Preliminary Bedrock Geology of the Area Between Chebogue Point, Yarmouth County, and Cape Sable Island, Shelburne County, Southwestern Nova Scotia

C. E. White

Introduction

Detailed bedrock mapping in the southwestern Meguma Terrane of Nova Scotia, from Digby to Shelburne (Fig. 1), is part of a multi-year program initiated in 1998 by the Nova Scotia Department of Natural Resources. The principal goals of the project are to produce a series of 1:50 000-scale geological maps of the area, describe and interpret the sedimentary, igneous, metamorphic, and deformational history, and evaluate the economic potential. Reported here are results from field mapping completed during the summer of 2002, including a preliminary bedrock geology map of the area between Chebogue Point, Yarmouth County, and Cape Sable Island, Shelburne County. Mapping covered parts of NTS map areas 20O/08, 20O/09, 20P/05 and 20P/12 (Fig. 1). Details of the mapping program, previous geological investigations, and methodology were summarized by White *et al.* (1999), and preliminary results of the first four years (covering parts of NTS map areas 21A/12, 21A/05, 21B/08, 21B01, 21O/16, 20P/13) were presented by White *et al.* (1999, 2001), White and King (2002) and Horne *et al.* (2000).

Field Relations and Map Units

Introduction

Metamorphic and igneous rock units defined in the previous map areas to the north (NTS 20O/16 and 20P/13) can be traced into the Chebogue Point -

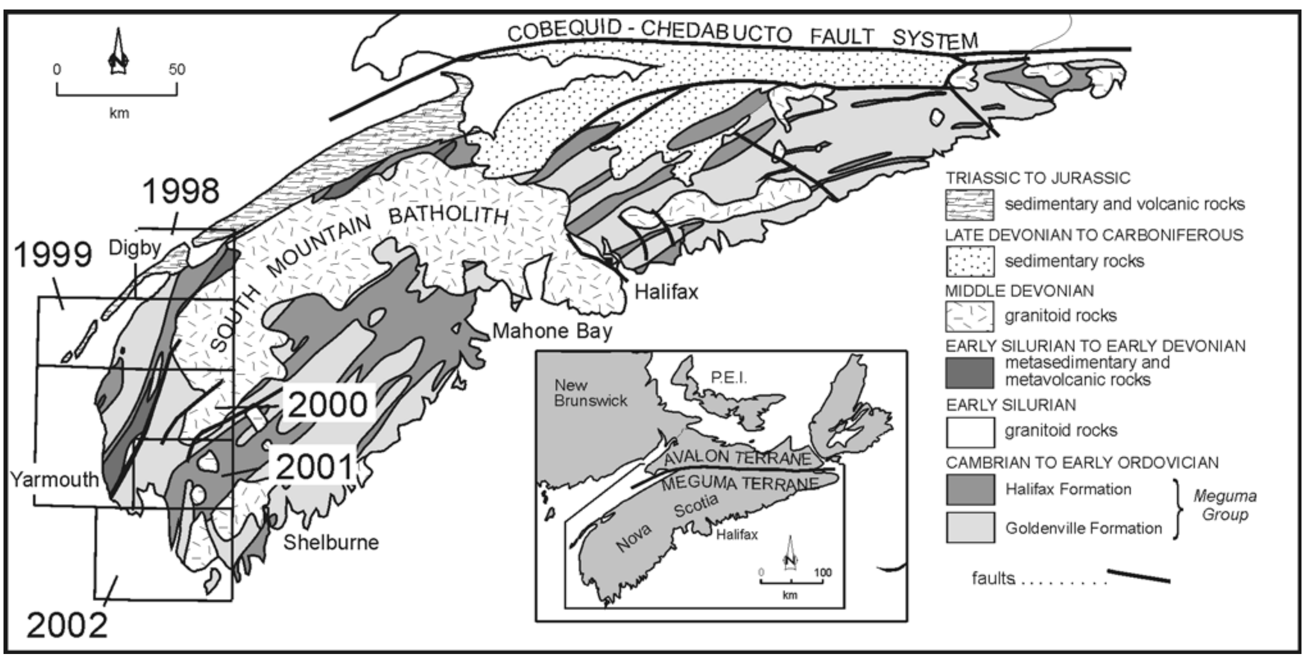


Figure 1. Simplified geological map of the Meguma Terrane, Nova Scotia, showing locations of mapped areas related to the Southwest Nova Scotia Mapping Project.

White, C. E. 2003: *in* Mineral Resources Branch, Report of Activities 2002; Nova Scotia Department of Natural Resources, Report 2003-1, p. 127-145.

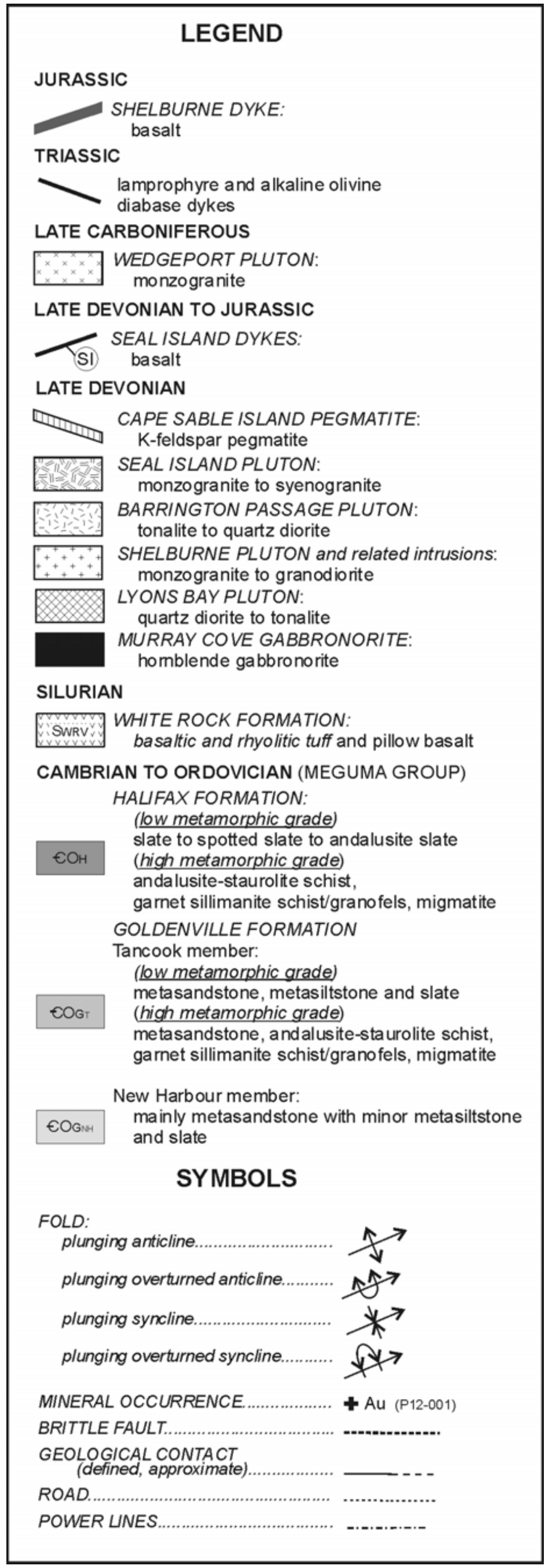
Cape Sable Island map area. They include the Cambrian to Ordovician Meguma Group, consisting of the Goldenville Formation and overlying Halifax Formation, and the Silurian White Rock Formation. These units have been deformed and regionally metamorphosed, with grade ranging from chlorite (greenschist facies) in the western half of the map area to sillimanite (amphibolite facies) in the eastern half. The metamorphic units are intruded by the Devonian Barrington Passage and Shelburne plutons, and the Carboniferous Wedgeport Pluton. The metamorphic units and Wedgeport Pluton are intruded by rare Early Mesozoic mafic dykes and sills (e.g. Pe-Piper and Reynolds, 2000).

Goldenville Formation

In the map area to the north (Fig. 1), the Goldenville Formation was subdivided into two units termed the New Harbour and Tancook members, based on similarities to those units as defined farther to the northeast in Queens and Lunenburg Counties (O'Brien, 1986, 1988; Waldron, 1992). These divisions are also recognized in the present map area.

New Harbour Member

The New Harbour member occurs in the western half of the map area (Fig. 2), but is poorly exposed due to glacial overburden. Based on limited outcrop, the member consists of grey thick-bedded metasandstone that is locally interlayered with green, cleaved metasiltstone. Black slate interbeds are rare and everywhere spotted with biotite. The metasandstone is light grey, thickly bedded, and typically contains abundant elliptical calc-silicate lenses. The calc-silicate lenses are flattened parallel to bedding and elongated parallel to the intersection lineation (see structural section). Despite the obvious structural overprinting, original sedimentary structures are common, which aids in determining stratigraphic tops. These observations are consistent with those observed in this member to the north (White and King, 2002). On the western margin of the map area, the New Harbour member is conformably overlain by the Tancook member at Chebogue Point. The eastern contact is not exposed because the contact is presumed to be



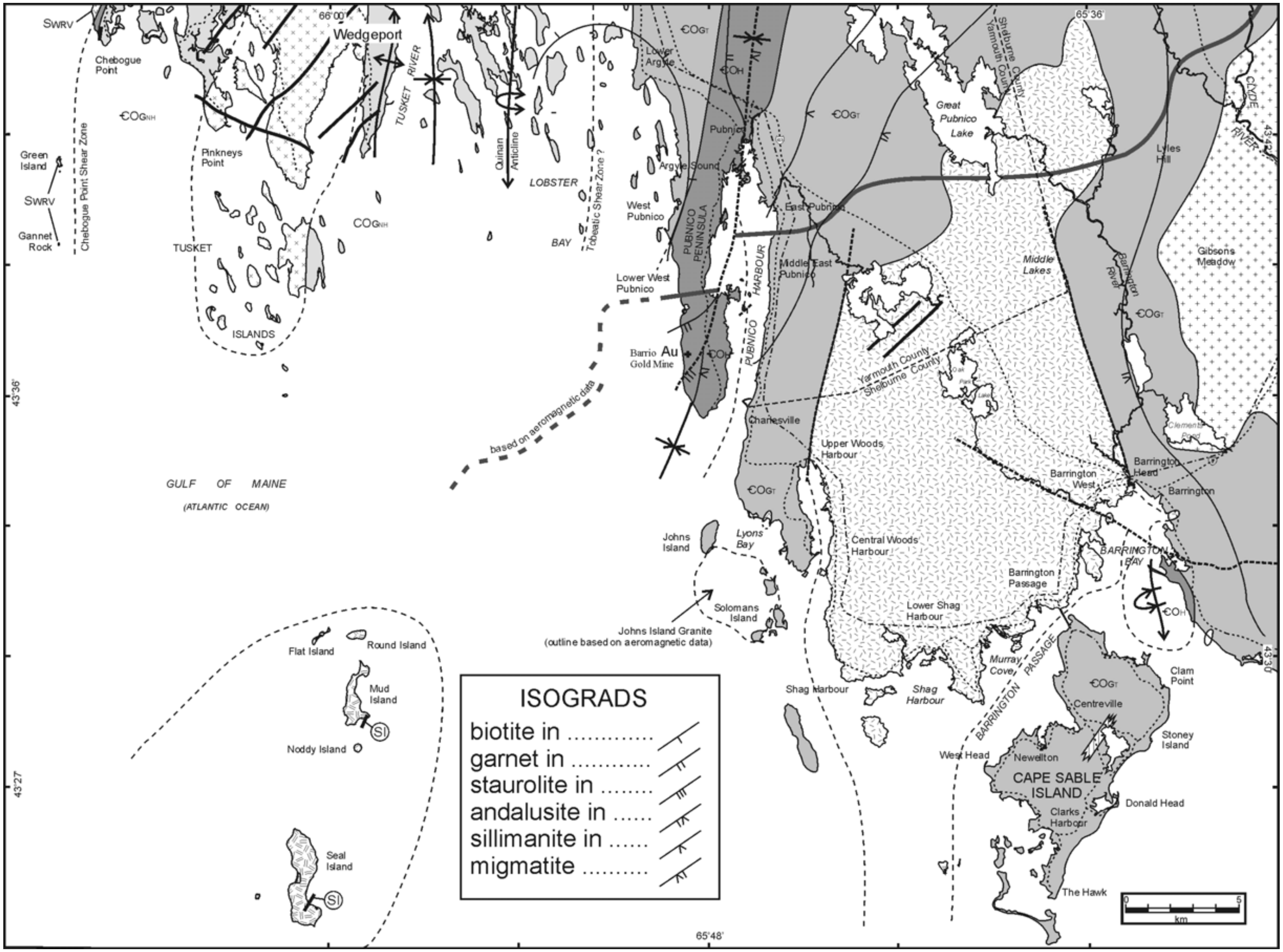


Figure 2. Simplified geological map of the area between Chebogue Point, Yarmouth County, and Cape Sable Island, Shelburne County, southwestern Nova Scotia. Legend on previous page.

underwater in Lobster Bay (Fig. 2).

Tancook Member

The Tancook member occurs mainly in the eastern half of the map area (Fig. 2), with a thin (< 100 m wide) part of the unit exposed in the west at Chebogue Point. In areas of low metamorphic grade, the Tancook member is typically composed of green, rhythmically laminated, cleaved metasiltstone and black slate, interlayered with laminated metasandstone in the proportion of about 50/50. As in the New Harbour member, calc-silicate nodules are very common in the metasandstone.

Stratigraphically above the Tancook member at Chebogue Point is a narrow (<100 m wide) unit of grey-green, well-laminated metasiltstone to slate. No metasandstone is associated with this unit, which is locally kinked and deformed, with boudinaged quartz veins. Along strike to the north this unit disappears, likely as a result of deformation related to the Chebogue Point shear zone. Although this unit was assigned to the Bloomfield member (basal part of the Halifax Formation) by White *et al.* (2001), it more closely resembles the Tancook member and is, therefore, included with it here.

At higher metamorphic grade, around the plutons to the east, the more pelitic beds in the Tancook member are composed of garnet-sillimanite schist/granofels and migmatite, similar to what was observed in the map area to the north (e.g. White and King, 2002). The spectacular development of garnet-sillimanite schist and granofels, however, with garnet crystals up to 2 cm in diameter adjacent to the Barrington Passage Pluton to the north, was not observed in the present map area.

Migmatitic rocks are more abundant in the present map area than to the north. They are characterized by dark grey fine-grained paleosomes with neosomes containing leucocratic medium-grained leucosomes and dark grey melanosomes. The leucosomes have quartzofelspathic compositions, whereas the melanosomes are mainly biotite and sillimanite. Small idioblastic red-brown garnet porphyroblasts occur in the melanosomes, but are generally absent in the leucosomes. Xenoblastic cordierite occurs in the melanosomes and locally in the leucosomes. Thick metasandstone beds are present and locally primary sedimentary features are preserved. The beds typically display “pinch and swell” textures and are commonly boudinaged parallel to the migmatitic foliation/layering.

Halifax Formation

Rocks typical of the Halifax Formation are exposed in three areas: (1) Chebogue Point, (2) Pubnico Peninsula and (3) east side of Barrington Bay (Fig. 2). The Halifax Formation at Chebogue Point consists of a fault-bounded unit of black to rust-brown slate with minor metasandstone laminations and lenses. It locally contains abundant pyrite and pyrrhotite. This unit is typical of the Cunard Formation in southwestern Nova Scotia (White *et al.,* 1999, 2001; Horne *et al.,* 2000). On the west side of Pubnico Peninsula, the Halifax Formation consists of rust-brown to grey slate that locally contains calc-silicate nodules and abundant pyrite and pyrrhotite. With an increase in metamorphic grade toward the east, the slates become increasingly andalusite-rich and form a wide band of chiastolite-bearing slates. On the east side of the peninsula, staurolite-andalusite schist and granofels are common. Along the east side of Barrington Bay, the Halifax Formation consists of coarse-grained muscovite-biotite schist and migmatite.

Although these higher metamorphic grade rocks are lithologically identical to those in the Tancook member, the lack of any substantial metasandstone beds suggests they belong to the Halifax Formation. The Cunard member is easily recognized at Chebogue Point, but because of the higher grade of metamorphism elsewhere in the map area it is more difficult to subdivide. As in the map area to the north, the Halifax Formation cannot be subdivided in the present map area.

White Rock Formation

The White Rock Formation is exposed only in the extreme western margin of the map area at Chebogue Point and on Green Island and Gannet

Rock (Fig. 2). Here the metavolcanic rocks consist of mafic lithic tuff with minor mafic ash beds, tuffaceous sandstone, and a distinctive felsic crystal tuff layer. Locally the mafic lithic tuff has a carbonate matrix. On Gannet Rock spectacular mafic pillow basalt is exposed. Primary volcanic textures are common and suggest stratigraphic tops to the east, which confirms the structural observations (bedding/cleavage relationship and fold asymmetry) on the islands. This unit corresponds to Unit 6 of White *et al.* (2001) and MacDonald *et al.* (2002), and corroborates the non-syncline model for the White Rock Formation (e.g. MacDonald *et al.,* 2002). Geochemistry of mafic volcanic rocks in the White Rock Formation indicate an alkalic affinity and a within-plate tectonic setting, and the felsic volcanic rocks have some characteristics similar to within-plate A-type granites (MacDonald, 2000; MacDonald *et al.,* 2002).

Intrusive Rocks

Introduction

Four major plutons occur in the map area: Barrington Passage, Shelburne, Seal Island and Wedgeport (Fig. 2). Smaller, minor intrusions occur in the metasedimentary rocks around the Barrington Passage Pluton (Fig. 2) and based on petrological evidence appear to be related to either the Barrington Passage or Shelburne plutons (e.g. Rogers, 1988). One minor intrusion, the Lyons Bay Pluton (Rogers, 1988), is mineralogically distinct from the rest. With the use of second derivative aeromagnetic data (King, unpublished data) and recent exposures of bedrock created by quarry and logging activities, both the shape and distribution of these plutons have been modified.

Barrington Passage Pluton

The Barrington Passage Pluton (BPP) (Taylor, 1967) occurs in the eastern part of the map area (Fig. 2) and was extensively studied by Rogers (1988). The pluton consists of grey, medium-grained, strongly foliated to equigranular biotite tonalite gradational to quartz diorite and granodiorite. Pegmatite is rare. Although amphibole was reported to occur by de Albuquerque (1979), none was observed in the tonalite during this study or the study by Rogers (1988). However, minor amphibole occurs in mafic enclaves and has been dated by the $^{40}Ar/^{39}Ar$ method (Reynolds *et al.,* 1987; see section on age). Mapping during the past summer has shown that the southern part of the BPP is not continuous with the northern part (cf. Rogers, 1986, 1988). The northern pluton, termed the Quinan Pluton by Reynolds *et al.* (1987), is more granodioritic in composition (Taylor, 1967) and appears to resemble rock types in the Shelburne Pluton. The eastern and western contacts of the BPP are faults (Fig. 2). The northern contact is well exposed on islands in Great Pubnico Lake and is clearly intrusive, with abundant tonalite dykes and sills intruding schist and migmatite of the Tancook member.

Locally the tonalite has layering defined by alternating biotite-rich and poor-bands, probably related to magma flow. It also exhibits a moderate to very strong tectonic foliation resulting from parallel alignment of biotite, and a lineation defined by elongate feldspar, quartz, and/or lens-shaped biotite aggregates. The tectonic foliation is generally parallel to the flow foliation. Small-scale isoclinal folds in the layering and boudinaged mafic enclaves are locally well developed. Toward the centre of the pluton, the "flow" foliation is locally preserved but the tectonic foliation is generally absent.

A black massive body of medium-grained gabbronorite is exposed along the coast and islands in the Murray Cove area (Fig. 2), and was termed the Murray Cove Diabase by Rogers (1988) and the Attwoods Brook Gabbronorite by Tate (1995). Contacts with the adjacent BPP were not observed during this study. Taylor (1967) and Rogers (1988), however, noted that the gabbronorite is intruded by tonalite and pegmatite dykes related to the BPP, and therefore interpreted the body as a xenolith. Based on textural and mineralogical evidence, subsequent workers demonstrated that the gabbronorite is more likely synplutonic with the BPP (e.g. Gallant, 1991; Tate, 1995; this study).

The irregular contact and the presence of numerous garnet-sillimanite schist/granofels xenoliths in the northern (Quinan) pluton was considered by Rogers (1986) and White and King (2002) to indicate a shallower level of erosion compared to the southern part. However, if the northern part is a separate pluton, it may have intruded at a higher level in the crust than its southern counterpart. A higher level of intrusion suggests higher fluid/water content in the northern part and helps to explain the varied texture in the granitoid rocks and abundant pegmatite and aplite compared to the southern part. It may also explain the lack of abundant coarse-grained garnet-sillimanite schist/granofels around the southern pluton. Further studies are needed to quantify these observations.

As summarized by White and King (2002) and references within, the BPP has an age of ca. 373 Ma and based on geochemistry was derived from an "S-type" magma of intermediate composition in a syn-collisional setting. Some characteristics of the BPP, however, are similar to those of volcanic-arc granites and a subduction setting cannot be discounted.

Shelburne Pluton

The Shelburne Pluton (Taylor, 1967) occurs along the extreme eastern margin of the map area (Fig. 2). It is poorly exposed but clearly indicated on areomagnetic data (King unpublished data) as magnetic "lows". Like the BPP, the Shelburne Pluton was extensively studied by Rogers (1988), and Rogers and Barr (1988). In the map area the pluton is composed of moderately foliated, pale grey, medium-grained, bioitite- and muscovite-bearing monzogranite. A small body of massive, medium- to coarse-grained diorite (Birchtown Diorite of Rogers, 1988) outcrops within the monzogranite. Based on the presence of granitic dykes and pegmatites from the Shelburne Pluton in the diorite, Rogers (1988) and Tate (1995) considered this body to be xenolithic in origin. The diorite has yielded U-Pb (zircon) ages of ca. 376 Ma (Tate, 1995; Currie *et al.,* 1998). On Johns and Solomans islands outcrops of two-mica granite exist that are similar to the Shelburne Pluton. Based on aeromagnetic data these outcrops represent the surface exposure of a much larger unexposed body. As summarized by White and King (2002), the Shelburne Pluton has an age of ca. 372Ma and may have been derived from a felsic "S-type" magma in a syn-collisional setting.

Seal Island Pluton

The Seal Island Pluton (Rogers, 1988) outcrops on Seal Island and adjacent islands 30 km west of Cape Sable Island (Fig. 2). It consists of coarse-grained to porphyritic monzogranite gradational to syenogranite. Contacts with country rocks were not observed but the presence of numerous metasand-stone and hornfels xenoliths suggests that it intruded rocks of the Meguma Group. Rogers (1988) mapped a systematic east-west mineralogical and modal variation across the islands from muscovite syenogranite in the west, to muscovite-biotite monzogranite in the centre, and biotite monzogranite to the east. Every outcrop is cut by aplite dykes and quartz veins.

A weak foliation is present in most samples and defined by parallel alignment of biotite and muscovite. Steep, north-northeast-trending, narrow shear zones (< 50 cm wide) are common, but the sense of shear is unknown. A distinctive feature of the pluton is the abundance of tourmaline patches and layers, up to 2% of the rock (e.g. Taylor, 1967). The age of the Seal Island Pluton is not known but is likely ca. 373 Ma, based on its textural and mineralogical similarities to the South Mountain Batholith.

Wedgeport Pluton

The Wedgeport Pluton (Taylor, 1967) is poorly exposed in the southwestern part of the map area and is the focus of a B.Sc. Honours thesis by N. MacLean at Acadia University. The pluton consists mainly of unfoliated, medium- to coarse-grained equigranular monzogranite that is in places garnetiferous (Goose Bay granite of Chatterjee and Keppie, 1981). Enclaves of biotite-rich granodiorite and coarse-grained granitic porphyry occur locally, as well as convolute compositional banding possibly related to magmatic flow near contacts with the country rock. Aplitic, pegmatitic, and mafic dykes are present locally. A narrow contact metamorphic aureole of garnet-bearing hornfels occurs on the exposed western margin of the pluton. Here the contact is concordant but dykes of granite extend into the hornfels. The location of the eastern margin of the pluton is based on aeromagnetic data and the presence of small granitic dykes, presumably related to the pluton, in outcrops of the Goldenville Formation. Preliminary chemical data suggest that the pluton is a within-plate A-type granite, derived from melting of continental crust (MacLean *et al.,* 2003). Based on a zircon U-Pb age of 316 Ma (Cormier *et al.,* 1988) it appears to be the youngest granitic pluton in the Meguma Terrane.

Lyons Bay Pluton

The Lyons Bay Pluton (Rogers, 1988) outcrops south of Charlesville on the north shore of Lyons Bay (Fig. 2). The pluton is hornblende-bearing and varies in composition from quartz diorite to tonalite (Rogers, 1988). The centre of the pluton is medium-grained and generally equigranular, but toward the margins the pluton becomes increasingly foliated and blastomylonitic in texture. The contact with the adjacent migmatite of the Tancook member is clearly tectonic. Although outcrop is sporadic, second derivative aeromagnetic data (King, unpublished data) indicate that the pluton is a small, north-south elliptical body, confirming the interpretation of Rogers (1988). The intrusive age of this pluton is unknown but hornblende from the unfoliated part of the pluton yielded an $^{Ar}40/^{39}Ar$ plateau age of ca. 389 Ma (Dallmeyer and Keppie, 1987).

Pegmatite and Aplite Dykes

Pegmatite and aplite dykes occur throughout the area in all units, but are most commonly associated with the Shelburne Pluton. They are massive and unzoned, and consist of smoky quartz, white to pink perthitic feldspar, biotite and minor muscovite. Tourmaline is common with lesser amounts of garnet. Beryl is rare. An isolated, northeast-trending pegmatite dyke is exposed on Cape Sable Island (Fig. 2). It is 100 m wide and over 1 km in length, and composed mainly of granophyric K-feldspar and quartz (Rogers, 1988). Aplite dykes are commonly associated with the Shelburne Pluton and also occur as small lenses in pegmatite. They are typically equigranular and consist of feldspar, quartz, muscovite and garnet. Locally pegmatite and aplite are foliated parallel to regional fabrics.

Mafic Dykes

As noted in mapping to the north (White and King, 2002), pre-Late Devonian mafic dykes and sills are noticeably absent in the Goldenville and Halifax formations southeast of the Chebogue Point shear zone compared to the area to the northwest. However, Early Mesozoic lamprophyre and alkaline olivine diabase dykes occur in the western part of the map area (Pe-Piper and Reynolds, 2000). The dykes are poorly exposed, but were intersected in drillholes in the Goldenville Formation and Wedgeport Pluton in the Plymouth area (Cant *et al.,* 1978) and are evident on the basis of their magnetic response (King, unpublished data). Two thin (<2 m wide) mafic sills outcrop at Chebogue Point in metasiltstone of the Tancook member. The presence of olivine indicates that they belong to the alkaline olivine diabase dykes described by Pe-Piper and Reynolds (2000). The Early Jurassic tholeiitic Shelburne Dyke is poorly exposed, but based on areomagnetic data can be traced across the map area and offshore (Fig. 2).

Three narrow (<1.5 m wide) mafic dykes are exposed in the Seal Island Pluton on Mud and Seal islands (Fig. 2). The dyke on Mud Island is clearly intrusive into the granite with a well-developed chill margin (Rogers, 1988). The two dykes on Seal Island are intensely deformed as they occupy the north-trending shear zones; however, locally the original contacts are preserved and based on co-mingling textures the dykes appear to be syn-to late intrusive with the granite.

Deformation and Metamorphism

The Meguma Group was regionally deformed and metamorphosed during the Acadian Orogeny. Detailed $^{40}Ar/^{39}Ar$ studies on single grain muscovite and whole-rock samples from the Meguma Group indicate that regional greenschist facies metamorphism associated with the Acadian Orogeny occurred between ca. 388-406 Ma

(Muecke *et al.,* 1988; Hicks *et al.,* 1999; Muir, 2000). In the map area, regional scale north-trending folds with a well developed axial planar cleavage, and regional metamorphism that grades from greenschist facies in the west to amphibolite facies in the east, are generally attributed to the Acadian Orogeny.

Deformation

In the western part of the map area outcrop is sparse but sufficient such that combined with aeromagnetic data the spatial extent of structural features can be delineated. In the western part of the map area the New Harbour member is folded into a pair of upright, shallow north-plunging anticlines and synclines. These folds are the southerly extensions of the same structures mapped to the north (e.g. White and King, 2002). The larger Quinan anticline (White and King, 2002) also extends into the map area (Fig. 2) and is moderately inclined to the west and subhorizontal with an overturned western limb. The Halifax Formation along the Pubnico Peninsula also lies in a regional syncline, but is structurally complex because of younger faulting. In the Barrington Bay area the migmatitic Halifax Formation also lies within a syncline. Based on outcrop and areomagnetic patterns, this syncline is steeply inclined to the west and gently plunging to the south with an overturned eastern limb (Fig. 2).

Poles to bedding from the entire area define a moderately developed girdle distribution with a shallow, north-plunging fold axis (Fig. 3a), and poles to foliation indicate a near-vertical north-striking axial planar foliation (Fig. 3b). Minor F_1 folds are not common in the low-grade metamorphic rocks, but are more common in the higher grade schistose rocks. Although data show scatter, folds are generally upright and plunge gently to steeply north and south (Fig. 3a). Intersection lineations (L_1) (bedding/foliation) are somewhat scattered but are generally subhorizontal or gently plunge to the north or south (Fig. 3b). Elongate calc-silicate nodules typically are parallel to the intersection lineation. Like the minor folds, crenulation cleavages are more common in the schistose rocks and deform the schistosity and bedding. The crenulation cleavage appears to be a conjugate set, striking northeast and north with moderately dips, and the crenulation lineation is generally vertical and northeast-plunging (Fig. 3c).

Mineral lineations are locally evident in staurolite-andalusite schist as either elongated andalusite crystals or lens-shaped biotite. Mineral lineations are also well developed in the migmatitic rocks, and defined by elongate fibrolite mats or quartz rods and lens-shaped biotite and muscovite aggregates. These mineral lineations (L_{m1}), although somewhat scattered, have gently north-plunging orientations (Fig. 3d) and parallel the long axes of boudinaged metasandstone layers. A gently north-plunging mineral lineation (L_{m2}) is also well developed in the BPP (Fig. 3e) and defined by prismatic plagioclase crystals, quartz rods and elongate mafic boudins and enclaves, as previously documented in the pluton (Pignotta and Benn, 1999; White and King, 2002). Poles to magmatic layering in the BPP (Fig. 3e) form a girdle distribution around a shallow north-plunging axis, suggesting that the magmatic layering has been folded, as evident from small-scale isoclinal folds in the pluton (e.g. Pignotta and Benn, 1999). The calculated fold axis is identical in orientation to the mineral lineation in the BPP and the surrounding migmatite (Figs. d, e). In addition, meso- to macroscopic, upright isoclinal folds in the migmatite have identical gently north-plunging fold axes (Fig. 3f).

Petrographic investigations confirm the early interpretation that structures observed in the BPP are magmatic to high-temperature subsolidus fabrics related to syntectonic intrusion (e.g. Pignotta and Benn, 1999; White and King, 2002). This interpretation indicates a maximum principle stress parallel to the magmatic mineral lineation and parallel to the shallowly north-plunging, north-south regional fold axis. The structural and available geochronological data demonstrate that the BPP was emplaced and deformed along with the migmatite, schist, granofels and lower grade metamorphic rocks ca. 373 Ma, considerably later than the often cited ca. 400 Ma Acadian Orogeny (e.g. Keppie and Dallmeyer, 1995).

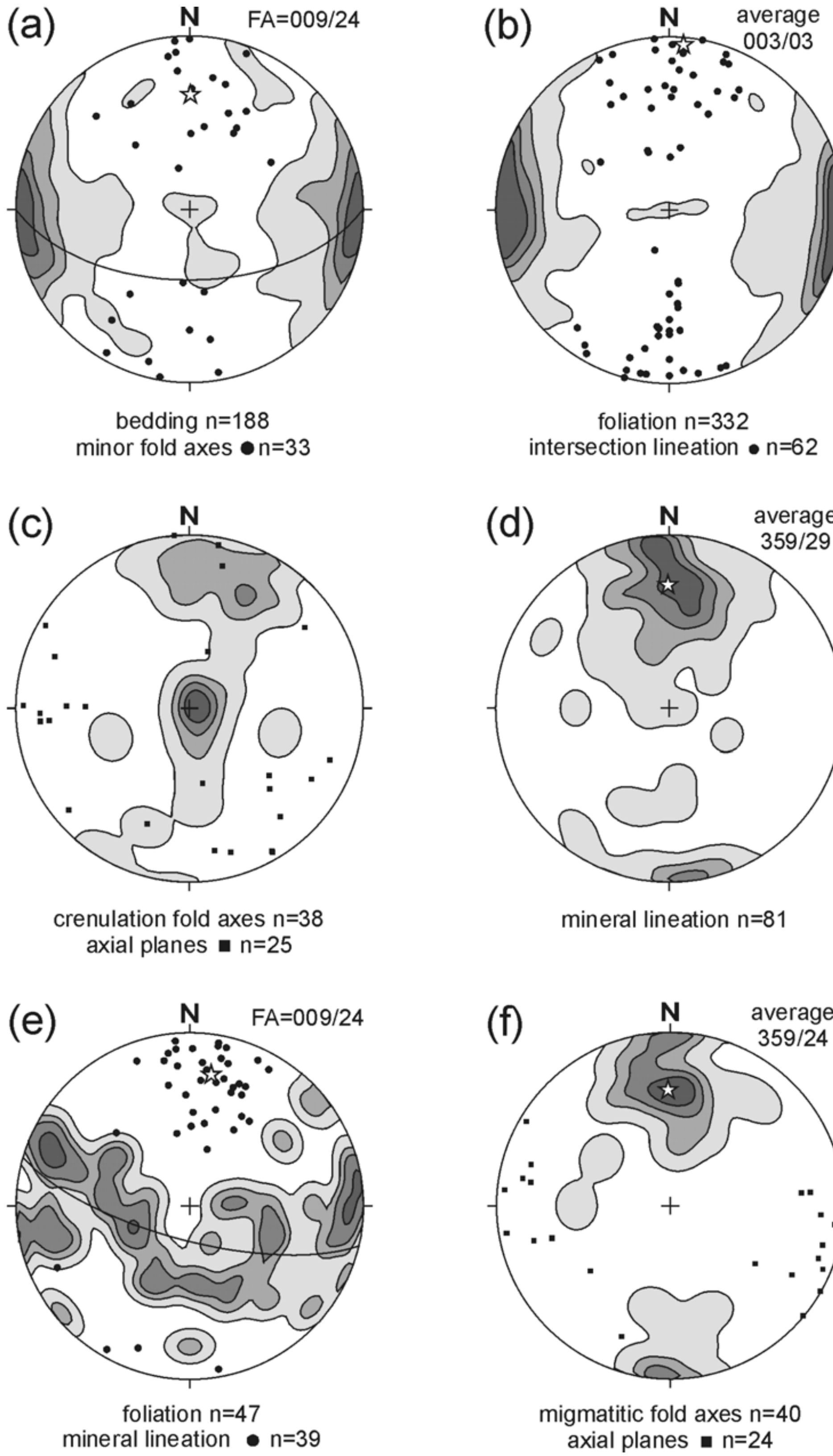


Figure 3. Equal area stereonets of structural data for the map area. (a) contoured poles to bedding and minor F_1 fold axes. (b) contoured poles to cleavage and schistosity and bedding-cleavage intersection lineations. (c) contoured crenulation lineations and filled squares represent poles to crenulation cleavage. (d) contoured mineral lineations in schist and migmatite. (e) contoured poles to banding/foliation in the Barrington Passage Pluton and associated mineral lineations. (f) contoured fold axes in migmatite and filled squares represent poles to axial planes. Contours on stereonets at 1, 3, 5, and greater than 7% per 1% area; darkest shading indicates highest contour area.

Shear Zones and Faults

Numerous shear zones have been well documented to the north and east of the map area (Giles, 1985; Smith, 1985; Keppie *et al.,* 1985; Hwang, 1990; White and King, 2002) and along the northwestern margin of the map area (White *et al.,* 2001). The southern extension of the Tobeatic Fault Zone (Giles, 1985) and Rushmere Lake shear zone (Smith, 1985) into the present map area was not confirmed. If present, the southern projection places these features underwater through Lobster Bay (Fig. 2). The Chebogue Point shear zone (Culshaw, 1994; Culshaw and Liesa, 1997) forms a wide north-south belt along the contact between the White Rock and Goldenville formations, incorporating the majority of the Halifax Formation (Fig. 2). Farther north, the shear zone juxtaposes chlorite/biotite-grade rocks of the Halifax and New Harbour member with staurolite-grade metamorphic rocks of the White Rock Formation (Hwang, 1985; Moynihan *et al.,* 2001, 2002). At Chebogue Point, kinematic indicators suggest west-side-up dip-slip motion (Culshaw and Liesa, 1997), whereas Dallmeyer and Keppie (1987) and Keppie and Dallmeyer (1995) argued for dextral shear. This zone is strongly overprinted by younger brittle deformation that locally obliterated earlier deformational textures.

High-strain zones are present in the schist, migmatite and granitic rocks of the Seal Island Pluton. Many are narrow features less than 50 cm in width. A major north-south shear zone is interpreted to underlie Pubnico Harbour. Schist along the east side of Pubnico Peninsula and migmatite along the Charlesville shore locally contain mesoscopic refolded isoclinal folds and strongly attenuated shallow south-plunging andalusite crystals interpreted to be the result of deformation. This shear zone is similar to those recognized to the east by Hwang (1990), which are also typically oriented north-south, post-date the metamorphic peak (e.g. Hwang, 1990), and have yielded $^{40}Ar/^{39}Ar$ muscovite ages of 335-320 Ma (Dallmeyer and Keppie, 1987). These ages are similar to those obtained in the Cape St. Marys and Cranberry Point shear zones, which yielded ca. 320 Ma muscovite ages (Culshaw and Reynolds, 1997). In addition, shearing in the ca. 316 Ma Wedgeport Pluton suggests that much of the ductile deformation in southwestern Nova Scotia may be of Carboniferous age.

Evidence for extensive low-grade deformation has been documented in Halifax Formation rocks along the western and southern coast of Pubnico Peninsula (e.g. Ross, 1985; Raeside and Jamieson, 1992). Here the banded slate contains shear bands, tightly folded bedding, layer parallel faults, and boudinaged sandstone and siltstone layers. In places the earlier isoclinal folds are refolded (e.g. Raeside and Jamieson, 1992). These structural features are overgrown by chiastolite crystals. In the coarse-grained andalusite schist and granofels units “millipede structures” are recognized in andalusite (Raeside and Jamieson, 1992). The age and sense of movement along this pre-porphryblastic shear zone are unknown.

Brittle faults are present throughout the map area. The Cunard member in the western part of the map area in the Chebogue Point shear zone (Fig. 2) is entirely fault-bounded (White *et al.,* 2001). The north-south Pubnico Harbour Fault offsets metamorphic isograds and juxtaposes garnet-grade slate on the west with andalusite schist on the east (Ross, 1985). Along with vertical movement, a significant amount of sinistral movement is suggested by the offset of the Shelburne Dyke and the presence of Z-shaped drag folds (e.g. Ross, 1985). Faults are inferred along the eastern and western margins of the BPP (Fig. 2) because of the strong linear aeromagnetic pattern. In addition, a northwest-trending fault, herein termed the Barrington Bay Fault (Fig. 2), is indicated by apparent offsets in aeromagnetic patterns. Senses of movement along these faults are not known.

Pseudotachylyte veins occur in many locations throughout the area. Many of the fractures that the veins occupy show evidence of microbrecciation along their margins and offsets up to 1-2 cm, suggesting that the veins represent *in situ* melts. They have been interpreted to be associated with shallow faulting and the intrusion of the BPP (Gareau, 1977).

Metamorphism

Several metamorphic zones have been determined in the map area (Bourque, 1985; Ross, 1985; Raeside and Jamieson, 1992), similar to those defined in the map area to the north (White and King, 2002). Chlorite-zone rocks have been recognized in the West Pubnico area (Raeside and Jamieson, 1992). In this zone the recognizable metamorphic minerals are chlorite and muscovite, which define the regional foliation. Locally spessartine garnet has been noted. Rocks assigned to the biotite zone occur in the western parts of the map area between Cheboque Point and Lower Argyle (Fig. 2). The biotite zone is characterized by the presence of prograde biotite, which gives the slate a more spotted appearance. A typical mineral assemblage is biotite + chlorite + muscovite + quartz + albite (e.g. Ross, 1985). Garnet zone rocks are similar to those in the biotite zone, except that they contain tiny porphyroblasts of garnet. The garnet zone grades into the chiastolite zone, which Ross (1985) considered to be a subzone of the garnet zone. Raeside and Jamieson (1992) considered the chiastolite-bearing slate to be part of the andalusite zone and possibly related to contact metamorphism by the BPP. This interpretation was based on the observed presence of chiastolite in the contact zone of the South Mountain Batholith. Rocks in the chlorite, biotite and garnet zones typically retain their original sedimentary textures, but their mineral assemblage is metamorphic.

The staurolite zone is recognized only on the southwestern tip of Pubnico Peninsula where it is in faulted contact with rocks of the garnet zone. The rocks in this zone represent the lowest metamorphic grade and display a coarse-grained schistosity defined by aligned biotite and muscovite. Most original sedimentary textures are obliterated. The typical mineral assemblage is staurolite + garnet + biotite + chlorite + muscovite + quartz + plagioclase (Ross, 1985). The andalusite zone (Fig. 2) is marked by the appearance of andalusite in schist. Andalusite typically forms very large crystals up to 40 cm long, which are typically randomly oriented on bedding planes but are locally elongate parallel to the regional fold axis. In addition to andalusite, staurolite and cordierite are locally abundant. In this zone cross-cutting andalusite veins are common.

The transition from the andalusite zone to the sillimanite zone (Fig. 2) is generally marked by the appearance of sillimanite as elongate fibrolite mats or prismatic crystals that, like some of the andalusite crystals in the andaluste zone, define a preferred orientation parallel to the regional fold axes. As metamorphic grade increases staurolite and andalusite disappear and garnet locally increases in size but still preserves spessartine-rich cores (Raeside and Jamieson, 1992). The garnet-sillimanite granofels zone around the Quinan Pluton to the north (White and King, 2002) is not present around the southern margin of the BPP.

Migmatite forms an aureole around the BPP up to 5 km in width (Fig. 2). Both anatectic and injection migmatite are present. Anatectic migmatite is developed in pelitic rocks and is commonly stromatic or opthalmitic with minor folded and nebulitic varieties (Bourque, 1985). Leucosome consists of quartz + feldspar + mica and rarely cordierite, and is granodioritic in composition, whereas both the melanosome and mesosome contain garnet + sillimanite + biotite + cordierite (Bourque, 1985; Raeside and Jamieson, 1992). The associated metasandstone layers contain the assemblage biotite + sillimanite + plagioclase + quartz (e.g. Raeside and Jamieson, 1992). Migmatitic rocks are not developed around the Shelburne Pluton.

Because migmatite borders the BPP, Taylor (1967) speculated that it was related to contact metamorphism by the BPP, but concluded that the regional metamorphic grade for the area was at least as high as the P-T conditions accompanying the emplacement of the granitic pluton. Bourque (1985) concluded that the combined effects of regional amphibolite-facies metamorphism and contact metamorphism resulted in migmatization. Based on structural observations the intrusion of the BPP accompanied or closely followed the peak of metamorphism.

The only clear evidence of contact metamorphism is associated with the Wedgeport Pluton. The pluton produced a narrow, 400 m contact metamorphic zone of spotted hornfels containing andalusite and cordierite superimposed on biotite zone assemblages (Cullen, 1983). Garnet is also present.

Age of Deformation and Metamorphism

A detailed $^{40}Ar/^{39}Ar$ study on single grain muscovite and whole-rock samples from the Meguma Group in the Digby area indicated that regional greenschist-facies metamorphism occurred ca. 400 Ma (Muir, 2000). This age is similar to $^{40}Ar/^{39}Ar$ ages reported elsewhere in the Meguma Group (405-390 Ma, Muecke *et al.,* 1988; 395-388 Ma, Hicks *et al.,* 1999) and was interpreted to date the timing of cleavage formation associated with the Acadian Orogeny. However, published U-Pb and $^{40}Ar/^{39}Ar$ data from the Pubnico-Shelburne area (Figs. 4, 5) suggest a more complex tectonic history for that area than previously thought (e.g. Taylor 1967; Rogers, 1988).

The only indication of a ca. 400 Ma metamorphic event is recorded in a poorly constrained $^{40}Ar/^{39}Ar$ hornblende total gas age of ca. 393 Ma (Figs. 4, 5) from a calc-silicate rock in the Goldenville Formation (Dallmeyer and Keppie, 1988) and a biotite total gas age of ca. 386 Ma (Fig. 4) from a staurolite schist (Muecke *et al.,* 1988). However, the biotite spectrum has a "saddle" distribution indicative of excess argon and the age should be considered a maximum.

Plutonic units in the map area have been generally well dated. Monazite, zircon and titanite from the BPP, Shelburne Pluton and Birchtown Diorite yielded U-Pb ages of ca. 377-362 Ma (Tate, 1995; Currie *et al.,* 1998; Keppie and Krogh, 1999) and there is some indication that older mafic intrusions exist in the area (e.g. ca. 389 Ma hornblende plateau age from undeformed diorite in the Lyons Cove Pluton; Dallmeyer and Keppie, 1987). Younger plutonism in the area is recorded in the U-Pb zircon age of ca. 316 Ma on the Wedgeport Pluton (Cormier *et al.,* 1988). A structural and magnetic fabric study of the BPP demonstrated that internal fabrics in the pluton parallel those in the country rocks, an observation interpreted to indicate that the pluton was emplaced and deformed during the Early Devonian Acadian Orogeny (Pignotta and Benn, 1999). Based on field relations that indicate that the pluton accompanied or closely followed the peak of metamorphism, however, it is likely that the ca. 373 Ma age for the BPP also dates the time of high-grade metamorphism in the map area.

Biotite and muscovite $^{40}Ar/^{39}Ar$ plateau and total gas ages from the plutonic units systematically increase from ca. 375 to 340 Ma (Figs. 4, 5). The easiest explanation for this feature is that it reflects post-intrusion cooling through the lower temperatures required for retention of argon in mica. A similar biotite and muscovite age pattern is present in the country rocks (Figs. 4, 5) and suggests similar cooling following the peak of regional and contact metamorphism.

Younger biotite and muscovite ages from the plutonic units form a peak distribution around ca. 315 Ma (Figs. 4, 5), suggesting that the mica ages were reset by some thermal event. This thermal event could be associated with intrusion of the ca. 316 Ma Wedgeport Pluton located farther to the west. If so, it would indicate the presence of several more ca. 316 Ma plutons at depth to account for the spatial distribution of these young mica ages in the plutons and in the country rocks. In addition, ca. 320 Ma ages have been acquired from recrystallized micas in ductile shear zones in the country rocks (Dallmeyer and Keppie, 1987; Keppie and Dallmeyer, 1995) and from shear zones farther west (Culshaw and Reynolds, 1997). These data suggest a recurrence of magmatism and deformation in the middle Carboniferous, probably related to the Alleghany Orogeny.

A third cluster is evident between ca. 290 to 250 Ma (Figs. 4, 5) from biotite and feldspar $^{40}Ar/^{39}Ar$ plateau and total gas ages in the plutonic units. Biotite ages in the country rocks also reflect this age range. It is unclear to what event these Permian ages could be attributed, but three biotite $^{40}Ar/^{39}Ar$ plateau ages of ca. 277, 269 and 258 Ma from the Wedgeport Pluton and associated contact metamorphic aureole (Fig. 4) suggest that they may be related to slow cooling following intrusion of the pluton. Dallmeyer and Keppie (1988) also recognized the lower biotite ages and suggested a ca. 290 Ma contact metamorphic event related to an offshore, subsurface pluton. This interpretation helps explain the lack of abundant muscovite ages in this range, and suggests that contact metamorphic temperatures were sufficient to totally rejuvenate biotite but remained low enough to not reset muscovite.

The youngest hornblende and biotite $^{40}Ar/^{39}Ar$ plateau ages (ca. 231 to 222 Ma and ca. 209 to 203 Ma) in the area (Figs. 4, 5) are from the lamprophyre and alkaline olivine diabase dykes that occur in the western part of the map area (Pe-Piper and Reynolds, 2000). Although the younger dykes may be related to the much larger Shelburne Dyke and North Mountain Basalt, this magmatic activity does not appear to have been a thermal event significant enough to reset biotite and muscovite ages in the Meguma Group.

Economic Geology

Significant mineralization has been documented in the map area in association with the ca. 316 Ma Wedgeport Pluton. Shear-related veins of greisen and greisenized biotite granite contain a complex mineral association representing different episodes of mineralization. The ore minerals include cassiterite, wolframite, molybdenite, pyrite, pyrrhotite, arsenopyrite, silver-bearing sulphosalts, native bismuth and rare uranium molybdate (Wolfson, 1983; Chatterjee *et al.,* 1985). Shear joints and veins in the adjacent metasandstone typically contain pyrite, pyrrhotite, chalcopyrite, sphalerite, cassiterite, native silver and bismuth, and complex Ag-Sb-Bi sulphosalts. Because of hydrothermal alteration, the host rock and associated calc-silicate layers are mineralized. Skarnoid rocks contain pyrite, pyrrhotite, chalcopyrite, scheelite, malayite and possibly pabstite (Chatterjee and Keppie, 1981).

The only gold occurrence (Barrio Gold Mine) in the area is located along the west shore of Pubnico Peninsula (Fig. 2) and is described in the Nova Scotia Department of Natural Resources Mineral Occurrence Data Base for NTS map area 20P/12. Most of the exploration concentrated on extraction of placer gold from the beach, although trenching was conducted to locate the source.

Granitic pegmatite is locally common in the BPP and associated migmatite. Although not yet investigated, this may be similar to Li-Ta-Nb-Sn-bearing pegmatite exposed at Brazil Lake in the White Rock Formation (e.g. MacDonald *et al.,* 1992).

From an industrial minerals perspective, the map area holds great potential. Local communities are making use of sand and gravel to produce cement and asphalt. The BPP has been quarried for rip-rap used in building breakwaters. The pluton is also being evaluated as a source of crusted bedrock aggregate.

Summary

A major result of mapping during the summer of 2002 is the confirmation that stratigraphy in the Goldenville and Halifax formations is identical to that defined in the map area to the north (e.g. White and King, 2002). These units do not correlate with Meguma Group map units defined to the northwest (c.f. White *et al.,* 1999, 2000, 2001; Horne *et al.,* 2000). The change occurs across the Chebogue Point shear zone, and suggests that this structure is a major feature in southwestern Nova Scotia. As documented to the north, the stratigraphy is more similar to that defined farther northeast in the Meguma Group in Queens and Lunenburg Counties (O'Brien, 1986, 1988; Waldron, 1992).

Regional folds in the area are oriented north-south, plunge gently to the north, and have well developed axial planar cleavage.

The Barrington Passage Pluton can be divided into two separate and distinct bodies. The southern pluton consists dominantly of tonalite and following the definition of Taylor (1967) and Rogers (1988) is the actual Barrington Passage Pluton. The northern body, termed the Quinan Pluton (Muecke *et al.,* 1988), is mainly granodioritic in composition and appears to have intruded higher in the crust compared to the southern pluton.

Peak amphibolite-facies regional metamorphism appears to have coincided with intrusion of the Barrington Passage Pluton ca. 373 Ma. It is considerably younger than the ca. 400 Ma greenschist-facies regional metamorphism in the Meguma Group elsewhere in the Meguma Terrane.

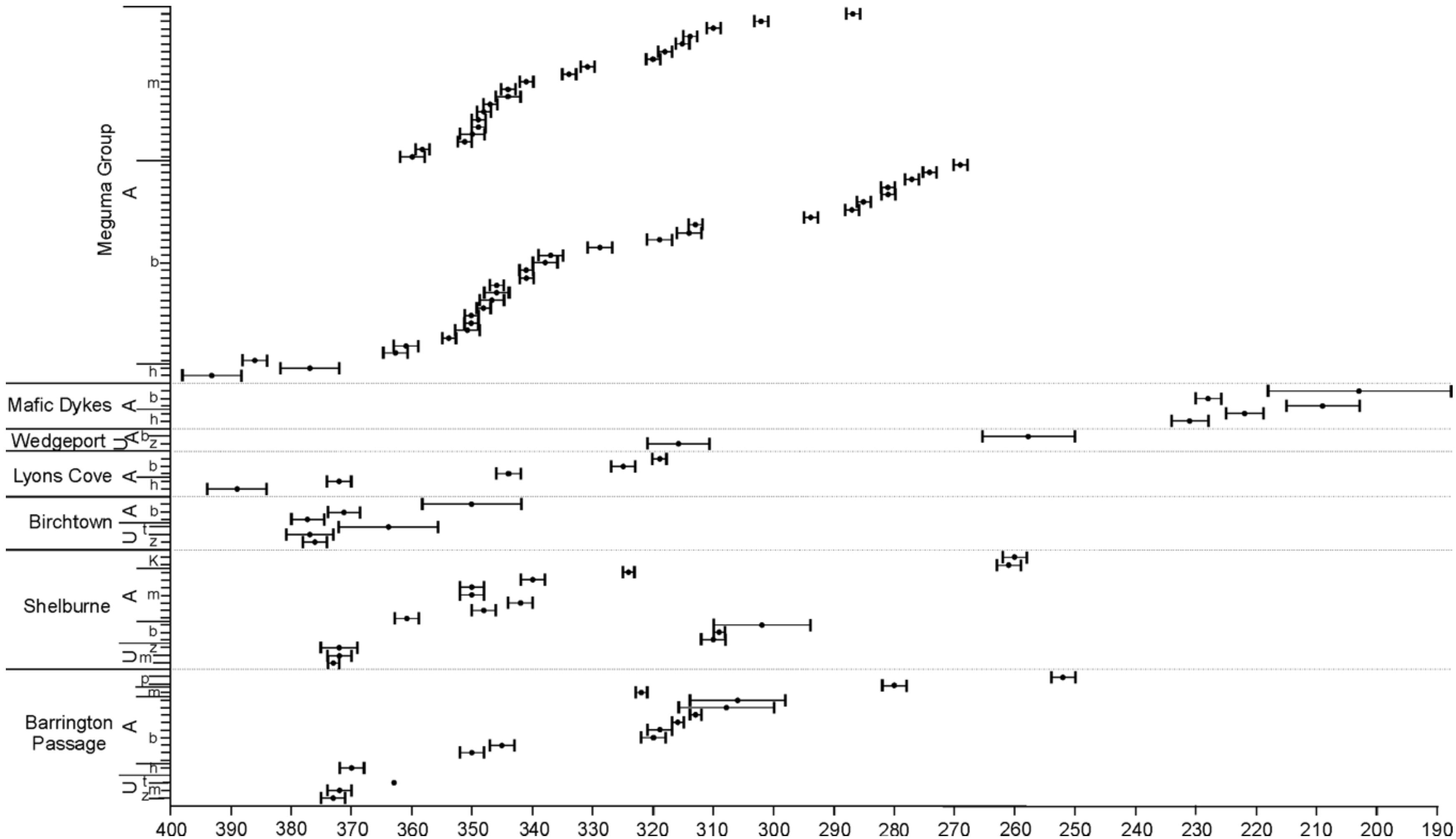


Figure 4. Compilation of published U-Pb and $^{40}Ar/^{39}Ar$ ages and errors from the Pubnico-Shelburne area. Abbreviations: U = U-Pb method (z = zircon, m = monazite, t = titanite); A = $^{40}Ar/^{39}Ar$ method (h = hornblende, b = biotite, m = muscovite, p = plagioclase, K = potassium feldspar). Data from Reynolds et al. (1981); Dallmeyer and Keppie, (1987, 1988); Reynolds et al. (1987); Cormier et al. (1988); Muecke et al. (1988); Keppie and Dallmeyer, (1995); Tate, (1995); Currie et al. (1998) Keppie and Krogh, (1999).

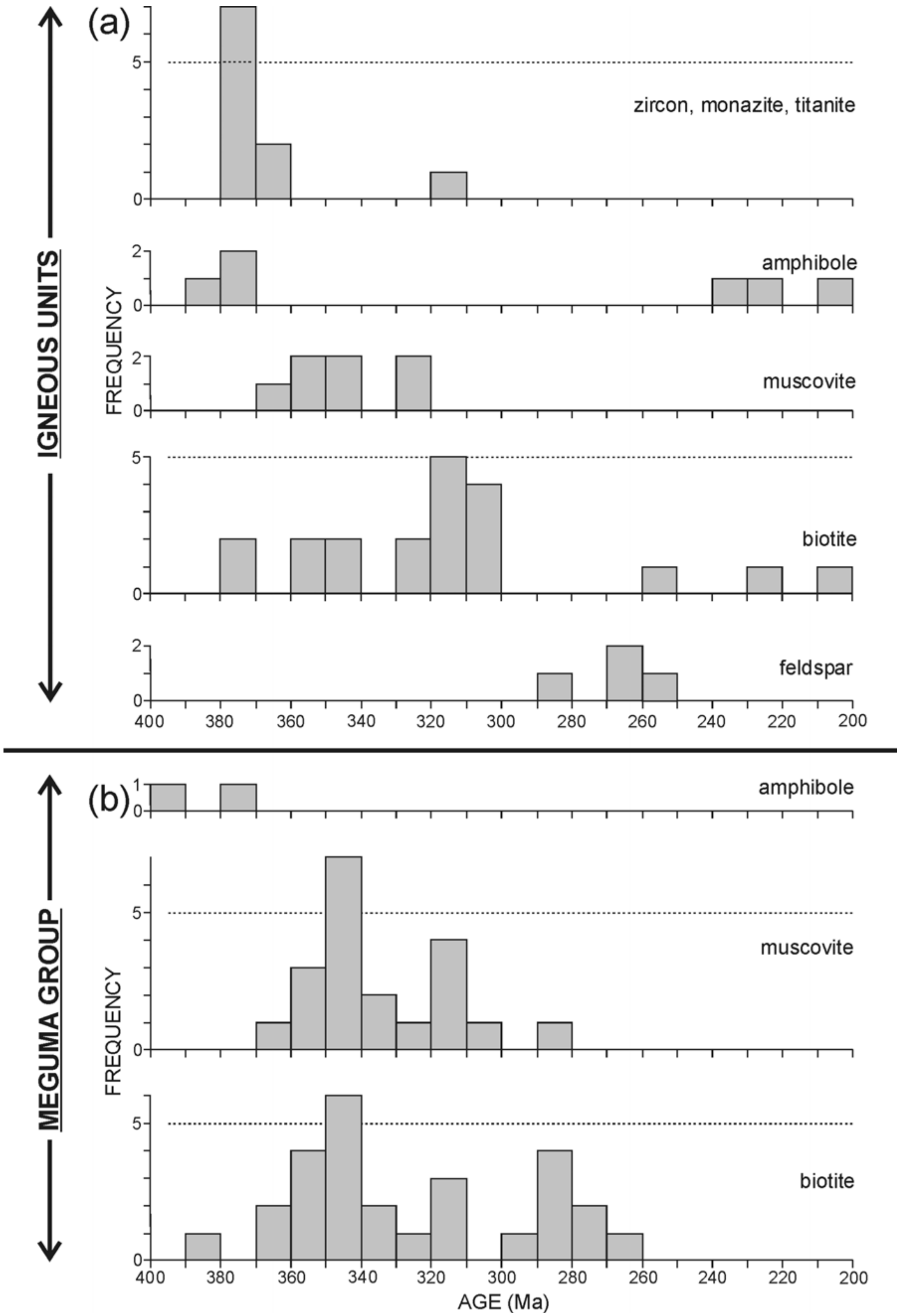


Figure 5. Histogram of U-Pb and $^{40}Ar/^{39}Ar$ ages from Figure 4 (a) ages from igneous units, (b) ages from metasedimentary rocks in the Meguma Group.

The Pubnico-Shelburne area experienced a younger tectonothermal event, apparently related to intrusion of the ca. 316 Ma Wedgeport Pluton. This event reset biotite ages in the area and appears to have been synchronous with ductile deformation related to the Alleghany Orogeny. Age data further suggest a tectonothermal event in the Permian that may have been be due to contact metamorphic effects of an unexposed pluton, or to slow cooling following intrusion of the Wedgeport Pluton.

The last geological event recorded by rocks in the area was intrusion of early Mesozoic lamprophyre and alkaline olivine diabase dykes. They did not have a thermal effect sufficient to reset biotite or muscovite ages in their host rocks.

Acknowledgments

S. Barr, R. Raeside and R. Horne are thanked for numerous discussions regarding the geology of southwestern Nova Scotia, and for the use of samples and unpublished information. I thank S. King for the use of unpublished aeromagnetic data that greatly helped in the interpretations of the geology. T. Lenfesty is thanked for her endless help in departmental library. A special thanks goes to N. MacLean for her endless enthusiasm in the field, plus her canoeing skills. Comments on various drafts of the manuscript by S. Barr were very helpful.

References

Bourque, A. D.1985: Migmatization and metamorphism associated with the Barrington Passage Pluton, Shelburne and Yarmouth Counties, Nova Scotia; BSc Honours thesis, Acadia University, Wolfville, Nova Scotia.

Cant, J. W., Fisher, D. F., Wilson, B. H., Dickie, G. B. and Sarkar, P. K. 1978: Report of exploration in Yarmouth County, Nova Scotia, (NTS 20/O and 20/P), May 1976 to April 1978; Shell Canada Resources Limited; Nova Scotia Department of Natural Resources Assessment Report A.R.-433144.

Chatterjee, A. K. and Keppie, J. D. 1981: Polymetallic mineralization in the endo- and exo-contact of the Wedgeport Pluton, Yarmouth County; *in* Report of Activities, 1980, ed. K. A. Mills; Province of Nova Scotia Department of Mines and Energy, Report 81-1, p. 43-46.

Chatterjee, A. K., Strong, D. F., Clarke, D. B. and Keppie, J. D. 1985: Geology and geochemistry of the Carboniferous Wedgeport Pluton hosting Sn-W mineralization; *in* Guide to Granites and Mineral Deposits of southwestern Nova Scotia, eds. A. K. Chatterjee and D. B. Clarke; Nova Scotia Department of Mines and Energy, Paper 85-3, p. 203-216.

Cormier, R. F., Keppie, J. D. and Odom, A. L. 1988: U-Pb and Rb-Sr geochronology of the Wedgeport granitoid pluton, southwestern Nova Scotia; Canadian Journal of Earth Sciences, v. 25, p. 255-261.

Cullen, J. D. 1983: Metamorphic petrology and geochemistry of the Goldenville Formation metasediments, Yarmouth, Nova Scotia; MSc thesis, Dalhousie University, Halifax, Nova Scotia.

Culshaw, N. 1994: A structural traverse from Yarmouth to Meteghan; Nova Scotia Department of Natural Resources Open File Report 94-025.

Culshaw, N. and Liesa, M. 1997: Alleghenian reactivation of the Acadian fold belt, Meguma Zone, southwest Nova Scotia; Canadian Journal of Earth Sciences, v. 34, p. 833-847.

Culshaw, N. and Reynolds, P. 1997: $^{40}Ar/^{39}Ar$ age of shear zones in the southwest Meguma Zone between Yarmouth and Meteghan, Nova Scotia; Canadian Journal of Earth Sciences, v. 34, p 848-853.

Currie, K. L., Whalen, J. B., Davis, W. J., Longstaffe, F. J. and Cousens, B. L. 1998: Geochemical evolution of peraluminous plutons in southern Nova Scotia, Canada-a pegmatite-poor suite; Lithos, v. 44, p. 117-140.

Dallmeyer, R. D. and Keppie, J. D. 1987: Polyphase late Paleozoic tectonothermal evolution of the southwestern Meguma Terrane, Nova Scotia: evidence from $^{40}Ar/^{39}Ar$ mineral ages; Canadian Journal of Earth Sciences, v. 24, p. 1242-1254.

Dallmeyer, R. D. and Keppie, J. D. 1988: Superposed Late Paleozoic thermal events in the southwestern Meguma Terrane, Nova Scotia; Maritimes Sediments and Atlantic Geology, v. 24, p. 157-169.

de Albuquerque, C. A. R. 1979: Origin of the plutonic mafic rocks of southern Nova Scotia; Geological Society of America Bulletin, v. 90, p. 719-731.

Gallant, G. K. 1991: Origin of the foliation in the Barrington Passage Pluton, southwest Nova Scotia; BSc thesis, Dalhousie University, Halifax, Nova Scotia.

Gareau, M. B. 1977: Pseudotachylytes of southwestern Nova Scotia; BSc thesis, Dalhousie University, Halifax, Nova Scotia.

Giles, P. S. 1985: A major post-Viséan sinistral shear zone-new perspectives on Devonian and Carboniferous rocks of southern Nova Scotia; *in* Guide to Granites and Mineral Deposits of southwestern Nova Scotia, eds. A. K. Chatterjee and D. B. Clarke; Nova Scotia Department of Mines and Energy, Paper 85-3, p. 233-264.

Hicks, R. J., Jamieson, R. A. and Reynolds, P. H. 1999: Detrital and metamorphic $^{40}Ar/^{39}Ar$ ages from muscovite and whole-rock samples, Meguma Supergroup, southern Nova Scotia; Canadian Journal of Earth Sciences, v. 36, p. 23-32.

Horne, R. J., White, C. E., Muir, C., Young, M. D. and King, M. S. 2000: Geology of the Weymouth-Church Point area (NTS 21A/05 and 21B/08, southwest Nova Scotia; *in* Report of Activities 1999, eds D. R. MacDonald and K. A. Mills; Nova Scotia Department of Natural Resources, Mines and Energy Branch Report ME 2000-1, p. 75-91.

Hwang, S. G. 1985: Geology and structure of the Yarmouth area, southwestern Nova Scotia; M.Sc. thesis, Acadia University, Wolfville, Nova Scotia.

Hwang, S. G. 1990: Structural and metamorphic geology of the Shelburne area, Nova Scotia; PhD thesis, University of New Brunswick, Fredericton, New Brunswick.

Keppie, J. D. and Dallmeyer, R. D. 1995: Late Paleozoic collision, delamination, short-lived magmatism, and rapid denudation in the Meguma Terrane (Nova Scotia, Canada): constraints from $^{40}Ar/^{39}Ar$ isotopic data; Canadian Journal of Earth Sciences, v. 32, p. 644-659.

Keppie, J. D. and Krogh, T. E. 1999: U-Pb geochronology of Devonian granites in the Meguma Terrane of Nova Scotia, Canada: Evidence for hotspot melting of a Neoproterozoic source; The Journal of Geology, v. 107, p. 555-568.

Keppie, J. D., Currie, K. L., Murphy, J. B., Pickerill, R. K., Fyffe, L. R. and St. Julien, P. 1985: Appalachian geotraverse (Canadian Mainland); Geological Association of Canada Excursion 1.

MacDonald, M. A., Boner, F. J. and Lombard, P. A. 1992: Multi-media detailed geochemical study of the Brazil Lake pegmatites, Yarmouth County, Nova Scotia; Nova Scotia Department of Natural Resources, Open File Report 92-016.

MacDonald, L. A. 2000: Petrology and stratigraphy of the White Rock Formation, Yarmouth area, Nova Scotia; M.Sc. thesis, Acadia University, Wolfville, Nova Scotia.

MacDonald, L. A., Barr, S. M., White, C. E. and Ketchum, J. W. F. 2002: Petrology, age, and tectonic setting of the White Rock Formation, Meguma terrane, Nova Scotia: evidence for Silurian continental rifting; Canadian Journal of Earth Sciences, v. 39, p. 1-19.

MacLean, N. J., Barr, S. M. and White, C. E. 2003: Petrology and tectonic setting of the Carboniferous Wedgeport Pluton, southwestern Nova Scotia: Presentation at the Northeastern Section, Geological Society of America 38th Annual Meeting, March 27-29; *in* Geological Society of America, Abstracts with Programs, v. 35, p. 54.

Moynihan, D. P., White, C. E. and Jamieson, R. A. 2001: Metamorphism and structure of the White Rock Formation in the Yarmouth area, Nova Scotia; *in* Mining Matters for Nova Scotia 2001, Opportunities for Economic Development, ed D. R. MacDonald; Nova Scotia Department of Natural Resources, Mines and Energy Branch Report ME 2001-2, p. 37.

Moynihan, D. P., White, C. E. and Jamieson, R. A. 2002: Metamorphism and structure of the White Rock Formation in the Yarmouth area, Nova Scotia; *in* Atlantic Geoscience Society Colloquium and Annual General Meeting, Program with Abstracts, p. 32.

Muecke, G. K, Elias, P. and Reynolds, P. H. 1988: Hercynian/Alleghanian overprinting of an Acadian Terrane: $^{40}Ar/^{39}Ar$ studies in the Meguma Zone, Nova Scotia; Chemical Geology, v. 73, p. 153-167.

Muir, C. M. 2000: An $^{40}Ar/^{39}Ar$ study of the Goldenville, Halifax, White Rock and Torbrook formations of the Digby area, southwest Nova Scotia; B.Sc. thesis, Dalhousie University, Halifax, Nova Scotia.

O'Brien, B. H. 1986: Preliminary report on the geology of the Mahone Bay area, Nova Scotia; in Current Research, Part A, Geological Survey of Canada, Paper 86-1A, p. 439-444.

O'Brien, B. H. 1988: A study of the Meguma Terrane in Lunenburg County, Nova Scotia; Geological Survey of Canada, Open File 1823.

Pe-Piper, G. A. and Reynolds, P. H. 2000: Early Mesozoic alkaline mafic dykes, southwestern Nova Scotia, Canada, and their bearing on Triassic-Jurassic magmatism; Canadian Mineralogist, v. 38, p. 217-232.

Pignotta, G. S. and Benn, K. 1999: Magnetic fabrics of the Barrington Passage pluton, Meguma Terrane, Nova Scotia: a two-stage fabric history of syntectonic emplacement; Tectonophysics, v. 307, p. 75-92.

Raeside, R. P. and Jamieson, R. A. 1992: Low-pressure metamorphism of the Meguma Terrane, Nova Scotia; Geological Association of Canada/ Mineralogical Association of Canada Joint Annual Meeting, June 1992; Field Excursion C-5: Guidebook.

Reynolds, P. H., Zentilli, M. and Muecke, G. K. 1981: K-Ar and $^{40}Ar/^{39}Ar$ geochronology of granitoid rocks from southern Nova Scotia: its bearing on the geological evolution of the Meguma Zone of the Appalachians; Canadian Journal of Earth Sciences, v. 18, p. 386-394.

Reynolds, P. H., Elias, P., Muecke, G. K. and Grist, A. M. 1987: Thermal history of the southwestern Meguma Group, Nova Scotia, from $^{40}Ar/^{39}Ar$ and fission track dating study of intrusive rocks; Canadian Journal of Earth Sciences, v. 24, p. 1952-1965.

Rogers, H. D. 1986: Igneous and metamorphic geology of Shelburne and eastern Yarmouth counties, Nova Scotia; Geological Survey of Canada, Open File Map 1374, Scale 1:50 000.

Rogers, H. D. 1988: Field relations, petrography, and geochemistry of granitoid plutons in the Shelburne area, southern Nova Scotia; Geological Survey of Canada, Open File 1835.

Rogers, H. D. and Barr, S. M. 1988: Petrography of the Shelburne and Barrington Passage plutons, southern Nova Scotia; Maritime Sediments and Atlantic Geology, v. 24, p. 21-31.

Ross, D. M. 1985: Structure and metamorphism of the Pubnico area, Yarmouth County, Nova Scotia; BSc Honours thesis, Acadia University, Wolfville, Nova Scotia.

Smith, P. K. 1985: Mylonitization and fluidised brecciation in southern Nova Scotia; *in* Mines and Minerals Branch, Report of Activities, 1984, eds. K. A. Mills and J. L. Bates; Nova Scotia Department of Mines and Energy, Report 85-1, p. 119-133.

Tate, M. C. 1995: The relationship between Late Devonian mafic intrusions and peraluminous granitoid generation in the Meguma Lithotectonic Zone, Nova Scotia, Canada; PhD thesis, Dalhousie University, Halifax, Nova Scotia.

Taylor, F. C. 1967: Reconnaissance Geology of Shelburne map-area, Queens, Shelburne, and Yarmouth Counties, Nova Scotia; Geological Survey of Canada Memoir 349.

Waldron, J. W. 1992: The Goldenville-Halifax transition, Mahone Bay, Nova Scotia: relative sea-level rise in the Meguma source terrane; Canadian Journal of Earth Sciences, v. 29, p. 1091-1105.

White, C. E. and King, 2002: Preliminary bedrock geology of the Tusket map area (NTS 20P/13), southwestern Nova Scotia; *in* Minerals and Energy Branch, Report of Activities 2001; Nova Scotia Department of Natural Resources, Minerals and Energy Branch, Report ME 2002-1, p. 141-158.

White, C. E., Horne, R. J., Muir, C., and Hunter, J. 1999: Preliminary bedrock geology of the Digby map sheet, southwestern Nova Scotia; *in* Minerals and Energy Branch, Report of Activities 1998; Nova Scotia Department of Natural Resources, Mines and Energy Branch, Report 98-1, p. 119-134.

White, C. E., Horne, R. J., Teniere, P. J., Jodrey, M. J. and King, M. S. 2001: Geology of the Meteghan River-Yarmouth area: a progress report on the Southwest Nova Scotia Mapping Project; *in* Minerals and Energy Branch, Report of Activities 2000; Nova Scotia Department of Natural Resources, Mines and Energy Branch, Report 2000-1, p. 95-111.

Wolfson, I. K. 1983: A study of the tin mineralization and lithogeochemistry in the area of the Wedgeport Pluton, southwestern Nova Scotia; MSc thesis, Dalhousie University, Halifax, Nova Scotia.