Geology of the Guysborough - Mulgrave - L'Ardoise area: a progress report[1]

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Introduction

Mapping in the area between Lochaber Lake in northern mainland Nova Scotia and Loch Lomond in southern Cape Breton Island (parts of NTS sheets 11E/08, 11F/05, 06, 10, 11, 12 and 15) (Fig. 1) was begun in 1995. This project follows up on work done by Cormier (1994) in the area west of Guysborough, and by Smith (1980, 1981) in the area northeast of Guysborough. The purpose of the project is to better define rock units, stratigraphy, and the igneous, metamorphic, and structural history in the area providing an improved basis for evaluation of economic resource potential. This paper provides an overview of the results of the project to date, and outlines the additional work planned to tackle some of the unresolved geological problems. A preliminary map of the area has been published (White and Barr, 1998); in so far as possible, the terminology adopted for rock units follows the work of Smith (1980, 1981, and cited in more detail *in* Williams *et al.,* 1985).

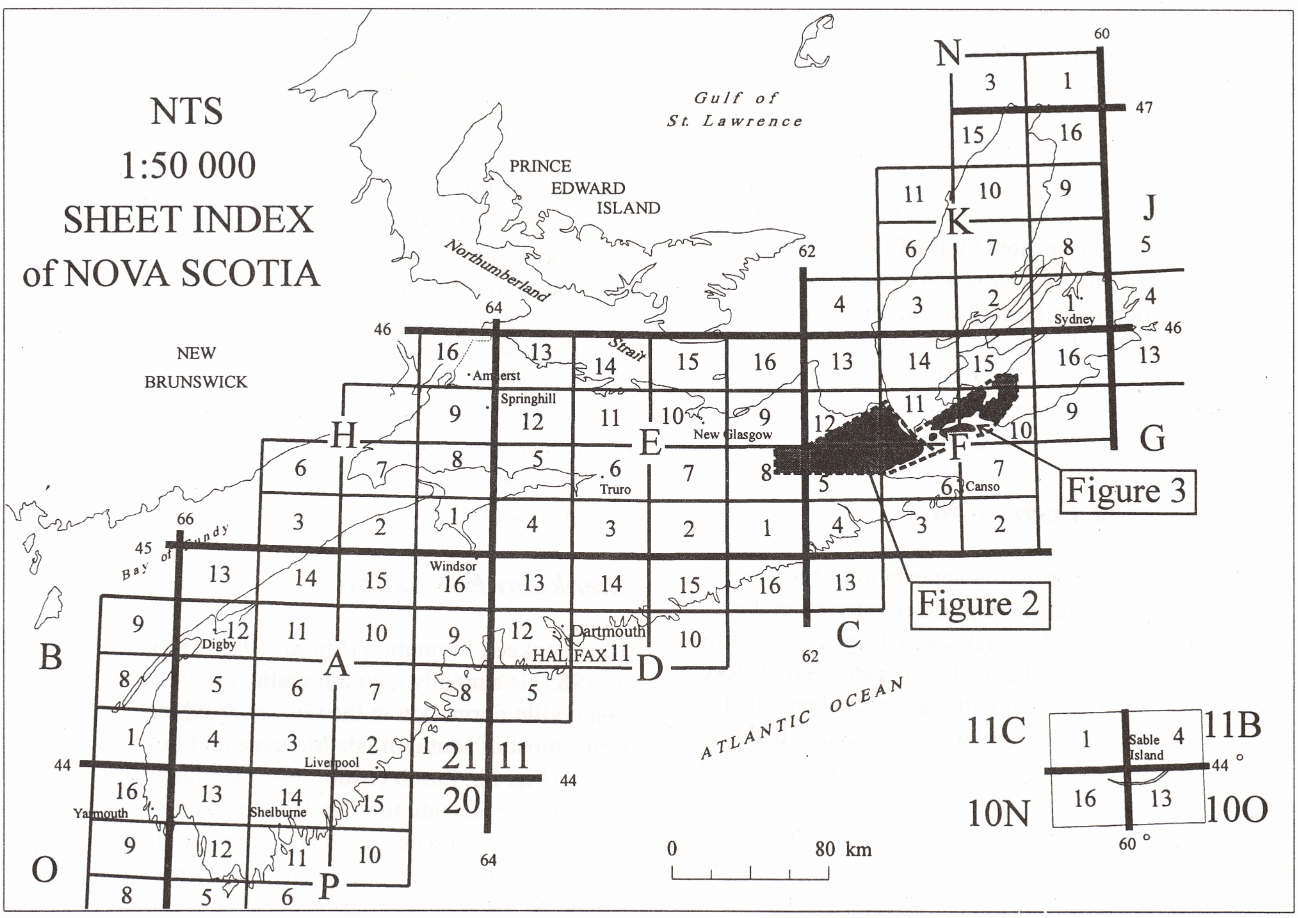

Figure 1. NTS index map for Nova Scotia showing the location of the mapped area (parts of 11E/08, 11F/05, 06, 10, 11, 12 and 15).

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Map Units

Guysborough Group

Introduction

A significant result of this project has been the recognition that the area located between the Chedabucto-Guysborough County Fault system in the south and the Roman Valley Fault in the north and extending through the southernmost part of Cape Breton Island, here termed the Guysborough block, is underlain by Middle Devonian volcanic and sedimentary rocks (Fig. 2). These rocks are referred to as the Guysborough Group, and preliminary subdivision includes five formations. The age of the Guysborough Group is constrained by a U-Pb (zircon) age of 389 ± 2 Ma for a rhyolitic tuff (Cormier *et al.*,1995) in the Hoppenderry Formation (see below), and a U-Pb (zircon and baddeleyite) age of 385 ± 2 Ma for the Erinville gabbro (Cormier *et al.*, 1995), which intruded the Roman Valley Formation (see below).

The Guysborough Group is in faulted contact with Carboniferous sedimentary rocks of the Horton Group on the north and west. On the south, the Guysborough Group is complexly truncated by the Chedabucto, Guysborough County, and subsidiary faults, which separate the group from faulted slivers of varied metamorphic rocks of uncertain age, metasedimentary rocks of the Meguma Terrane (Hill, 1987, 1991), and Carboniferous sedimentary rocks of the Horton Group in the St. Marys Basin (Murphy and Rice, 1998).

Minister Brook Formation

The Minister Brook Formation appears to be the oldest unit of the Guysborough Group and is exposed in the central part of the Guysborough block (Fig. 2). It consists of: (1) light grey, thickly bedded, feldspathic greywacke to quartzwacke interlayered with dark grey, laminated siltstone, and (2) slate with brown-grey, thickly bedded, medium grained subarkose beds. Rare, grey, massive to faintly bedded, quartz arenite beds occur throughout the formation, as well as thin (<10 cm) beds or lenses of dark grey to black, clast-supported conglomerate. Clasts (<2 cm in diameter) include quartz arenite and other intraformational sedimentary rocks. Along the faulted southern margin of the formation, small lenses of dark grey to green, amygdaloidal to massive basalt are locally interlayered with black, basaltic, lithic lapilli tuff.

Sunnyville Formation

The name Sunnyville Formation (Mooney, 1990; Cormier *et al.*, 1995) is retained for a distinct package of volcanic and sedimentary rocks within the Guysborough block. The mainly sedimentary part of the formation is in gradational contact with the underlying Minister Brook Formation. These rocks consist of mainly maroon to grey, polymictic pebble conglomerate interlayered with minor maroon to red-brown subarkose and sublitharenite and minor basalt and basaltic tuff. The conglomerate is typically well indurated, poorly sorted, immature, and matrix supported. Clasts are predominantly sedimentary, with minor basalt and rhyolite. Subarkose and sublitharenite layers (<2 m thick) are typically of limited lateral extent, are massive to well bedded, and locally display trough cross-stratification and ripple marks. Rare grey to dark green basaltic flows (5-10 m thick) are associated with dark grey to black basaltic lithic lapilli tuff.

The mainly volcanic unit of the Sunnyville Formation consists of dark maroon to grey basalt and andesite flows interlayered with minor maroon to grey polymictic breccia and conglomerate and maroon to grey-green siltstone. The flows are typically fine- to medium-grained, vary from massive to amygdaloidal, and locally contain plagioclase phenocrysts. Amygdaloidal flow tops and peperitic textures are common, indicating extrusion on a muddy substrate. The breccia and conglomerate are poorly sorted and vary from matrix to clast supported. Large clasts are predominantly composed of basalt and chert, whereas the matrix consists of volcanic and sedimentary clasts and broken plagioclase crystals. These rocks probably represent reworked mafic lithic lapilli tuff.

Glenkeen Formation

The Glenkeen Formation (Smith, 1980, 1981; Williams *et al.*,1985) is a mainly conglomeratic unit that overlies the Sunnyville Formation in the Guysborough area and also forms most of southern Isle Madame and Petit-de-Grat Island (Fig. 3). Smith (1980, 1981; Williams *et al.*, 1985) assigned the formation to the Horton Group and suggested the presence of an angular unconformity between the Glenkeen and Sunnyville formations. However, observations during the present study suggest that the two formations are conformable and that the Glenkeen Formation is part of the Guysborough Group.

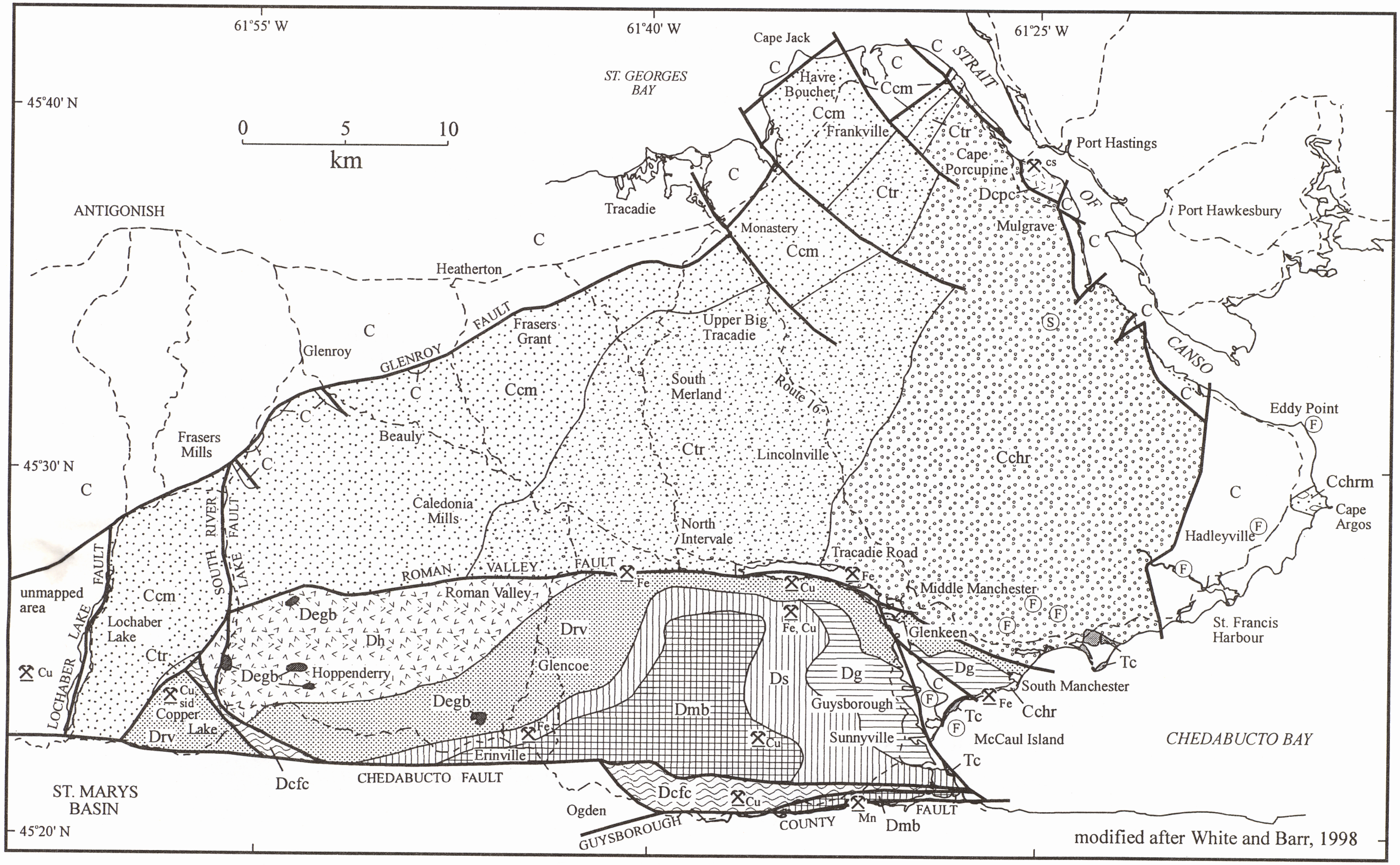
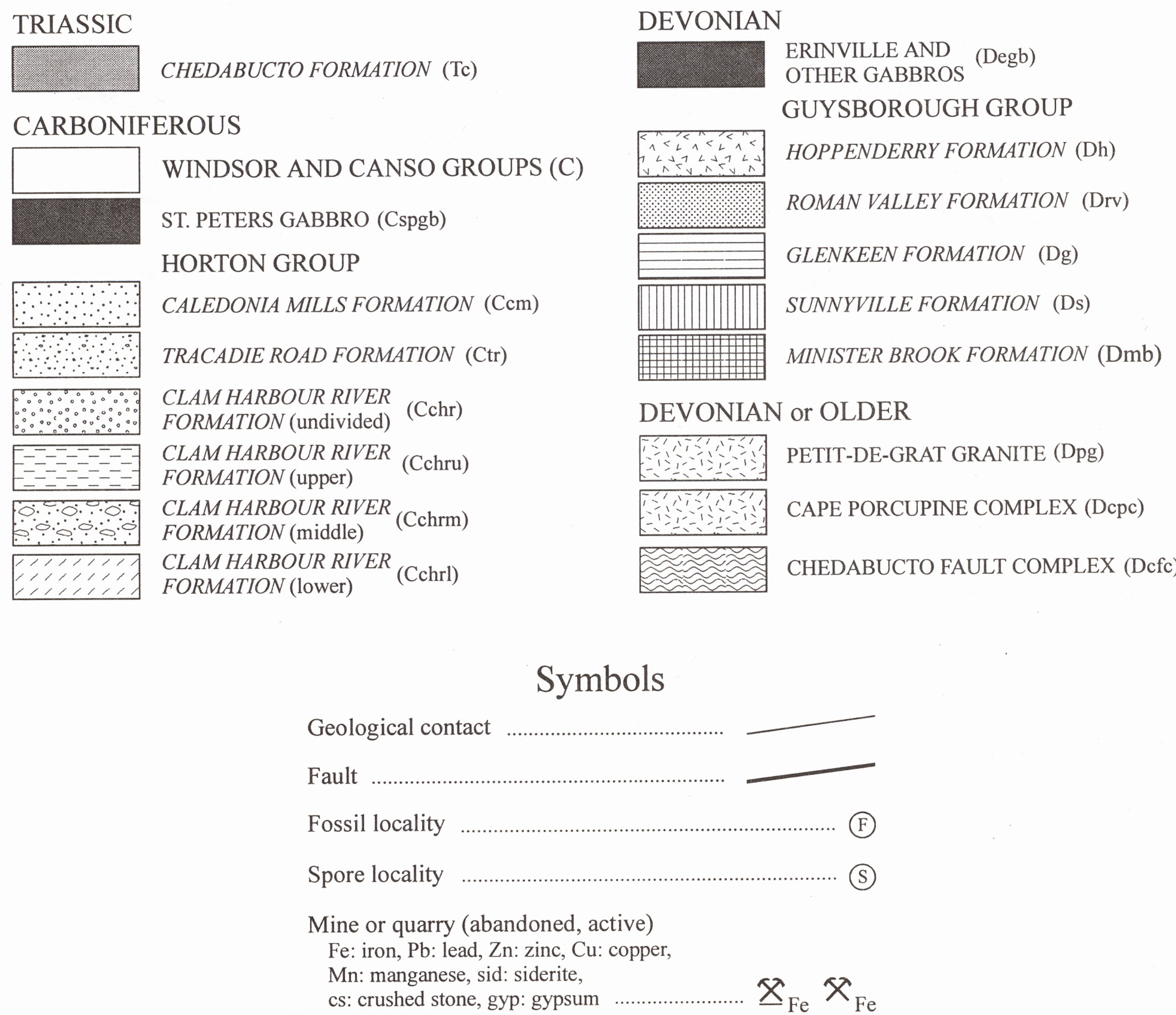


Figure 2. Simplified geological map of the western part of the mapped area, northern mainland Nova Scotia.

Legend For Figures 2 and 3



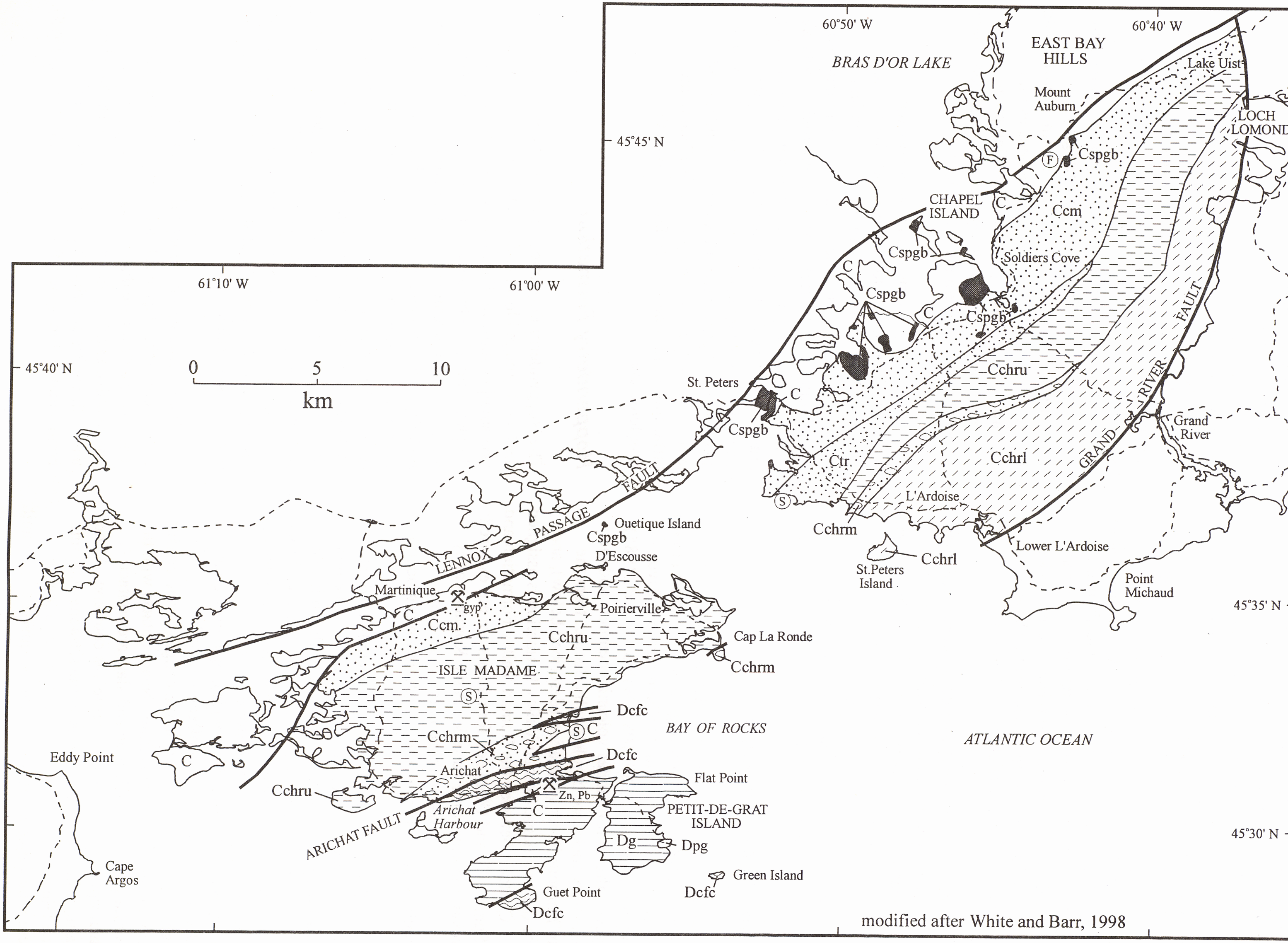


Figure 3. Simplified geological map of the eastern part of the mapped area, southern Cape Breton Island.

The Glenkeen Formation consists mainly of polymictic, well indurated conglomerate. In the Guysborough area, the formation is predominantly a maroon to grey, massive, immature, poorly sorted, typically matrix supported pebble- to cobble-conglomerate. Clasts consist mainly of basalt, with subordinate red quartz arenite and siltstone. On Petit-de-Grat Island the formation is grey to red, contains cobble- to locally boulder-size clasts, typically massive, poorly- to well-sorted, and clast supported. Clasts are predominantly composed of red felsic volcanic rocks, quartzite and siltstone, with rare andesitic clasts; however, toward the north quartzite clasts predominate.

In both areas, the conglomerate is interlayered with minor maroon subarkose and maroon to grey siltstone. Also present are red and purple volcanogenic breccia and conglomerate, similar to those in the Sunnyville Formation, and associated dark grey, coarse grained, tuffaceous sandstone, rare, dark grey, basaltic flows (<5 m thick), and lithic lapilli tuff.

Roman Valley Formation

The Roman Valley Formation underlies much of the northern part of the Guysborough block. Cormier (1994) included these rocks within the Clam Harbour River Formation of Smith (1980, 1981; Williams *et al.*, 1985). However, this unit includes volcanic members and the sedimentary rocks are lithologically distinct from the Clam Harbour River Formation (described below), and hence the new name Roman Valley Formation is assigned here. Contacts between the Roman Valley Formation and the Sunnyville and Glenkeen formations are not exposed; however, the sandstone varieties in the Roman Valley Formation are similar to those in the underlying formations, suggesting that the relationship is gradational.

The Roman Valley Formation is subdivided into three units (too small to show on Figure 2). One unit consists mainly of black to dark grey, well-laminated siltstone and slate, similar to those in the Minister Brook Formation. The slate weathers rust-brown where pyrite nodules are present. The siltstone and slate are interlayered with thin (<5 cm wide), light grey quartz wacke and minor dark grey oligomictic pebble conglomerate lenses. Clasts in the conglomerate consist predominantly of quartz arenite. Near contacts with the Erinville gabbro, the siltstone and slate are contact metamorphosed and spotted hornfels is common. Minor basaltic lithic lapilli tuff occurs in the siltstone/slate unit in the Glencoe area. The unit pinches out to the east where it becomes interbedded with the quartz arenite unit. The siltstone/slate unit is host to the Copper Lake Cu-siderite deposit.

A second unit consists of grey, massive to well-laminated, quartz arenite to subarkose interlayered with weakly laminated, quartz wacke and feldspathic greywacke. The rocks are typically fine grained, and bedded on a scale of 10s of centimetres; cross-stratification, ripple marks, and graded bedding are locally preserved. Minor, thin (<5 cm), grey, well-laminated siltstone and slate are common throughout the unit. Pyrite locally occurs in slate beds as thin (<2 mm thick) stringers parallel to bedding planes. Thin (<1 cm), brown to orange dolomitic lenses and beds were observed in the northern part of the unit.

The third unit consists of brown to orange, polymictic pebble conglomerate, quartz arenite, and quartz wacke interlayered with grey to green laminated siltstone. The conglomerate is massive, well indurated, poorly sorted, and typically matrix supported. Clasts are mainly sedimentary in origin, with minor basalt and rare granodiorite fragments. The quartz arenite is fine grained, weakly laminated, and forms thin (<20 cm thick) layers. Minor, grey basalt flows (5-20 m thick), lithic lapilli tuff, and rare, coarse grained, well-laminated, tuffaceous sandstone are interlayered with the conglomerate.

Hoppenderry Formation

The Hoppenderry Formation occurs in the western part of the Guysborough block, and is subdivided into four units (too small to show on Figure 2) which include: (1) a rhyolitic unit, (2) a basaltic unit, (3) a conglomeratic unit, and (4) a quartz arenite unit. The rhyolitic unit includes both rhyolite flows and welded tuff. Flows are buff to purple, locally flow banded and spherulitic, and quartz-feldspar phyric. Associated pyroclastic rocks include rhyolitic lithic crystal and lithic crystal vitric lapilli tuff. The former ranges from dark grey to buff to purple, and displays well-developed layering and flow-banding. The vitric tuff is massive, pale green, and consists of a glassy matrix of shards with quartz and anorthoclase grains.

The basaltic unit includes flows with minor interlayered lithic lapilli tuff and rare green-grey siltstone. The basaltic flows are dark to light green, fine grained, and massive to amygdaloidal. The basalts are tholeiitic and both basalts and rhyolites apparently formed in a continental within-plate rift setting (Cormier *et al.*, 1995).

The conglomeratic unit is predominantly orange, polymictic, pebble- to cobble-conglomerate. The conglomerate is immature, well indurated, poorly sorted, and matrix supported, and contains clasts of quartzite, siltstone, tuff and granite. Basaltic flows and tuffs are locally interlayered with the conglomerate and appear identical to those in the underlying basaltic unit.

The quartz arenite unit consists mainly of grey, massive to well-laminated quartz arenite and quartz wacke, interlayered with grey to green, laminated siltstone, slate, and rare basaltic lithic lapilli tuff and thin (<1 cm wide), brown dolomitic beds.

Gabbroic Rocks

Gabbroic dykes and sills, generally <5 m wide, are common in all formations of the Guysborough Group. In addition, small gabbroic plutons occur at scattered locations throughout the Guysborough block. The gabbroic rocks range from dark green to black, and from fine- to coarse-grained. They display intergranular to subophitic textures, and consist mainly of plagioclase and clinopyroxene (augite), and accessory amounts of opaque phases, apatite and titanite. The gabbro pluton west of Hoppenderry contains up to 30% forsteritic olivine. The Erinville gabbro contains abundant apatite (3%) compared to the other gabbros. Drill core from the Erinville gabbro indicates that it becomes increasingly anorthositic with depth (Cormier, 1994; Dickie, 1989).

Horton Group

Introduction

The area north of the Guysborough block is assigned to the Horton Group based on lithological similarities to Horton Group strata in the St. Marys Basin (Murphy and Rice, 1998) and western Cape Breton Island (e.g. Giles *et al.,* 1997) and sparse palynological evidence (White and Barr, 1998). The group is divided into three northeastward-trending formations that young toward the northwest (Figs. 2, 3).

Clam Harbour River Formation

The Clam Harbour River Formation underlies a large area between the Roman Valley Fault and the Strait of Canso (Fig. 2), as well as in the Isle Madame-Loch Lomond area (Fig. 3). In southern Cape Breton Island, the formation is subdivided into three units, but an equivalent subdivision cannot yet be made in the mainland part of the formation. Smith (*in* Williams *et al.,* 1985) recognized two formations in the area northeast of Guysborough, but our mapping is not yet sufficiently detailed to make such a subdivision. The formation was intruded by rare, narrow (<5 m wide), mafic dykes. It appears to be broadly equivalent to the Creignish Formation of the Horton Group in western Cape Breton Island (Williams *et al.,* 1985).

The lower unit of the Clam Harbour River Formation is well exposed along the coast south of L'Ardoise (Fig. 3). The rocks are in faulted contact with mainly Neoproterozoic rocks to the southeast (Barr *et al.,* 1996) and hence the base is not exposed. This unit consists predominantly of light grey to white quartz arenite interlayered with minor black laminated siltstone, shale and conglomerate. The quartz arenite forms layers up to 5 m thick and is typically medium- to coarse-grained and massive, although it is locally well laminated and cross-stratified, and contains abundant quartz veins. The black laminated siltstone and shale layers are typically 2-5 m thick and contain thin (<5 cm wide), fine grained quartz arenite beds and lenses, as well as rare, thin (<1 cm thick), cream coloured limy layers. Slump folds and crosslaminations are locally preserved in these fine grained quartz arenite interbeds. Thin (10-20 cm thick) beds or lenses of matrix-supported, poorly indurated, grey, polymictic pebble conglomerate also occur in the quartz arenite. Clasts are generally up to 2 cm in diameter and are intraformational, composed of black shale and quartz arenite.

The middle unit of the Clam Harbour River Formation is narrow (<1500 m thick), and extends from Cape Argos through Isle Madame to north of L'Ardoise (Figs. 2, 3). It is in sharp, but conformable contact with the underlying quartz arenite unit, and consists predominantly of red to grey massive polymictic boulder conglomerate/breccia, locally interlayered with grey quartz arenite and red arkose and siltstone. The conglomerate/breccia is poorly indurated, clast to matrix supported, and poorly sorted. Clasts include quartzite and siltstone, with subordinate rhyolite, basalt, granite and diorite. On Isle Madame, clasts include amphibolite and mylonite and in this area the unit may have originally, unconformably, overlain the Chedabucto Fault Complex (see below). The quartz arenite and arkose/siltstone layers are 0.5-5 m thick, massive to laminated, and commonly display graded bedding and cross-stratification.

The upper unit of the Clam Harbour River Formation consists of light grey to green to maroon quartz arenite and siltstone interlayered with grey to black laminated siltstone. The quartz arenite (1-5 m thick) is fine- to coarse-grained, typically laminated, and locally cross-stratified and rippled. Carbonized plant remains are rare. The black laminated siltstone is locally interlayered with thin (<2 cm thick) quartz arenite and rare dolomitic lenses. On Isle Madame, polymictic pebble to boulder conglomerate is commonly interlayered with the arenite and siltstone. The conglomerate is maroon to grey and closely resembles conglomerate in the middle part of the formation.

Tracadie Road Formation

The Tracadie Road Formation (Smith *in* Williams *et al.*, 1985) is predominantly siltstone and is well exposed along Route 16. It is interpreted to be broadly equivalent to the lower (Strathlorne) part of the Strathlorne-Ainslie Formation of the Horton Group in western Cape Breton Island (Williams *et al.*, 1985). The formation is mainly grey to black laminated siltstone interlayered with light grey, fine- to coarse-grained quartz arenite layers (2 cm to 2 m in thickness). Brown dolomitic lenses and beds, <2 cm thick, are common, and polymictic pebble conglomerate layers, <50 cm thick, are a minor component. The conglomerate is matrix supported and moderately well indurated and sorted. It contains clasts of quartzite, siltstone, and other sedimentary lithologies. The quartz arenite layers are more abundant and thicker toward the base of the formation, and the contact with the underlying Clam Harbour River Formation is gradational.

Caledonia Mills Formation

The Caledonia Mills Formation is a new name suggested for a previously unnamed sequence of rocks that gradationally overlies the Tracadie Road Formation. The formation appears to be equivalent to the upper (Ainslie) part of the Strathlorne-Ainslie Formation of the Horton Group in western Cape Breton Island (Williams *et al.*, 1985). East of St. Peters (Fig. 3), the formation has been intruded by minor, narrow (5 m wide), mafic dykes probably related to the St. Peters gabbro (Barr *et al.*, 1994).

The Caledonia Mills Formation consists predominantly of red to maroon siltstone and arkose, with less abundant quartz arenite, conglomerate and limestone. The siltstone contains abundant detrital muscovite, and locally has small, grey reduction spots. Arkosic units are fine- to medium-grained, locally well laminated and cross-stratified, and form beds up to 0.5 m thick. Grey, massive to well laminated, fine grained quartz arenite, forming layers up to 5 m wide, is interbedded with the siltstone and may contain abundant plant fragments. Rare, light grey limestone lenses and grey polymictic conglomerate also occur locally. These conglomerates are well indurated, vary from grey to red, and contain volcanic, sedimentary, and may contain granitic clasts. Grey to green laminated siltstone is locally interlayered with the red to maroon siltstone.

St. Peters Gabbro, Minor Basalt, and Mafic Dykes and Sills

Small bodies of gabbro, minor basalt, and related dykes and sills occur in the St. Peters area. Their age is well constrained by U-Pb dating at 339 ± 1 Ma (Barr *et al.*, 1994), so they appear to have been intruded more or less after deposition of the Horton Group and before the Windsor Group. Plagioclase and clinopyroxene predominate, with minor amphibole, biotite, and accessory phases. Their chemical characteristics suggest that they are tholeiitic and formed in a continental within-plate tectonic setting (Barr *et al.*, 1994).

Windsor and Canso Groups

The Windsor and Canso groups occur mainly around the fringes of the mapped area, in faulted or unconformable contacts with the units described above. They generally consist of red, green and grey siltstone interbedded with sandstone, shale and mudstone. Carbonized plant remains are locally quite abundant. Well-laminated grey limestone, massive fossiliferous limestone, and gypsum are minor components.

Locally, areas of Macumber Formation, the lowest member of the Windsor Group, occur on the northwestern margin of the mapped area southeast of the Glenroy Fault. These areas consist of grey, laminated, locally fossiliferous limestones that lie conformably on redbeds (Boehner and Giles, 1993) which we assign to the Caledonia Mills Formation.

Triassic Rocks

Small areas of Triassic strata occur east of Guysborough, and were informally termed the Chedabucto Formation by Tanner (1997). They consist of red to brown, polymictic pebble to cobble conglomerate, sandstone and shale. The conglomerate is typically poorly indurated, poorly sorted, matrix supported, and includes volcanic, sedimentary and plutonic clasts. The sandstone is fine- to medium-grained and consists predominantly of arkose. Cross-stratification and grey reduction spots are common. Vertebrate fossils occur in strata northeast of McCaul Island (Stevenson, 1964). Contacts with older rocks are angular unconformities or faults.

Metamorphic and Granitic Rocks

Chedabucto Fault Complex

Varied metamorphic rocks that occur in a zone broadly associated with the Chedabucto and subsidiary faults are here grouped together as the Chedabucto Fault Complex. They occur in the area southwest of Hoppenderry in the western part of the mapped area, in a narrow belt between the Chedabucto and Guysborough County faults, and on Isle Madame and Green Island. Although contacts between these rocks and adjacent units are not exposed, it is clear that they have been faulted into their present positions. The belt between the Chedabucto and Guysborough County faults is mainly composed of strongly laminated and foliated phyllonite, but includes at least one area of garnet sillimanite schist. In thin section, micas in the phyllonite show extreme parallelism, and pressure shadows occur around quartz grains. The garnet sillimanite schist contains fine grained quartz, red-brown biotite, sillimanite and garnet, with bands and lenses of disaggregated quartz, oriented parallel to the foliation. The western fault-bounded area consists of mylonitic amphibolite and sheared granitoid rocks. On Isle Madame and Green Island, amphibolite predominates, with minor areas of garnet sillimanite schist, chlorite schist, quartzite, basalt, and granitic mylonite (Barr *et al.*, 1992).

The ages of these varied rocks are uncertain. Amphibole from amphibolite on Green Island yielded a Devonian $^{40}Ar/^{39}Ar$ cooling age of ca. 391 ± 4 Ma (Keppie, 1982). Similar types of rocks are exposed, west of the mapped area, along the Cobequid-Chedabucto Fault system in the Melrose area (Edmonds, 1990) and at Clarke Head; the latter have yielded Devonian U-Pb and Carboniferous $^{40}Ar/^{39}Ar$ dates (Gibbons *et al.*, 1996).

Cape Porcupine Complex

In the Cape Porcupine area, on the Strait of Canso, coarse grained granite, with minor granodiorite and diorite and mafic dykes, occur in association with mylonitic and phyllonitic rocks (Barr *et al.*, 1992). The mylonitic rocks include granite and probable metasedimentary lithologies, whereas the phyllonites are metasedimentary and contain abundant muscovite and biotite. Minor brecciated tuffaceous(?) rocks are also present. The complex occurs in faulted contact with the Clam Harbour River Formation. A sample from the granitic part of the complex is being dated by the U-Pb (zircon) method to try to resolve the age of this assemblage.

Petit-de-Grat Granite

The Petit-de-Grat Granite is a small body located on the southeastern tip of Petit-de-Grat Island. A smaller body of similar granite occurs to the west near Guet Point on Isle Madame (not shown on map because of scale). The granite produced a contact metamorphic aureole in the adjacent Glenkeen Formation, which in that area includes mafic volcanic rocks and dykes that were previously included in the Fourchu Group (Weeks, 1964). The petrochemistry of the granite was described by Barr *et al.* (1982), who inferred a Carboniferous age based on Rb-Sr dating.

Structural Features

Introduction

Within the mapped area two structural domains with contrasting structural geometries and histories are recognized. Domain I includes the sedimentary and volcanic rocks of the Devonian Guysborough Group on mainland Nova Scotia (Fig. 4). They are typically unmetamorphosed, although locally reach chlorite grade of greenschist facies metamorphism. Domain II includes rocks and structures related to the Carboniferous Horton Group, which have been further subdivided into smaller domains in order to define the character of regional-scale structures.

Domain I

Based on the distribution of map units, Cormier (1994) interpreted the Guysborough Group to have been folded into a regional northeastward-plunging anticlinal fold that was refolded about an east-west trending fold axis. However, poles to bedding form a broad girdle of points (Fig. 4a) defining a shallow northeastward-plunging fold axis (044/34) and poles to cleavage (Fig. 4a) form a cluster with an average cleavage that strikes northeast and is steep (045/90). These data suggest that the structures observed in the Guysborough Group are related to one episode of deformation. The deformation in this area may have been related to dextral movements along the bounding faults which resulted in the development of a positive flower structure (Webster, 1996; Webster *et al.*, 1998).

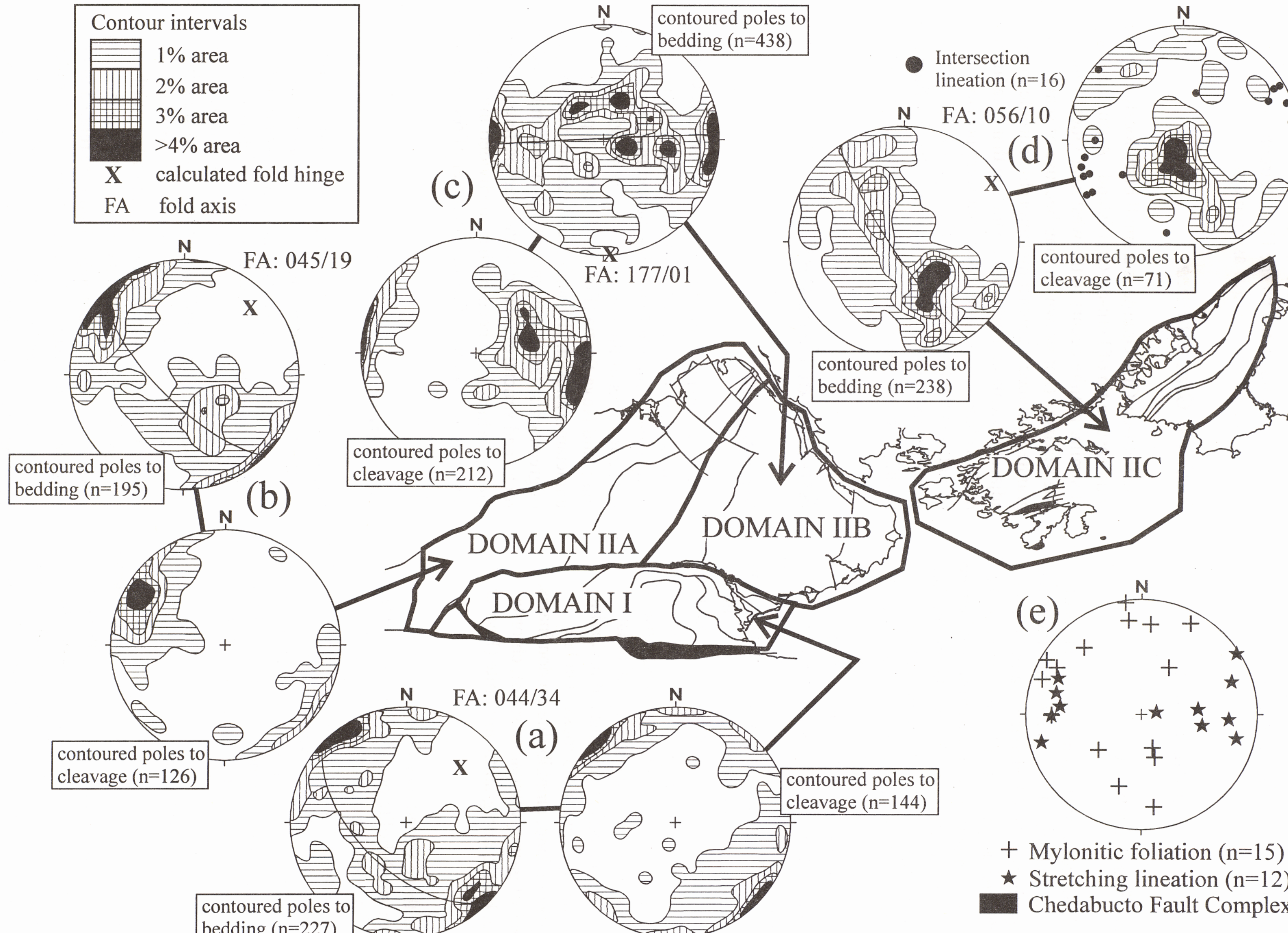


Figure 4. Summary of structural data from the mapped area, northern mainland Nova Scotia and southern Cape Breton Island. (a) Domain I, Guysborough Group; (b) Domain IIA, Horton Group (western); (c) Domain IIB, Horton Group (central); (d) Domain IIC, Horton Group (eastern); (e) Chedabucto Fault Complex.

Domain II

Domain II (Horton Group) occupies the area north of the Guysborough Group and has been subdivided into three smaller subareas (Fig. 4). Domain IIA (Fig. 4b) is the most westerly part of Domain II and is characterized by open to tight, upright to slightly inclined folds with a moderately developed axial planar cleavage. Poles to bedding form a girdle distribution with shallow northeastward-plunging fold axis (045/19). Poles to cleavage form a well-defined cluster with an average cleavage that strikes north-northeast and dips steeply to the southeast (036/78SE).

Domain IIB (Fig. 4c) is to the east of Domain IIA and is characterized by tight to close, upright, subhorizontal folds with a weakly to locally strongly developed axial planar cleavage. In contrast to Domain IIA, folds in Domain IIB are north-south trending. Poles to bedding define an east-west-trending girdle with a very shallow southward plunging fold axis (177/01). Poles to cleavage are more scattered, but still indicate northward-striking, steeply- to moderately-westward dipping features.

Domain IIC (Fig. 4d) is the most easterly part of Domain II and extends from Isle Madame to Loch Lomond. In the L'Ardoise-Loch Lomond area exposed folds are typically isoclinal and recumbent with a prominent subhorizontal cleavage and a shallow northeast-southwest intersection lineation whereas on Isle Madame folds are open upright structures with a poorly developed cleavage. Poles to bedding form a girdle distribution about a shallow northeastward plunging axis (056/10). Poles to cleavage form a well-defined cluster indicative of a subhorizontal feature.

Faults

The most significant faults in the mapped area are the east-west-trending dextral Chedabucto and Roman Valley faults (Fig. 2) that are part of the Minas Fault system (Webster, 1996; Webster *et al.,* 1998). Splays from this fault system bound the Glenkeen Formation on Petit-de-Grat Island (Fig. 3) where mylonitic foliation are generally anastomosing with variable dips (Fig. 4e) and shallow east-west-plunging stretching lineations. Other major faults trend northeast, such as the Glenroy, Lennox Passage, and Grand River faults (Figs. 2, 3). Less major faults trending northwest are common along the northernmost part of northern mainland, and offset the Glenroy Fault (Fig. 2). Northward-trending faults in the westernmost part of the mapped area locally contain mylonitic textures (e.g. Lochaber Lake Fault of Murphy *et al.,* 1991 and South River Lake Fault).

Economic Geology

Minor metallic mineral showings occur throughout the mapped area. Specular hematite commonly occurs on fractures and in veins throughout the area, but is especially abundant in rocks of the Guysborough Group. Specular hematite was mined from a large vein near South Manchester (Stevenson, 1964) and from smaller veins throughout the Guysborough block (Nova Scotia Mineral Occurrence Database). Locally specular hematite is associated with chalcopyrite. Lead and zinc minerals were mined in Windsor limestone near Arichat Harbour (Weeks, 1964), and gypsum was quarried near Lennox (Collins, 1962). Chalcopyrite and siderite were mined from veins near Copper Lake in the Roman Valley Formation (e.g. MacDonald, 1937), and siderite veins are also common in the Tracadie Road Formation. Copper and manganese occur in phyllonite of the Chedabucto Fault Complex near the Chedabucto Fault (Hill, 1991).

Gabbro bodies near Erinville and South River Lake have been quarried for 'black granite' (Dickie, 1989). Granite at Cape Porcupine is quarried for crushed stone (Graves, 1990).

Conclusions

The Guysborough-Mulgrave-L'Ardoise mapping project has led to a new perspective on the geology in this area of limited previous geological investigation. However, further mapping is planned to verify the distribution and contact relations among units in the Guysborough and Horton groups. For example, subdivision of the Clam Harbour River Formation in the area between the Roman Valley Fault and the Strait of Canso should be possible with more detailed mapping. Formalization of unit names and establishment of type sections is required, and additional age control and more detailed structural studies are needed to resolve stratigraphic uncertainties in the Horton Group, and to compare the formations to those established in the St. Marys Basin (Murphy and Rice, 1998) and in western Cape Breton Island (Giles *et al.,* 1997). The extent of the units defined in this study in the area west of Lochaber Lake will be investigated, and is of particular importance because of copper mineralization in this area (e.g. Benson, 1974). Lithologies of clasts in conglomeratic units in both the Guysborough and Horton groups will be examined to establish provenance, as done by Murphy and Rice (1998).

Additional geochemical studies will be done to assess stratigraphic variations in volcanic rock composition in the Guysborough Group, and petrologic studies of the mylonitic amphibolitic and granitic lithologies within the Chedabucto Fault Complex will be done to determine the origin and tectonic setting of these units.

Acknowledgments

We thank Peter Giles, Bob Boehner, Bob Ryan and Paul Smith for the many helpful discussions of the geological relationships of northern mainland Nova Scotia and southern Cape Breton Island. Rob Naylor is thanked for numerous discussions regarding the sedimentological and stratigraphic aspects of the Horton Group. We also thank Rick Horne for his helpful review of this paper, and editor, Kathy Mills for her helpful suggestions.

References

Barr, S. M., O'Reilly, G. A. and O'Beirne, A. M. 1982: Geology and geochemistry of selected granitoid plutons of Cape Breton Island; Nova Scotia Department of Mines and Energy, Paper 82-1.

Barr, S. M., White, C. E. and Graves, M. 1992: Meguma Terrane in southern Cape Breton Island?; Atlantic Geology, v. 28, p. 194.

Barr, S. M., Grammatikopoulos, A. L. and Dunning, G. R. 1994: Early Carboniferous gabbro and basalt in the St. Peters area, southern Cape Breton Island, Nova Scotia; Atlantic Geology, v. 30, p. 247-258.

Barr, S. M., White, C. E. and Macdonald, A. S. 1996: Stratigraphy, tectonic setting, and geological history of Late Precambrian volcanic-sedimentary-plutonic belts in southeastern Cape Breton Island, Nova Scotia; Geological Survey of Canada, Bulletin 468.

Benson, D. G. 1974: Geology of the Antigonish Highlands; Geological Survey of Canada, Memoir 376.

Boehner, R. C. and Giles, P. S. 1993: Geology of the Antigonish Basin, Antigonish County, Nova Scotia; Nova Scotia Department of Natural Resources, Mines and Energy Branches, Memoir 8.

Collins, G. A. 1962: Arichat map area, 11F/11E, Richmond-Inverness counties, Nova Scotia, Canada; Geological Survey of Canada, Open File 18.

Cormier, C. F. M. 1994: Field relations, petrology, and age of volcanic and associated sedimentary and gabbroic rocks in the Guysborough area, Nova Scotia; M.Sc. thesis, Acadia University, Wolfville, Nova Scotia.

Cormier, C. F. M., Barr, S. M. and Dunning, G. R. 1995: Geological setting, petrology, and age of volcanic and gabbroic rocks in the Guysborough area, Nova Scotia; Atlantic Geology, v. 31, p. 153-166.

Dickie, G. B. 1989: Building stone project; *in* Mines and Minerals Branch, Report of Activities 1989, Part A, eds. D. R. MacDonald and K. A. Mills; Nova Scotia Department of Mines and Energy, Report 89-3, p. 31.

Edmonds, S. L. 1990: Petrology of dioritic and gneissic rocks in the Melrose area, eastern Nova Scotia; B.Sc. honours thesis, Acadia University, Wolfville, Nova Scotia.

Gibbons, W., Doig, R., Gordon, T., Murphy, J. B., Reynolds, P. and White, J. C. 1996: Mylonite to megabreccia: tracking fault events within a transcurrent terrane boundary in Nova Scotia, Canada; Geology, v. 24, p. 411-414.

Giles, P. S., Hein, F. J. and Allen, T. L. 1997: Bedrock geology of Margaree (11K/06), Cape Breton Island, Nova Scotia; Geological Survey of Canada, Open File 3254, scale 1:50 000, map with marginal notes.

Graves, M. 1990: Geology and lithological correlation of Cape Porcupine, Aulds Cove, Guysborough County, Nova Scotia; Atlantic Geology, v. 26, p. 171.

Hill, J. D. 1987: Geology of the Guysborough-Country Harbour area, Nova Scotia; *in* Current Research, Part A; Geological Survey of Canada, Paper 87-1A, p. 415-422.

Hill, J. D. 1991: Petrology, tectonic significance and economic potential of Devonian peraluminous granitoid plutons in the Canso and Forest Hill areas, Eastern Meguma Terrane, Nova Scotia; Geological Survey of Canada, Bulletin 383.

Keppie, J. D. 1982: The Minas Geofracture; *in* Major Structural Zones and Faults of the Northern Appalachians, eds. P. St-Julien and J. Beland; Geological Association of Canada, Special Paper 24, p. 263-280.

MacDonald, D. F. 1937: Final report on the Copper Lake prospect and the Lochaber copper prospect, Antigonish

County, Nova Scotia; Nova Scotia Department of Mines, Assessment Report 13-B-11(01).

Mooney, S. 1990: Stratigraphy of two late Paleozoic basins: implications for the timing of final emplacement of the Meguma Terrane; M.Sc. thesis, Lakehead University, Thunder Bay, Ontario.

Murphy, J. B., Keppie, J. D. and Hynes, A. J. 1991: The geology of the Antigonish Highlands, Nova Scotia; Geological Survey of Canada, Paper 89-10.

Murphy, J. B. and Rice, R. J. 1998: Stratigraphy and depositional environment of the Horton Group in the St. Marys Basin, central mainland Nova Scotia; Atlantic Geology, v. 34, p. 1-25.

Smith, P. K. 1980: Geology of the Guysborough area, Guysborough County, Nova Scotia; *in* Mineral Resources Division, Report of Activities 1979, ed. K. A. McMillan; Nova Scotia Department of Mines and Energy, Report 80-1, p. 109.

Smith, P. K. 1981: Horton Group stratigraphy in the Guysborough area, Nova Scotia; *in* Mineral Resources Division, Report of Activities 1980, ed. K. A. Mills; Nova Scotia Department of Mines and Energy, Report 81-1, p. 37.

Stevenson, I. M. 1964: Geology, Chedabucto Bay, Nova Scotia; Geological Survey of Canada, Map 1156A, scale 1:63 360.

Tanner, L. H. 1997: The Chedabucto Formation: Evidence for a Mesozoic "broad terrain" in the Canadian Maritimes; *in* Geological Society of America, Abstracts with Programs, v. 29, p. 84.

Webster, T. L. 1996: Integrated GIS and geological study of the St. Mary's Graben and adjacent areas, northern Nova Scotia; M.Sc. thesis, Acadia University, Wolfville, Nova Scotia.

Webster, T. L., Murphy, J. B. and Barr, S. M. 1998: Anatomy of a terrane boundary: an integrated structural, geographic information system, and remote sensing study of the late Paleozoic Avalon-Meguma Terrane boundary, mainland Nova Scotia, Canada; Canadian Journal of Earth Sciences, v. 35, p. 787-801.

Weeks, F. J. 1964: Geology, St. Peters, Richmond County, Cape Breton Island, Nova Scotia; Geological Survey of Canada, Map 1083A, scale 1:63 360.

White, C. E. and Barr, S. M. 1998: Preliminary geological map of Guysborough, Richmond and Antigonish counties (parts of NTS sheets 11E/08, 11F/05, 11F/06, 11F/10, 11F/11, 11F/12 and 11F/15), Nova Scotia, Canada; Nova Scotia Department of Natural Resources, Minerals and Energy Branch, Open File Map 1998-001, scale 1:100 000.

Williams, G. L., Fyffe, L. R., Wardle, R. J., Colman-Sadd, S. P. and Boehner, R. C. 1985: Lexicon of Canadian Stratigraphy, Volume VI, Atlantic Region.