocks that cluster around 560 Ma in age, although the first two lithologies are more typical of the part of the Bras d'Or Terrane south of the Cape Breton Highlands.

In the Bras d'Or Terrane in the Cape Breton Highlands, one major stratified unit, the McMillan Flowage Formation, has been defined, and a number of less extensive units are also present. Some of these units may be correlative, but are separated by extensive intervening plutons. Intrusive rocks compose about 80 percent of the Bras d'Or Terrane in the Cape Breton Highlands, and range from tonalitic to granitic in composition, and from more than 600 Ma to 400 Ma in age, although most are latest Hadrynian to earliest Cambrian (about 560 Ma).

The boundary between the Aspy and Bras d'Or terranes is the Eastern Highlands shear zone, which attains its greatest width in the central highlands. In the northeast, the shear zone splays into a series of east-trending faults and shear zones which have been intruded by the Black Brook Granitic Suite and the Cameron Brook Granodiorite. Toward the southern highlands, the shear zone has been intruded by the West Branch North River Granite. South of this granite, the shear zone appears to splay into a series of faults which form the western boundaries of the Kathy Road Dioritic Suite and the North Branch Baddeck River Leucotonalite, and extend into units of the Aspy Terrane to the west.

Precambrian stratified units

McMillan Flowage Formation

The McMillan Flowage Formation is the largest, most continuous, and most compositionally variable stratified unit in the Bras d'Or Terrane of the Cape Breton Highlands. It terminates in the north against the Eastern Highlands shear zone and the Black Brook Granitic Suite, and extends south to the Baddeck River area where it is overlain by Carboniferous sedimentary rocks. It is cut off on the east and west by plutonic units. Throughout most of this area it has been metamorphosed to middle amphibolite facies conditions, but south of the North River area, and to the north of the Clyburn Brook fault (Fig. 4), metamorphic grade decreases to chlorite.

The oldest dated units that are known to cut the McMillan Flowage Formation are the Gisborne Flowage Quartz Diorite, which has yielded a U-Pb (zircon) age of 564 ± 2 Ma, and the Ingonish River Tonalite, which has yielded

a U-Pb (zircon) age of 555 ± 2 Ma (Dunning *et al.*, in press). In both cases the plutons are tectonically foliated, with foliation parallel to that in the McMillan Flowage Formation, indicating they have undergone a fabric-forming event together. However, structural analysis of the McMillan Flowage Formation indicates that it underwent regional folding before the intrusion of the Gisborne Flowage Quartz Diorite.

The McMillan Flowage Formation was defined by Raeside and Barr (1986) who recognized five divisions in the area south of the Clyburn Brook fault, only one of which is recognized in the area north of the fault. The rock types are predominantly clastic, but include substantial amounts of mafic rocks, and smaller quantities of calcareous lithologies. The main characteristics of the five divisions south of the Clyburn Brook fault were described by Raeside and Barr (1986), and are summarized below. The rocks in the area north of the fault have not been described previously.

The lower clastic division is composed of a series of quartzites, semipelitic phyllites, and black slates at the bottom and garnet phyllites interbedded with psammites at the top. The stratigraphic base of the McMillan Flowage Formation is not known. Mafic layers are discontinuous laterally, and calc-silicate lithologies are thin (less than 2 m wide) and rare.

The quartzite division conformably overlies the lower clastic division, and forms the bedrock to a prominent northerly-trending ridge, from the Christopher MacLeod Brook area in the south to McMillan Flowage in the central highlands. It is up to 1500 m wide, and is composed predominantly of a relatively pure quartzite, although some arkosic and psammitic varieties are present. Mafic lithologies are rare.

The middle clastic division was described as the thickest division by Raeside and Barr (1986), ranging up to 2000 m in the McMillan Flowage area. It is composed of three sections, a lower pelitic and semipelitic part with thin amphibolites and calc-silicate lithologies, a middle section containing abundant interstratified quartzites and amphibolites with fewer pelitic units, and an upper section of semipelitic schists and less abundant quartzite and amphibolite layers. In the upper part of the middle clastic division is the Roper Brook amphibolite, a thick mafic unit, which can be traced along strike for 28 km, from a fold closure at East Branch Indian Brook to a screen extending into the southern margin of the Black Brook Granitic Suite north of the Clyburn Brook fault.

The marble division is a thin, but persistent, horizon that outcrops only in the area between the Clyburn Brook fault and McMillan Flowage. It consists of a 25 to 35 m thick marble and calc-silicate horizon with 1 to 2 m thick amphibolite layers, overlain by a 25 to 75 m thick quartzite or feldspathic quartzite. The distinctive lithology of the marble division is useful in outlining the core of a synclinorium that extends throughout much of the outcrop area of the McMillan Flowage Formation. The metamorphism of the largest outcrop of the marble division has been investigated by Davis (1983).

The upper clastic division is preserved only in the core of the major synclinorium south of the Clyburn Brook fault. The division is at least 500 m thick, and consists of quartzites, feldspathic quartzites, and semipelites at its base, and predominantly semipelites with thin lensoid amphibolites in its upper part.

Of these five divisions, only the middle clastic division is inferred to extend north of the Clyburn Brook fault, beyond the area described by Raeside and Barr (1986). The lower part resembles that south of the fault, but the uppermost part of the division appears to be thicker in this northern area, and is composed of a thick sequence of volcaniclastic, clastic, and volcanic lithologies. Metamorphic grade generally decreases up the section, to the northeast, but near the Cameron Brook Granodiorite, contact metamorphism has locally increased the metamorphic grade.

The lowermost part of the middle clastic division exposed north of the Clyburn Brook fault consists of a 500 m thick section of semipelitic schists and thin amphibolite horizons. The semipelitic schists occur as thick layers, interbedded with minor more quartzofeldspathic lithologies. They are typically medium grained biotite-muscovite schists with abundant quartz and plagioclase, and commonly display cataclastic effects associated with the adjacent Eastern Highlands shear zone. Amphibolitic layers range from less than 2 m to over 15 m thick, and in at least two cases were noted as crosscutting. The amphibolites typically are mesocratic rocks, with pargasitic hornblende and plagioclase of andesine to labradorite composition. Some varieties contain significant amounts of epidote.

Overlying the lowermost clastic portion of the middle clastic division is the 500 m thick Roper Brook amphibolite. In detail, the amphibolite is compound, with a massive central portion of coarse grained mildly foliated amphibolite (± epidote), and with upper and lower portions which include significant quantities of epidote-hornblende (± biotite) schists. Much of the amphibolite in the map area lies against the Eastern Highlands shear zone, or has been incorporated into the shear zone, and sheared textures are prevalent in most samples.

The remainder of the middle clastic division includes a 2 to 3 km thick series of volcaniclastic rocks, volcanic layers, green and black slates and phyllites, and coarser grained clastic rocks. A kilometre-scale syncline has been recognized in the Clyburn Brook area (Raeside *et al.*, 1984) and extensive structural repetition is probable. These lithologies are interlayered, with individual beds ranging from a few centimetres to five metres in thickness. Volcaniclastic rocks are most abundant, especially in the western part of the area, where they compose over 75 percent of the unit. To the east, mafic volcanic layers and green and black slates predominate. Coarser grained clastic rocks and rhyolite sheets are restricted to the eastern part of the unit.

The volcaniclastic rocks include a wide range of rock types, variably metamorphosed to the prehnite-pumpellyite, greenschist, and amphibolite facies. Most common is a medium to coarse grained volcaniclastic breccia with clasts

ranging from 1 to 10 mm across, in a recrystallized matrix of chlorite, muscovite, quartz, plagioclase, and calcite. The clasts display relict volcanic textures typical of both basaltic (diabasic texture) and more felsic (corroded quartz and feldspar phenocrysts) types. Other volcaniclastic textures include lithic lapilli-tuffs, and possibly also crystal tuffs, although many of the finer grained rock types have developed a slaty or phyllitic cleavage which has obliterated primary depositional features.

Other volcanic rocks in the upper part of the middle clastic division include massive basaltic layers, associated with the volcaniclastic layers, and thinner rhyolite layers. Basaltic layers range up to 6 m thick, and preserve relict diabasic texture, although considerably modified by subsequent metamorphism and deformation. Some samples preserve igneous textures with replacement of pyroxenes by actinolite, chlorite, and pumpellyite; others also display a shear fabric, and are preserved as greenschists. Rhyolitic layers are up to 1.5 m thick, and tend to have preserved their original porphyritic texture, with corroded phenocrysts of quartz and feldspar in a pervasively altered but unfoliated to mildly foliated matrix of quartz, feldspar, muscovite, and chlorite. Such rhyolitic layers may be intrusive into the sequence and may be part of a younger Late Silurian or Devonian igneous phase, represented by the Ingonish Island rhyolite as suggested by radiometric dating by Keppie and Halliday (1986). The margins of rhyolitic layers are too severely altered to determine the presence or absence of contact metamorphic effects.

Sedimentary units include interbedded green and black slates which are composed of muscovite, chlorite, and quartz. The colour changes are sharp, but apparently due only to varying concentrations of graphite. Individual colour bands range from less than 1 cm to 25 m in thickness, although many are from 50 to 100 cm thick. Minor components of the unit are coarser grained clastic rocks, including siltstones and fine grained sandstones. These tend to be arkosic, and their matrices have been replaced by muscovite, chlorite, and quartz $\pm$ biotite.

Barachois River Metamorphic Suite

Two isolated blocks of gneissic rocks occur in the southeastern highlands, enclosed as screens by the Indian Brook Granodiorite, Ingonish River Tonalite, and Timber Lake Diorite, and unconformably overlain by Horton Group conglomerates and sandstones. Representative sections are well exposed at the confluence of East and West branches of Indian Brook, and in Barachois River. Both blocks are composed mainly of potassium feldspar augen gneiss interlayered with flaggy semipelitic gneiss and rare mafic gneisses. The relationship between these gneisses and the other stratified units of the Cape Breton Highlands is unknown because of their isolated location in the plutonic rocks of the southeastern highlands.

Rocks of similar composition to the gneiss are also found south of Goose Cove Brook, and have been intruded by the Goose Cove Brook Granodiorite and St. Anns Leucogranite. In this area the metamorphic grade decreases to the south through zones of sillimanite schist, garnet phyllites, and biotite siltstones to weakly metamorphosed greywackes which are exposed in the Big Hill inlier near Baddeck. These metawackes are likely correlative with the greywackes exposed in the southern end of Kellys Mountain (Barr *et al.*, 1982). The parallel decrease in metamorphic grade in the Barachois River Metamorphic Suite and in the McMillan Flowage Formation indicates that both units have undergone the same tectonothermal events.

Bateman Brook Metamorphic Suite

The Bateman Brook Metamorphic Suite occurs along the western margin of the Bras d'Or Terrane. Along much of its exposed length it is cut off by the Eastern Highlands shear zone and the Devonian West Branch North River Granite to the west, and by the Kathy Road Dioritic Suite to the east. In the northern part of its outcrop area it is juxtaposed against the McMillan Flowage Formation, but its relationship to this unit is unknown. Based on a pronounced aeromagnetic anomaly, and on the exposure of severely sheared rocks, a fault contact has been inferred between these two units.

The Bateman Brook Metamorphic Suite is predominantly a mixed quartzofeldspathic and amphibolitic gneiss. Semipelites are more abundant to the south and metabasites to the north, but throughout the unit, interlayered sequences of quartzofeldspathic and mafic lithologies have been observed. The quartzofeldspathic lithologies include a variety of siliciclastic rock types, predominantly semipelitic gneiss and pelitic migmatite. Schistose psammite and augen gneiss are less common, and a rare, but distinctive, quartz-muscovite schist outcrops on roads north of the northern margin of the Kathy Road Dioritic Suite and in the West Branch North River. This schist contains relict euhedral to subhedral phenocrysts of oligoclase, and appears to be volcanic in origin. The metabasic lithologies are amphibolites, ranging from fine to medium grained, and including variably migmatized and banded varieties. In many places, the distinction between the Bateman Brook Metamorphic Suite and the adjacent Kathy Road Dioritic Suite is difficult, as coarse grained diorite appears to grade into finer grained varieties which are indistinguishable from amphibolite. Coarse grained hornblendite occurs in the West Branch North River in association with the quartz-muscovite schist described above.

Metamorphic grade appears to be uniform in the amphibolite facies. Garnet is common in the quartzofeldspathic rocks, and sillimanite was noted in one specimen. The metabasic rocks display hornblende + plagioclase assemblages.

The age of the Bateman Brook Metamorphic Suite can be constrained only by the 560 Ma age of the Kathy Road Dioritic Suite which has intruded it. The depositional age is unknown.

Neils Harbour Gneiss

Heterogeneous gneissic rocks (the Coastal Gneisses of Wiebe, 1972) occur in three areas in the eastern part of the map area. The best exposed gneisses outcrop along the coast

north of Neils Harbour, but other significant sections of gneiss are also found northwest of Neils Harbour and along the coast north of Ingonish. In each case the gneiss is engulfed by the granites of the Black Brook Granitic Suite, and has been intruded by abundant sheets and pegmatites derived from these granites. Rarely do the gneisses form more than 75 percent of the outcrop. Areas that exceed 50 percent gneiss are shown as gneiss on the map. Screens, schlieren, and xenoliths of gneiss are abundant in the granite.

The Neils Harbour Gneiss is distinguished from the gneisses of units in the central part of the map area by being predominantly orthogneissic in appearance, although locally screens of biotite schist are preserved. Typically the gneisses are granodioritic, and locally they are porphyroblastic with megacrysts of microcline (Yaowanoiyothin, 1988). A Rb-Sr whole-rock isochron reported by Cormier (1972), recalculated by Keppie and Smith (1978), indicated a late Precambrian to Cambrian age (550 $\pm$ 80 Ma) for these gneisses, but more recent U-Pb dating of zircon from a megacrystic sample from the southern outcrop area has yielded an age of 403 $\pm$ 3 Ma (Dunning *et al.*, in press), identical to that of the Cameron Brook Granodiorite.

Undifferentiated gneissic rocks

Two small blocks of gneissic rocks are exposed north of Clyburn Brook and between the valleys of Clyburn Brook and Power Brook, near Ingonish Beach. They are primarily tonalitic in composition with granitic bands, but have been separated from the Ingonish River Tonalite because of their more varied lithology (including semipelitic layers locally) and an abrupt (although not observed) contact with the tonalite. The northern block has been severely cataclased by the Clyburn Brook fault, and has been intruded by the Cameron Brook Granodiorite. These rocks could be correlative with either the Barachois River Metamorphic Suite or with the Neils Harbour Gneiss.

Price Point Formation

The volcanic rocks of the Price Point Formation (described informally as the Price Point unit by Macdonald and Barr, 1985) flank and transect (in a graben-like structure) the granitoid rocks of Murray Mountain north of St. Anns Harbour. Although most contacts are faulted, intrusive contacts are exposed locally with the Indian Brook Granodiorite and the St. Anns Leucogranite, and a variety of granitoid dykes occur within the volcanic sequence. Hence the Price Point Formation is assigned a late Precambrian age, in contrast with the Devono-Carboniferous age inferred for these rocks by previous workers (Kelley, 1960; Kelley and Mackasey, 1965).

The volcanic rocks of the Price Point Formation are dominantly of intermediate composition, and consist of crystal and lithic-crystal tuffs and less abundant andesitic-dacitic flows. All mafic rocks in the sequence appear to be dykes, of unknown age but possibly related to the volcanic rocks. No sedimentary rocks are present. Mineralogy in the volcanic rocks is dominantly of low grade metamorphic origin (saussuritized feldspars, quartz, chlorite, epidote, actinolite, calcite, sericite, and opaque minerals), but no systematic foliation is present.

Silurian stratified unit

Ingonish Island rhyolite

A series of banded rhyolites unconformably overlain by limestone of the Windsor Group is exposed on Ingonish Island. Based on the orientation of banding in the rhyolites, they appear to have been deformed into a series of open to tight upright folds. Many outcrops display a crosscutting foliation, although this does not appear to be related to the folds. In outcrop most of the rhyolites are dark brown to black massive splintery rocks, with sparse phenocrysts of alkali feldspar and quartz. Some are aphanitic, and some contain strongly flattened fragments. Cutting across the rhyolites are four red, abundantly porphyritic, mildly cleaved rhyolitic to dacitic dykes, 2 to 5 m wide. These have variable orientation — two are approximately northerly trending, one trends to the east, and one trends to the northeast.

The dark colour of these felsic volcanic rocks is due to finely disseminated magnetite. Flows consist of cryptocrystalline to microcrystalline quartz and potassium feldspar, with sparse phenocrysts of euhedral to subhedral anorthoclase. The microcrystalline groundmass displays trachytic texture. Interbedded with these flows are pyroclastic flows, consisting of sparse crystal and lithic fragments in a recrystallized tuffaceous flow-banded matrix of quartz, alkali feldspar, and magnetite. Small randomly oriented muscovite plates are probably of metamorphic origin.

A Rb-Sr age of 412 $\pm$ 15 Ma was reported for the Ingonish Island rhyolites by Keppie and Halliday (1986). However the position of these volcanic rocks in the regional stratigraphic sequence is not clear. They may be correlative with rhyolitic dykes that occur in the McMillan Flowage Formation, as suggested by Keppie and Halliday (1986), and with rhyolite dykes that cut the 403 Ma Cameron Brook Granodiorite.

Late Precambrian plutonic units

North Branch Baddeck River Leucotonalite

The North Branch Baddeck River Leucotonalite is a mainly fault-bounded pluton well exposed on the Bell Lakes Road South, spur #2 logging road in the south-central highlands. Its bounding faults may be part of the Eastern Highlands shear zone system. The leucotonalite was originally included by Jamieson and Craw (1983) and Jamieson and Doucet (1983) in the Baddeck Lakes complex; however, more detailed mapping in the area has shown that the leucotonalite is a separate relatively homogeneous body which is in faulted contact with the Kathy Road Dioritic Suite to the east. Its other contacts are faulted against the Sarach Brook Metamorphic Suite, the Leonard MacLeod Brook Complex, and the Bateman Brook Metamorphic Suite. It was intruded by the West Branch North River Granite. A

late Hadrynian age for the leucotonalite is suggested by a U-Pb (zircon) age of 614 +38/−4 Ma (Jamieson *et al.*, 1986).

The leucotonalite is medium to coarse grained and white to grey. It consists of plagioclase of oligoclase-andesine composition and quartz (up to 30%), with only minor amounts of chloritized biotite (and amphibole?). It is pervasively cataclased, and locally protomylonitic. In its northern part, the leucotonalite becomes more gneissic in appearance, with abundant biotite/chlorite and minor blue-green amphibole forming bands around plagioclase augen.

Kathy Road Dioritic Suite

The Kathy Road Dioritic Suite is the most extensive of the dioritic intrusions that are characteristic of the Bras d'Or Terrane. Excellent exposures of the diorite occur along Kathy Road and its branches to the north and south. The pluton is elongate north-south, broadly parallel to the inferred boundary with the Aspy Terrane to the west. It is strongly foliated (sheared) near its margins (especially the western margin), but appears to have an intrusive relationship with the Bateman Brook Metamorphic Suite. A U-Pb (zircon) age of 560 ± 2 Ma from the diorite indicates that it is a late Precambrian to Cambrian intrusion (Dunning *et al.*, in press).

The dioritic rocks are generally homogeneous on the outcrop scale, but wide variations in composition and texture (especially in degree of foliation/lineation) occur over the map area. The most abundant lithology is medium grained quartz diorite, but variations occur to more mafic diorite and more leucocratic tonalite, and grain size ranges from fine to coarse. Locally coarse hornblendite occurs as layers or possibly dyke-like bodies of limited width.

The most abundant minerals are plagioclase and strongly pleochroic blue-green-pale yellow hornblende. The texture of these rocks ranges from hypidiomorphic equigranular to strongly recrystallized and foliated, in which the hornblende forms long prisms. Quartz abundance ranges from essentially 0 percent to 20 percent or more. Biotite is commonly present but only in minor amounts. Epidote of magmatic origin indicating relatively high pressures of crystallization (Zen and Hammarstrom, 1984) is present in biotite-rich lithologies from the central parts of the pluton. Titanite and opaque phases are much less abundant than in most of the other dioritic units described below and apatite is the most abundant accessory mineral. Epidote, chlorite, actinolite, and sericite are locally abundant secondary minerals but in many areas these rocks are remarkably unaltered.

Timber Lake Dioritic Suite

Dioritic rocks of the Timber Lake Dioritic Suite are very similar to those of the Kathy Road Dioritic Suite and, although the two intrusions are separated by the McMillan Flowage Formation, they are probably related and/or correlative. The Timber Lake unit is well exposed on Mariana Road, to the south of Timber Lake. No age data are available but a late Precambrian age is inferred by comparison with the Kathy Road Dioritic Suite.

The Timber Lake intrusion is weakly foliated, medium grained, and ranges from quartz diorite to diorite in composition. The rocks contain abundant blue-green hornblende similar to that in the Kathy Road unit, plagioclase, about 10 percent interstitial quartz, and minor biotite. Texture is generally equigranular. Opaque phases and small subhedral grains of titanite are generally more abundant than in the Kathy Road Dioritic Suite.

Gisborne Flowage Quartz Diorite

The Gisborne Flowage Quartz Diorite outcrops in the area of Gisborne Flowage, and is well exposed along the roads south of the flowage. The shape of the pluton suggests an intrusive relationship with the McMillan Flowage Formation; Raeside *et al.* (1984) suggested that the pluton was emplaced penecontemporaneously with the peak of metamorphism of the McMillan Flowage Formation and during the development of S_2 schistosity, which is present in both the pluton and the host rocks. U-Pb (zircon) dating of the Gisborne Flowage Quartz Diorite has indicated an intrusion age of 564 ± 2 Ma, whereas titanite has yielded an age of 548 ± 2 Ma (Dunning *et al.*, in press).

The Gisborne Flowage Quartz Diorite is characterized by a much greater abundance of biotite than the other dioritic plutons in the area, a feature which is obvious in hand specimen. Also, unlike the other units, it contains abundant streaks, layers, and patches of amphibolitic composition, and numerous dykes and small bodies of foliated grey fine to medium grained granodiorite and of granitic pegmatite.

The diorite is medium grained, with a strong foliation, and consists of plagioclase (andesine), hornblende, and biotite, with 5 to 10 percent quartz. Biotite is typically as abundant or even more abundant than hornblende; the latter is the same pleochroic blue-green variety as in the Kathy Road and Timber Lake dioritic rocks. Apatite, titanite, zircon, epidote, and magnetite are abundant accessory minerals. Some of the epidote is secondary, but much has characteristics typical of primary (magmatic) origin (Zen and Hammarstrom, 1984).

Wreck Cove Dioritic Suite

Heterogeneous dioritic rocks assigned to this unit extend from Ingonish Harbour to the south beyond Wreck Cove Brook where they are intruded by the Indian Brook Granodiorite. Rocks of the unit are well exposed on roads north and south of Wreck Cove Brook. The Ingonish River Tonalite occurs west of the diorite, and near the contact contains dioritic xenoliths, indicating that the tonalite is the younger unit. On its eastern margin, the diorite has been intruded by granitic and granodioritic rocks of the Cape Smokey, Birch Plain, and Indian Brook units. Hornblende from a pegmatoid area within the diorite has yielded an $^{40}Ar/^{39}Ar$ age of about 560 Ma (Reynolds *et al.*, in press).

The Wreck Cove Dioritic Suite consists mainly of medium grained quartz diorite but ranges, typically within a single outcrop, from diorite to granodiorite, from fine to

coarse grained, and from equigranular to porphyritic or pegmatoid. Porphyritic areas are characterized by poikilitic phenocrysts of pleochroic green hornblende. Biotite is present locally but is always subordinate to hornblende. Apatite, titanite, and opaque phases are typical accessory minerals. Epidote is abundant but appears to be mainly of secondary origin.

Foliation is variably developed and generally trends to the northeast. Abundant amphibolitic screens are common, as are dykes which include fine grained diorite, Cape Smokey Granite, Birch Plain Granite, and diabase.

Ingonish River Tonalite

The Ingonish River Tonalite is a large intrusion which extends from the Clyburn Brook area south to Barachois River. It is well exposed in Ingonish River, and corresponds in part to the Ingonish River Pluton of Wiebe (1972). However, Wiebe also included the Wreck Cove Dioritic Suite in his Ingonish River Pluton. The tonalite appears to have an intrusive relationship with the Wreck Cove Dioritic Suite, and probably also with the Gisborne Flowage and Timber Lake diorites, and with gneissic units in the north and southeast. The age of the tonalite is well constrained by a U-Pb (zircon) age of 555 $\pm$ 2 Ma (Dunning *et al.*, in press), consistent with it being the youngest of the various dioritic units.

The tonalite is medium to coarse grained, and varies from medium to dark grey. It consists primarily of plagioclase, hornblende, and quartz, with less abundant biotite and rare potassium feldspar. Epidote of magmatic origin forms zoned twinned subhedral grains, commonly associated with biotite and hornblende. Zircon, apatite, and opaque minerals are other important accessory minerals. Foliation is variably developed, being difficult to discern in coarse grained leucocratic varieties and more prominent in medium grained hornblende-rich areas. Toward its northern end, the tonalite is strongly sheared where cut by major shallow-dipping thrust zones (e.g. in Power Brook), and near Clyburn Brook it is locally gneissic in appearance, and difficult to distinguish from adjacent gneisses.

Near its southern margin, the tonalite contains more abundant biotite and microcline, and locally grades to granodiorite.

Birch Plain Granite

The Birch Plain Granite is inferred to be the oldest of several large dominantly granodioritic to granitic intrusions which form most of the eastern highlands from St. Anns Harbour to Ingonish Harbour. The intrusive sequence is based on the presence of xenoliths apparently of the Birch Plain Granite within the Indian Brook Granodiorite. The Birch Plain Granite is well exposed on roadcuts on the north side of the access road to the Wreck Cove generating station. It extends from the Wreck Cove area where it has been intruded by the Morrison Brook Quartz Monzonite and the Cape Smokey Granite, south to the Indian Brook area, where it was apparently squeezed out by lobes of the Indian Brook Granodiorite. Isolated areas (xenoliths?) of the Birch Plain lithology continue within the Indian Brook Granodiorite farther to the south.

The granite is medium grained, pink to red, and contains less than 10 percent mafic minerals. It consists of plagioclase (oligoclase), strongly perthitic microcline, quartz, and biotite. Locally the granite is porphyritic with phenocrysts of microcline up to 3 to 4 cm in length. Allanite and zircon are very abundant accessory phases, together with titanite, apatite, and magnetite. It typically displays a weak to moderately strong foliation defined mainly by biotite alignment.

Indian Brook Granodiorite

The Indian Brook Granodiorite forms two lobes east and west of the Murray Mountain Quartz Monzodiorite and the Birch Plain Granite, and is well exposed in the valley of Indian Brook, south of the confluence of the East and West branches. Near its contact with the Barachois River Metamorphic Suite, it contains abundant gneissic xenoliths, and the relationship is clearly intrusive. Its contacts with plutonic units are less clear, but it is inferred to have intruded the Wreck Cove Dioritic Suite and the Birch Plain Granite, and to have been intruded by the Ingonish River Tonalite and the Murray Mountain Quartz Monzodiorite. This is consistent with its U-Pb (zircon) age of 575 to 572 Ma and its U-Pb (titanite) age of 564 $\pm$ 5 Ma (Dunning *et al.*, in press). Within error limits the latter age is the same as the ages of the various dated dioritic units in the Bras d'Or Terrane and significantly older than the Ingonish River Tonalite.

The Indian Brook Granodiorite resembles the Birch Plain Granite in colour and grain size but characteristically contains more mafic minerals (10-30 %); the mafic minerals include both hornblende and biotite, with the former being more abundant (in contrast to the Birch Plain Granite which contains biotite and no hornblende). The hornblende is typically subhedral and exhibits pleochroism in shades of green. The granodiorite also contains plagioclase, perthitic microcline, and quartz, and is characterized by a high abundance of large anhedral to subhedral titanite which is interstitial. Other accessory minerals include zircon, apatite, and magnetite.

Kerrs Brook Granite/Granodiorite

A small area of granodiorite (gradational to granite) in the vicinity of Kerrs Brook on the Murray Mountain Peninsula is very similar to the Indian Brook Granodiorite, and is probably related to it. It has been intruded by the St. Anns Leucogranite.

Like the Indian Brook Granodiorite, the Kerrs Brook Granodiorite contains both hornblende and biotite, and has abundant large interstitial grains of titanite.

Murray Brook Granodiorite

The small Murray Brook Granodiorite has intruded the Price Point Formation and has been intruded by the St. Anns Leucogranite. It is a hornblende-biotite granodiorite which is probably also related to the Indian Brook Granodiorite, but it has been strongly affected by alteration and veining,

and hosts the Murray Brook Cu-Mo occurrence (Kirkham and Soregaroli, 1975). This occurrence consists of pyrite, chalcopyrite, and molybdenite in a calcite-bearing quartz vein swarm (Macdonald and Barr, 1985).

St. Anns Leucogranite

The St. Anns Leucogranite occurs in the Murray Mountain area north of St. Anns Harbour and also in thin slivers in Goose Cove Brook and other brooks to the south. It appears to be identical to the Kellys Mountain Leucogranite (Barr *et al.*, 1982) to the east, and it is possible that left-lateral offset on a fault through St. Anns Harbour may have separated parts of a once-continuous pluton. A Rb-Sr isochron age of 515 ± 17 Ma (Cormier, 1980) has been obtained from the St. Anns Leucogranite, whereas the Kellys Mountain Leucogranite has yielded an older Rb-Sr age (Cormier, 1972). However, based on U-Pb ages, these leucogranites may be similar in age to the Cape Smokey Granite (Dunning *et al.*, in press).

The St. Anns Leucogranite is a distinctive medium to coarse grained pink granite consisting of plagioclase (albite-oligoclase), perthite, and quartz, with only minor mafic minerals (1-2 % chloritized biotite). Local fine grained aplitic-textured areas of the same composition are characteristic of the leucogranite.

Murray Mountain Quartz Monzodiorite

The Murray Mountain Quartz Monzodiorite forms the central part of the Murray Mountain Peninsula. It intruded the Price Point Formation and also appears to have intruded the Indian Brook Granodiorite. It also occurs as dykes in both the Murray Brook Granodiorite and the St. Anns Leucogranite, and hence is inferred to be the youngest of the plutons in the St. Anns-Wreck Cove belt. Typical exposures occur in Tarbotvale Pool in the Barachois River and in the central portion of North Brook, a tributary of Barachois River.

The quartz monzodiorite is generally dark grey to pinkish grey, and varies from fine grained and porphyritic to medium grained and subporphyritic. Plagioclase forms euhedral to subhedral phenocrysts. Both hornblende and biotite are abundant, and quartz and potassium feldspar are interstitial. In some samples they form poorly developed granophyric intergrowths. The texture suggests that the intrusion was emplaced at a relatively high crustal level.

Goose Cove Brook Granodiorite

An elongate pluton of mainly granodiorite composition extends from Goose Cove Brook south through Big Hill, with a small outlier in Big Brook to the north. The pluton has an intrusive relationship with the Barachois River Metamorphic Suite and its inferred lower grade equivalents at Big Hill, and probably with the Timber Lake Dioritic Suite, but its age is not known. It is well exposed in the upper part of Goose Cove Brook or (more accessibly) on a road across the western part of Big Hill.

The pluton consists of hornblende-biotite granodiorite, gradational to granite, locally with microcline megacrysts.

Beinn Bhreagh Suite

In the vicinity of Alexander Graham Bell's summer home at Beinn Bhreagh, a small area of varied plutonic rocks is termed the Beinn Bhreagh Suite. It includes diorite, granodiorite, and granite of unknown age. Most abundant is medium to coarse grained hornblende-biotite granodiorite with abundant allanite. Coarse grained biotite leucogranite is also present. None of these rocks are identical to those in the highlands to the north, although they have a similar character overall.

Bell Lakes Suite

The Bell Lakes Suite consists of three separate mappable units which probably have a gradational relationship and which are certainly closely related to one another and probably to the Cross Mountain Suite. All units display variable but generally strong evidence of deformation and alteration. Typical exposures occur near the end of Bell Lakes Road South, south of the Bell Lakes.

The *Baddeck River granodiorite* is characterized by abundant muscovite (up to 4 %) and less abundant biotite, and no amphibole. It is medium grained, weakly foliated, and white. The relative abundance of perthitic microcline and plagioclase varies so that the rocks grade from leucotonalite through granodiorite to granite. Abundant accessory phases include garnet, apatite, allanite, titanite, monazite, and zircon, an unusual assemblage. Magmatic epidote has also been found.

The *Snake Cat Lake granodiorite* is the most extensively exposed lithology. It is similar to the Baddeck River granodiorite but contains little if any magmatic muscovite, biotite is much more abundant, and quartz forms sparse large anhedral glomeroporphyritic clusters.

The *New Glen megacrystic granite* is gradational with both of the above lithologies. It contains no magmatic muscovite, but potassium feldspar (microcline perthite) forms large megacrysts (phenocrysts?).

A sample of the Baddeck River granodiorite has yielded a U-Pb (zircon) age of 556 ± 4 Ma, equivalent to that of the Ingonish River Tonalite (Dunning *et al.*, in press).

Cross Mountain Suite

Granitic, granodioritic, and tonalitic rocks occur in the Cross Mountain area of the east-central highlands. Sparse outcrop hampers more detailed subdivision, but typical outcrops occur along logging roads on Cross Mountain. Granitic rocks are clearly intrusive into the Ingonish River Tonalite in West Branch Indian Brook at the northeastern margin of the pluton, and into the McMillan Flowage Formation in the Cross Mountain area. Hence the maximum age of at least some lithologies in the pluton is late Precambrian to Cambrian.

The rocks of the Cross Mountain Suite vary, but typically are white, fine to medium grained, and weakly foliated. Most contain abundant muscovite, as well as biotite, but no amphibole. Plagioclase and quartz are the most abundant felsic minerals, with variable amounts of potassium feldspar.

Middle Head Leucodiorite

Dioritic rocks occur in several small areas around the shore of South Bay Ingonish, and are best exposed on the shoreline of the Middle Head Peninsula. Wiebe (1972) included all of these rocks with his Ingonish River Pluton, but they differ from both the Ingonish River Tonalite and the Wreck Cove Dioritic Suite as defined herein and by Raeside *et al.* (1984) and Barr *et al.* (1985). They are intruded by the Cape Smokey Granite on Middle Head, and probably at the tip of Cape Smokey (Raeside *et al.*, 1984) (Map 1752A), and hence they are pre-Early Ordovician in age (Dunning *et al.*, in press).

These dioritic rocks are somewhat varied in appearance but are typically medium to coarse grained and dark grey. At the tip of Middle Head, the medium grained leucodiorite is intermixed with (intruded into?) fine grained dioritic rocks which may be part of the Wreck Cove Dioritic Suite. Typical samples of the unit consist dominantly of subhedral plagioclase, with between 10 and 20 percent mafic minerals (both hornblende and biotite), and interstitial quartz. Because of the relatively low abundance of mafic minerals, these rocks are termed leucodiorites. They resemble the Ingonish River Tonalite, but the hornblende lacks the blue-green pleochroism of that in the tonalite, quartz is less abundant, and although epidote is present, none has the magmatic characteristics of epidote in the tonalite.

Ski Hill Granodiorite

The Ski Hill Granodiorite is exposed on the Cape Smokey ski hill and resembles the Ingonish River Tonalite, as well as the Middle Head Leucodiorite, but is maintained as a separate unit because of its granodioritic composition. Field relations suggest that it is intrusive into the Ingonish River Tonalite, and also the Wreck Cove Dioritic Suite. Based on its similarity to the tonalite, it is probably similar in age (Early Cambrian).

The granodiorite is light grey to pinkish grey, medium to coarse grained, and hypidiomorphic granular. It consists of large subhedral plagioclase, amphibole with blue-green-colourless pleochroism, biotite, and abundant interstitial quartz and less abundant microcline. Coarse grained epidote is also abundant, some of which may be magmatic in origin.

Ordovician plutonic units

Cape Smokey Granite

The Cape Smokey Granite was named by Wiebe (1972). It extends south from the Cape Smokey area toward Wreck Cove, occurs as sheets on Middle Head, and also forms Red Head to the north of Ingonish Island. It is well exposed along the Cabot Trail over Smokey Mountain. The Cape Smokey Granite has intruded all of the adjacent plutonic units except for the Cameron Brook Granodiorite. Rb-Sr whole-rock isochrons (Cormier, 1972, 1980) have indicated Ordovician to Silurian ages, and U-Pb dating of zircon separates gave an age of 493 $+1/-2$ Ma (Dunning *et al.*, in press).

The Cape Smokey Granite consists of pink to red leucogranite, similar in appearance to the St. Anns Leucogranite. Texture is medium to coarse grained and allotriomorphic granular, with approximately equal abundances of plagioclase, orthoclase, and quartz. Biotite forms only 1 to 2 percent, and is almost entirely chloritized.

Morrison Brook Quartz Monzonite

The Morrison Brook Quartz Monzonite occurs in two small plutons, one in the vicinity of the community of Wreck Cove and the other to the north on the coast east of the Cape Smokey Granite. The Wreck Cove body has a finer grained margin and hence is inferred to have an intrusive relationship with the adjacent Birch Plain Granite. However, the smaller coastal body was interpreted to have been intruded by the Cape Smokey Granite by Barr *et al.* (1982). As the age of the latter unit is Early Ordovician (Dunning *et al.*, in press) an Early Ordovician to Devonian age is assigned to the Morrison Brook Quartz Monzonite.

The quartz monzonite is fine (near margins) to medium grained, and dark grey to pinkish grey. It contains abundant subhedral plagioclase, interstitial microcline, and less abundant quartz, with about 20 percent biotite and hornblende combined. It lacks the abundant titanite characteristic of the Birch Plain and Indian Brook units.

Devonian plutonic unit

Cameron Brook Granodiorite

The Cameron Brook Granodiorite was originally described and named the Cameron Brook Pluton by Wiebe (1972), and the present mapping essentially confirms the boundaries of the pluton shown by Wiebe. The pluton intruded the McMillan Flowage Formation on the west and a contact metamorphic aureole is developed adjacent to the pluton, as described previously. In addition, xenoliths of both metavolcanic and metasedimentary composition, probably from the McMillan Flowage Formation, are common in the pluton.

On the south the pluton intruded the Ingonish River Tonalite and adjacent tonalitic gneiss (Raeside *et al.*, 1984). A fine grained chilled margin is developed in the pluton where the contact is exposed on the steep slope north of Clyburn Brook. The pluton does not appear to be affected by the extensive mylonitic shearing in Clyburn Brook (Raeside *et al.*, 1984), but the northern margin of the pluton is sheared by the branch of the Eastern Highlands shear zone which separates the pluton from the Black Brook Granitic Suite to the north. Although an earlier Rb-Sr whole-rock isochron suggested an Ordovician-Silurian age for the

Cameron Brook Granodiorite (O'Beirne-Ryan *et al.*, 1986), a more recent U-Pb (zircon) age of 402 ± 3 Ma (Dunning *et al.*, in press) indicates a Devonian age.

The Cameron Brook Granodiorite consists mainly of coarse grained, variably megacrystic granodiorite (locally gradational to granite). Megacrysts are mostly of plagioclase (oligoclase), with less abundant perthitic alkali feldspar. Biotite is the main mafic mineral, locally accompanied by subordinate amphibole. Accessory apatite, titanite, and opaque oxides are abundant. Weak to strong foliation is defined by alignment of megacrysts and biotite. It is not clear whether this is dominantly an intrusive or a tectonic foliation. More detailed petrographical descriptions and chemical data are presented by O'Beirne-Ryan *et al.* (1986).

Undifferentiated granitoid rocks

Other smaller areas of granitoid rocks occur locally in the Bras d'Or Terrane. The largest of these is a band of red, medium grained, strongly foliated granite which occurs between the Gisborne Flowage Quartz Diorite and the Ingonish River Tonalite. Similar granitic rocks also occur in McKinnon Brook to the north, where they locally contain greisen zones with disseminated pyrite and chalcopyrite. These are hornblende-biotite granites and granodiorites of uncertain age.

A large area of pegmatitic granite and muscovite-biotite granite and granodiorite occurs in East Branch Indian Brook and adjacent areas. The pegmatite bodies are typically very coarse grained simple pegmatites consisting of perthitic potassium feldspar, albitic plagioclase, quartz, muscovite, and biotite. The granodiorites and granites are generally fine grained, grey, and contain biotite and muscovite. These rocks are similar to granodioritic rocks and pegmatites intruded into the Gisborne Flowage Quartz Diorite, and all may be related to the Cross Mountain Suite.

Similar small areas of granite and pegmatite also occur within the northern part of the Kathy Road Dioritic Suite, Bateman Brook Metamorphic Suite, and the McMillan Flowage Formation.

Farther south in the Oxford Lakes area, a small area of muscovite-biotite granodiorite appears to have intruded both the Kathy Road Dioritic Suite and the McMillan Flowage Formation. It is very similar to parts of the Cross Mountain Suite.

To the east, in the Birch Plain Granite, a small area of fine grained pink aplitic granite is present.

Widespread throughout the area are fine to medium grained dioritic dykes. These occur in most of the map units, and are too small to show on Figure 4. The largest examples of these dykes are well exposed in both the East and West branches of Indian Brook and in Barachois River. Their age is uncertain. They consist of plagioclase and hornblende (with minor biotite and accessory minerals) and have a distinctive even-grained texture.

In addition to the above mappable bodies, numerous small granitoid bodies occur in many of the map units in the Bras d'Or Terrane, but cannot be individually described at the scale of this report.

UNMETAMORPHOSED DEVONO-CARBONIFEROUS UNITS

Fisset Brook Formation

Discontinuous occurrences of unmetamorphosed volcanic and sedimentary rocks around the periphery of crystalline units in the Blair River Çomplex were assigned to the Devono-Carboniferous Fisset Brook Formation by most earlier workers (Mackasey, 1963; Kelley and Mackasey, 1965; Smith and Macdonald, 1981; Blanchard *et al.*, 1984). Correlation of these with the Fisset Brook Formation has been based on lithological similarities and on the presence of poorly preserved trilete spores from the Lowland Cove area (Smith and Macdonald, 1981). However, Cormier and Kelley (1964) reported a whole-rock Rb-Sr isochron age of 491 ± 25 Ma (recalculated by Keppie and Smith, 1978) from volcanic rocks near Lowland Cove, the significance of which is not certain (Smith and Macdonald, 1981). In the Lowland Cove area, Smith and Macdonald (1981) identified a stratigraphic succession from porphyritic rhyolite at the base through sedimentary and tuffaceous units to basalt and andesite flows at the top. During the present study, similar rhyolites were found east and southeast of the Lowland Brook Syenite and in the western part of the map area north of Red River and in Polletts Cove River. Although variable in groundmass grain size and texture, and in proportion of phenocrysts, these rhyolites are all characterized by the presence of resorbed quartz and sanidine phenocrysts in a spherulitic microcrystalline or cryptocrystalline quartz and potassium feldspar groundmass.

In the area north of Red River, a more extensive stratigraphic section is preserved, consisting of a thin amygdaloidal basalt lying unconformably on Andrews Mountain Granite, overlain by a massive variably porphyritic rhyolite and a series of interbedded rhyolites and conglomerates, with conglomerate making up approximately 40 percent of the section.

Dykes of rhyolite porphyry observed in the Andrews Mountain Granite south of Red River may be related to these rhyolite flows. Similarly, unmetamorphosed mafic dykes (see below) in the Polletts Cove River Group and associated plutonic units may be related to mafic flows of the Fisset Brook Formation.

MacMillan Mountain Formation

In the extreme southern part of the map area, volcanic rocks of the MacMillan Mountain Formation have been described by Jamieson and Craw (1983), and these, along with basaltic layers in the overlying sedimentary units in the New Glen area of the Bras d'Or Terrane may be correlated with the Fisset Brook Formation.

Mafic dykes

Mafic dykes are common throughout the map area. In the Blair River Complex, mafic dykes within the Polletts Cove River Group are difficult to distinguish in the field from mafic layers within the gneiss. However, within the anorthosite and syenite bodies, dykes are clearly recognizable and are of two types. Most abundant are amphibolites, consisting mainly of plagioclase and hornblende, which are correlated with amphibolite sheets or layers within the Polletts Cove River Group. Contrasting with these are less numerous unmetamorphosed dykes consisting essentially of plagioclase and clinopyroxene in ophitic texture. The latter dykes may be related to mafic volcanism in the Fisset Brook Formation.

Similar unmetamorphosed mafic dykes occur sporadically throughout most of the other map units in the Aspy and Bras d'Or terranes, except for the Carboniferous sedimentary rocks. Most are massive, dark grey to black, and nonporphyritic. The dioritic units of the Bras d'Or Terrane contain a particularly large number of mafic dykes. In addition, an unusual plagioclase-phyric dyke with phenocrysts up to 10 cm in length was observed in the upper reaches of Black Brook. No systematic study of mafic dyke orientation, distribution, or composition has yet been undertaken. It seems likely that the unmetamorphosed dykes are Devono-Carboniferous in age, emplaced in response to regional extension during that time period as discussed by Blanchard *et al.* (1984).

Horton and Windsor groups

Carboniferous sedimentary units of the Horton and Windsor groups occur in several areas around the periphery of the Cape Breton Highlands. These include the Pleasant Bay, Salmon River, and Aspy lowlands, small areas between Dingwall and Ingonish, the Ingonish Beach area, the coastal plain of the eastern highlands, and the St. Anns Harbour to Baddeck areas (Fig. 4). These were not mapped in this study, and have been described by Neale and Kelley (1960), Kelley and Mackasey (1965), and Kelley (1967).

STRUCTURAL GEOLOGY

On the basis of lithological variation, ages of intrusions and deformations, and structural and metamorphic styles, the pre-Carboniferous rocks of the map area have been divided into the Blair River Complex, and the Aspy and the Bras d'Or terranes. These areas appear to have been affected by tectonic events of variable intensity, effect, and age, and are considered independently.

Blair River Complex

The rocks of the Polletts Cove River Group and associated plutons in the Blair River Complex display particularly complex structural styles. In any one outcrop, single orientations of foliation or compositional layering can be measured and evidence of pervasive polyphase deformation is rare. However, the overall pattern of foliation orientations is complex, even for limited domains in the complex. In the gneisses of the Polletts Cove River Group, foliation, as defined by the orientation of micas and amphiboles, tends to be parallel to the compositional layering of light and dark layers. The foliated intrusive rocks of the Blair River Complex typically display trends parallel to those of the stratified gneissic rocks, even where the contact between the plutons and the gneisses are at an angle to the foliation. The foliation and compositional layering are therefore inferred to have developed during a high grade metamorphic event, subsequent to the intrusion of the syenite, anorthosite, and monzodiorite plutons.

Based on a visual appraisal of the general orientations of structural trends, five domains have been recognized in the Blair River Complex (Fig. 5). These domains include elements of both the Polletts Cove River Group and the plutons, as the structural trends appear to overprint early lithological differences.

Domain A includes the Lowland Brook Syenite and a portion of the Polletts Cove River Group gneiss, and is characterized by generally northwesterly-trending steeply-dipping foliations, although there is considerable scatter of the data. Domain B includes much of the Polletts Cove River Group, and displays highly variable trends. No single concentration of data appears meaningful, possibly as a result of greater development of younger variably-oriented open folds, and possibly because the effects of more than one foliation-forming event are recorded. Mapping on a scale of 1:50 000 did not permit a detailed analysis of the structural development of this area. Domain C, in the Salmon River area, did not provide a large sampling of data points, but appears to preserve a poorly defined northeasterly-trending foliation pattern. This area has been moderately affected by post-Acadian faulting (some of which is also post-Mississippian), and foliation trends may be overprinted or rotated by this deformation resulting in many near-horizontal foliation measurements. Domain D which includes both Polletts Cove River Group gneisses and part of the Red River Anorthosite displays a concentration of northerly-trending foliations, implying that the southern extension of the Blair River Complex has been involved in compressional tectonics between the Red River and Wilkie Brook fault systems. Domain E includes the rocks deformed in the Wilkie Brook fault system, and adjacent areas where there is a pronounced northeasterly-trending foliation. Within the Wilkie Brook fault zone porphyroclasts display highly variable trends of relict layering, indicating that the foliation is a relatively young feature and is associated with the mylonitization along the fault zone.

Aspy Terrane

Although the structural patterns in the Aspy Terrane appear more uniform than in the Blair River Complex, Macdonald and Smith (1980) have demonstrated that two pervasive and two regional nonpervasive structural episodes have affected the rocks of the Cape North and Money Point groups, at least in the Cape North Peninsula. It is probable that a similar complexity exists throughout the stratified rocks of the Aspy Terrane, as other sections of the terrane have generally undergone greater degrees of metamorphism than the Cape North Peninsula.

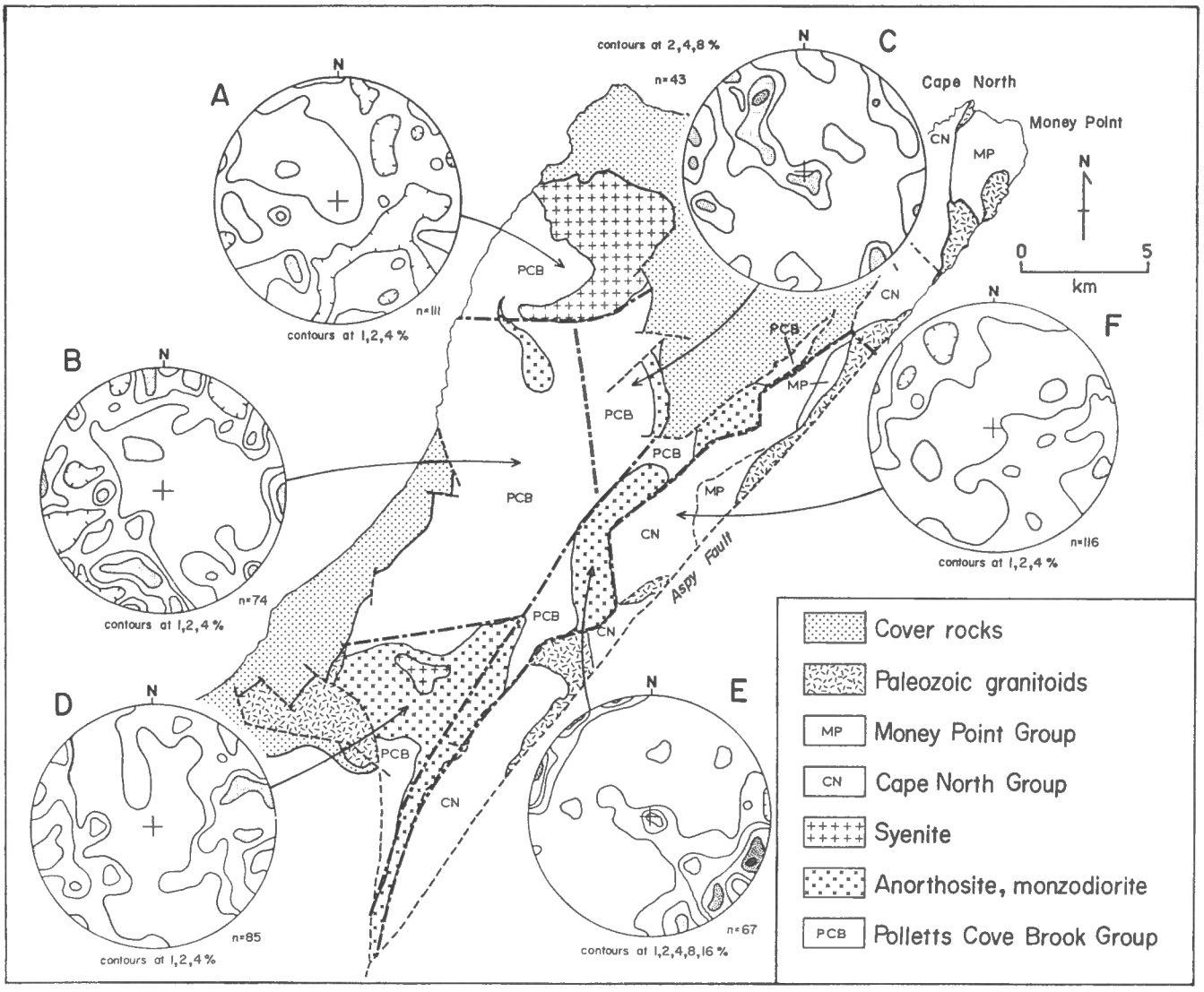

Figure 5. Equal area stereographic projections of poles to foliation, Blair River Complex and part of the Aspy Terrane. Dot-dash lines subdivide the area into six domains, as described in text.

The Money Point Group and the Cape North Group appear to have been deformed together throughout the Aspy Terrane; in all areas where the two units are exposed in close proximity, they display similar fabric development and similar late stage structural effects. The Cheticamp Lake Gneiss, however, shows fewer fabric elements as much of the unit consists of severely metamorphosed and foliated plutonic units. Similarly, the orthogneiss bodies (Middle Aspy River and Glasgow Brook orthogneisses) display foliations that are generally parallel to the regional trends and appear to have been involved in at least the later stages of pervasive foliation development.

The Aspy Terrane can be divided into seven subareas, each characterized by internally uniform fabric orientations or structural styles (Fig. 5 and 6). The area west of the Aspy Fault has been grouped into one subarea (Fig. 5, domain F). This area is known to preserve particularly complex fabric elements in the Cape North Peninsula (Macdonald and Smith, 1980), and although mapping in the remainder of the domain has not been in the same detail, similar conclusions appear to be valid. Mesoscopic F_1 and F_2 folds are developed in well layered lithologies, particularly mica schists. These are coaxial and plunge gently to moderately along the length of the subarea. Folds range from isoclinal to open, and are characterized by axial planar schistosities. In a number of outcrops refolded folds were identified, corroborating Macdonald and Smith's (1980) conclusion of two phases of pervasive deformation.

In domain G (Fig. 6) refolded folds with axial planar schistosities have also been identified. Structural style generally appears very similar to that of the subarea west of the Aspy Fault, but the orientations of the planar structures have been affected by a large scale easterly-trending flexure, resulting in a gradual curve of trends from north-

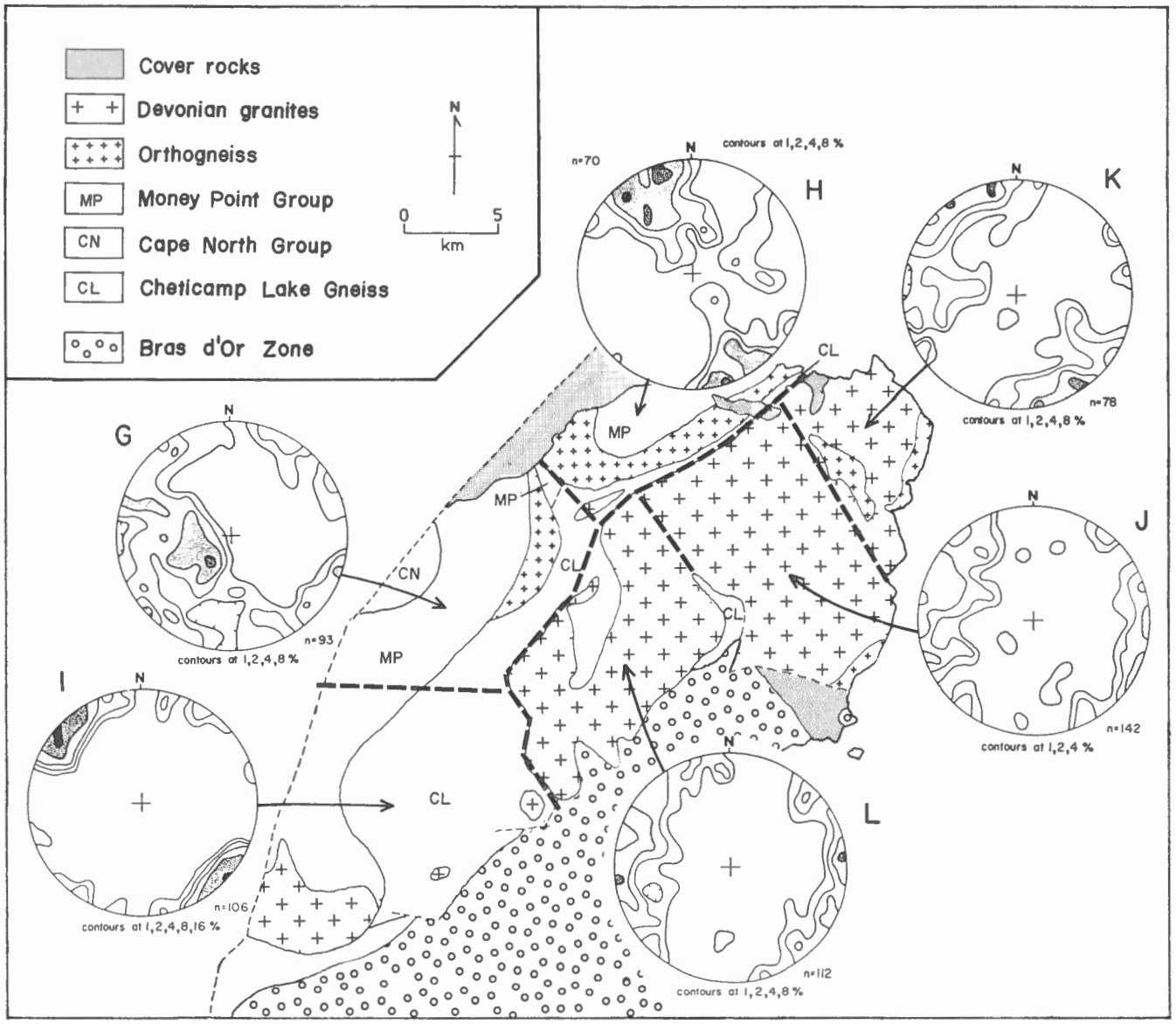

Figure 6. Equal area stereographic projections of poles to foliation, Aspy Terrane. Dot-dash lines subdivide the area into six domains, as described in text. (The portion of the Aspy Terrane, west of the Aspy Fault, is shown in Fig. 5.)

westerly through northerly to northeasterly across the area, parallel to the contact between the Money Point and Cape North groups.

In domain H trends of foliations appear to be relatively uniform to the northeast, although in several places mesoscopic to macroscopic folding has reoriented these trends. This is particularly prominent in South Aspy River where the river flows for 500 m along the core of a synform in the folded foliation of the Glasgow Brook Orthogneiss. This folding appears to be late stage, and has no axial planar fabric associated with it.

In domain I foliation trends appear very consistent in the Cheticamp Lake Gneiss, and may be an extension of domain G described above. This could be taken as evidence that the Cape North and Money Point groups and the Cheticamp Lake Gneiss were all involved in the same deformation. In Cheticamp River, foliations are deflected to a more easterly trend. The relationship between the structures in this area and in the remainder of the map area is not well understood because of limited outcrop and mapping.

The Black Brook Granitic Suite has been divided into three domains. These plutons make up a large part of the Aspy Terrane in the map area, and show variable intensities of foliation development from unfoliated to strongly foliated granites. Domain J appears to be particularly strongly foliated. Foliation trends are highly variable across the pluton. In the southeastern part, where the foliations are particularly well developed, they display a general northerly

trend, but there are many examples of high angle oblique trends. In domain K trends are more northeasterly, and in domain L there is a scatter of trends from northeasterly to northwesterly.

Bras d'Or Terrane

Introduction

The effects of deformation and metamorphism in the rocks of the Bras d'Or Terrane are also highly variable. In the south, and north of the Clyburn Brook fault, the rocks of the McMillan Flowage Formation are less severely metamorphosed than those in the central areas, and in most cases have preserved an indication of bedding through the development of a slaty or phyllitic cleavage. Sufficient way-up indicators have been identified in the well exposed outcrops of the Clyburn Brook section to permit the recognition of a gently northeasterly-plunging syncline. Outcrops in the smaller tributary brooks do not display fine structures, and it was not possible to demonstrate this synclinal structure in the area to the north. However, the syncline involves a sequence of pelitic and volcaniclastic slaty rocks and these lithologies persist to the margin of the Cameron Brook Granodiorite.

In the higher metamorphic grade areas in the central Cape Breton Highlands, the structure is relatively complex, although individual outcrops typically display simple patterns. The major trends vary from northerly in the area south of McMillan Flowage, to generally northeasterly in the remainder of the belt, although north of the Clyburn Brook fault, trends are more erratic. Both the metasedimentary units and most of the adjacent plutonic units display parallel foliation development throughout most of this part of the Bras d'Or Terrane.

The McMillan Flowage Formation is particularly significant in the structural analysis of the northern Bras d'Or Terrane, as it extends throughout the area, and contains both marker horizons and lithologies suitable for the development of a pervasive fabric. Figure 7 displays a modification of the structural domains described by Raeside and Barr (1986), showing the structural trends of the McMillan Flowage Formation, the Cameron Brook Granodiorite, and adjacent plutonic and stratified rocks. The McMillan Flowage Formation has been divided into four domains from north to south, and the plutonic rocks (and enclosed screens of Barachois River Metamorphic Suite) have been assigned to another four domains.

McMillan Flowage Formation

In domain M (north of the Clyburn Brook fault) metamorphic grade is generally low, and it appears that only one pervasive foliation has affected these rocks. This is variably developed as a slaty or phyllitic cleavage, a solution cleavage in tuffaceous rocks, a schistosity in the higher grade rocks west of the Roper Brook amphibolite, and as a patchy epidote-hornblende layering in the amphibolite. Trends are generally northeasterly (Fig. 7), and lineations are gently southwesterly plunging.

In the higher grade rocks of domain N between the Clyburn Brook fault and the East Branch Indian Brook fault, foliation (i.e. schistosity) trends are also generally northeasterly, and more uniform than in the area to the north. Ten fold hinge lineation measurements in this area indicate a generally shallow southwesterly-plunging structure. The map pattern outlined by the marble division marker horizon is complicated by extensive folding and faulting. The folding is tight, and outlines a series of synclines; however, many of the limbs are faulted, and intervening anticlines have been sheared out. Some of these faults are reverse faults or thrusts, although the sense of displacement is not known in all cases.

Domain O, between the East Branch Indian Brook fault and the McMillan Flowage area, is characterized by higher grade metamorphic rocks which display consistent northeasterly-trending foliation, and gently to moderately southwesterly-plunging minor fold hinge lineations. Folding in this area is well outlined by the marble division, as a series of tight to near-isoclinal kilometre-scale folds. The stratigraphic arrangement of these folds indicates that they occur in the core of a 5 km wide synclinorial structure, which plunges gently to the southwest. The absence of refolded folds and repeated stratigraphy in this area implies a relatively simple single-stage early deformational history. The similar structural patterns in each of these domains (Fig. 7) shows that in spite of the large throws on the easterly-trending faults (e.g. chlorite against sillimanite grade on the Clyburn Brook fault) and the wide range in metamorphic grades, each domain appears to have preserved evidence of the same tectonic event.

South of McMillan Flowage (domain P), the general trend of foliations changes from northeasterly to northerly, and a single stratigraphic section of the McMillan Flowage Formation, younging to the west, is present along 30 km of strike. This section is inferred to be the eastern limb of the synclinorial structure identified to the north. Minor folds are well developed on scales of two centimetres to several metres wavelength, particularly in the quartzite division, and fold hinge orientations are near vertical. They are predominantly sinistrally asymmetrical (S-shaped) when viewed down-plunge, although in any one outcrop both sinistral and dextral orientations may be found. The presence of two orientations of vergence implies that two phases of coplanar deformation exist, the first presumably being the one responsible for the large-scale folding, and the second overprinting the earlier structures with the vertical minor fold hinges. The lateral continuity of these structures and the 50 to 60° change in plunge orientation between the areas north and south of McMillan Flowage indicates that this major structure formed as a vertical fold, rather than as a moderately-plunging fold, subsequently reoriented. No repetition of stratigraphy is recognized in areas to the west of the presumed fold axial plane of the synclinorial structure, and the western limb of the fold is assumed to have been removed either by the intrusion of the Kathy Road Dioritic Suite and Bell Lakes Suite or by strike-slip movement on faults which mark the southern extension of the Eastern Highlands shear zone.

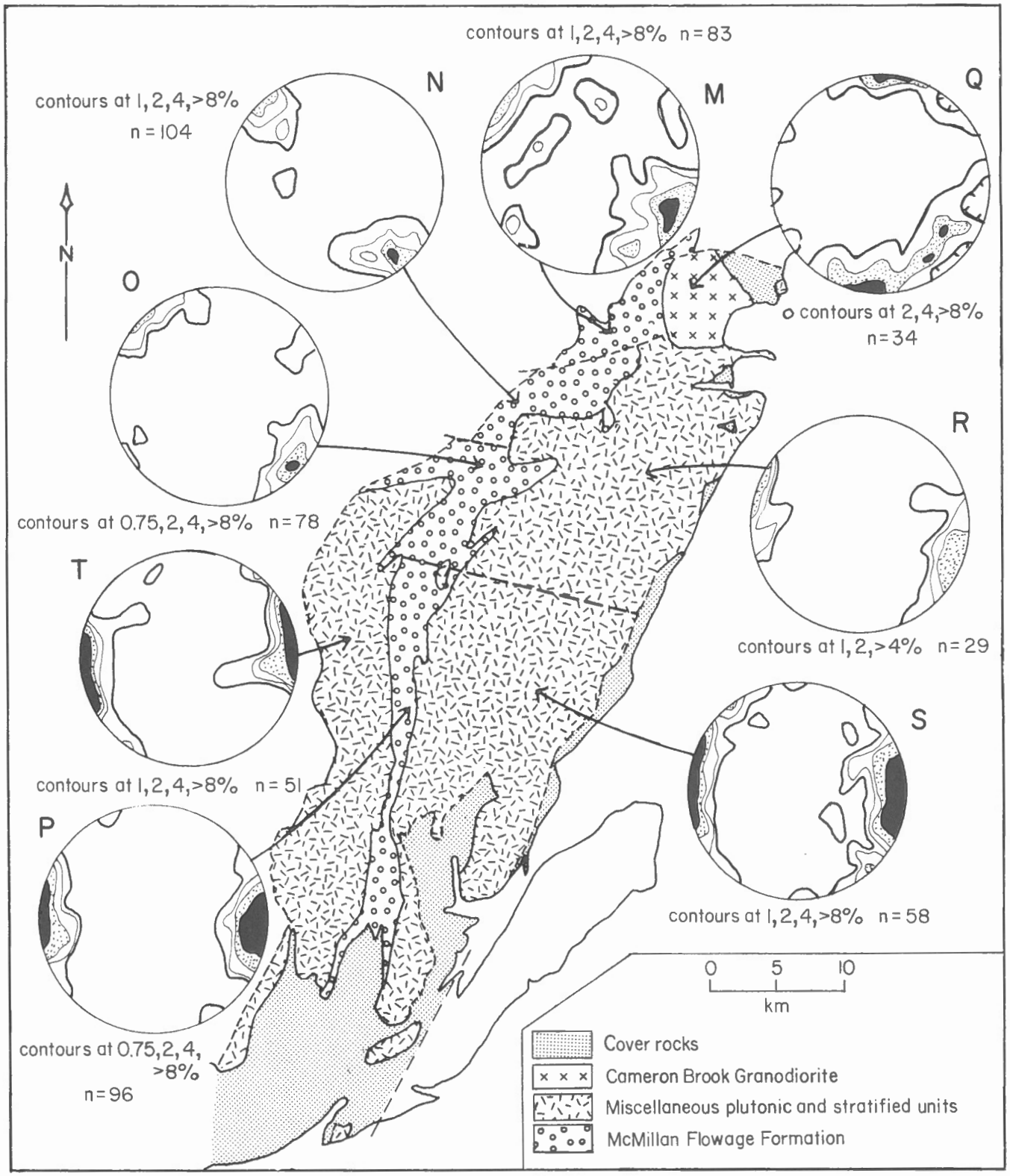

Figure 7. Equal area stereographic projections of poles to foliation, Bras d'Or Terrane. Dot-dash lines subdivide the area into eight domains, as described in text.

Plutonic rocks east of the McMillan Flowage Formation

Three structural domains have been identified in the plutonic rocks east of the McMillan Flowage Formation. The Cameron Brook Granodiorite (domain Q) displays a generally easterly-trending foliation, defined by the orientation of potassium feldspar megacrysts and micas. Although the data set is small, this trend appears real, and is markedly different from trends in the surrounding components of the Bras d'Or Terrane. These trends probably reflect emplacement into an easterly-trending zone of shearing.

The remainder of the plutonic rocks, and metasedimentary screens contained within them, in the area east of the McMillan Flowage Formation can be assigned to two structural domains (R and S, Fig. 7), which are comparable to domains O and P in the McMillan Flowage Formation. Most of the plutonic rocks display a moderate to pronounced patchily-developed foliation, which parallels the foliation developed in the McMillan Flowage Formation. Some of the plutons (e.g. Gisborne Flowage Quartz Diorite, Ingonish River Tonalite) cut across the McMillan Flowage Formation, but display parallel foliations, which are axial planar to the fold structures in the metasedimentary rocks. These observations imply that the plutons were intruded and crystallized during the deformational event and the maintenance of the regional stress field.

Plutonic rocks west of the McMillan Flowage Formation

Plutonic rocks west of the McMillan Flowage Formation (domain T) are mainly the Kathy Road Dioritic Suite, the North Branch Baddeck River Leucotonalite, and the Bell Lakes Suite. Foliations are moderately well developed in the first two units, and locally developed in the latter. Trends are generally similar to those in the southern domain of the McMillan Flowage Formation, and also imply syntectonic deformation.

Shear zones and faults

Wilkie Brook-Red River fault system

The eastern boundary between the Blair River Complex and the Aspy Terrane is a fault zone, 50 to 1300 m wide, which extends along the valleys of Wilkie Brook and Grays Hollow Brook. It is not restricted to valleys, however, and forms part of the North Mountain plateau, particularly in the south, where it is well exposed near the Cabot Trail at an altitude of 445 m. The southwestern boundary between these two zones is also a wide fault zone which in part underlies the valley of the Red River, and extends across plateau ridges. It ranges from 200 to 500 m wide. These two fault systems approach to within 800 m of each other south of the Cabot Trail. They do not intersect, but are cut off by Carboniferous or younger faulting along the margin of the Margaree Pluton and by the Aspy Fault.

Lithologies in both fault zones are similar, consisting of extensively chloritized mica schists which commonly preserve porphyroclasts that display strongly cataclased textures. Some less chloritized rocks preserve strong blastomylonitic textures. Recrystallization of these cataclastic rocks appears to be pervasive, and typically the foliation trends are at an angle to the margins of the fault zone. Where the fault zone has involved less micaceous lithologies (e.g. the Grays Hollow monzodiorite), large numbers of clasts of the protolith, up to 50 cm across, are preserved. These are commonly strongly cataclased and foliated parallel to the trend of the fault zone, whereas both the country rocks (outside the shear zone) and the chloritic matrix of the shear zone display highly discordant foliations. From these observations it is inferred that movement occurred between the amphibolite-granulite facies metamorphism of the Polletts Cove River Group, and a second greenschist facies retrograde metamorphism which affected both the Blair River Complex and the Aspy Terrane and the mylonites in the fault zones.

Late brittle movement, as indicated by open kink-band structures, was probably associated with Carboniferous or younger movement.

Eastern Highlands shear zone

The boundary between the Aspy Terrane and the Bras d'Or Terrane is the Eastern Highlands shear zone. This zone of mylonites, blastomylonites, and chlorite schists ranges from 200 to 1300 m wide, and extends from the Ingonish area, where it is cut off by the Black Brook Granitic Suite, for 40 km to the south to where it has been intruded by the West Branch North River Granite. Like the Wilkie Brook fault zone, the Eastern Highlands shear zone appears to have undergone greenschist facies metamorphism after cessation of movement, and chloritic schistosities are developed parallel to regional schistosities at high angles to the trend of the fault zone.

The Eastern Highlands shear zone is dextrally offset by the East Branch Indian Brook and Clyburn Brook faults, and in the Ingonish area appears to splay into a series of shallow-dipping faults, some of which are thrusts. Movement on the shear zone and the associated faults appears to have continued from at least the Middle Devonian to Early Mississippian. In particular, the Clyburn Brook fault is cut off by the 402 $\pm$ 3 Ma Cameron Brook Granodiorite, whereas a splay of the shear zone which contains clasts of the Black Brook Granitic Suite has deformed the Mississippian conglomerates, sandstones, and mudstones of the Horton Group. It appears probable that the Eastern Highlands shear zone and associated faults have developed over an extended period, and that some parts of the system have undergone more than one phase of movement.

Aspy Fault

A number of faults have been identified across the map area. In most cases these are minor, but some have a significant effect on the distribution of units. The most prominent is the Aspy Fault, which extends across the entire map area, and probably correlates with similar faults in the Margaree Valley in the southwestern Cape Breton Highlands. Deformational effects of the Aspy Fault were only rarely noted, as the faulting was brittle, and the zone affected was narrow. Throughout most of the area the trace of the fault is overlain

by alluvial or scree deposits. However, sheared rocks are exposed in the North Aspy River. Typically these display brittle fracturing textures, with abundant quartz or calcite veining. In the middle reaches of the North Aspy River, gypsum and limestone of the Windsor Group have been remobilized by the Aspy Fault, and in the headwaters the Margaree Pluton has been cut by the fault, indicating that movement was post-Late Devonian to Early Mississippian. The prominent escarpment above the Aspy Fault is a consequence of the relatively easily eroded rocks of the Horton and Windsor groups having been dropped and preserved against the more resistant rocks of the Cape North and Money Point groups and associated granitic units.

Minor faults in the Bras d'Or Terrane

In the southeastern highlands, several faults have been inferred, mostly on the basis of contrasting lithology, but in some cases sheared rocks are exposed. These range from zones of ductile deformation, e.g. along the eastern margin of the Ingonish River Tonalite where xenoliths have been stretched and have attained length to width ratios of 10:1, to shallow faults which show no consistent orientation patterns. In the St. Anns area, Murray Mountain is flanked and transected by a graben-like structure, in which are preserved rocks of the Price Point Formation.

Carboniferous deformation

The Carboniferous sedimentary rocks that overlie the Bras d'Or Terrane have not been mapped in detail. However, in some areas the relationship between these rocks and the metamorphic and plutonic rocks is complicated by the presence of faults. In particular, the sedimentary units of the Coastal Plain from Wreck Cove to Jersey Cove are in faulted contact with the plutonic rocks of the Indian Brook Granodiorite, and in the St. Anns area, the metamorphic and plutonic units appear to be thrust eastward over the Mississippian Windsor and Horton groups, as originally proposed by Currie (1977). A similar thrust relationship has also been inferred in the Baddeck River area; however, thrusts proposed by Currie (1977) in the South Aspy River and Christopher MacLeod Brook areas have not been substantiated in this study.

METAMORPHISM

Blair River Complex

Peak metamorphic grades have reached upper amphibolite, transitional to granulite facies conditions throughout the metasedimentary and probably most of the metaigneous rocks of the Blair River Complex. Indicative mineral assemblages are best developed in mafic rocks, where hornblende-plagioclase-ilmenite assemblages are almost ubiquitous, and in many cases clinopyroxene or orthopyroxene are also developed. The distribution of mineral assemblages is sporadic: a general area of pyroxene-bearing amphibolites extends across the north-central part of the complex, but does not appear to be uniformly developed (Fig. 8). No pyroxene-bearing assemblages were noted in mafic lithologies from the southern half of the complex. The sporadic distribution of high grade assemblages may in part be due to retrograde metamorphism completely overprinting early assemblages, as symplectic intergrowths of hornblende and quartz are found in some samples, and many examples of relict pyroxene mantled and partly replaced by hornblende were noted. In one sample the assemblage hornblende-hypersthene-clinopyroxene-plagioclase-quartz-ilmenite is developed, which may be indicative of granulite facies metamorphism (Turner, 1981). In this sample, however, a pronounced relict gabbroic texture is preserved with hornblende occurring as fine grained granoblastic patches interstitial to the pyroxenes, suggesting that the two-pyroxene mineral assemblage is a primary igneous feature.

The psammitic and semipelitic gneisses of the Polletts Cove River Group provide few useful indicator minerals for the determination of metamorphic conditions. Kyanite (without potassium feldspar and muscovite) was noted in one specimen from the Wilkie Brook area, but only four specimens yielded garnet. No samples contain primary muscovite, although muscovite was noted in blastomylonites on the edges of the Blair River Complex. Microcline is relatively common: in many rocks it is strongly perthitic, and one sample from the Wilkie Brook area contains quartz-microcline-hypersthene-cummingtonite-biotite, indicative of transitional amphibolite-granulite facies metamorphism.

Syenite intruded into the Polletts Cove River Group has also undergone a period of high grade metamorphism, during which Barr *et al.* (1987b) postulated that clinopyroxene had broken down to mildly sodic amphiboles, yielding large amounts of zirconium, now represented by large zircon grains in amphibole clusters. These zircon grains display textures typical of recrystallization under granulite facies conditions, with multifaceted form and general ovoid shape (van Breemen *et al.*, 1986).

Moderate to severe retrograde metamorphism has affected most of the rocks of the Blair River Complex. Sericitized plagioclase, chloritized biotite, and secondary epidote are developed across much of the area. Strongly sheared and mylonitized rocks were particularly affected by retrograde metamorphism, especially in the eastern part of the map area. It appears that postmylonitization metamorphism increased in intensity from minor sericitization in the coastal parts of the map area, through a belt of moderately extensive sericitization and chloritization in the central part, to very extensive chloritization and growth of muscovite and epidote in a belt parallel to the Wilkie Brook Fault. The mylonites of the Wilkie Brook and Red River fault zones have typically been extensively recrystallized, with blastomylonitic textures in the more quartzofeldspathic rocks and chlorite $\pm$ epidote developed in the more mafic lithologies.

Aspy Terrane

The semipelitic and pelitic rocks of the Aspy Terrane provide appropriate lithologies to display the effects of amphibolite facies Barrovian metamorphism. A sequence of zones, involving staurolite, kyanite, and sillimanite have

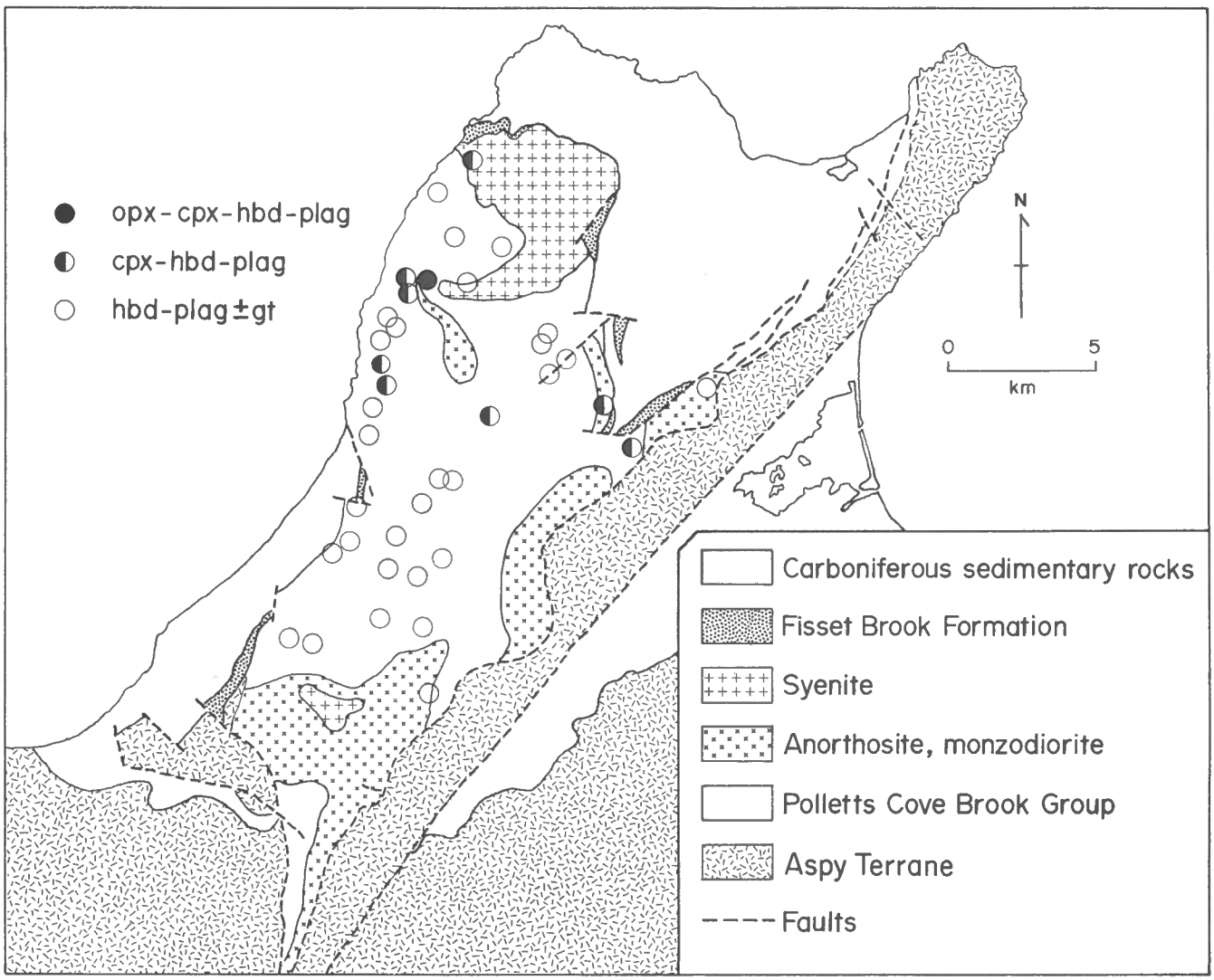

Figure 8. Metamorphic assemblages of the Blair River Complex.

been described by Phinney (1963) and Macdonald and Smith (1980) in the Cape North Peninsula. Lower grade assemblages also include cordierite, garnet, biotite, and chlorite. In the Cape North Peninsula, metamorphic grade increases rapidly from east to west, and in part is coincident with the distinction between the Money Point Group and the Cape North Group (Macdonald and Smith, 1980). Farther to the south, the low grade zones are cut off by the Aspy Fault (Fig. 9), and at Grays Hollow Brook kyanite zone assemblages are stable across the entire width of the Aspy Terrane. Macdonald and Smith (1980) identified two sillimanite-bearing rocks (one with kyanite) in rocks assigned to the Cape North Group, 1 km west of Cape North. They also identified the kyanite-sillimanite isograd on the coast, 2 km west of Cape North, and coincident with a major mylonitic shear zone. However, it is possible that the narrow belt of rocks exposed west of this shear zone represents lithologies of the Polletts Cove River Group (A.S. Macdonald, pers. comm., 1987), and that the shear zone is an extension of the Wilkie Brook Fault. Hence, these rocks have not been considered as part of the Cape North Group or the Aspy Terrane.

To the east of the Aspy Fault, metamorphic grade increases from west to east, from staurolite-kyanite zone rocks near the fault, into an extensive zone of kyanite-bearing lithologies in the North Aspy River area. Sillimanite zone rocks underlie much of the South and Middle Aspy River areas, and the areas to the south, and potassium feldspar-sillimanite assemblages are relatively common in the Cheticamp Lake Gneiss. West of the study area Jamieson (pers. comm., 1987) has recognized kyanite-potassium feldspar assemblages in rocks of the Jumping Brook Metamorphic Suite.

Retrograde metamorphism has affected most of the lithologies of the Aspy Terrane. Many samples have an extensive development of large irregular coarse grained masses of muscovite, indicating a period of mid-amphibolite

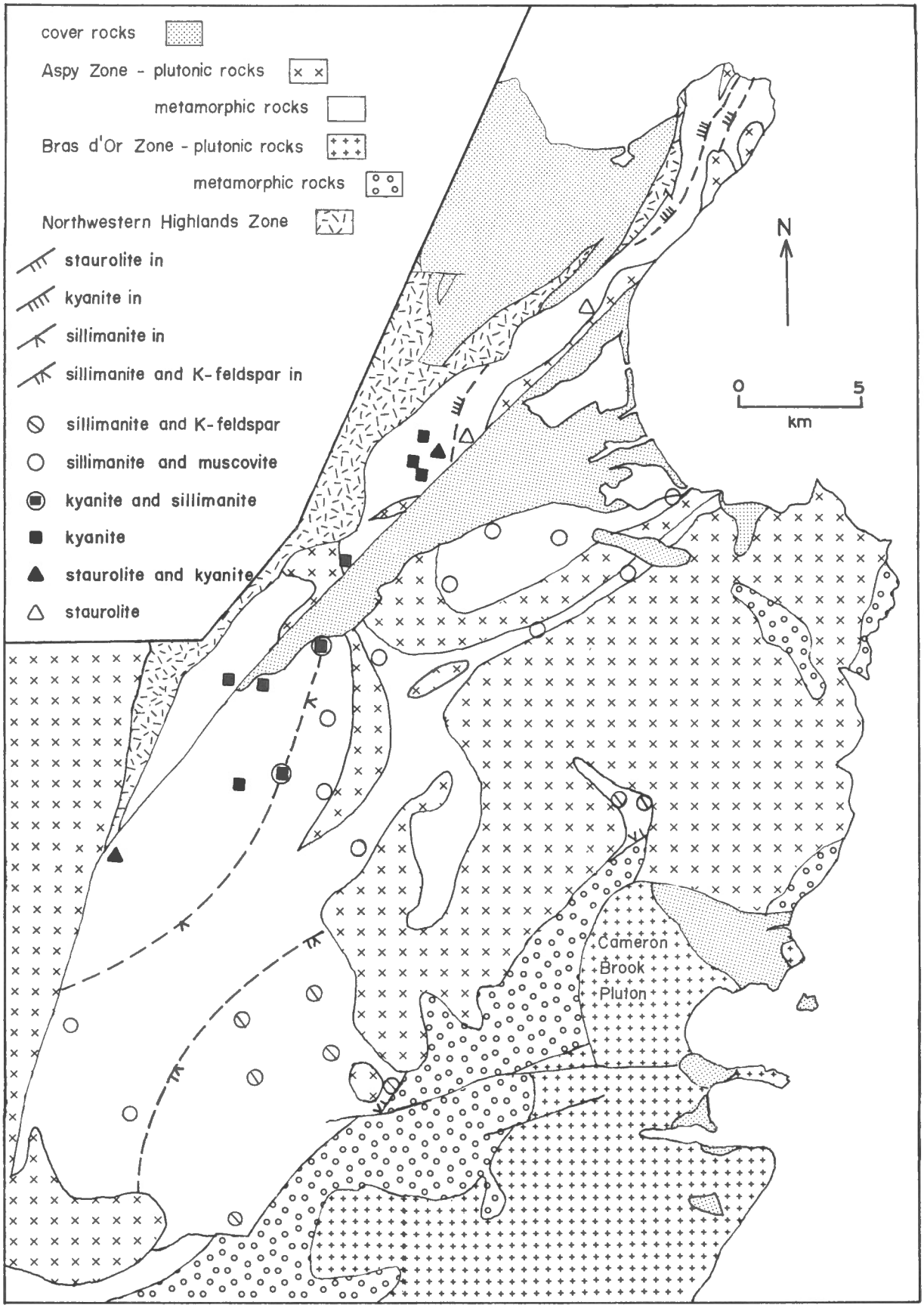

Figure 9. Metamorphic assemblages and isograds in the Aspy Terrane. Isograds in the Cape North Peninsula are from Macdonald and Smith (1980).

facies retrograde metamorphism. Most samples also display some chloritization of micas and sericitization of feldspars, particularly adjacent to the margins of the Aspy Terrane.

Bras d'Or Terrane

In the Bras d'Or Terrane of the Cape Breton Highlands, regional metamorphic grade is highest in the McMillan Flowage area, and decreases both to the northeast and to the south (Fig. 10). The area north of the Clyburn Brook fault is underlain by black and green slates, which probably contain chlorite, although in many cases the minerals are too fine grained to identify petrographically. Raeside *et al.* (1984) recognized a prograde metamorphic sequence involving biotite, garnet, staurolite, and sillimanite in pelitic rocks and actinolite and hornblende in metabasites of the

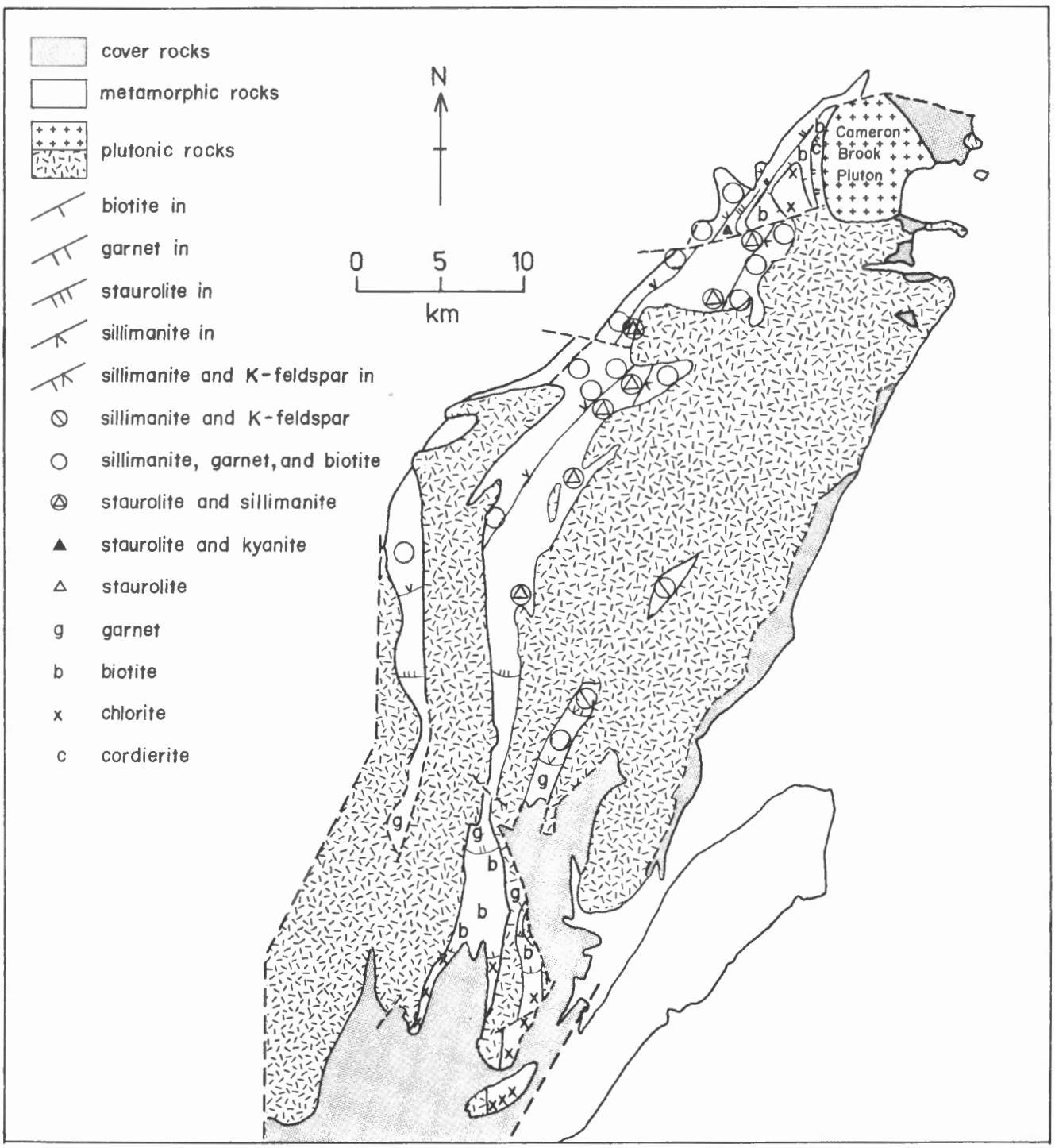

Figure 10. Metamorphic assemblages and isograds in the Bras d'Or Terrane.

Clyburn Brook area. These index minerals persist in the area of this study, although they appear to taper to the north as the outcrop width of the McMillan Flowage Formation thins. Throughout its outcrop area, the Roper Brook amphibolite displays hornblende-plagioclase-ilmenite assemblages, and all rocks to the west of the amphibolite are in the sillimanite zone.

In the block of McMillan Flowage Formation between the Clyburn Brook fault and the McMillan Flowage area, metamorphic grade is uniform in the staurolite and sillimanite-staurolite zones (Fig. 10). Sillimanite is only developed along the eastern and western margins of this block, and staurolite zone assemblages are typical of the central part of the belt.

To the south of McMillan Flowage, to the North River area, sillimanite-bearing assemblages are less common, mainly because the rocks of the McMillan Flowage Formation are dominantly quartzite or metabasite in this area. However, the persistence of amphibolites indicates that amphibolite facies conditions were achieved throughout this area.

South of the North River area, metamorphic grade continuously decreases through garnet, biotite, and chlorite zones in the rocks of the McMillan Flowage Formation. The Barachois River Metamorphic Suite also displays a decrease in grade, extending to subgreenschist facies lithologies in the Big Hill inlier.

The only pluton which intruded the McMillan Flowage Formation and developed a pronounced contact metamorphic aureole is the Cameron Brook Granodiorite. The aureole is narrow and is composed of a zone of spotted slates at 300 m distance from the contact, and successive zones involving the development of biotite, garnet, and cordierite in pelitic lithologies closer to the contact. Wiebe (1972) reported andalusite in some rocks, but this was not detected in the present study. These observations support the conclusion that the Cameron Brook Granodiorite is the youngest pluton in the Bras d'Or Terrane.

Retrograde metamorphism is less obvious in the Bras d'Or Terrane than in either the Aspy Terrane or the Blair River Complex. This is in part due to the lower grade of prograde metamorphism, but it appears that the Bras d'Or Terrane remained unaffected by the phase of muscovite blastesis which characterizes the retrograde metamorphism of the remainder of the northern highlands. Chloritization of micas and sericitization of feldspars is moderately pervasive, especially in rocks adjacent to the Clyburn Brook fault.

ECONOMIC GEOLOGY

Blair River Complex

The Meat Cove zinc deposit occurs in skarn in a sequence of marbles and minor schists which form a large xenolith within the Lowland Brook Syenite. Chatterjee (1979) described the mineralogy of the deposit and associated alteration. Sphalerite with subordinate pyrite, pyrrhotite, chalcopyrite, galena, and bornite are the main sulphide minerals. They occur in skarn bodies confined to the contact between the syenite and siliceous and dolomitic marbles.

Similar sulphide-bearing skarns occur in smaller marble xenoliths in Pine Brook and Sailor Cove Brook.

Aspy Terrane

The metavolcanic-granitoid associations of the Money Point Group represent potentially favourable environments for sulphide mineralization, and host numerous small polymetallic Cu, Zn, Au, Ag, Pb, and Fe showings in the western Cape Breton Highlands (e.g. Milligan, 1970; Ponsford and Lyttle, 1984). Macdonald and Smith (1980) reported approximately 35 minor metallic and related mineral showings in the Cape North Peninsula. During the present study, similar minor occurrences (mainly pyritic) were noted in the Money Point Group throughout the map area.

Little modern exploration has been done in the part of the map area which lies within the Cape Breton Highlands National Park. In the past, mica was mined from pegmatites associated with the Black Brook Granitic Suite.

Bras d'Or Terrane

Polymetallic sulphide showings in the Murray Mountain area occur in quartz-calcite veins in both the Murray Brook Granodiorite and the Price Point Formation. The granodiorite hosts mainly Cu-Mo-Au-bearing veins whereas the volcanic rocks of the Price Point Formation host Cu-Zn-Pb-Ag veins (Macdonald and Barr, 1985). However, based on their studies in the area, Macdonald and Barr (1985) concluded that both types of veins have a common origin. Muscovite from one of the veins gave a Cambrian K-Ar age, similar to the Rb-Sr age of the St. Anns Leucogranite.

Barren pyrite occurrences are also common in the various plutonic units of the Murray Mountain-Barachois River area (Macdonald and Barr, 1985), but are not yet known to be associated with any significant mineralization. During the present study, pyrite and chalcopyrite were noted in greisenized areas within unnamed granitic units intruded into the Ingonish River Tonalite. Pyrite occurs in many of the amphibolitic units and mafic dykes throughout the map area.

Gold was mined in the past in Franey Brook, a south-flowing tributary of Clyburn Brook, apparently associated with quartz veins in sheared gneissic rocks. This area is now within the Cape Breton Highlands National Park.

During construction of the Wreck Cove hydroelectric project, sulphide mineralization was discovered in skarns in McMillan Brook, an area now flooded by McMillan Flowage. The copper-zinc (+ minor Be, W, Mo, and Sn) mineralization was described by Chatterjee (1977). On the basis of the present study, the showing is within the middle clastic division of the McMillan Flowage Formation.

Recently, gold has been discovered by Inco Limited in the Bateman Brook Metamorphic Suite adjacent to the Kathy Road Dioritic Suite and near the Eastern Highlands shear zone. Few details about this mineralization have been released as yet.

IMPLICATIONS

Three contrasting tectonostratigraphic zones separated by major faults can be defined in the Cape Breton Highlands. The Blair River Complex of the northwestern highlands has lithological and age correlations with the Grenville Province of the Canadian Shield, like the Indian Head Range Complex and the Long Range Inlier of western Newfoundland (Williams, 1979). Whether this area is *in situ* basement or was tectonically transported is not certain. On the basis of aeromagnetic and deep seismic reflection data, Loncarevic *et al.* (in press) inferred that the Blair River Complex extends to the Moho and is not a thin crustal flake. They also reported that the nature of the crustal boundary between the Blair River Complex and the Aspy Terrane is unclear from seismic data: the Moho appears to be deeper under the Blair River Complex, and other reflections in the lower and middle crust appear to terminate against the interpreted boundary, suggesting that the boundary is very steep.

The Aspy Terrane, in the central part of the map area, consists of a metasedimentary, metavolcanic, and metaigneous assemblage, much of which appears to be Silurian or younger. The terrane has been extensively intruded by varied granitic rocks which range in age from Devonian to Early Carboniferous. Many of these show characteristics of crustal derivation and appear to be related to the Acadian Orogeny, and associated crustal thickening.

The Aspy Terrane displays many similarities in lithology and age relations to southwestern Newfoundland. Silurian rhyolites of the La Poile Group (eruption ages between 428 $\pm$ 6 Ma and 420 $+8/-3$ Ma) may be equivalent to volcanic units in the Sarach Brook and Jumping Brook metamorphic suites. Silurian metamorphism of the Port aux Basques Gneiss and Little Passage Gneiss (Dunning *et al.*, 1988) is similar in style to the middle Silurian to Early Devonian phase of high grade metamorphism in the Aspy Terrane. $^{40}Ar/^{39}Ar$ mineral cooling ages of biotite and hornblende from rocks north of the Gunflap Hills Fault in southwestern Newfoundland range from 384 to 378 Ma (Chorlton and Dallmeyer, 1986), like those of the Aspy Terrane (Reynolds *et al.*, in press).

The Bras d'Or Terrane forms the southeastern part of the map area. It consists of Precambrian eruptive and sedimentary rocks of the McMillan Flowage Formation, late Precambrian-Early Cambrian dioritic, tonalitic, granodioritic, and granitic intrusions, and possibly some younger plutons. Cooling ages from $^{40}Ar/^{39}Ar$ geochronology indicate that this terrane was uplifted before the onset of Acadian deformation (Reynolds *et al.*, in press), and was relatively unaffected by the Acadian Orogeny.

The Bras d'Or Terrane also displays some similarities in lithology and age relations to southwestern Newfoundland. In southwestern Newfoundland, the oldest dated tonalitic rocks of the Roti Granite (Bettys Pond) have given a zircon age of 563 $\pm$ 4 Ma, whereas the younger granodioritic portion (Roti Bay area) has yielded a zircon age of 499 $+3/-2$ Ma (Dunning *et al.*, 1988). These ages are almost identical to the ages of the tonalitic rocks of the Bras d'Or Terrane, and the Cape Smokey Pluton, respectively. In addition late Precambrian gneisses have recently been recognized in the Grey River Gneiss (O'Brien *et al.*, 1988).

The present arrangement of the three terranes appears to have been reached late in, or after, the Acadian Orogeny. In particular, the extensive dyke swarm emanating from the Black Brook Granitic Suite is absent from the Bras d'Or Terrane, implying separation of the two terranes up to the Middle Devonian. However, the Cameron Brook Granodiorite, which is located in the Bras d'Or Terrane, has more similarity to Aspy Terrane plutons, and may imply juxtaposition of the two terranes by the Early Devonian. Similarly, the absence of dykes related to the Wilkie Sugarloaf Granite in the Blair River Complex implies that this zone was distant from the Aspy Terrane during the Late Devonian. The correlation of the Andrews Mountain Granite across the Red River fault zone may mean that movement on this fault was slightly earlier than on the Wilkie Brook fault. All three terranes appear to have reached approximately their present configuration by the Early Carboniferous deposition of the Horton and Windsor groups, although late readjustments can be demonstrated on the Eastern Highlands shear zone, one splay of which brittly deformed Horton Group sedimentary rocks. Post-Early Carboniferous movements were responsible for a number of normal faults throughout the map area, the most prominent of which is the Aspy Fault.

Completion of basic geological mapping has led to more detailed follow-up studies in the Cape Breton Highlands. These have involved U-Pb and $^{40}Ar/^{39}Ar$ isotopic dating studies (Dunning *et al.*, in press; Reynolds *et al.*, in press) which have resolved some problems in age relationships and equivalence of units, investigation of the magnetic and gravity anomaly patterns and deep seismic reflection profiles (Loncarevic *et al.*, in press), and detailed studies of the petrogenesis of plutonic units, e.g. the Lowland Brook Syenite (Deveau, 1988) and the Black Brook Granitic Suite (Yaowanoiyothin, 1988).

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