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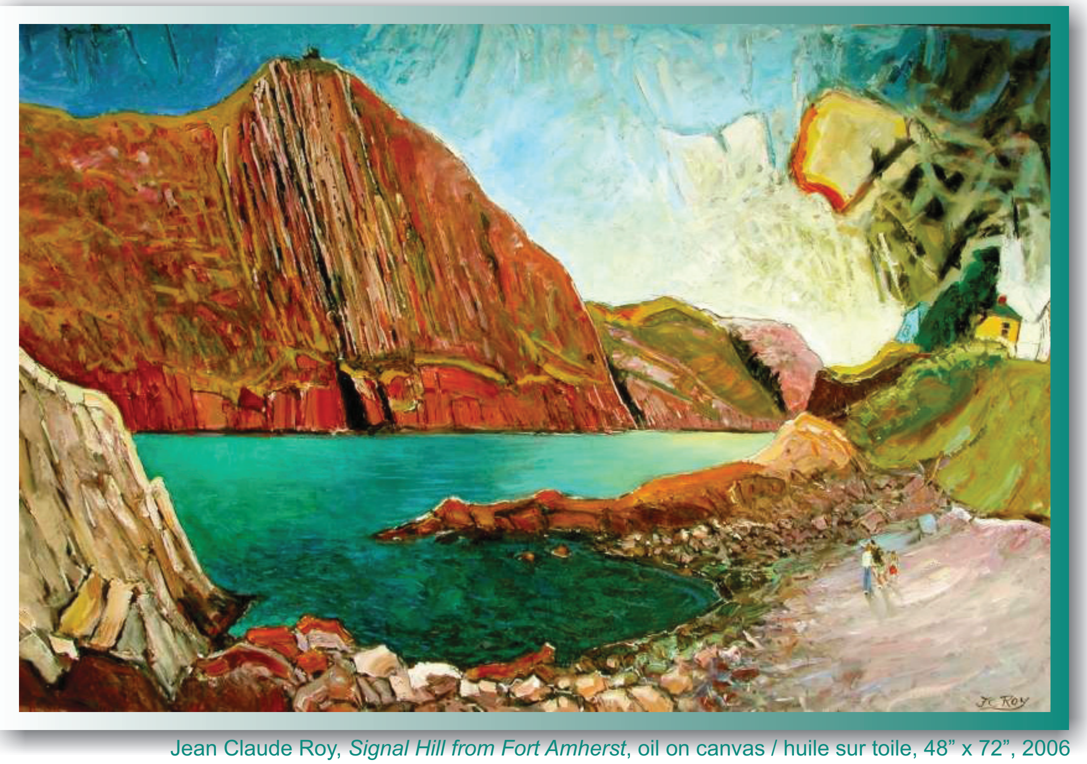
Jean Claude Roy, *Signal Hill from Fort Amherst*, oil on canvas / huile sur toile, 48" x 72", 2006

FIELD TRIP GUIDEBOOK - B5

THE NEW MEGUMA: STRATIGRAPHY METAMORPHISM, PALEONTOLOGY, AND PROVENANCE

Leaders: Chris E. White and Sandra M. Barr

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FIELD TRIP GUIDEBOOK – B5

THE NEW MEGUMA: STRATIGRAPHY, METAMORPHISM, PALEONTOLOGY, AND PROVENANCE

FIELD TRIP LEADERS

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May 30th to June 1st, 2012

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SAFETY INFORMATION

General Information

The Geological Association of Canada (GAC) recognizes that its field trips may involve hazards to the leaders and participants. It is the policy of the Geological Association of Canada to provide for the safety of participants during field trips, and to take every precaution, reasonable in the circumstances, to ensure that field trips are run with due regard for the safety of leaders and participants. GAC recommends steel-toed safety boots when working around road cuts, cliffs, or other locations where there is a potential hazard from falling objects. GAC will not supply safety boots to participants. Some field trip stops require sturdy hiking boots for safety. Field trip leaders are responsible for identifying any such stops, making participants aware well in advance that such footwear is required for the stop, and ensuring that participants do not go into areas for which their footwear is inadequate for safety. Field trip leaders should notify participants if some stops will require waterproof footwear.

The weather in Nova Scotia in May is unpredictable, and participants should be prepared for a wide range of temperatures and conditions. Always take suitable clothing. A rain suit, sweater, and sturdy footwear are essential at almost any time of the year. Gloves and a warm hat could prove invaluable if it is cold and wet, and a sunhat and sunscreen might be just as essential. It is not impossible for all such clothing items to be needed on the same day.

Above all, field trip participants are responsible for acting in a manner that is safe for themselves and their co-participants. This responsibility includes using personal protective equipment (PPE) when necessary (when recommended by the field trip leader or upon personal identification of a hazard requiring PPE use). It also includes informing the field trip leaders of any matters of which they have knowledge that may affect their health and safety or that of co-participants. Field Trip participants should pay close attention to instructions from the trip leaders and GAC representatives at all field trip stops. Specific dangers and precautions will be reiterated at individual localities.

Specific Hazards

Some of the stops on this field trip are in coastal localities. Access to the coastal sections may require short hikes, in some cases over rough, stony or wet terrain. Participants should be in good physical condition and accustomed to exercise. The coastal sections contain saltwater pools, seaweed, mud and other wet areas; in some cases it may be necessary to cross brooks or rivers. There is a strong possibility that participants will get their feet wet, and we recommend waterproof footwear. We also recommend footwear that provides sturdy ankle support, as localities may also involve traversing across beach boulders or uneven rock surfaces. On some of the coastal sections that have boulders or weed-covered sections, participants may find a hiking stick a useful aid in walking safely.

Coastal localities present some specific hazards, and participants MUST behave appropriately for the safety of all. High sea cliffs are extremely dangerous, and falls at such localities would almost certainly be fatal. Participants must stay clear of the cliff edges at all times, stay with the field trip group, and follow instructions from leaders. Coastal sections elsewhere may lie below cliff faces, and participants must be aware of the constant danger from falling debris. Please stay away from any overhanging cliffs or steep faces, and do not hammer any locations immediately beneath the cliffs. In all coastal localities, participants must keep a safe distance from the ocean, and be aware of the magnitude and reach of ocean waves. Participants should be aware that unusually large "freak" waves present a very real hazard in some areas. If you are swept off the rocks into the ocean, your chances of survival are negligible. If possible, stay on dry sections of outcrops that lack any seaweed or algal deposits, and stay well back from the open water. Remember that wave-washed surfaces may be slippery and treacherous, and avoid any area where there is even a slight possibility of falling into the water. If it is necessary to ascend from the shoreline, avoid unconsolidated material, and be aware that other participants may be below you. Take care descending to the shoreline from above.

Other field trip stops are located on or adjacent to roads. At these stops, participants should make sure that they stay off the roads, and pay careful attention to traffic, which may be distracted by the field trip group. Participants should be extremely cautious in crossing roads, and ensure that they are visible to any drivers. Roadcut outcrops present hazards from loose material, and they should be treated with the same caution as coastal cliffs; be extremely careful and avoid hammering beneath any overhanging surfaces.

The hammering of rock outcrops, which is in most cases completely unnecessary, represents a significant "flying debris" hazard to the perpetrator and other participants. For this reason, we ask that outcrops not be assaulted in this way; if you have a genuine reason to collect a sample, inform the leaders, and then make sure that you do so safely and with concern for others. Many locations on trips contain outcrops that have unusual features, and these should be preserved for future visitors. Frankly, our preference is that you leave hammers at home or in the field trip vans.

Subsequent sections of this guidebook contain the stop descriptions and outcrop information for the field trip. In addition to the general precautions and hazards noted above, the introductions for specific localities make note of specific safety concerns such as traffic, water, cliffs or loose ground. Field trip participants must read these cautions carefully and take appropriate precautions for their own safety and the safety of others.

Other Hazards

Lyme disease is a bacterial infection transmitted to humans and pets by a bite from a Blacklegged tick but not all ticks carry the bacteria. The Blacklegged tick has been found in all areas of Nova Scotia, especially in the area of this fieldtrip. The tick that carries the bacteria can only transmit Lyme disease after it has filled itself with blood, which takes at least 24 hours. In most cases, the first symptom of Lyme disease is a rash near the tick bite that may look like a bull's eye target. The bite is often painless, so you may not even know that you have been bitten. The rash usually appears between 7 to 10 days after the bite, but the range is between 3 and 30 days. Antibiotics are used to treat Lyme disease. Early treatment almost always results in full recovery.

When possible use insect repellent containing DEET. Follow manufacturer's directions. Cover as much of your skin as possible when walking, working, or playing in areas where ticks are found. Wear enclosed shoes, tuck your shirt into your pants, and tuck your pant legs into your socks. Wear light-coloured clothing with a tight weave to see ticks more easily. Check yourself after walking in grassy or wooded areas. Inspect all parts of the skin, including arm pits, groin, and scalp. Remove ticks as soon as you find them. If attached remove by carefully grasping the tick with tweezers or fingers as close to the skin as possible. Gently and slowly pull the tick straight out. Do not jerk, twist, or squeeze it. Disinfect the site with soap and water, rubbing alcohol, or hydrogen peroxide to avoid other infections.

OVERVIEW

This 3-day field trip highlights our new understanding of the unique geology of the Meguma terrane of Nova Scotia, the most easterly (outboard) component of the northern Appalachian orogen. Recent work has resulted in changes to previous interpretations of the terrane and provided new insights into its evolution and relationship to other peri-Gondwanan terranes. Participants will visit key locations for appreciating the characteristic Cambrian–Ordovician turbiditic units of the Meguma terrane, including coticule horizons and trace fossils, and overlying Silurian–Devonian rift-basin sequences, as well as its distinctive high temperature–low pressure metamorphism and associated Devonian–Carboniferous deformation and plutonism.

The focus of the trip is the stratigraphy in the Goldenville and Halifax groups, and the characteristics that enable the stratigraphic units to be recognized even at sillimanite grade. At several stops we will see the manganiferous uppermost unit of the Goldenville Group, a key marker unit throughout the terrane. Similarities and differences between the rocks northwest and southeast of the Chebogue Point shear zone are demonstrated. It is anticipated that outcrop and evening discussions will provide new insights about the still-enigmatic origin of the Meguma terrane, its relationship to Avalonia and Gondwana, and the nature of its accretion to the rest of the Appalachian orogen.

On **Day 1**, between the Halifax Stanfield International Airport and Yarmouth, we will see examples of metasedimentary rocks of the Goldenville and Halifax groups southeast of the Chebogue Point shear zone, at both low and high metamorphic grades, as well as some of the granitoid plutons that intruded them and their contact metamorphic aureoles. Day 1 is a long day, involving a lengthy drive and up to 9 stops (some stops are optional depending on weather and stamina of the participants). We anticipate arrival in Yarmouth at 7:00–7:30 pm.

On **Day 2**, we will look at rocks northwest of the Chebogue Point shear zone, including the Goldenville and Halifax groups and metavolcanic and metasedimentary rocks of the Silurian White Rock Formation of the Rockville Notch Group. In contrast to Day 1, the amount of driving is minimal, and we will have lengthy (up to 500 m) shoreline walks at most stops.

On **Day 3**, we will focus on stratigraphy in the upper part of the Goldenville Group and the overlying Halifax Group in the Bear River and Wolfville areas, looking at type localities for several of the new formations. Like Day 1, Day 3 involves a lengthy drive, and a number of the stops are optional. Most of the stops are short and at roadside outcrops, or require very short walks.

INTRODUCTION

This field trip highlights our new current understanding of the unique geology of the Meguma terrane of Nova Scotia, the most easterly (outboard) element of the northern Appalachian orogen (Figure 1). Recent work has modified previous interpretations of the terrane and provided new insight into its origin, evolution, and relationship to other peri-Gondwanan terranes.

The Meguma terrane is composed of a thick (~11–13 km) sequence of variably metamorphosed Early Cambrian (Terreneuvian, but the base is not exposed) to Early Ordovician (Floian) turbiditic metasandstone and slate (Goldenville and Halifax groups), and a much thinner sequence of Early Silurian to Early Devonian slate, quartzite, and metavolcanic rocks (Rockville Notch Group) (Figures 2 and 3). These rocks were deformed and metamorphosed during the Early to Middle Devonian Neoacadian orogeny, and intruded by numerous, late syn- to post-tectonic, mainly Middle to Late Devonian, peraluminous granitic plutons (Figures 2 and 3). This orogenic event is not yet well understood but was related at least in part to dextral transpressive accretion of the Meguma terrane against adjacent Avalonia along the Cobequid–Chedabucto fault system (Figure 4a). Subsequent Carboniferous motion on the fault system and renewed transpression throughout the Meguma terrane was related to docking of Gondwana (Africa) outboard of Meguma terrane in the Alleghanian orogeny (Figure 4b).

Based on detailed mapping during the past decade (*e.g.*, White 2010a, b, *in press*) the metasandstone-dominated Goldenville and slate-dominated Halifax groups have been divided into formations and members (Figure 3). An important advance was the recognition that a major high-strain zone (Chebogue Point shear zone), in combination with the South Mountain Batholith, divides the Meguma terrane into northwestern and southeastern parts with broad similarities but also important stratigraphic differences. The formations of the Rockville Notch Group, as well as two suites of mafic sills and dykes, occur only northwest of the shear zone (Figures 2 and 3).

An overview of the geology of the southwestern two-thirds of the Meguma terrane is shown in Figure 5, together with the field trip stops numbered by day. The descriptive material in this guidebook draws heavily on recent papers by White (2010a) and White *et al.* (*in press*).

PALEOGEOGRAPHY AND PROVENANCE

Meguma is generally accepted to be a peri-Gondwanan terrane, the most outboard in the northern Appalachian orogen (Figure 1). Pratt and Waldron (1991) observed that trilobites from the Government Point formation belong to the Acado-Baltic faunal province, which includes Avalonia, parts of Baltica and various regions in present-day southwestern Europe. The precise location of Meguma within this region, however, remains a matter of speculation. The Meguma terrane has generally been viewed as having been part of, or adjacent to, northern Gondwana (North African craton) during the Cambrian, perhaps in close association with Armorica (Schenk, 1971, 1981; Waldron *et al.*, 2009; van Staal and Hatcher, 2010). Van Staal (2007, p. 801) encapsulated the most accepted model when he wrote that it was "largely deposited on the continental rise and/or slope to outer shelf of a Gondwanan passive margin". However, other workers have considered Meguma as always part of Avalonia (Murphy *et al.*, 2004a), and/or formed as a continental shelf sequence on Avalonia (Romer *et al.*, 2011).

During opening of the Rheic Ocean, Meguma was one of several terranes that broke away from Gondwana and were eventually accreted to Laurentia. Waldron *et al.* (2009) used detrital zircon and Sm–Nd isotopic data to suggest that sediment near the base of the Goldenville Group was derived from Avalonian–Pan-African sources, whereas at higher stratigraphic levels, sediment was derived from West Africa and/or Amazonia. Acritarch assemblages preserved in the middle and upper parts of the stratigraphy are similar to those documented elsewhere in sedimentary sequences deposited in cold-water, southern hemisphere, peri-Gondwanan settings but do not provide more specific paleogeographic constraints (White *et al.*, *in press*).

Waldron *et al.* (2011) noted similarities in the Cambrian to Tremadocian lithological successions of the Meguma terrane and the Harlech Dome of North Wales, including the presence of Cambrian Series 3 manganese-rich sedimentary rocks. They proposed that both Meguma and North Wales were part of a "Megumia domain" that occupied a rift at the margin of Gondwana. Acritarch data suggest that deposition continued in the Halifax Group at a time when rocks of the Harlech Dome were being uplifted and eroded (White *et al.*, *in press*), and the Meguma terrane lacks evidence for the Ordovician volcanism present in North Wales. The acritarch data combined with U–Pb and fossil ages from the unconformably overlying Silurian–Devonian Rockville Notch Group indicate that the time gap represented by the unconformity between the Halifax and Rockville Notch groups is about 30 million years (Figure 6).

The nature of the thick (*ca.* 35 km; Jackson *et al.*, 2000) crust underlying the Meguma terrane is uncertain. Gneissic-looking rocks in the Trafalgar area in the northern part of the terrane, interpreted previously to represent possible basement units (*e.g.*, Dostal *et al.*, 2006), have been demonstrated to be deformed plutons and contact metamorphosed Goldenville and Halifax groups around Devonian plutons (White *et al.*, 2009; White and Scallion, 2011; Scallion *et al.*, 2011). Granulite-facies xenoliths in rare lamprophyric dykes in the Sheet Harbour area in the northeastern part of the terrane (Figure 2) also have been interpreted to represent lower crustal and mantle rocks underlying the Goldenville and Halifax groups (Owen *et al.*, 1988; Ruffman and Greenough, 1990; Eberz *et al.*, 1991; Greenough *et al.*, 1999). The xenoliths are heterogeneous and include both mafic igneous and aluminous metasedimentary compositions, the latter being isotopically suitable components in the sources of peraluminous granitoid rocks of the Meguma terrane (Eberz *et al.*, 1991). Overall, the chemical, isotopic, and age data from these xenoliths have led to the interpretation that they were derived from underlying Avalonian crust (Eberz *et al.*, 1991; Greenough *et al.*, 1999). Most workers assumed that this scenario was the result of Meguma being thrust over Avalonia during terrane amalgamation (*e.g.*, Tate and Clarke, 1995, 1997; Clarke *et al.*, 1997; Greenough *et al.*, 1999), but others have interpreted Meguma terrane to have formed on Avalonia basement (Murphy *et al.*, 2004a, b; Romer *et al.*, 2011). Seismic data show that Meguma terrane overlies Avalonia (*e.g.*, Keen *et al.*, 1991a, b; Jackson *et al.*, 2000), but it is not clear from the seismic models that Avalonia is far enough under Meguma terrane for it to have contributed to magma generation in the area of the Sheet Harbour dykes, or exactly when that underthrusting took place relative to plutonism. Furthermore, some of the inferences on which these interpretations were based have been complicated by more recent data; for example, Grenvillian-age detrital components are now known to occur in sedimentary rocks of the Meguma terrane, as well as in Avalonia (Waldron *et al.*, 2009). The nature of the crust and upper mantle underneath the bulk of the Meguma terrane remains uncertain. Based in part on the complete absence in Avalonia of granites similar to those of the Meguma terrane, we prefer a model where Avalonia and Meguma have different crust and lithosphere (Figure 4).

STRATIGRAPHY

OVERVIEW

As summarized by White (2010a), stratigraphic nomenclature in the Meguma terrane has had a complex history. The two-fold character of the rocks now included in the Goldenville and Halifax groups was recognized by Campbell (1863), who called the lower division the ‘quartzite group’ and the upper the ‘lower clay slate group’. Woodman (1902, 1904a, b) proposed the terms Goldenville formation for the lower division, Halifax formation for the upper slate division, and Meguma series for both formations. The latter was changed to Meguma Group by Stevenson (1959).

During the 1980s and 1990s, members were established locally in the Goldenville and Halifax formations and a transition zone was mapped in the Mahone Bay area (O’Brien 1986, 1988; Zentilli *et al.*, 1986; Waldron, 1987, 1992). Schenk (1991, 1995) proposed correlations among these members at a number of localities around the western margin of southern Nova Scotia and, in the 1995 paper, proposed elevation of the members to formation status, and of the Goldenville and Halifax formations to group status and hence, Meguma Group to Supergroup. However, because of limited field constraints, the proposed terminology was not widely accepted (*e.g.*, Keppie, 2000).

The situation has changed during the past 15 years, when systematic mapping was undertaken throughout the southwestern part of the Meguma terrane by geologists with the Nova Scotia Department of Natural Resources. This work resulted in division of the Goldenville and Halifax groups into mappable formations and the establishment of a new regional stratigraphy (White, 2010a, *in press*). The eastern half of Meguma terrane also has had preliminary subdivisions into formations that appear to correspond approximately with those included here (Ryan *et al.*, 1996; Horne and Pelley, 2007; White *et al.*, 2009, 2010a) but formal unit definition is not yet possible. To avoid a long-standing source of ambiguity and confusion in nomenclature, White and Barr (2010) suggested that the term ‘Meguma’ be restricted to the name of the pre-Carboniferous terrane, and not used as the name for the supergroup comprising the Goldenville and Halifax groups. That terminology is adopted here.

Until recently, age constraints on the Goldenville and Halifax groups were limited. A metacarbonate bed near the top of the Goldenville Group had yielded Middle Cambrian, Acado-Baltic trilobite fragments (Pratt and Waldron, 1991), and rare graptolites in the upper part of the overlying Halifax Group (Lumsden Dam and Bear River formations of White, 2010a, b; Figure 2) indicate an Early Ordovician age (Ami, 1902, 1903; Crosby, 1962; Smitheringale, 1973; Cumming, 1985; White *et al.*, *in press*). Doyle (1979) reported acritarchs from the Halifax Group in the Bear River area (Bear River formation of White 2010a; Figure 2), including *Acanthodiacrodium complanatum* and *Polygonium gracilis*, consistent with Tremadocian age. A maximum deposition age of 566 ± 8 Ma was indicated by the youngest detrital zircon grain in samples from the Goldenville Group from east of Halifax (Krogh and Keppie, 1990). Age constraints improved in recent years by the acquisition of additional detrital zircon age data (Waldron *et al.*, 2009), the documentation of Cambrian trace fossils (Gingras *et al.*, 2011), and acritarch identifications in the upper part of the Goldenville Group and through the Halifax Group (White *et al.*, *in press*). The results of this work are summarized on Figure 6.

Psammitic rocks in both the Goldenville and Halifax groups are dominantly feldspathic wackes, with mineralogical compositions indicative of deposition in an active margin from a source dominated by quartz and plagioclase; rare conglomeratic units contain mainly psammitic clasts with some mafic through felsic volcanic clasts, and rare tonalite clasts (White and Barr, 2010). Although fine material increases in relative abundance, little change in provenance up-section is indicated by petrography of psammitic rocks. Whole-rock chemical compositions are indicative of derivation from felsic to intermediate igneous material; it is likely that Pan-African orogenic belts containing recycled sediments from older cratons were major contributors to the sediments, rather than the sediments being derived directly from large ancient cratonic areas (White and Barr, 2010).

Along the northwestern margin of the Meguma terrane, the Halifax Group is overlain by shallow marine sedimentary and rift-related volcanic rocks of Silurian and Devonian age (Figure 2). Schenk (1995) proposed the name Annapolis Group for these rocks, but White (2010a) adopted the name Rockville Notch to avoid confusion with Mesozoic rocks which underlie the adjacent Annapolis Valley. Some previous workers (*e.g.*, Crosby, 1962; Taylor, 1969; Smitheringale, 1973; Schenk, 1997; Keppie, 2000) considered the contact between the Halifax Group and the overlying Silurian and Devonian rocks to be, at least in places, conformable. However, MacDonald *et al.* (2002) and White (2010a, b) suggested that the contact is a major disconformity.

The Silurian–Devonian units are not present southeast of the Chebogue Point shear zone and South Mountain Batholith (Figure 2). Also, as described in more detail below, the Goldenville and Halifax groups northwest and southeast of the shear zone exhibit stratigraphic differences, and pre-Middle Devonian mafic sills are abundant in the northwest but absent in the southeast (Barr *et al.*, 1983; White *et al.*, 1999; White and Barr, 2004; White, 2010a). These differences suggest that the high-strain zone and batholith may mark a fundamental break within the Meguma terrane. Waldron *et al.* (2009) suggested on the basis of stratigraphic and isotopic differences and limited paleocurrent data that the northwestern and southeastern parts of the terrane may represent opposing sides of a continental rift basin in which the Goldenville and Halifax formations were deposited (Figure 7a).

Both the Cambrian–Ordovician and Silurian–Devonian successions were regionally metamorphosed to lower greenschist facies and locally to lower amphibolite facies (Figure 8a). They were deformed into north- and northeast-trending folds with associated axial planar cleavage during the Middle Devonian, an event now referred to as the Neoacadian Orogeny (van Staal, 2007; White, 2010a). They were intruded by abundant 385–357 Ma peraluminous granitoid rocks (*e.g.*, Clarke *et al.*, 1997; Reynolds *et al.*, 2004; Moran *et al.*, 2007), largest of which is the South Mountain Batholith (Figure 2), with narrow, well developed contact metamorphic aureoles containing mineral assemblages characteristic of up to hornblende–hornfels facies (Mahoney, 1996; White, 2003). Upper Devonian–Carboniferous and Mesozoic rocks unconformably overlie the northern margin of the Meguma terrane and are preserved locally elsewhere in the terrane (Figure 2).

GOLDENVILLE GROUP

Southeast of the Chebogue Point Shear Zone

The lowermost strata of the Goldenville Group southeast of the Chebogue Point shear zone are assigned to the Moses Lake formation (Figures 5 and 6). It is exposed only in the cores of anticlines in the Wedgeport area (Figure 5), and consists mainly of grey, thin- to medium-bedded metasandstone, interlayered with minor green, cleaved metasiltstone. Calc-silicate concretions and thin calc-silicate beds (<5 cm) occur throughout. Also present are beds of black, magnetic slate with abundant sulphide minerals (pyrite, pyrrhotite, and arsenopyrite), a distinctive feature of the formation.

The overlying Green Harbour formation is the most extensive unit in the southeastern part of the Meguma terrane (White, 2010a, *in press*). The formation is dominated by grey, thick-bedded, medium-grained metasandstone, locally interbedded with minor green, cleaved metasiltstone, and rare black rusty slate. Large (up to 50 cm – long axis) brown carbonate-rich concretions and beds (<10 cm thick) are locally abundant. Most metasandstone beds are internally featureless but typically laminated to cross-laminated and rippled in the uppermost 10 cm. The metasandstone displays de-watering structures and was likely the product of deposition from high-concentration turbidity currents (Waldron, 1987, 1992; O'Brien, 1988; Schenk, 1997). Rare bedding-plane grazing trace fossils are present. Paleocurrent data indicate northwestward paleoflow during sediment deposition (Waldron, 1987, 1988; Waldron *et al.*, 2009).

The Lake Rossignol member was recognized as a distinct unit in the upper part of the Green Harbour formation (White, 2010a). It is approximately 1 km thick, and consists of rhythmically layered (2 to 3 m thick) grey, fine-grained metasandstone. Many of the beds have conglomeratic bases with thin (<20 cm) well laminated metasiltstone at the top. Large, up to 2 cm wide, pyrite cubes are locally abundant in the metasandstone. The base of the unit appears to be erosional into underlying metasandstone of the Green Harbour formation and is composed of poorly sorted, granule to cobble metaconglomerate in a coarse-grained metasandstone matrix.

The Government Point formation overlies the Green Harbour formation and is typically composed of grey, thin- to thick-bedded metasandstone, rhythmically laminated green to greyish-green metasiltstone, and black slate. Calc-silicate nodules are common in the metasandstone and are locally manganese-rich (White and Barr, 2010). A bioclastic limestone near the top of the formation yielded a Middle Cambrian trilobite faunule (Pratt and Waldron, 1991), and a pelmatozoan-bearing calc-silicate nodule at a similar stratigraphic level farther west was reported by White (2005). Trace fossils are abundant, including some of the earliest examples of *Paleodictyon* (Pickerill and Keppie, 1981; Waldron, 1987; White *et al.*, *in press*). Rare quartz-pebble conglomerate beds form deeply scoured channels that can be traced locally for 10s of metres along strike. They are probably the result of high-concentration turbidity currents (*e.g.*, Waldron, 1987).

The Moshers Island formation is a thin (<300–500 m) unit of green to greenish-grey to grey to purple, well laminated metasiltstone to slate, interlayered with minor, fine-grained, 1 to10 cm-thick metasandstone beds. A characteristic feature in this unit is the presence of steel-blue manganiferous nodules and laminations. At slightly higher metamorphic grades these nodules and laminations form thin (up to 10 cm thick), pink coticule beds and lenses due to the growth of spessartine garnet. Carbonate laminations and concretions are locally present and some contain rare ooid-like structures.

Northwest of the Chebogue Point Shear Zone

The lowermost unit of the Goldenville Group in the northwestern part of the Meguma terrane is the Church Point formation (Figures 5 and 6). It consists of grey, medium- to thick-bedded metasandstone, locally interlayered with green, cleaved metasiltstone, and rare black slate. The stratigraphically lowest and highest metasandstone beds in the formation yielded concordant detrital zircon ages of 544 ± 18 and 529 ± 19 Ma, respectively, limiting the maximum depositional age of the exposed part of the formation to Early Cambrian or possibly Late Ediacaran (Waldron *et al.*, 2009). The metasandstone typically lacks sedimentary structures, whereas metasiltstone interbeds locally preserve cross-bedding, ripple marks, and graded bedding. Limited paleocurrent data indicate south-directed flow (Waldron *et al.*, 2009). Calc-silicate lenses are a characteristic component of the metasandstone beds. Although broadly similar in overall composition, the three formations mapped southeast of the Chebogue Point shear zone (Moses Lake, Green Harbour, and Government Point formations) cannot be identified in the Church Point formation.

The High Head member is a distinctive interval about 1 km thick of greyish-green, parallel-laminated (rarely cross-laminated), magnetite-rich, metasiltstone to slate that occurs about 4 km up-section in the Church Point formation. The metasiltstone locally contains a remarkable trace fossil assemblage which includes irregular to meandering bedding-plane parallel forms such as *Gordia marina* and *Helminthopsis* sp., branching burrow systems (*Treptichnus* and *Phycodes*) and the vertical spreite burrow *Teichichnus* (Gingras *et al.*, 2011). Some of the *Treptichnus* burrows are exceptionally large, possibly the largest described to date. They differ in size and arrangement of segments from *Treptichnus pedum*. Of particular interest for constraining the age of the High Head member is the small radiating trace fossil *Oldhamia radiata* (Gingras *et al.*, 2011).The High Head member includes several massive metasandstone beds up to 3 m thick; the youngest detrital zircon extracted from the uppermost metasandstone bed has an age of 537 ± 15 Ma, indicating the maximum depositional age and consistent with similar (within error) ages obtained from the base and top of the formation (Waldron *et al.*, 2009). No unit like the High Head member was observed southeast of the Chebogue Point shear zone.

The upper part of the Goldenville Group in the Yarmouth to Bear River area is the Bloomfield formation, which consists mainly of distinctive banded maroon and green, thin- to medium-bedded metasiltstone to slate. The corresponding unit in the Torbrook–Wolfville area is the Tupper Lake Brook formation; it is lithologically similar but also contains 5 to 20 mm wide, ptygmatically folded, Mn-rich brown carbonate laminations and lenses like those in the Moshers Island formation southeast of the Chebogue Point shear zone. Within the contact metamorphic aureole of the South Mountain Batholith, these laminations and lenses have been converted to coticules, and contain spessartine garnet. The absence of Mn-enrichment in the correlative Bloomfield formation (White and Barr, 2010) is likely due to small differences in water depth during sediment deposition (Waldron, 1992). Both the Bloomfield and Tupper Lake Brook formations are in sharp, conformable contact with the underlying Church Point formation.

HALIFAX GROUP

Southeast of the Chebogue Point Shear Zone

The basal unit of the Halifax Group, the Cunard formation, consists predominantly of black to rust-brown slate with thin beds and lenses of minor black metasiltstone. Cross-laminated, fine- to medium-grained, poorly sorted, pyritiferous metasandstone beds, up to 30 cm thick, are locally present. The contact with the underlying Moshers Island formation is conformable and sharp, and placed at the base of the first sulphide-bearing black slate horizon. The abundance of graphite and sulphide minerals suggest deposition under anaerobic sea-floor conditions during a period of basin-wide stagnation (Waldron, 1987, 1992).

The overlying Feltzen formation is composed of light grey to blue-grey slate, rhythmically interlayered with laminated to thinly bedded, fine-grained metasandstone. In contrast to the Cunard formation, abundant trace fossils are a characteristic feature of the Feltzen formation (O'Brien, 1988), including large and deep paired burrows (Pickerill and Williams, 1989). The stratigraphic top of the Feltzen formation is not exposed. The Feltzen formation contains rare graptolites (*Rhabdinopora flabelliformis*) indicating an Early Ordovician age (*e.g.*, Cumming 1985).

Northwest of the Chebogue Point Shear Zone

The Acacia Brook formation is the lowermost unit of the Halifax Group in the Yarmouth and Bear River areas, and the corresponding unit in the Wolfville area is named the North Alton formation (Figure 6). The contact between the Tupper Lake Brook and North Alton formations was not observed in the Wolfville area (White, 2010b), but the corresponding Bloomfield-Acacia Brook contact was observed locally in the Bear River area to be sharp and conformable (Horne *et al.*, 2000). Like the stratigraphically equivalent Cunard formation southeast of the Chebogue Point shear zone, the Acacia Brook and North Alton formations consist mainly of grey to dark grey laminated slate with minor, thin (<5 mm thick) beds and lenses of light grey metasiltstone, as well as beds of cross-laminated fine- to medium-grained metasandstone up to 20 cm thick. The North Alton formation contains more abundant sulphide minerals (pyrite, pyrrhotite, and arsenopyrite) than the Acacia Brook formation.

The contact between the Acacia Brook/North Alton formations and the overlying Bear River/Lumsden Dam formations is gradational over a 5 m interval. The Bear River and Lumsden Dam formations consist of light grey, well laminated to thinly bedded, cleaved metasiltstone, with minor, thin (<10 cm thick) slate beds. Fine-grained, cross-laminated metasandstone beds (up to 20 cm thick) are a characteristic feature of these formations and are typically laterally continuous over at least 10s of metres. Pyrite and arsenopyrite are considerably less abundant than in the underlying Acacia Brook/North Alton formations. Primary sedimentary structures include cross- and graded-bedding, groove, tool, and load marks, ripples, and small-scale slump features. Trace fossils are relatively common and include horizontal looping forms, similar to those reported from somewhat younger Ordovician successions in central England and Portugal (Orr, 1996). Graptolites are known from a number of localities in the Lumsden Dam and Bear River formations, and recently collected material from the Lumsden Dam formation has been identified as *R. flabelliformis flabelliformis* (M. Melchin, written communication, 2011).

The Bear River formation is the uppermost unit preserved in the Halifax Group in the Yarmouth–Bear River area, but in the Wolfville area, the Lumsden Dam formation is gradational into the overlying Elderkin Brook formation. In places the Elderkin Brook formation consists of light grey to red-brown, laminated slate and metamudstone, but laterally grades into grey, well laminated to thinly bedded very fine-grained metasandstone–metasiltstone with thin (< 5 cm thick) cross-laminated metasiltstone and metasandstone beds and lenses. Carbonate-rich to silty carbonate-rich beds and lenses locally occur. The overlying Hellgate Falls formation is the uppermost unit of the Halifax Group (Figure 6). It is composed of light to dark grey slate rhythmically interbedded with laminated to thinly bedded metasiltstone and light grey metasandstone; thin lenses of cross-laminated metasandstone are common. Locally the upper part of the formation is capped by laminated black slate. Both the Elderkin Brook and Hellgate Falls formations contain abundant trace fossils, including large horizontal looping forms like those in the underlying Lumsden Dam formation, and heavily bioturbated metasiltstone beds.

In the Wolfville area, the White Rock Formation of the Rockville Notch Group disconformably overlies the Hellgate Falls formation but in the Bear River area, the White Rock Formation overlies the older Bear River formation (Figure 6).

ROCKVILLE NOTCH GROUP

In contrast to the deep water depositional environment and absence of volcanic rocks in the Goldenville and Halifax groups, the Rockville Notch Group consists of shallow marine sedimentary rocks (now quartzite, metasiltstone, and slate) and heterogeneously distributed interlayered mafic and felsic metavolcanic rocks. Metavolcanic rocks dominate in the Yarmouth area and Cape St. Marys areas, where they are mainly mafic tuffaceous rocks with less abundant mafic flows, epiclastic and clastic sedimentary rocks, and minor intermediate and felsic crystal tuff, all assigned to the Silurian White Rock Formation (Figure 6). In the Bear River area, volcanic rocks are absent and the White Rock Formation consists of mainly grey slate and metasiltstone with a thick (*ca.* 30 m wide) white quartz arenite near the base. It is conformably overlain by the Pridoli to Early Devonian Torbrook Formation, consisting of grey metasiltstone and calcareous metasiltstone, slate, metasandstone, and rare marble and ironstone. Mafic and felsic metavolcanic rocks reappear in the White Rock Formation of the Torbrook area, interlayered with quartzite, metasiltstone, and slate, but they are absent in the Wolfville area. In both the Torbrook and Wolfville areas, the Kentville Formation is recognized as a separate mappable unit (Figure 6), dominated by metasiltstone and slate. In the Wolfville area, it is overlain by a metavolcanic–metasedimentary unit, the New Canaan Formation (Crosby, 1962; James, 1998), which is probably laterally equivalent to the Torbrook Formation of the Torbrook and Bear River areas (White, 2010b).

Both fossils and U–Pb (zircon) dates provide age constraints on the Rockville Notch Group (Figure 6). A rhynconellid brachiopod from the Yarmouth area has a maximum age of Caradocian (A. Boucot, personal communication, 1971 in Lane (1975)). However, Boucot (written communication, 2002) indicated that an assemblage of brachiopods and gastropods found by C. White at this location (Overton section, Stop 2.2) is likely Early Silurian. Ludlovian graptolite specimens, identified as *Monograptus* sp. cf. *M. tumescens* Wood, were collected from strata assigned to the Kentville Formation (Smitheringale, 1960, 1973). Bouyx *et al.* (1997) also described graptolites and other fossils collected from the base of the Kentville Formation in that area and assigned an age of Late Wenlock to Early Ludlow whereas samples collected from the top of the Kentville Formation yielded Pridoli microfossils. The overlying New Canaan Formation contains crinoids, brachiopods (*?Conchidium*), and corals, and Boucot *et al.* (1974) placed the formation in the latest Silurian (Pridoli). The Torbrook Formation contains abundant fauna that Boucot (1960) and Cumming (*in* Smitheringale, 1973) considered to be Early Devonian. However, Bouyx *et al.* (1997) reported samples bearing *Urnochitina urna* (Eisenack), a Pridolian chitinozoan, from the basal part of the Torbrook Formation, indicating that the age extends back into the Late Silurian and overlaps with the age of the New Canaan Formation (Figure 6).

U–Pb (zircon) ages from the White Rock Formation are consistent with the fossil ages. In the Torbrook area, the base of the White Rock Formation is marked in places by a rhyolitic metatuff or flow that yielded a U–Pb zircon crystallization age of 442 ± 4 Ma (Keppie and Krogh, 2000). A felsic metatuff from higher in the stratigraphy in the Yarmouth area gave a similar age of 438 +3/-2 Ma (MacDonald *et al.*, 2002). The granitic Brenton Pluton in the Yarmouth area forms a faulted lens within the Chebogue Point shear zone; the pluton yielded a similar U–Pb (zircon) age of 439 ± 3 Ma (Keppie and Krogh, 2000) and is interpreted to be co-magmatic with the volcanic rocks (MacDonald *et al.*, 2002).

In the Yarmouth area, the White Rock Formation has been metamorphosed to upper greenschist and amphibolite facies. It is flanked on both west and east by the Halifax Group, but the northwestern contact is interpreted to be a sheared disconformity, whereas the southeastern contact is the Chebogue Point shear zone which juxtaposes rocks of the White Rock Formation at amphibolite facies west of the shear zone against lower greenschist facies rocks of the Halifax Group (Cunard formation) east of the shear zone (Figures 5 and 8a). Although traditionally inferred to form a syncline, the White Rock Formation in the Yarmouth area has been suggested instead to be a faulted/sheared stratigraphic succession of 7 map units, all younging to the east (MacDonald *et al.*, 2002).

The chemical characteristics of the mafic volcanic rocks in the White Rock Formation in the Yarmouth and Torbrook areas, and in the New Canaan Formation in the Wolfville area, consistently indicate alkalic affinity and a continental within-plate setting (James, 1998; MacDonald *et al.*, 2002; Hagan, 2002). The felsic volcanic rocks in the White Rock Formation, as well as the Brenton Pluton, have chemical characteristics of within-plate anorogenic granitic rocks (MacDonald *et al.*, 2002; Hagan, 2002). The igneous activity may have occurred in response to extension as the Meguma terrane rifted from Gondwana during the Silurian (Figure 7b).

Gabbroic rocks form scattered small plutons and abundant sills in the Goldenville and Halifax groups, as well as in the Rockville Notch Group, throughout the area west of the Chebogue Point shear zone (Barr *et al.*, 1983; White *et al.*, 2003; White and Barr, 2004). Less altered sills throughout the stratigraphy were termed “type II” in earlier work (*e.g.*, Barr *et al.*, 1983) to distinguish them from the more abundant and more altered “type I” sills that occur only in the Goldenville and Halifax groups. Some of the type I sills show evidence for soft-sediment interaction with their host rocks (*e.g.*, peperitic features; Stop 2.4), indicating that their emplacement occurred throughout deposition of the Goldenville and Halifax groups. Both the type I and type II sills have chemical characteristics consistent with emplacement in extensional tectonic settings. The type II sills may be related to mafic volcanism in the White Rock and New Canaan formations (Figure 7b). The type I sills were interpreted by Waldron *et al.* (2009) to be related to the formation of the rift basin in which the Goldenville and Halifax groups were deposited (Figure 7a).

DEFORMATION AND METAMORPHISM

INTRODUCTION

The Goldenville, Halifax, and Rockville Notch groups were regionally metamorphosed and deformed during the Neoacadian orogeny (Figure 3). Traditionally, this event was considered to be part of the Acadian orogeny (*e.g.*, Keppie and Dallmeyer, 1995; Culshaw and Lee, 2006) but has been renamed to distinguish the deformation and metamorphism observed in the Meguma terrane from that related to the older and probably unrelated Acadian orogeny that occurred elsewhere in the northern Appalachian orogen (van Staal, 2007; White *et al.*, 2007; Moran *et al.*, 2007). Detailed ^{40}Ar/^{39}Ar studies (single grain white mica and whole-rock slate samples) indicate that the regional deformation and greenschist-facies metamorphism associated with the Neoacadian orogeny occurred between *ca.* 406–388 Ma (Muecke *et al.*, 1988; Hicks *et al.*, 1999; Muir, 2000; Reynolds *et al.*, *in press*) during the docking of the Meguma terrane with Avalonia. This event is younger than the deformation and metamorphism related to the Acadian orogeny which occurred during Late Silurian–Early Devonian accretion of Avalonia to the composite margin of Ganderia and Laurentia (Hibbard *et al.*, 2007).

Although considerable work has been done on the metamorphism and deformation in the Meguma terrane, not much has been formally published, attesting to the difficulty of understanding the details of the tectonothermal history. The map in Figure 8a was compiled from observations by the authors, information in student theses, and the field trip guide by Raeside and Jamieson (1992). The descriptions here focus on southeastern part of the terrane, where most of these studies were focused.

Regional metamorphic grade varies across the Meguma terrane; the highest grade areas occur around Shelburne–Barrington in the southwest and Canso in the northeastern part of the terrane (Figure 8a). These Neoacadian-produced regional structures and related metamorphism were overprinted locally by contact metamorphism up to hornblende–hornfels-facies around the late syn- to post-tectonic (with respect to the Neoacadian orogeny) South Mountain Batholith and other smaller plutons (Mahoney, 1996). In addition, younger thermal and deformational events are locally recorded, mainly associated with shear zones at *ca.* 370 Ma and *ca.* 325 Ma (Figure 9).

METAMORPHISM

Taylor and Schiller (1966) described both regional and contact metamorphism in the Goldenville and Halifax groups and divided the regionally metamorphosed rocks into greenschist and almandine–amphibolite facies types. Contact metamorphic effects were noted around many of the plutonic units. Several metamorphic zones were later determined in southern Nova Scotia (Chu, 1977; White, 1984; Bourque, 1985; Ross, 1985; Misner, 1986; Hope *et al.*, 1988; Raeside and Jamieson, 1992; Moynihan, 2003) which have been modified slightly as a result of regional mapping (Figure 8a). Five metamorphic zones can be recognized, based mainly on pelitic lithologies. The exact position of the isograds separating these zones is difficult to determine in some areas due to lack of exposure and/or pelitic lithologies.

Rocks characteristic of the chlorite zone (Figure 8a) have been recognized west of the Yarmouth area (Raeside and Jamieson, 1992; White, 2003), in the Bridgewater area (White, 2008), and in the Torbrook–Wolfville area (White, 2010b). In this zone the recognizable metamorphic minerals are chlorite and muscovite, which define the regional foliation. Epidote is a common accessory mineral and locally spessartine garnet and ilmenite are present. In the Port Mouton area cordierite is locally associated with chlorite (*e.g.*, Hope *et al.*, 1988). However, cordierite in this zone appears to have formed by the reaction chlorite + muscovite + quartz = cordierite + biotite + water which places this assemblage in the biotite zone. Given the proximity of this chlorite–cordierite zone to the Port Mouton Pluton it is unclear if the cordierite in this case is not the product of contact metamorphism.

Rocks assigned to the biotite zone are more widespread across the map area from Cape St. Marys to Liverpool (Figure 8a). The biotite zone is characterized by the presence of prograde biotite that gives the slate a spotted appearance. A typical mineral assemblage is biotite + chlorite + muscovite + quartz + albite (*e.g.*, Ross, 1985) but rocks at similar grades in the Rockville Notch Group in the Yarmouth area locally contain chloritoid porphyroblasts

(White *et al.*, 2001; Moynihan, 2003). In mafic lithologies in the Rockville Notch Group amphibole is typically zoned with actinolitic cores and actinolitic–pargasite or pargasite rims (MacDonald, 2000; MacDonald *et al.*, 2002).

The garnet zone is generally narrower (2-5 km wide) than the biotite and chlorite zones and is mineralogically similar to the biotite zone except that the rocks contain tiny porphyroblasts of almandine garnet and An content of plagioclase has increased (An_{18-20}). On Pubnico Peninsula the garnet zone grades into a chiastolite zone that 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 Barrington Passage Pluton. Garnet zone rocks in the Rockville Notch Group in the Yarmouth area are associated with the bounding shear zones and contain the same mineral assemblage as the biotite zone but with the addition of garnet. However, with the addition of garnet, biotite content decreases and the abundance of chloritoid increases (Moynihan, 2003). Rocks in the chlorite, biotite and garnet zones typically retain their original sedimentary textures but their mineral assemblage is metamorphic.

In contrast, in the staurolite zone (Figure 8a) most original sedimentary textures have been obliterated. The typical mineral assemblage is staurolite + garnet + biotite + chlorite + muscovite + quartz + plagioclase (An_{17-27}) (Ross, 1985; Hope *et al.*, 1988). However, the appearance of andalusite and cordierite is locally synchronous with staurolite. The development of this assemblage appears to be the product of two independent reactions as noted by Hope *et al.* (1988): muscovite +chlorite = biotite + staurolite + cordierite + water and staurolite + cordierite + muscovite = biotite + andalusite + water. However, the assemblage muscovite + cordierite + staurolite + biotite is relatively rare and generally interpreted to be the result of polymetamorphism (*e.g.*, Pattison *et al.*, 1999). Andalusite typically forms very large crystals up to 40 cm long that are randomly oriented on bedding planes but locally elongate parallel to the regional fold axis. In this zone crosscutting andalusite veins are common.

In the Rockville Notch Group in the Yarmouth area the staurolite zone is directly associated with the bounding shear zones. Here the typical mineral assemblage consists of staurolite + garnet + biotite + oligoclase + muscovite + ilmenite ± chlorite ± chloritoid (Moynihan, 2003). Cordierite was not observed. Peak metamorphic conditions in these bounding shear zones reached 550–600°C at 4 kb with $^{40}Ar/^{39}Ar$ muscovite ages of *ca.* 325 Ma and shear zone kinematics which suggest that Alleghanian transpression was responsible for emplacement of these amphibolite-facies rocks to shallower crustal levels (Moynihan, 2003).

The transition from the staurolite–andalusite zone in the Shelburne area to the sillimanite zone (Figure 8a) is generally marked by the appearance of sillimanite as elongate fibrolite mats or prismatic crystals that 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).

Migmatite forms an aureole up to 5 km in width around the Barrington Passage Pluton. Both anatectic and injection migmatite is 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 lithologies are not developed around the Shelburne Pluton. Because migmatite borders the Barrington Passage Pluton, Taylor (1967) speculated that its development was related to contact metamorphism by the Barrington Passage Pluton 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 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 Barrington Passage Pluton accompanied or closely followed the peak of metamorphism which reached 650–675°C at 3.75 to 4 kb (Figure 8b).

DEFORMATION

The Goldenville, Halifax, and Rockville Notch groups are folded into a series of regional upright, shallow north- and south-plunging F_1 anticlines and synclines with a well developed, steep axial planar, north-striking, foliation (S_1) dated at *ca.* 406–388 Ma (Hicks *et al.*, 1999). Towards the north these F_1 fold structures plunge more to the northeast and southwest (Figure 5) and the steep axial planar foliation (S_1) strikes northeast. Minor F_1 folds are upright and mimic the regional fold style. Intersection lineations (L_1) (bedding/foliation) and elongate calc-silicate nodules are parallel to orientation of the minor fold axes. Doubly plunging anticlines and synclines are common throughout the Meguma terrane. South of the South Mountain Batholith where the regional fold patterns change in trend from north to northeast, the anticlines and synclines are overturned and moderately inclined to the southeast and plunge to the south and northeast (Figure 5).

In addition to the folding and accompanying regional metamorphism associated with the Neoacadian orogeny, numerous post-Neoacadian shear zones have been documented, especially in the southwestern Meguma terrane (*e.g.*, Giles, 1985; Culshaw and Leisa, 1997; Clarke *et al.*, 2002; Horne *et al.*, 2006). Some of these shear zones are demonstrably synchronous with Late Devonian granite emplacement, and other are of Carboniferous age, linked mainly to the *ca.* 325 Ma peak seen in ^{40}Ar/^{39}Ar cooling ages (Figure 9).

In the area around the Barrington Passage Pluton (Figure 5), the rocks have experienced a younger deformational event, approximately synchronous with pluton emplacement at *ca.* 373 Ma. 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 lithologies around the Barrington Passage Pluton and are 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 and parallel the long axes of boudinaged metasandstone layers. A mineral lineation (L_{m2}) gently plunging north is also well developed in the Barrington Passage Pluton and defined by prismatic plagioclase crystals, quartz rods, and elongate mafic enclaves (Pignotta and Benn, 1999; White and King, 2002). Magmatic layering in the Barrington Passage Pluton has been folded, as evident from small-scale isoclinal folds in the pluton (*e.g.*, Pignotta and Benn, 1999) and the overall regional structural patterns (White, 2003). The structural styles observed in the pluton are identical in orientation to those in the surrounding migmatitic units and demonstrate that the pluton was emplaced and deformed along with the migmatite, and schist at *ca.* 373 Ma, considerably later than the deformation and metamorphism of the Neoacadian orogeny, and presumably within a large shear zone. Similar syntectonic emplacement features have been documented in the *ca.* 373 Ma Port Mouton Pluton, emplaced in the Port Mouton shear zone (Clarke *et al.*, 2002).

A major shear zone trending north-south is interpreted to underlie Pubnico Harbour east of Stop 1.9 (Figure 5), in which schist and migmatite locally contain mesoscopic refolded isoclinal folds and strongly attenuated shallow south-plunging andalusite crystals interpreted to be the result of deformation. Similar shear zones to the east also typically trend north-south and post-date peak metamorphism (Hwang, 1990), and have yielded ^{40}Ar/^{39}Ar muscovite ages of 335–320 Ma (Dallmeyer and Keppie, 1987, 1988). The Cape St. Marys and Cranberry Point shear zones (Figure 5) yielded similar muscovite ages of *ca.* 320 Ma (Culshaw and Reynolds, 1997). In addition, shearing in the *ca.* 357 Ma Wedgeport Pluton (MacLean *et al.*, 2003) suggests that ductile deformation in southwestern Nova Scotia continued into the Carboniferous, as also indicated by ^{40}Ar/^{39}Ar cooling ages (Figure 9; Reynolds *et al.*, 1987).

The most important of these shear zones appears to be the Chebogue Point shear zone of Culshaw and Liesa (1997), the regional significance of which has only recently been recognized (White, 2010a). This shear zone is 2 km wide, and trends north to northeast (Figure 2). It is inferred to extend along the western and northern margins of the South Mountain Batholith to the contact between Meguma terrane rocks and Carboniferous rocks, where it may merge with faults associated with the Cobequid–Chedabucto system (Murphy *et al.*, 2011). To the south, the Chebogue Point shear zone can be traced as far as Seal Island (Figure 5). In the Yarmouth area, it juxtaposes chlorite/biotite-grade rocks of the Halifax Group on the east with staurolite–andalusite grade metamorphic rocks of the Rockville Notch Group on the west (Figures 5 and 8a). Moynihan (2003) conducted the most detailed study so far of this zone in the Yarmouth area and concluded that movement was both dip-slip and oblique dextral, with the northwest (Rockville Notch Group) side up, at *ca.* 325 Ma. However, in that area, the shear zone is strongly overprinted by younger brittle deformation that locally obliterated earlier deformational textures. On Seal Island the kinematic indicators are better preserved in the Seal Island Pluton and indicate dextral strike-slip movement late synchronous with intrusion at *ca.* 367 Ma (Moran *et al.*, 2007). The northeastern extension of the shear zone in the Trafalgar area also displays dextral strike-slip sense of movement and is interpreted to be late synchronous with *ca.* 373 intrusions in that area (Puchalski, 2012).

Brittle faults are also present locally throughout the map area. For example, a fault through the Pubnico peninsula 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 presence of Z-shaped drag folds (*e.g.*, Ross, 1985) and offset of the Shelburne dyke (Figure 5).

Pseudotachylyte veins are another feature indicative of brittle deformation in the southwestern Meguma terrane. 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 intrusion of the Barrington Passage Pluton (Gareau, 1977). Another possibility is an association with the Montagnais offshore meteorite impact at *ca.* 50 Ma (*e.g.*, Jansa *et al.*, 1989).

PLUTONIC HISTORY

Peraluminous mid- to late Devonian granitoid plutons, dominated by the South Mountain Batholith (Figure 2), are a characteristic component of the Meguma terrane (*e.g.*, Clarke *et al.*, 1997). The peraluminous (molar Al > Ca+Na+K) composition of the granodioritic to leucogranitic South Mountain Batholith has been attributed to melting of sub-Goldenville Group crust combined with contamination from the Goldenville and Halifax groups, whereas the "peripheral plutons" (Port Mouton, Shelburne, and Barrington Passage) have been interpreted to be of mixed derivation from sub-Goldenville Group crustal sources mixed with mantle-derived mafic magmas (Tate and Clarke, 1995, 1997; Clarke *et al.*, 1997). Obtaining precise ages for such contaminated and multi-sourced plutons has been challenging but monazite, zircon and/or titanite from the Barrington Passage, Shelburne, and Port Mouton plutons and associated Birchtown diorite yielded U–Pb ages of *ca.* 377–362 Ma (*e.g.*, Clarke *et al.*, 1997; Currie *et al.*, 1998; Keppie and Krogh, 1999; Clarke *et al.*, 2000) and there is some indication that somewhat older mafic intrusions also exist in the area (*e.g.*, Dallmeyer and Keppie, 1987). The Wedgeport Pluton, considered to be much younger in previous work (Cormier *et al.*, 1988), is now reliably dated at 357 ± 1 Ma (MacLean *et al.*, 2003), about 15 million years younger than the nearby Barrington Passage and Shelburne plutons. Seal Island biotite monzogranite yielded a similar age of 367 Ma (Moran *et al.*, 2007). Meguma terrane granites, including South Mountain Batholith, with their characteristic peraluminous signatures and εNd values that range from slightly positive to moderately negative were generated over a time span of at least 15–20 Ma, an important constraint on tectonic models as it suggests that the source area and magma genesis processes did not change significantly during that time. Tendency for higher εNd values in peripheral plutons has been attributed to more interaction with mantle-derived magma compared to the central plutons (*e.g.*, Tate and Clarke, 1995, 1997; Clarke *et al.*, 1997).

Overall, based on their petrological characteristics, general consensus exists that the plutons of the Meguma terrane were formed in association with subduction; however, the direction of subduction is uncertain. Most models (*e.g.*, Tate and Clarke 1995) infer subduction to the present-day southeast, underneath Meguma terrane, to generate subduction-related mafic magmas that triggered crustal melting to form the abundant granitoid plutons.

Alternatively, in Figure 4a we show subduction to the present-day northeast in order to explain mid-Devonian plutons present locally in Avalonia. The model in Figure 4 links ongoing plutonism in the southern part of the Meguma terrane to renewed subduction from southeast to northwest after Meguma–Avalonia collision. This model incorporates flat-slab subduction of Theic Ocean crust and subsequent mantle upwelling and possible Theic crust delamination, as proposed by Murphy *et al.* (1999) and van Staal (2007). The combination of oblique collision and flat-slab subduction can explain the relative lack of magmatism in much of Avalonia at this time, and is analogous to the earlier Avalonia–Ganderia relationship during and after the Acadian orogeny, which resulted in voluminous granitoid plutons in more inboard parts of the Appalachian orogen (van Staal, 2007). Decreasing age of magmatism in the Meguma terrane could be linked to the stepping back of the locus of subduction to a position now under the continental margin well outboard of exposed Meguma terrane rock, prior to Carboniferous accretion of Gondwana (Figure 4). The key to confirming or disproving this speculative model lies in knowing the age(s) and more detailed petrochemical characteristics of the granitoid rocks that apparently form much of the offshore part of the Meguma terrane, from which ages as young as 300 Ma have been reported (Pe-Piper *et al.*, 2009). Related questions include whether or not co-genetic volcanic rocks are present in the offshore parts of Meguma terrane, and perhaps even the relict suture with Gondwana.

GOLD OCCURRENCES

The Meguma terrane has a long history of gold mining, dating back to the 1800s. The gold mineralization occurs in bedding-parallel and associated discordant vein arrays within the hinge zone of regional anticlines, and locally in the wall rock in those areas (*e.g.*, Horne and Pelley, 2007). Various studies have considered a correlation between gold deposits and certain stratigraphic units; however, Horne and Pelley (2007) noted that in the area east of Halifax where most gold districts are located, such inferences are unwarranted. They suggested that gold districts in that area occur throughout the Goldenville and Halifax groups, with no indication that stratigraphic position has any control in their distribution. Instead, they concluded that the key factor in gold mineralization is the presence of tight fold hinges. Such anticlinal hinges are more common in the Goldenville Group than in the overlying Halifax Group at the current level of exposure, and hence so are the gold districts.

In contrast to the apparent situation in the eastern part of the terrane, some stratigraphic control of gold districts in the southern part of the Meguma terrane is suggested by comparing their distribution to stratigraphy (Figure 10). Five gold occurrences southeast of the Chebogue Point shear zone are located in the Lake Rossignol member of the Green Harbour formation, and the two others are close to that stratigraphic level, as is the occurrence located northwest of the Chebogue Point shear zone (Figure 10). The association with regional anticlinal fold hinges is much less apparent (Figure 11).

In addition to the typical vein-hosted gold districts, gold also occurs in veins associated with shear zones in the East Kemptville area (Figure 5). It is not yet clear whether gold mineralization in that area is related to the early bedding-parallel veins deformed in the shear zone, or to veins and alteration that developed in shear-related structures (Horne *et al.*, 2006) or if it occurs at the same stratigraphic horizon as the Lake Rossignol member. This area also contains several tin and base metal occurrences within a broad zone of shear which spanned granite emplacement (*e.g.*, Horne *et al.*, 2006).

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STOP DESCRIPTIONS

DAY 1. (Figure 11)

Drive from Halifax Stanfield International Airport to Bridgewater, via Highways 102 and 103. Distance – 130 km, about 1.5 hours.

Follow Highway 10 to 331, from Bridgewater to Dublin Shore (21 km); turn left at Bells Cove Road, proceed about 700 m to shore at Bells Cove.

STOP 1.1: Dublin Shore – Goldenville Group – Halifax Group Contact (UTM Zone 20T E=390665 N=4902070 and E=390692 N=4901808)

The Goldenville Group consists mainly of metasandstone with subordinate slate, and the overlying Halifax Group consists mainly of slate with subordinate metasandstone. The position of the contact between the two groups has been controversial because of the previous designation of a "transition zone" of mixed metasandstone–slate units between the two units in some well exposed sections in the Lahave and Mahone Bay areas (O'Brien, 1988). Also, some past workers (*e.g.*, Waldron, 1992) placed the Goldenville–Halifax boundary at the base of the manganiferous Moshers Island formation within that transition zone. However, based on regional mapping, White (2010a) placed the contact at the base of the Cunard formation (Figure 6), a more prominent lithological boundary. This interpretation is also supported by the occurrence of manganiferous beds deeper in Goldenville Group stratigraphy, and their absence in the Halifax Group (White, 2010a; White and Barr, 2010).

This stop is located at the Goldenville–Halifax contact as defined by White (2010a). On the northeast side of the cove black graphitic slate and pyrite-rich metasiltstone are assigned to the Cunard formation, the lowermost unit of the Halifax Group. Bedding is relatively shallow at this location with a well developed steep axial planar cleavage with multiple upright and open minor folds as we are close to the crest of a regional northeast plunging anticline. The metamorphic grade of these rocks is greenschist facies (chlorite zone) which is characterized by the presence of prograde chlorite, which can give the slate a spotted appearance. A typical mineral assemblage is chlorite + muscovite + quartz + plagioclase (albite) ± epidote.

Southwest of the cove, pale grey to green metasiltstone and metamudstone are assigned to the Moshers Island formation, the uppermost unit of the Goldenville Group. These rocks appear coarser grained and are less well cleaved than the overlying black slate. However, thin sections show that the coarse grains are all metamorphic and that the original grain size was very fine. Manganese-rich horizons (coticules) can be recognized by their distinctive pale pink colour. They contain diagenetic concretions of manganoan carbonate rimmed to totally replaced by spessartine garnet, quartz, and ± ilmenite.

Continue on Highway 331 to Petite Rivière, cross bridge and turn left (south) at the crossroads, on Green Bay Road, and continue to the Canteen at Green Bay (12 km).

STOP 1.2: Green Bay – Government Point and Green Harbour Formations (UTM Zone 20T E=385233 N=4896736)

In the terminology of White (2010a), this locality is at the contact between the Government Point formation (northeast of the canteen) and underlying Green Harbour formation (southwest of the canteen), both part of the Goldenville Group. The contact is not exposed here but elsewhere the contact is gradational over 100–200 m. The Government Point formation consists of metasiltstone and subordinate slate and graded, ripple cross-laminated fine-grained metasandstone showing partial Bouma sequences with a total thickness of 1750 m. The underlying Green Harbour formation consists of massive metasandstone showing internal scour-and-fill structures, a variety of dewatering features, and rare grazing trace fossils. The metasandstone beds are deposits of high-concentration turbidity currents and do not show typical Bouma sequences. This formation is about 4000 m thick (White, 2010a).

Scattered carbonate nodules (concretions) and diffuse carbonate-cemented areas are visible on weathered surfaces in both formations. Some carbonate concretions are elevated in Mn contents and contain minor spessartine garnet. Based on the mineral assemblage the regional metamorphic grade continues to be relatively low at chlorite zone.

Return to Petite Rivière, cross Highway 331 and continue northwest on Italy Crossing Road for 10.5 km. At intersection with Highway 3 turn right (east) and drive 250 m. Park on northside of highway in Volunteer Fire Department parking lot. Walk south about 75 m to Crouse Settlement Road and walk uphill for another 75 m. Outcrop is in the ditch on the east (right) side of the road.

STOP 1.3: Moshers Island Formation: Top of the Goldenville Group (UTM Zone 20T E=376175 N=4902157)

At this location we are close to the hinge of a regional northeast-plunging syncline and near the top of the Moshers Island formation. Here well developed pink coticule beds and nodules locally display ptygmatic fold structures compared to the interlayered pale grey metasiltstone to fine-grained metasandstone. In contrast to the first two stops, regional metamorphic grade has increased slightly to the chlorite–biotite zone of the greenschist facies. The more slaty rocks contain tiny biotite and chlorite spots that parallel the regional cleavage.

Continue southwest on Highway 103. West of Liverpool, take the Summerville Beach turn-off onto Highway 3, going east. Outcrops are on the coast by a grove of pine trees, 2.5 km along the road at a roadside pull off. Caution: poison ivy has been sighted here.

STOP 1.4: Summerville Beach – Migmatitic Contact between the Port Mouton Pluton and Goldenville Group

(UTM Zone 20T E=355620 N=4867855)

Summerville Beach is located near the eastern end of the metamorphic culmination in the Shelburne–Barrington area (Figure 8a). The complex injection migmatite that crops out along the shore is developed in metasedimentary rocks of the Green Harbour formation (Goldenville Group), on the margin of the Port Mouton Pluton. The metasedimentary rocks are cut by dykes of granite, aplite, and pegmatite ranging from a few centimetres to about one metre thick. Metasedimentary rock fragments occur in the larger granite dykes, and some dykes have mafic selvages. Ptygmatically folded quartz veins are also present.

The Green Harbour formation at this locality consists of interlayered psammite and semi-pelite containing calc-silicate nodules. The mineral assemblage (in semi-pelite) consists of intermediate plagioclase (An_{28-43}) + quartz + biotite + muscovite (Merrett, 1987). The psammite clearly behaved as competent layers during deformation and dyke injection; both granite dykes and quartz veins tend to cut straight across psammite layers but are generally folded in the semi-pelitic layers. In places, semi-pelitic layers develop a patchy or segregated appearance, which may indicate the early stages of anatexis. However, the general correspondence of granite dyke compositions with those in the nearby pluton, their cross-cutting character, and the demonstrable continuity of some dykes with larger igneous bodies suggest that at this location much of the migmatitic character of the rocks results from injection. Rafts of biotite in granite dykes and "ghost" structures visible in the granite near the contact are probably relicts of the metasandstone after partial assimilation into the granite.

The granite dykes exposed here represent four units of the Port Mouton Pluton (Douma, 1988). The most abundant granite is medium-grained, muscovite biotite granodiorite to monzogranite. Also present are fine-grained aplite and medium- to coarse-grained pegmatite (the youngest unit of the pluton), medium- to coarse-grained tonalite, and rare fine-grained leucomonzogranite. The main granite body outcrops to the east of the migmatite zone and on the Port Mouton Peninsula and Mouton Island (Figure 1). Attempts to date the Port Mouton Pluton have yielded U–Pb monazite crystallization ages ranging from 368 ± 1 Ma to 378 ± 3 Ma (Currie *et al.*, 1998; Clarke *et al.*, 2000) with identical ^{40}Ar/^{39}Ar muscovite ages (Fallon *et al.*, 2001) suggesting that the pluton cooled rapidly.

Continue on Highway 103 to Jordan Falls. From the bridge over the Jordan River, proceed west on the highway for 0.9 km, pulling off on the shoulder. Across the highway (cross with caution!) are glacially scraped outcrops in a grown-over former clearing.

STOP 1.5: Jordan Falls – Staurolite–Andalusite Porphyroblastic Metapelite (UTM Zone 20T E=318835 N=4853432)

Outcrops in this area expose medium-grade metasedimentary rocks, generally of low to moderate dip with a north-northeast strike. They occur in the trough of a large syncline, near the base of a thick pelitic sequence of the Government Point formation. The abundant (now deformed) ripple cross-laminations in sandy layers are characteristic of the Government Point formation, as we saw at Stop 1.2.

Poikiloblasts of staurolite, garnet, andalusite, cordierite, biotite, and magnetite are abundant. Biotite and garnet grains tend to be small, and incorporated into the other porphyroblast phases. Garnet is compositionally zoned, with spessartine-rich cores. Staurolite is typically about 1 cm across, and weathers out to produce idioblastic staurolite gravel, with many examples of interpenetrant twins. In thin section, staurolite porphyroblasts are seen to contain quartz and graphite inclusions where it grew in the matrix, but where it replaced biotite porphyroblasts, it is inclusion-free. Randomly oriented andalusite porphyroblasts reach up to 15 cm in length. They occur as vague, pale pink patches on smooth surfaces, and are oikocrystic, with up to 95% inclusions in sandier layers. Biotite inclusions in andalusite typically have been 10–20% replaced by inclusion-free andalusite on their {001} forms. Elsewhere, andalusite has replaced matrix plagioclase and muscovite, but quartz, garnet, and opaque minerals have remained inert, and, as inclusions, show the same distribution in the andalusite as in the matrix. Cordierite porphyroblasts appear to have formed at least in part by replacement of andalusite, although there are many examples of hexagonal cordierite patches (now altered to pinite).

Because growth of these porphyroblastic minerals is governed by the availability of aluminum, iron, and magnesium, they are best developed in pelitic beds. Graded bedding is therefore reflected in the growth of new metamorphic minerals, but with the grading reversed. Some layers are particularly rich in certain minerals, presumably reflecting subtle variations in the original compositional layering.

Proceed west 6.9 km from stop 6 (8.3 km from the first Jordan Falls outcrop), past Exits 25 and 26. The outcrop is located 3.7 km west of Exit 26 from Highway 103, on the north side of the road.

STOP 1.6 (optional): Shelburne Pluton – Screens of Metapsammite and Sillimanite-bearing Semi-pelite ± Zoned Calc-silicate Concretions in Granite
(UTM Zone 20T E=308906 N=4847634)

At approximately Exit 25, we crossed into the Shelburne Pluton (contact not exposed along the highway). The outcrop at Stop 1.6 is at the southwestern margin of the eastern lobe of the pluton where metasedimentary screens are abundant. They are derived from the host Government Point formation, and hence are not rich in aluminosilicate minerals (although sillimanite/fibrolite is present in some thin sections from this location). Original compositional layering is preserved, although some of the biotite-rich layers may be restite from limited melting and assimilation. Calc-silicate nodules are present, with an anorthite–zoisite core and an outer biotite-depleted rim characterized by spectacular symplectic intergrowths of plagioclase, microcline, and quartz.

The Shelburne Pluton consists of muscovite–biotite granodiorite gradational to granite and tonalite (Rogers and Barr, 1988; Currie *et al.*, 1998). It is typically medium-grained, equigranular, and locally foliated, and inhomogeneous to compositionally banded/layered (as seen in the western part of this outcrop). It has been intruded by garnetiferous pegmatite and aplite dykes, and contains abundant metasedimentary xenoliths. U–Pb dating indicates an age of *ca.* 373 Ma (Keppie and Krogh, 1999; Currie *et al.*, 1998).

Continue southwest on highway 103. The outcrop is 2.2 km west of exit 29, and east of where the highway crosses Barrington River.

STOP 1.7: Migmatite Adjacent to the Barrington Passage Pluton (UTM Zone 20T E=292054 N=4828046)

In these roadside outcrops we are close to the contact with the tonalitic Barrington Passage Pluton. Rocks of the Goldenville Group (Government Point formation) have been brought close to or above the melting temperature depending on composition. The more psammitic beds are medium grained with abundant biotite that defines a subhorizontal foliation. Thin, 2–5 mm wide, quartz-feldspar layers and lenses parallel the foliation and are interpreted to be leucosome. Calc-silicate nodules are present in the psammitic layers. Biotite- and sillimanite-bearing pelitic layers with large muscovite porphyroblasts are interlayered with the psammitic lithologies. Quartz and feldspar-rich leucosomes are common in the pelitic layers. The outcrops are cut by muscovite-bearing, medium- to coarse-grained to pegmatitic, locally foliated, leucogranite.

Continue on highway 103, crossing the bridges over the Barrington River, for another 3.2 km (5.4 km west of exit 29).

STOP 1.8 (optional): Barrington Passage Pluton (UTM Zone 20T E=288984 N=4828895)

The Barrington Passage Pluton presents an interesting contrast to the Shelburne Pluton which you saw at Stop 1.6. Although it is the same age (373 ± 2 Ma; U–Pb zircon; Keppie and Krogh, 1999), it has very different composition – biotite tonalite gradational to quartz diorite and granodiorite. Amphibole is minor component. It is equigranular and strongly foliated and locally well lineated, and cut by pegmatite dykes. The pluton has layering defined by biotite-rich and biotite-poor bands, perhaps related to magma flow, and at this outcrop the foliation is near horizontal, as in the previous outcrop in the contact metamorphic aureole. It also exhibits moderate to very strong tectonic foliation defined by the parallel alignment of biotite which is generally aligned parallel to the ‘flow’ foliation (White, 2003; Rogers and Barr, 1988). Towards the centre of the pluton the tectonic foliation is absent but the ‘flow’ foliation is locally preserved. Locally, a gently north-plunging mineral lineation is well developed, and defined by prismatic plagioclase crystals, quartz rods, and elongate biotite-rich enclaves. The tectonic foliation and related mineral lineation mimics those in the migmatitic country rocks. The structural and geochronological data demonstrate that the pluton was emplaced and deformed along with the migmatitic country rocks at *ca.* 373 Ma (White, 2003).

Take highway 335 to Lower West Pubnico, and continue beyond the end of the pavement down the gravel road (accessing the Atlantic Wind Power site) to the end of the road at the shore (about 2 km). Walk south along the shore 100 m to the rocky point.

STOP 1.9: Pubnico Point – Moshers Island Formation
(UTM Zone 20T E=273903 N=4830530)

The Goldenville Group (Moshers Island formation) is exposed in a faulted syncline that forms Pubnico Point. The rocks are at andalusite–staurolite cordierite grade. On the coast at Pubnico Point, andalusite is abundant but cordierite is not common. The relative abundances of andalusite and cordierite are probably related to different reactions:

staur + musc + qtz = garnet + biot + and + H_2O

staur + qtz = cord + garnet + and + H_2O.

Detailed examination of the andalusite porphyroblasts reveals the presence of growth unconformities within individual metacrysts. This feature suggests that the andalusite grains grew in at least two stages. Perhaps two metamorphic events or pulses occurred, or perhaps two separate reactions were responsible for the generation of the andalusite. Notice that the cores of the andalusite do not contain any biotite inclusions, implying that the andalusite-producing reaction for the cores did not also produce biotite.

The andalusite rich layers were originally the more pelitic layers. Graded bedding (even of the reverse "metamorphic" variety) is absent at this outcrop, implying that the protolith was either very uniform in composition, or that deformation has transposed any original compositional layering. Many apparent large scale cross bedding structures are probably sheared-off folds. However, it can be difficult to distinguish structural “cross bedding” from sedimentary cross bedding. Isoclinal folds are evident. Careful examination of the porphyroblast matrix relationships on the outcrop (but better seen in thin section) reveals the presence of "millipede structures" involving the andalusite grains (evidence of pervasive inhomogeneous deformation in these apparently only slightly deformed rocks). The andalusite porphyroblasts show a weak preferred orientation. Collectively, these features suggest that these rocks are located within a high-strain zone.

Overnight at the Comfort Inn, 96 Starrs Rd., Yarmouth, Nova Scotia, Canada B5A 2T5 (902-742-1119)

STOP DESCRIPTIONS

DAY 2. (Figures 12 and 13)

From the Comfort Inn turn right (northwest) on Starrs Road (HWY 3) until T-junction at 1.2 km (next to McDonalds). At lights turn right (north) on HWY 1 for 475 m. At the horse statue turn left (west) on Route 304. After 750 m turn left (southwest) on Grove Road (Route 304) for 2 km until T-junction with Overton and South Bar roads. Turn left (south) on South Bar Road (Route 304) and continue for 7 km until the road ends near the lighthouse. Walk trail to south to East Cape Forchu. Be cautious when climbing on the rock surfaces.

STOP 2.1: East Cape Forchu – White Rock Formation
(UTM Zone 19T E=728922 N=4852956)

Mafic metatuff occurs throughout the volcanic succession in the White Rock Formation in the Yarmouth area but forms a particularly thick unit in the Cape Forchu area. Typically the mafic metatuff is greenish grey, fine to coarse grained, and well bedded. These rocks were originally crystal tuffs. They consist of plagioclase and amphibole (actinolite) crystals in a fine grained recrystallized matrix of albite, actinolite, chlorite, epidote, quartz, and opaque minerals. The plagioclase crystals are interpreted to be of relict igneous origin, but the amphibole is metamorphic (MacDonald, 2000). No glass shards or other volcanic characteristics have been preserved because of the grade of metamorphism.

Locally graded bedding is evident. In places, volcanic bombs, up to 25 cm long, have fallen into soft unconsolidated bedded ash so as to transect the uppermost laminae and bend downward those below. Later laminae arch over the bombs. Bomb-sag, like graded bedding, can be used for top determinations; the rocks young to the east, as do the rocks on the eastern side of the harbour.

In outcrops along the water's edge to the east of the point, possible relict pillow structures consistent with subaqueous conditions at times in the eruptive history.

Walk back along the trail to the car park area and ascend the steps to the lighthouse area. On the sloping outcrops of metatuff below the lighthouse, thin black "veins" of pseudotachylite are prominent. Pseudotachylite is generally produced by melting due to frictional heating on fault planes during cataclasis. Specific details of its origin here have not been investigated.

Return toward Yarmouth on South Bar Road (Route 304). At 5.4 km take a small dirt track (Churn Road) to the left (west) for 400 m down to the shore at Overton. At this point if the *north-trending road parallel to the beach is drivable continue for an additional 400 m….if not…walk.*

STOP 2.2: Overton Section – White Rock Formation
(UTM Zone 19T E=729144 N=4856993 to E=729111 N=4857365)

The shoreline section at Overton exposes a mixed metavolcanic and metasedimentary unit that underlies the mafic metatuff unit exposed at Cape Forchu. We will be walking down-section. The top of the exposed section is epiclastic metaconglomerate with elongate clasts that consist predominantly of felsic and mafic metavolcanic rocks and, more rarely, metasandstone. These rock types generally match those of the underlying volcaniclastic rocks, flows, and metasedimentary rocks.

A thick, light coloured crystal metatuff(?) unit of varied but generally intermediate composition underlies the conglomerate, and is in turn underlain by a sequence of predominantly mafic pyroclastic rocks. Near the base of this volcanic unit, banded amphibolite is interbedded with metasandstone and calc-silicate rocks. In some of the metasandstone beds, excellent examples of the trace fossil "Chondrites" and other burrows are present along bedding surfaces. The tubes show a very distinct orientation subparallel to the regional lineation and may have been rotated into their present orientation during deformation.

Continuing down section, calc-silicate lenses and beds up to 50 cm in thickness are interstratified with semi pelitic phyllite. Close examination of the calc-silicate beds shows them to be compositionally zoned: the margins are uniformly fine grained whereas the interiors contain porphyroblasts of light pink garnet and amphibole.

Farther down section quartzite beds are interstratified with semi pelitic phyllite and thin amphibolite. Rare lower Silurian gastropod and brachiopod shells are present in the semi-pelitic units. The base of the section is not exposed.

Return to Yarmouth via Route 304 and turn left (north) at horse statute on to Highway #1. Continue north on HWY 1 through Hebron, Wellington, Darlings Lake, Port Maitland and finally Beaver River for a distance of 20 km. Turn left (west) onto Bartlett Shore Road and drive to the end of the road. Walk about 300 m to outcrops on the beach to the south.

STOP 2.3: Barletts Beach – Lowest Exposed Goldenville Group (Church Point Formation)
(UTM Zone 19T E=727811 N=4877343)

This outcrop is the lowermost exposed part of the Goldenville Group (Church Point formation). The youngest detrital zircon grain from this outcrop yielded an age of 544 ± 18 (Waldron *et al.*, 2009). The rocks are grey, medium- to thick-bedded metasandstone (feldspathic wacke) typical of the Church Point formation. The metasandstone is typically very fine- to medium-grained and poorly sorted. Although the original mud matrix has recrystallized to a mixture of sericite, chlorite, and epidote, subangular to rounded sand-sized detrital grains are present still in many samples. Thin, conglomeratic lenses likely represent channel lag deposits. Clast lithologies consist of quartzite, metasiltstone/slate, and rare chert and basalt.

Return to Highway #1 and turn right (south) and travel 4.7 km to intersection with Richmond and Quaco roads. Turn right (west) on Quaco Road until T-junction at 1.4 km. Park on side of road and walk 250 m down trail to west (past mail boxes) toward beach. At beach walk left (south) for 200 m until past thick metasandstone beds and on well laminated metasiltstone. This is the base of the High Head member. Continue walking for an additional 700 m until you reach a series of 5-6 thick metasandstone beds and a thin mafic sill/dyke. Trace fossils start here and continue to the south.

STOP 2.4: High Head – High Head Member (Goldenville Group)
(UTM Zone 19T E=727620 N=4870981)

The High Head member occurs about 4.5 km above the lowest exposed units of the Church Point formation seen at Stop 2.3. The stratigraphic thickness is about 850 m, as measured by John Waldron and illustrated in Gingras *et al.* (2011). We will be looking at a section from about 375 m (true thickness) above the base to 650 m, in which trace fossils are most abundant.

The sedimentary strata of the High Head member are dominated by thinly bedded, planar laminated somewhat metamorphosed mudrocks which dip ~55° to the southeast. Locally, a separate cleavage is discernible, dipping slightly more steeply than bedding. Very fine-grained metasandstone is locally interlaminated or interbedded with the slatey mudstone and display low-angle cross-lamination and rare bedding surfaces show low-relief, short wavelength (10–20 cm) undulations interpreted to represent ripple marks. Where present, thin (1–3 cm), graded metasandstone beds are sharp-based with rare, small load casts.

In the lower part of the section, sand beds are thicker (typically decimetre-scale) and more abundant. They show planar and cross-laminae organized in partial Bouma (1962) sequences, and are interbedded with metamudstone in up to metre-scale bedsets dominated by fine metasandstone. In the centre of the mudrock-dominated succession are several metre-scale bedsets of medium to fine-grained, graded metasandstone beds that display complete and partial Bouma (1962) sequences. Rare water-escape pipes are present. At the top of section very fine to fine-grained metasandstone reappears in very thin to medium thick (1–30 cm) graded beds with planar and cross-laminae in partial Bouma sequences, organized in bedsets 2–5 m thick.

At several points in the section, greenish-black mafic sills/dykes cut the sedimentary rocks. Based on the geometry of xenoliths and contacts in these dykes, White and Barr (2004) suggested that they were intruded soon after deposition, while the sediments were still wet.

The High Head member contains an important assemblage of trace fossils preserved in a deep-marine environment influenced by turbidite deposition (Gingras *et al.*, 2011). However, the depositional environment was also stabilized by biomats between turbidite-depositing events. The nature of the sedimentation (*i.e.*, largely episodic) and the characteristics of the sedimentary environment (*i.e.*, influenced by biomats) have led to excellent preservation of the trace-fossil assemblage. The trace fossil assemblage includes (in approximate order of abundance) *Planolites, Helminthopsis, Oldhamia, Chondrites, Gordia, Taenidium, Psammichnites gigas, Treptichnus, Phycodes, Lorenzinia, Palaeophycus*, and *Teichichnus*, as documented and illustrated in Gingras *et al.* (2011).

Return to Beaver River and continue north on Highway #1 to Mavillette for a distance of 10.5 km. Turn left (west) on Cape St. Marys Road and stop at the western end of the beach (about 2 km) before the road climbs above the cliff into the village. [Note: The contact between the Halifax Group (Bear River formation) and White Rock Formation is exposed in two places on Cape St. Marys, at the point in the village and on the beach. The "beach" section described below is accessible only at low tide.]

STOP 2.5: Cape St. Marys – Halifax Group and White Rock Formation (UTM Zone 19T E=723793 N=4885461)

To the west from the spectacular sandy beach and Quaternary sediments, the White Rock Formation is well exposed. The section begins in metabasalt and goes down through slate and cross-bedded metasandstone units into mafic metatuff interbedded with quartzite. The basal 20 m of the White Rock Formation is dominantly volcanic (mafic metatuff underlain by felsic metatuff). Underlying the felsic metatuff is a thin "diamictite" (pebbly phyllite) that has sharp contacts with both the metatuff and the underlying bleached slate of the Bear River formation of the Halifax Group. The diamictite has been interpreted to be a Late Ordovician glacial deposit (Schenk, 1992). The underlying Bear River formation consists of grey, well laminated to thinly bedded, cleaved metasiltstone, with minor, thin (<10 cm thick) slate beds and fine-grained, cross-laminated metasandstone beds (up to 20 cm thick). The Bear River formation is not the uppermost unit of the Halifax Group (Fig. 6), and so stratigraphic units are missing in this section.

The contact is steeply inclined to the southeast and parallel to a second generation foliation (S_2) and transposed layering (S_0) in the White Rock Formation. In the adjacent Bear River formation the contact is parallel to a penetrative crenulation cleavage (S_2), but generally discordant to layering. Reverse-sense (White Rock Formation over Bear River formation) kinematic indicators occur close to the contact. The presence of crenulation cleavage and east-verging extended folds in the Bear River formation suggest a complex deformational history for the reworking of the original contact, interpreted to have been an angular unconformity (Culshaw and Liesa, 1997).

All of this section is in the northwestern part of the very wide (~5 km) Cape St. Marys shear zone (*ca.* 320 Ma) as defined by Culshaw and Liesa (1997). Farther north along the coast towards the footwall of the Cape St. Marys shear zone, the second generation D_2 transposition fabric (S_2) decreases in intensity and relict D_1 structures are more prevalent.

Return to vehicles and continue on Cape St. Marys Road until it ends at the wharf. Trail continues to west toward beach.

STOP 2.6 (optional): Cape St. Marys Wharf
(UTM Zone 19T E=723496 N=4884994)

On the "point" section you can see the same contact as at Stop 2.5 exposed on the wave-cut platform. Folds are prominent in the Bear River formation but are not apparent in the White Rock Formation. Was the Halifax Group deformed prior to deposition of the White Rock Formation, or are these folds related to the Cape St. Marys shear zone?

Return to Yarmouth
Overnight at Comfort Inn, 96 Starrs Rd., Yarmouth, Nova Scotia, Canada B5A 2T5
(902-742-1119)

STOP DESCRIPTIONS

DAY 3. (Figures 14 and 15)

Drive north on Highway 101 to Digby (100 km). Stop at a small pull-off at the end of a chained driveway on the right 1.8 km before the Digby exit. Walk south on old road about 300 m to an abandoned quarry.

STOP 3.1: Digby Exit – Bloomfield Formation, Goldenville Group
(UTM Zone 20T E=278381 N=4941100)

The Bloomfield formation is exposed in a narrow (350 m wide) belt between the metasandstone-rich Church Point formation to the northwest and the slate-rich Acacia Brook formation (Halifax Group) to the southeast. The rocks in this quarry are distinctive pale green, purple, and maroon, well cleaved metasiltstone characteristic of the formation. Pink calc-silicate nodules are locally present. This unit occupies the same stratigraphic position as the Moshers Island formation southeast of the Chebogue Point shear zone, but in contrast to that formation, the Bloomfield formation does not contain elevated MnO. The lack of Mn enrichment may have been related to water depth during sediment deposition – the water in this area may have been somewhat shallower and above the Mn precipitation depth.

Continue on Highway 101 toward Bear River. Take the exit ramp to Bear River, and stop on the ramp 20 m before the stop sign at the intersection with the road to Bear River.

STOP 3.2: Bear River Exit Ramp – Halifax Group, Bear River Formation
(UTM Zone 20T E=286991 N=4943654)

These large roadcuts expose typical rocks of the Bear River formation, less deformed than rocks of the same formation at Cape St. Marys. The Bear River formation overlies slate of the Acacia Brook formation, the basal unit of the Halifax Group northwest of the Chebogue Point shear zone. It consists of grey and black laminated slate, metasiltstone, and feldspathic metawacke, but contains less slate than the stratigraphically equivalent Feltzen formation (not seen on this field trip) southeast of the Chebogue Point shear zone. These outcrops at this location are on the western limb of a major synclinal structure (Bear River syncline). Minor folding is displayed on various scales.

Numerous mafic intrusions occur in the Halifax and Goldenville groups in western Nova Scotia (White and Barr, 2004) and are quite abundant in this outcrop, forming both sills and dykes. They typically display chilled margins and, locally, peperitic relations with the host rocks. Early workers in the area (*e.g.*, Smitheringale 1973) referred to these sills and dykes as spilitic because of their intense alteration to albite and chlorite. They are the "type I sills" of Barr *et al.* (1983).

Continue on Highway 101 towards Wolfville (120 km).Take Exit 13, south side of Highway 101 and turn south on Route 12. After 150 m turn west on Prospect Road and continue for 3.9 km. Turn south on English Mountain Road and continue for 400 m. Turn east on logging road to old quarry.

STOP 3.3: Tupper Lake Brook Formation, Goldenville Group
(UTM Zone 20T E=37691 N=4987799)

Rocks in this quarry occupy the same stratigraphic position as the Moshers Island and Bloomfield formations. In contrast to the Bloomfield formation, they contain significantly more MnO and are interpreted to have been deposited in deeper water. Rocks in this quarry are close to the core of a regional anticline and consist of thin- to medium-bedded light grey-green metasiltstone. A characteristic feature in this unit is the presence of steel-blue manganiferous laminations, nodules, and staining along fracture surfaces. At higher metamorphic grades in the contact aureole of the South Mountain Batholith (to the south) these nodules and laminations form thin (up to 2 cm wide), pink coticule beds and lenses due to the growth of spesssartine garnet. Acritarch microfossils collected elsewhere from this formation suggests a latest middle Cambrian to early Furongian age (White *et al.*, *in press*).

Retrace route back toward Exit 13 and take onramp to Highway 101 east towards Wolfville. After 1.2 km stop at brook and cross highway to north.

STOP 3.4: Lumsden Dam Formation, Halifax Group
(UTM Zone 20T E=381302 N=4989554)

The Lumsden Dam formation is stratigraphically equivalent to the Bear River and Feltzen formations. The outcrop here in Moores Brook consists of light grey, well laminated to thinly bedded metasiltstone, with minor, thin (<10 cm thick) slate beds. Fine-grained, cross-laminated metasandstone beds (up to 20 cm thick) are a characteristic feature of this formation and are typically continuous over 10s of metres. Primary sedimentary structures are common and include cross- and graded-bedding, groove, tool, and load marks, ripples, and small-scale slump features. Fossil occurrences are generally sparse in this formation but this location contains the Early Tremadocian graptolite *Rhabdinopora flabelliformis flabelliformis*. Acritarch microfossils confirm the Early Tremadocian age.

Continue east on Highway 101 towards Wolfville. Note that at 2 km from Stop 3.4, examples of "type II" gabbroic dykes of Barr et al. *(1983) form large roadside outcrops. After 5.6 km stop at stretch of outcrop along south side of highway (just before water tower on north side of highway).*

STOP 3.5: Hellgate Falls Formation, Top of the Halifax Group (UTM Zone 20T E=385617 N=4990522)

In this roadside outcrop rocks of the Hellgate Falls formation are composed of light to dark grey slate rhythmically interbedded with laminated to thinly-bedded metasiltstone and light grey metasandstone. Thin lenses of cross-laminated metasandstone are common. Characteristic features of the Hellgate Falls formation (which are present here) include abundant bioturbation textures and trace fossils. Many of the burrows are infilled with fine-grained white metasandstone that locally has a carbonate matrix. These trace fossils display a diverse assemblage of complex trails and based on the morphology, appear to be Early Ordovician. This is confirmed by the presence of Floian acritarch species. Because this is the uppermost formation in the Halifax Group, the maximum thickness is difficult to know with certainty but at least 1100 m are exposed.

Continue east on Highway 101 and take Exit 11 to Greenwich. Turn north on Greenwich Road, proceed 950 m to Commercial Street (Highway 1), and at the traffic light turn right (east) toward Wolfville. Continue for 3.3 km through Wolfville and turn south on Gaspereau Avenue. After 1.5 km stop at outcrop under the Highway 101 overpass.

STOP 3.6: Elderkin Brook Formation (UTM Zone 20T E=385617 N=4990522)

At this location the rocks of the Elderkin Brook formation occupy the core of a regional southwest-plunging anticline. Here the formation consists of light grey to red-brown, laminated slate and fine-grained metasiltstone which locally contain numerous trace fossils. Coarse metasiltstone and metasandstone beds are virtually missing. Carbonate-rich to silty carbonate-rich beds and lenses locally occur. Compared to trace fossils in the overlying Hellgate Falls formation, the trace fossils in this formation display a less diverse assemblage and display 'simple' trails and burrows. Acritarchs recovered from this formation are latest Tremodocian (White *et al.*, *in press*).

Continue south on Gaspereau Avenue/Greenfield Road for 1.8 km, Turn west on White Rock Road for 2.1 km and turn south on Black River Road for 500 m. At the stop sign turn west and continue on Black River Road for 4.6 km. Turn west on Corkum Burns Road along the top of Lumsden dam for 250 m. Find trail to north along spillway to large outcrop (150 m north of road).

STOP 3.7 (optional): Lumsden Dam – Lumsden Dam Formation (Halifax Group) (UTM Zone 20T E=389877 N=4986983)

When the water level above the dam is low and the spillway clear of water this spectacular expanse of outcrop is considered to be the type area/section for the lower part of the Lumsden Dam formation. Here the formation consists of grey thickly to thinly bedded and well laminated metasandstone to metasiltstone. Like at Stop 3.4, sedimentary structures are common and include cross laminations and graded-bedding, groove, tool, and load marks, ripples, and small-scale slump features. The outcrop contains several mafic sills, often mistakenly identified as metasandstone beds. Towards the northern end of the outcrop rare graptolite specimens are preserved.

The contact with the underlying formation is not exposed, however, when water levels are low in Lumsden Lake to the south the exposed outcrops are sulphide-rich slates and metasandstone typical of the North Alton formation.

Retrace route back across the dam to Corkum Burns Road and turn south, back on Black River Road. Continue for 1 km and turn left (east) on Newtonville Road. Continue for 1.4 km to quarry on north side of road.

STOP 3.8 (optional): North Alton Formation (Halifax Group) (UTM Zone 20T E=391298 N=4986994)

The North Alton formation is stratigraphically equivalent to the Acacia Brook formation in the Bear River area and Cunard formation in the area southeast of the Chebogue Point shear zone (*e.g.*, Stop 1.1). The quarry exposes black to rust-brown slate with thin beds and lenses of black cleaved metasiltstone interbedded with cross-laminated, fine-grained, pyritiferous metasandstone. The slate contains abundant pyrite, arsenopyrite, and pyrrhotite that form nodules and beds up to 5 cm thick and may be the source of potential acid rock drainage issues. From this quarry several Late Cambrian (Furongian) acritarchs have been identified (White *et al.*, *in press*). The North Alton formation is about 1000 m thick, although in areas of abundant folds it appears much thicker.

Return to Highway 101. Continue to Halifax Stanfield International Airport via Highways 101 and 102 (95 km ~ 1 hour).

FIGURES

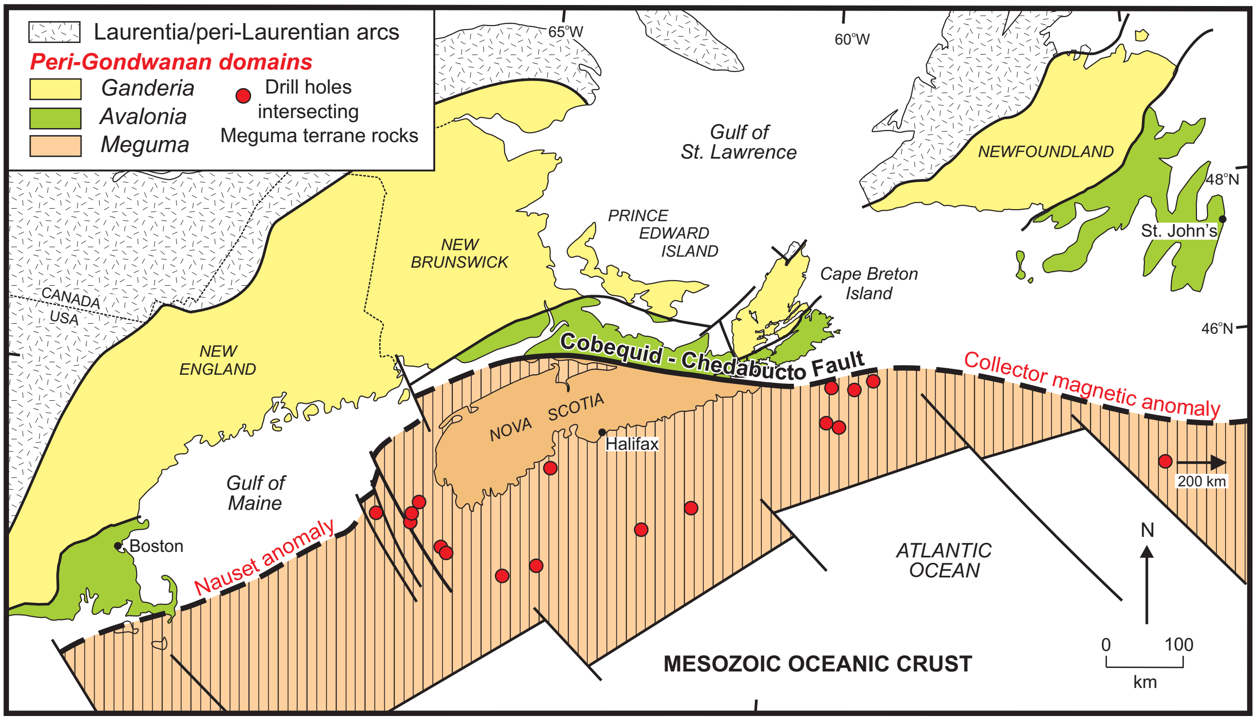


Figure 1. *Inferred extent of the Meguma terrane onshore and offshore in the northern Appalachian orogen (after Hibbard* et al., *2006). Drill hole locations are after Pe-Piper and Loncaerevic (1989) and Pe-Piper and Jansa (1999).*

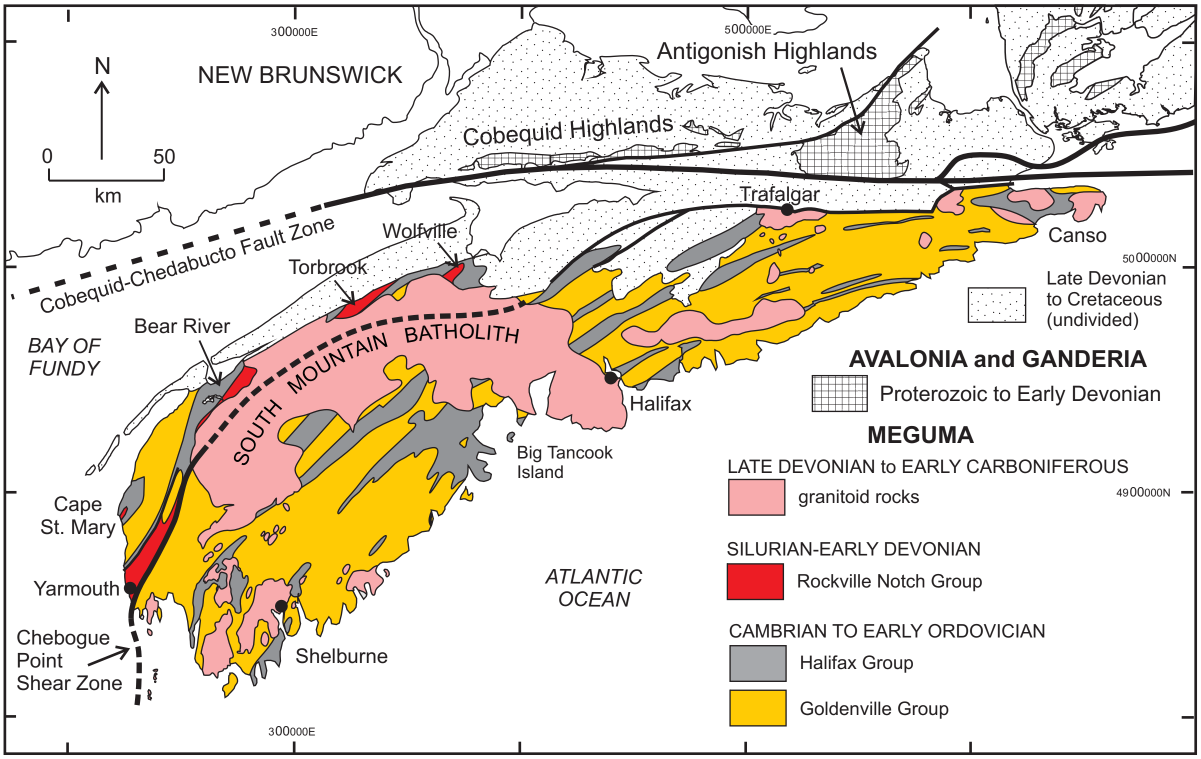


Figure 2. *Simplified geological map of the Meguma terrane showing the distribution of major rock units. Map is after White (*in press*).*

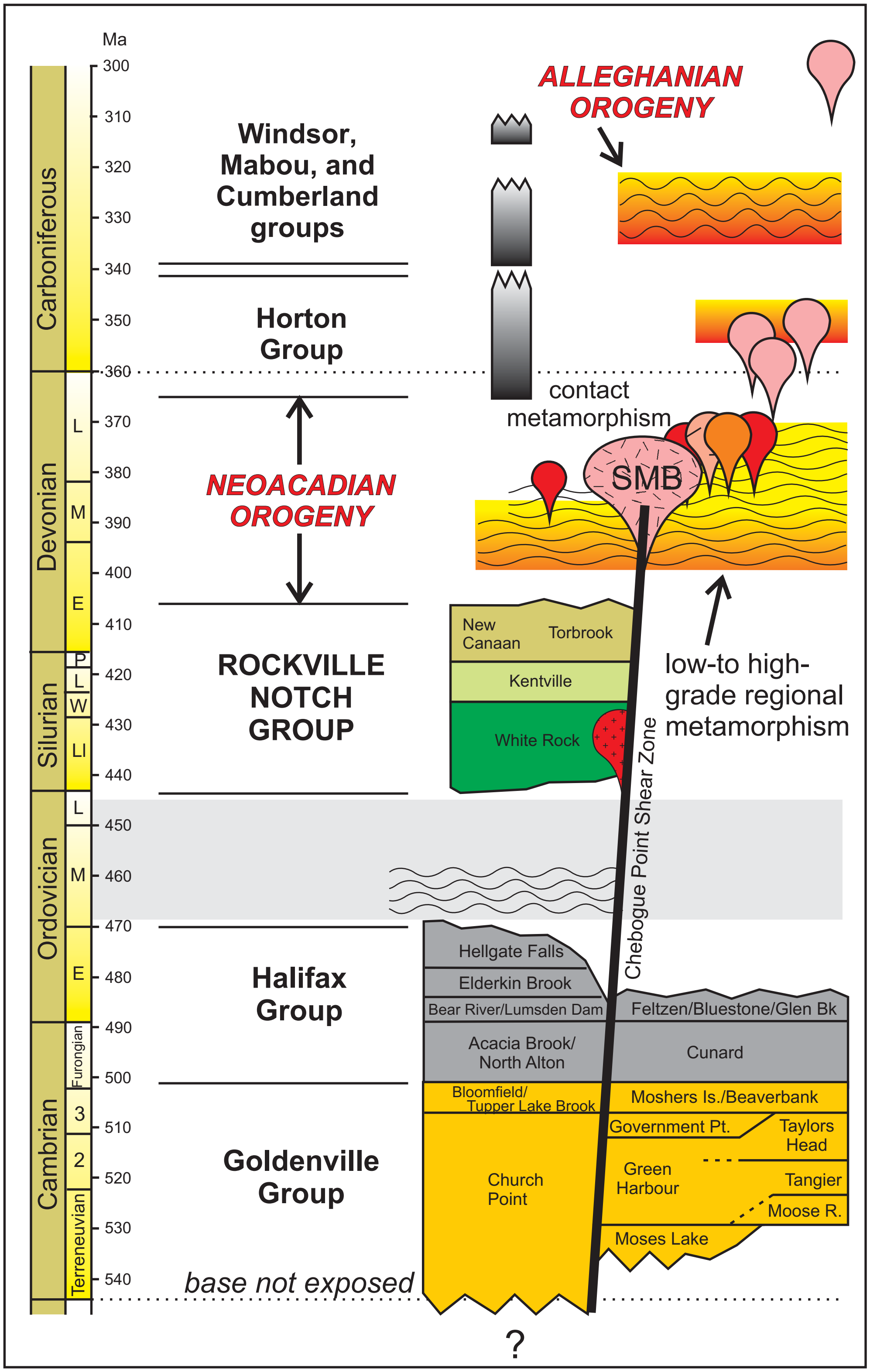


Figure 3. *Simplifed stratigraphic columns for the Meguma terrane northwest (on left) and southeast (on right) of the Chebogue Point shear zone summarizing stratigraphic and tectonic evolution. Time scale is after Ogg* et al. *(2008). Abbreviations: Bk, Brook; E, Early; L, Late; Lk, Lake; Ll, Llandovery; Lu, Ludlow; M, Middle; P, Pridoli; Pt, Point; R, River; W, Wenlock.*

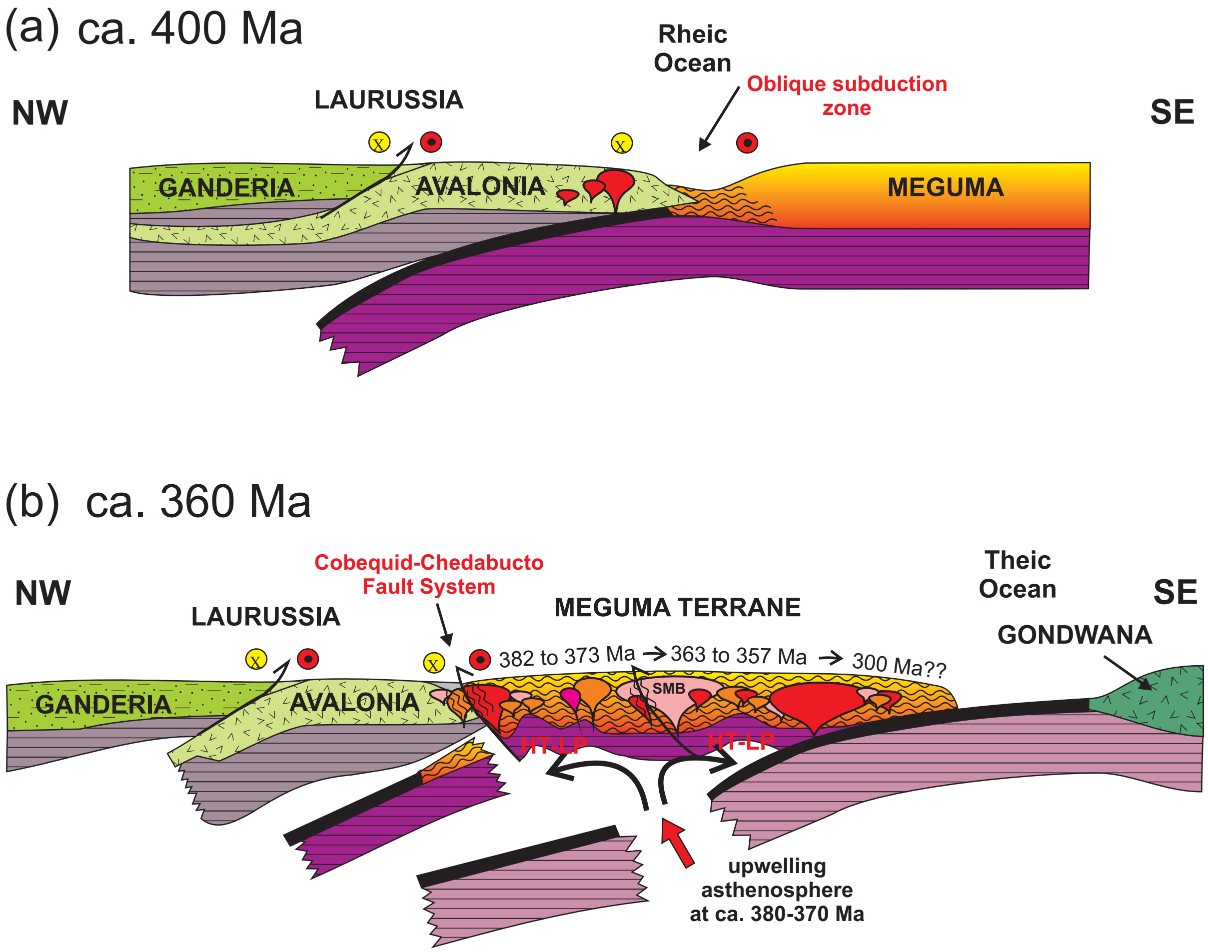


Figure 4. *Schematic tectonic models for Meguma and adjacent terranes in the (a) early Devonian* (ca. *400 Ma) and (b) late Devonian* (ca. *360 Ma), modified after van Staal (2007) and Moran* et al. *(2007).*

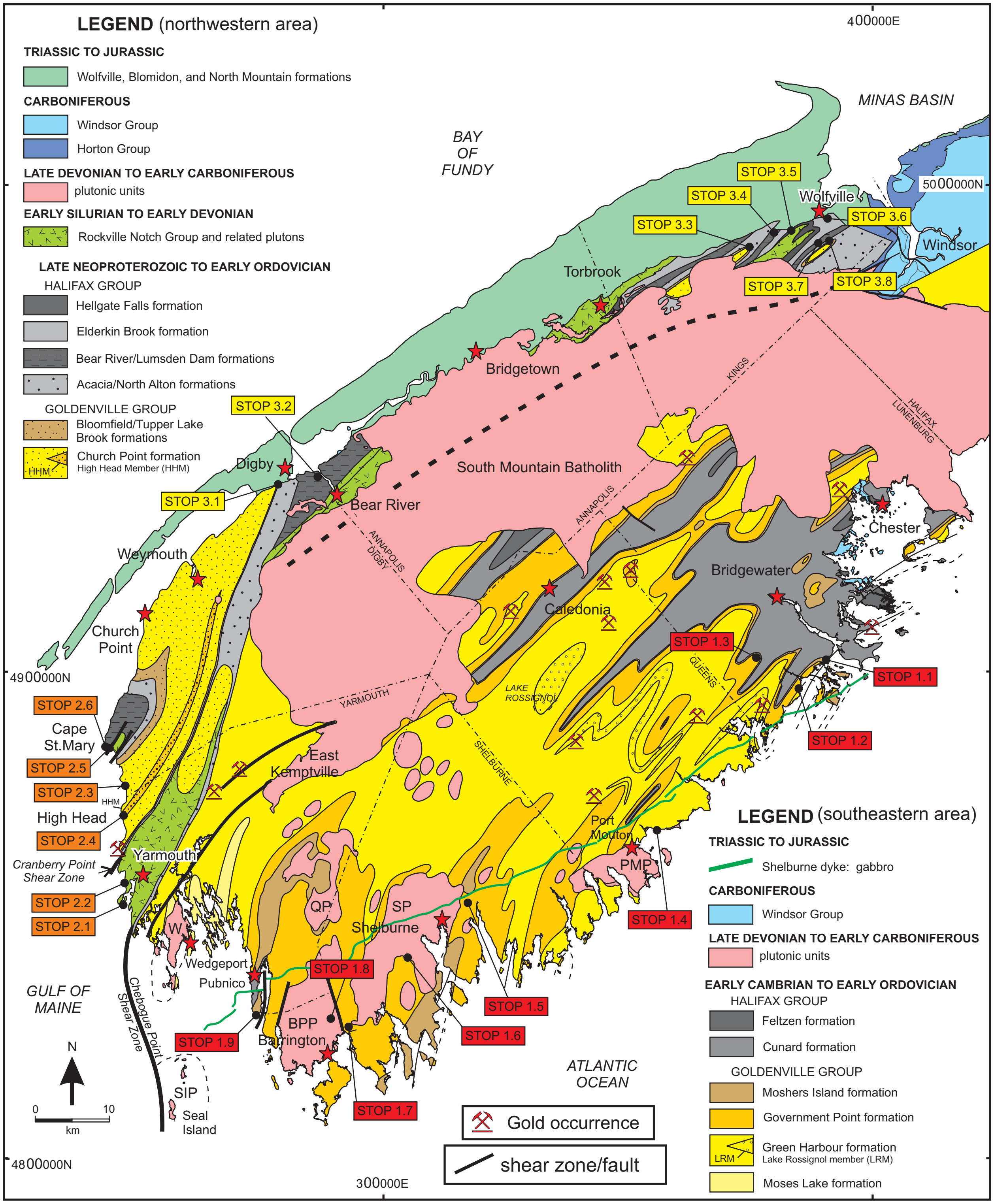


Figure 5. *Simplified geological map of the southern part of the Meguma terrane showing field trip stops on Day 1 (1.1 to 1.9), Day 2 (2.1 to 2.6), and Day 3 (3.1 to 3.8). Geology is from White (*in press*). Pluton abbreviations: BPP, Barrington Passage, PMP, Port Mouton; QP, Quinan; SP, Shelburne; SIP, Seal Island; W, Wedgeport.*

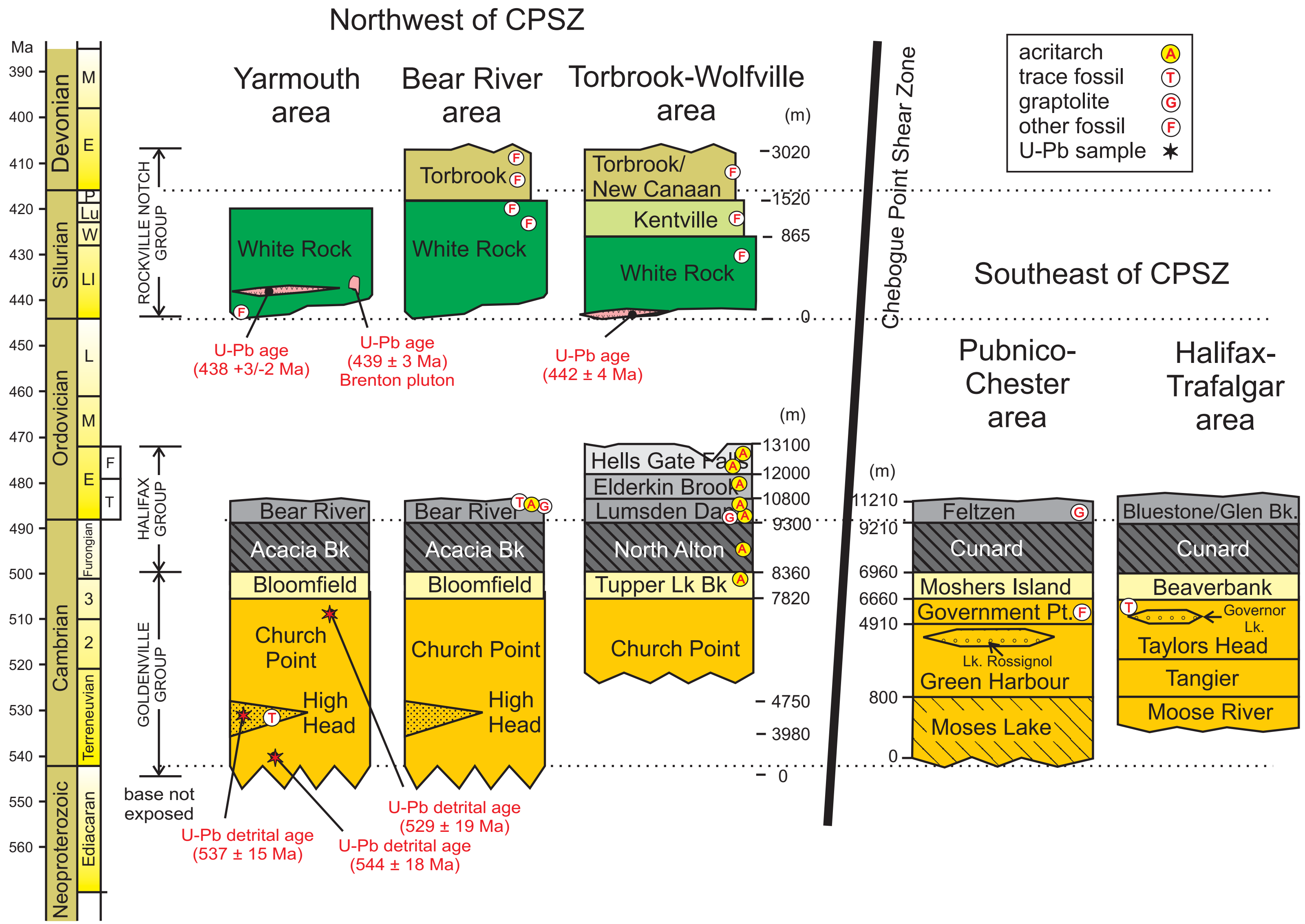
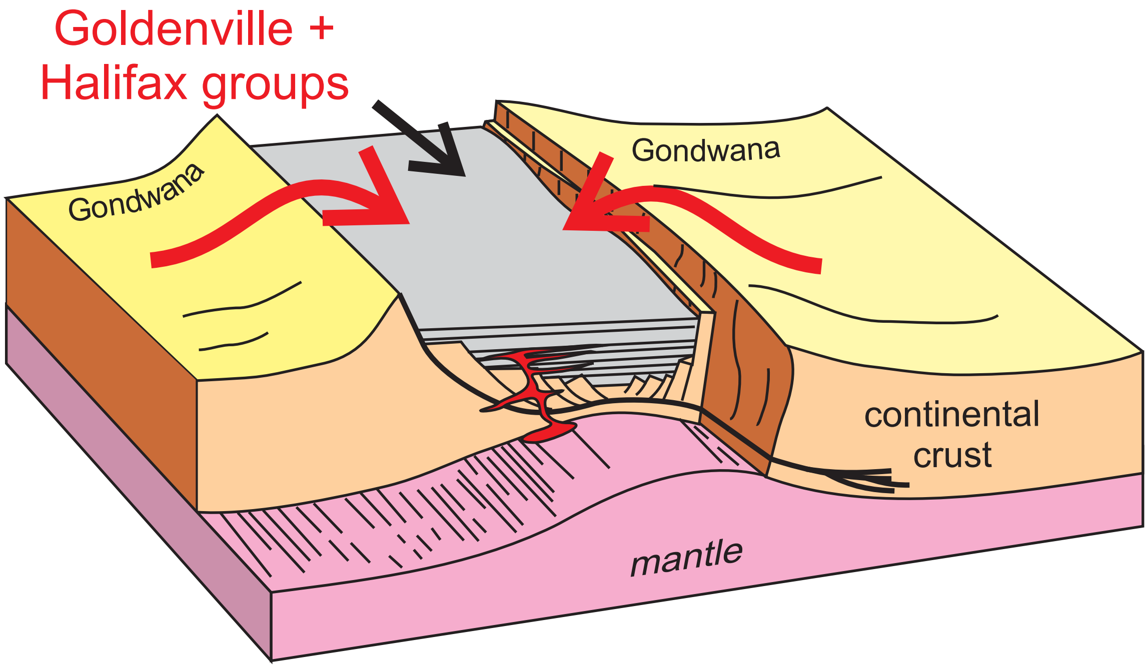
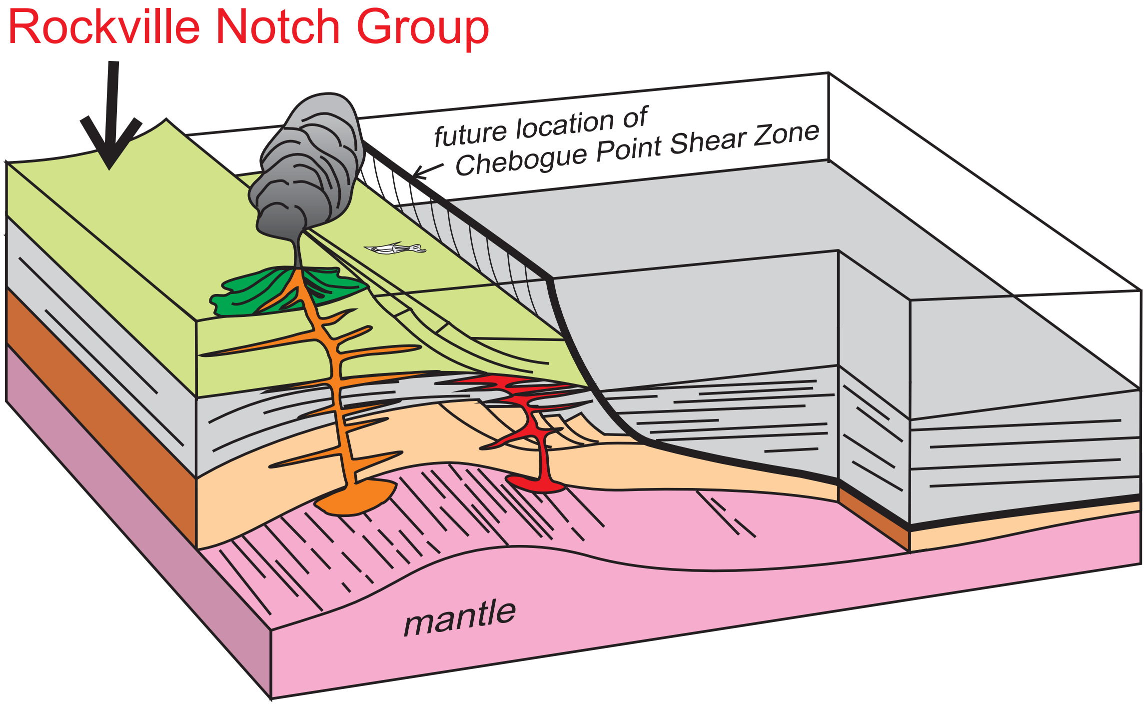


Figure 6. *Summary of Cambrian to Devonian stratigraphy in the Meguma terrane in the area of Figure 5, showing differences northwest and southeast of the Chebogue Point Shear Zone after White (2010a, b,* in press*) and White* et al. *(*in press*). Paleontological and U–Pb age data are from sources described in the text. All units are formations except High Head, Lake Rossignol, and Governor Lake which are members. Estimated stratigraphic thicknesses are shown in metres (m). Formations and members in the Goldenville and Halifax groups are mainly informal and hence not capitalized, whereas those in the Rockville Notch Group are established formal names and hence capitalized. Abbreviations: Bk, Brook; CPSZ, Chebogue Point shear zone; E, Early; F, Floian; L, Late; Lk, Lake; Ll, Llandovery; Lu, Ludlow; M, Middle; P, Pridoli; Pt, Point; T, Tremadocian; W, Wenlock.*



(a) Early Cambrian to Early Ordovician



(b) Silurian to Early Devonian

Figure 7. *Schematic models for Cambrian to early Devonian igneous activity in the Meguma terrane. (a) Emplacement of sills and dykes during extension and deposition of the Goldenville and Halifax groups in the area now northwest of the Chebogue Point shear zone. (b) Volcanism in a shallow marine environment during rifting in the Silurian–Early Devonian, perhaps associated with final separation of Meguma terrane from Gondwana.*

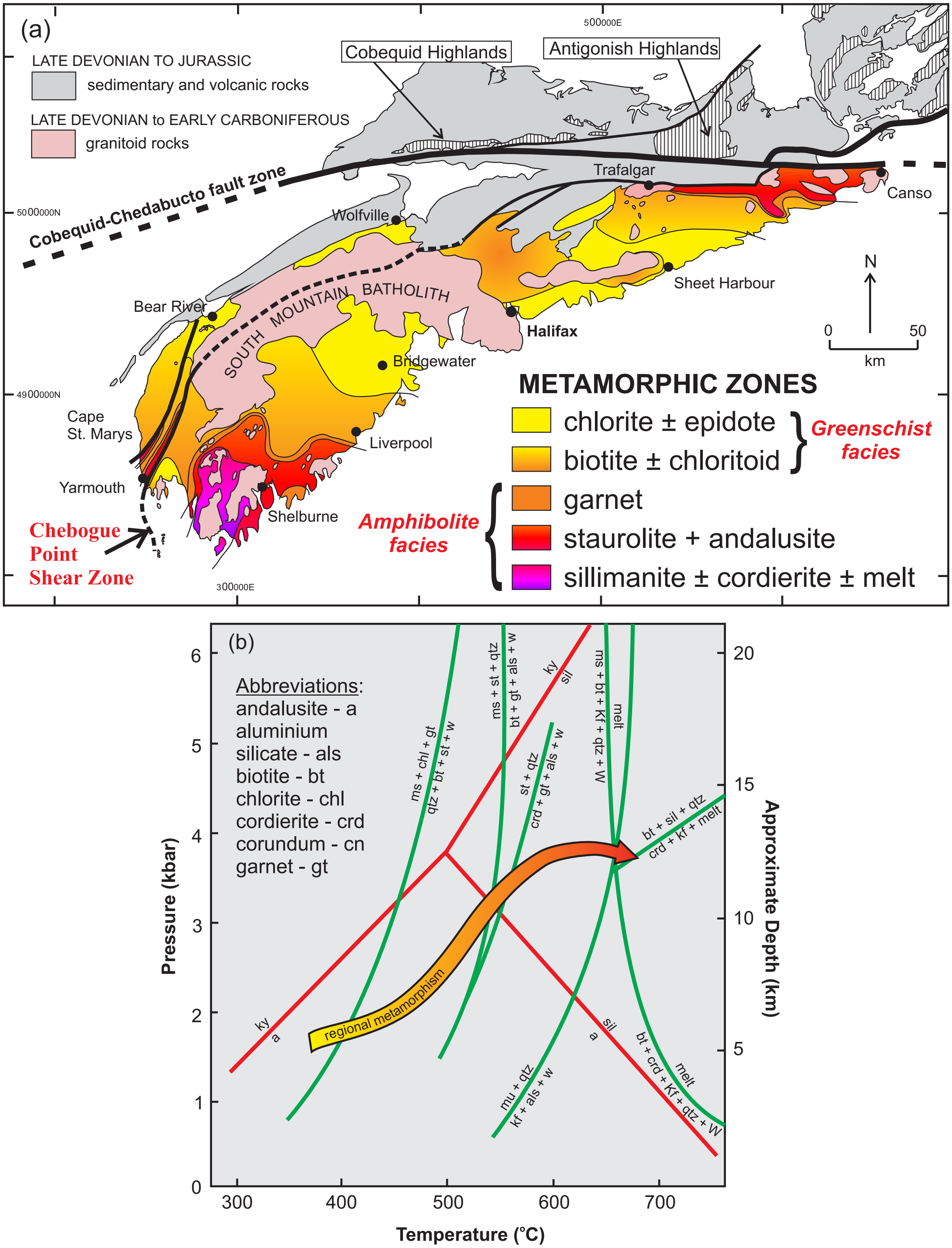


Figure 8. *Regional metamorphism in the Meguma terrane. (a) Distribution of regional metamorphic isograds, compiled from sources cited in the text and observations by the authors. (b) Pressure-temperature diagram showing P-T path inferred for regional metamorphism.*

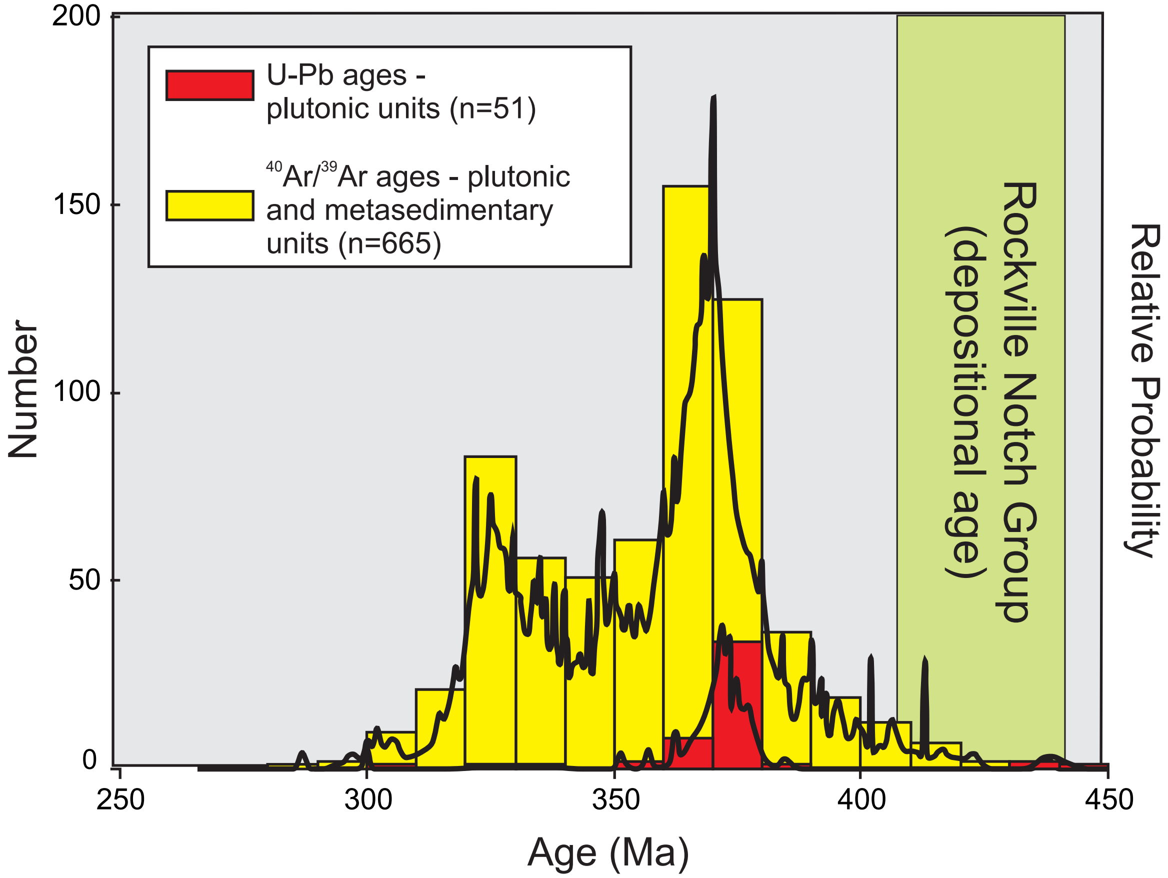


Figure 9. *Histograms and probabilty plots for U–Pb ages from plutons (red) and* $^{40}Ar/^{39}Ar$ *ages from amphibole, muscovite, and whole-rock samples from plutonic and metasedimentary rocks (yellow) in the Meguma terrane. Data are compiled from numerous sources listed in White (2003) and/or in the reference list for this field guide.*

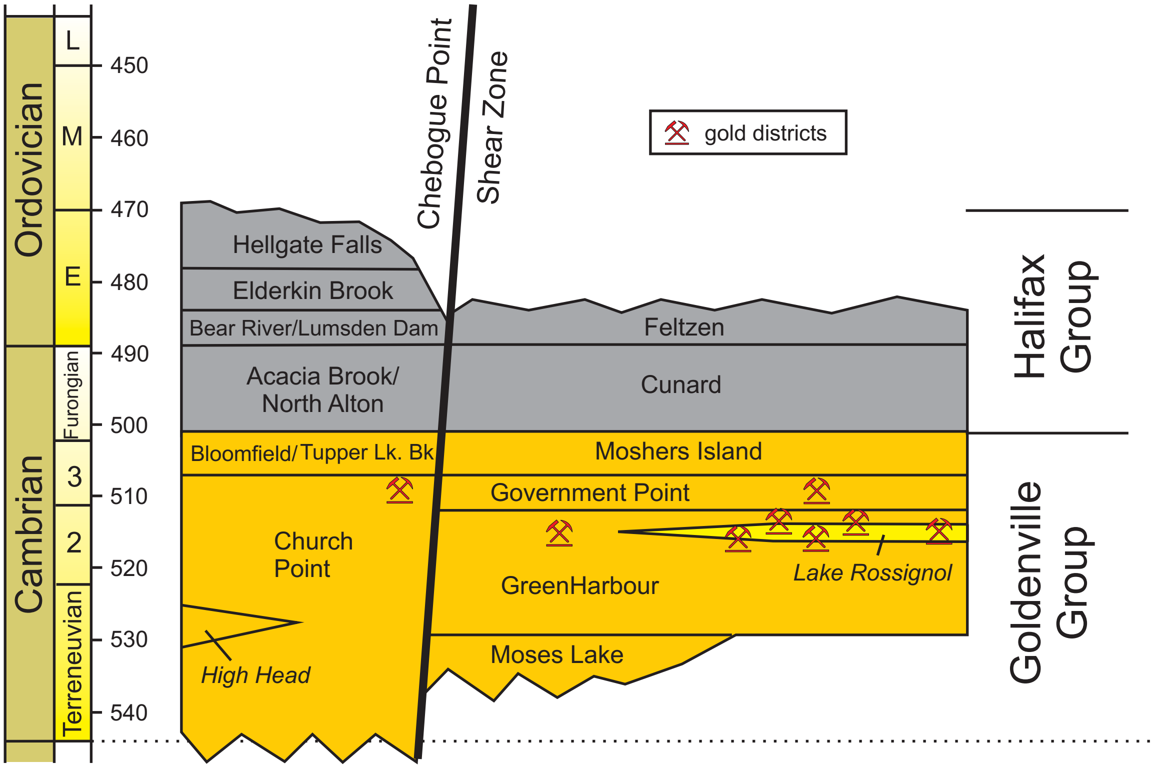


Figure 10. *Stratigraphy in the Goldenville and Halifax groups in the southern part of the Meguma terrane showing the approximate stratigraphic position of gold occurrences shown on Figures 5 and 11.*

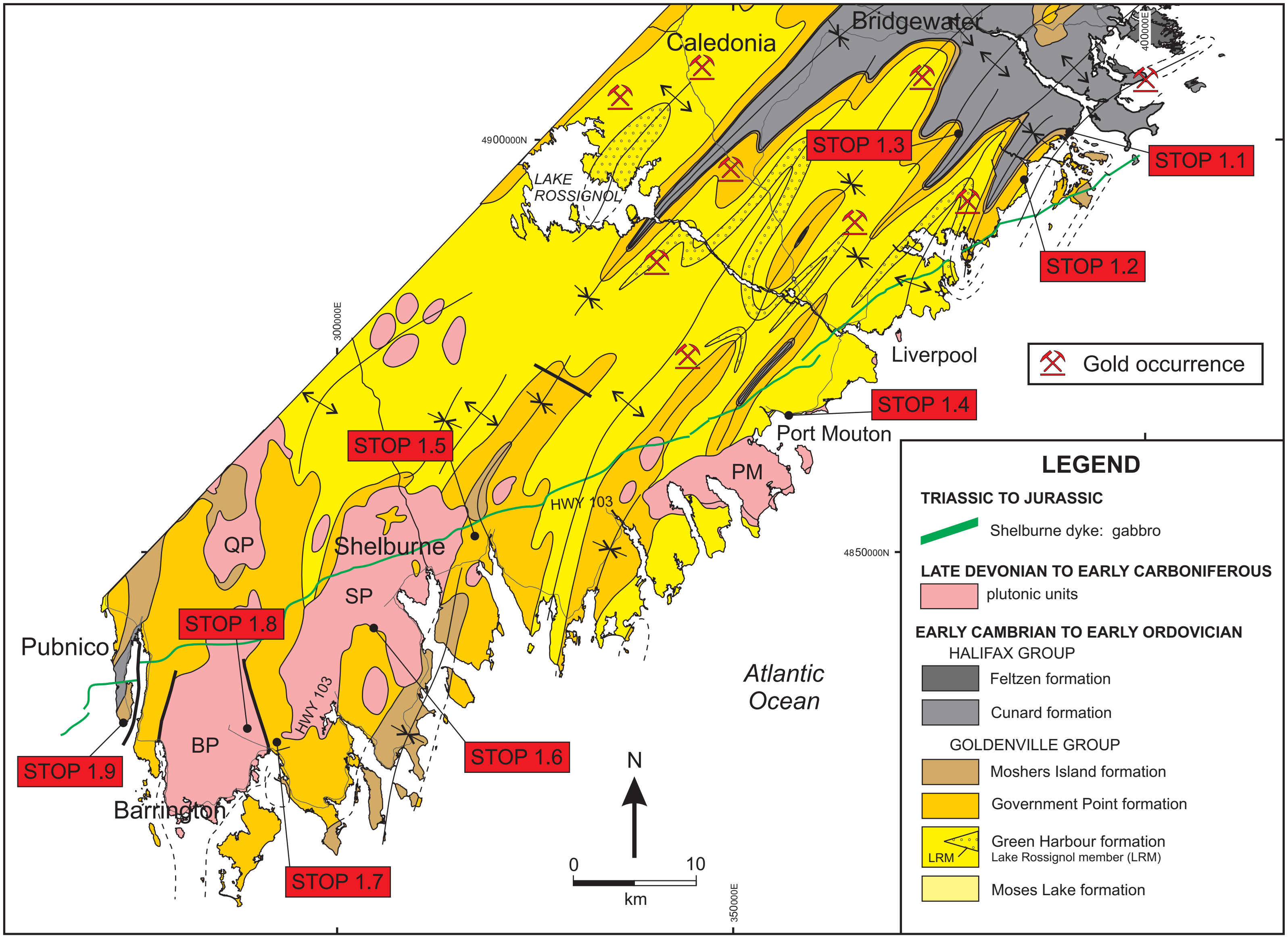


Figure 11. *Geological map of the "south shore" of Nova Scotia from Bridgewater to Pubnico, showing more detail for stops on Day 1.*

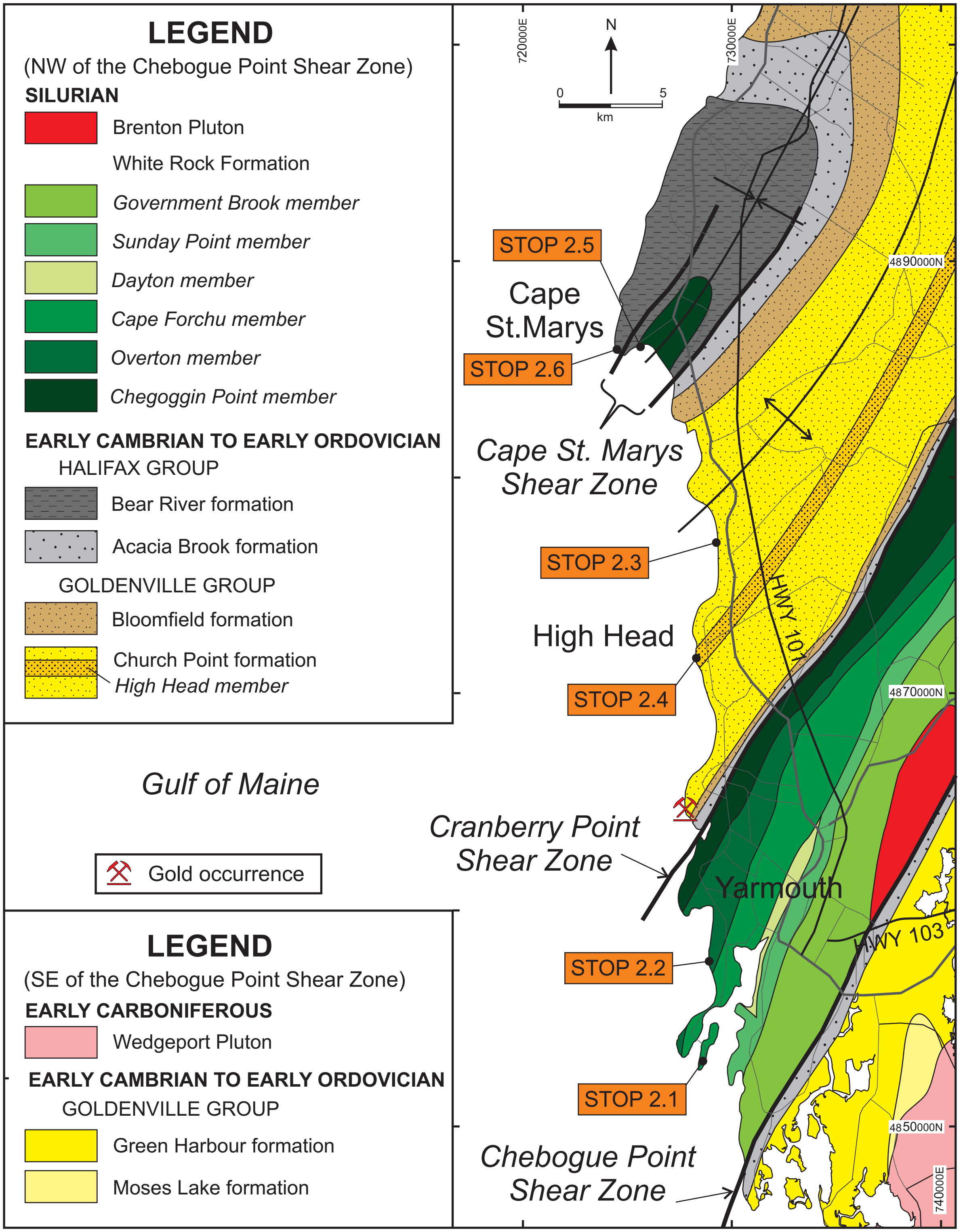


Figure 12. *Geological map of the Yarmouth–Cape St. Marys area after White* et al. *(2001) and White (*in press*) showing more detail for stops on Day 2.*

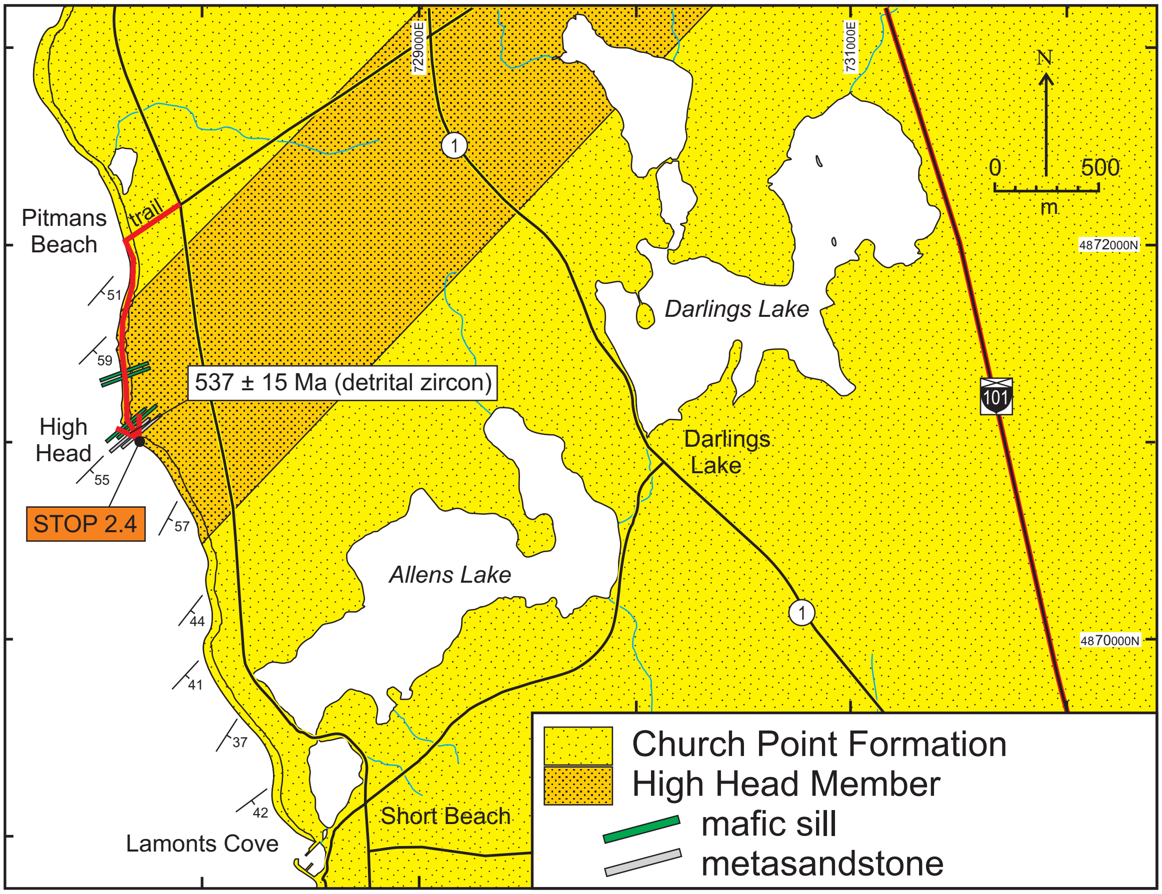


Figure 13. *Geological map of the High Head area showing details for Stop 2.4. Map is modified after Gingras* et al. *(2011).*

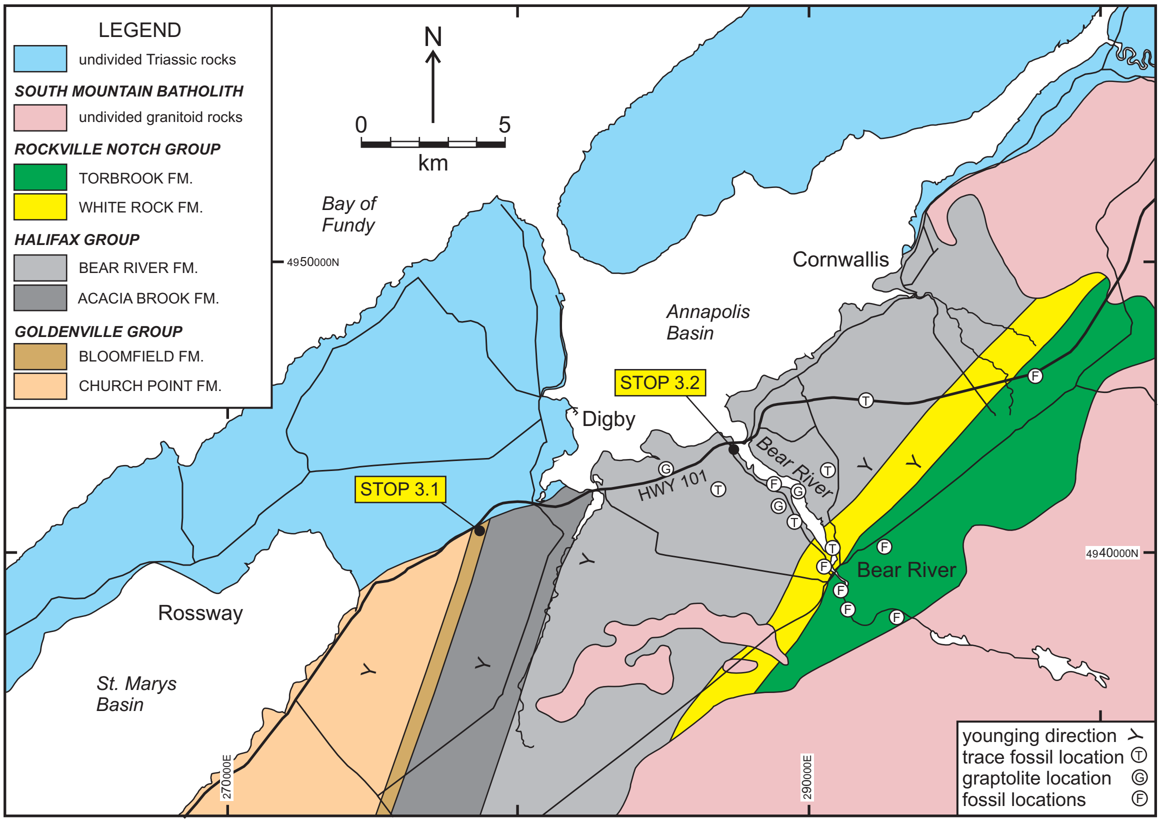


Figure 14. *Geological map of the Bear River area showing Stops 3.1 and 3.2 on Day 3. Map is modified from White* et al. *(1999).*

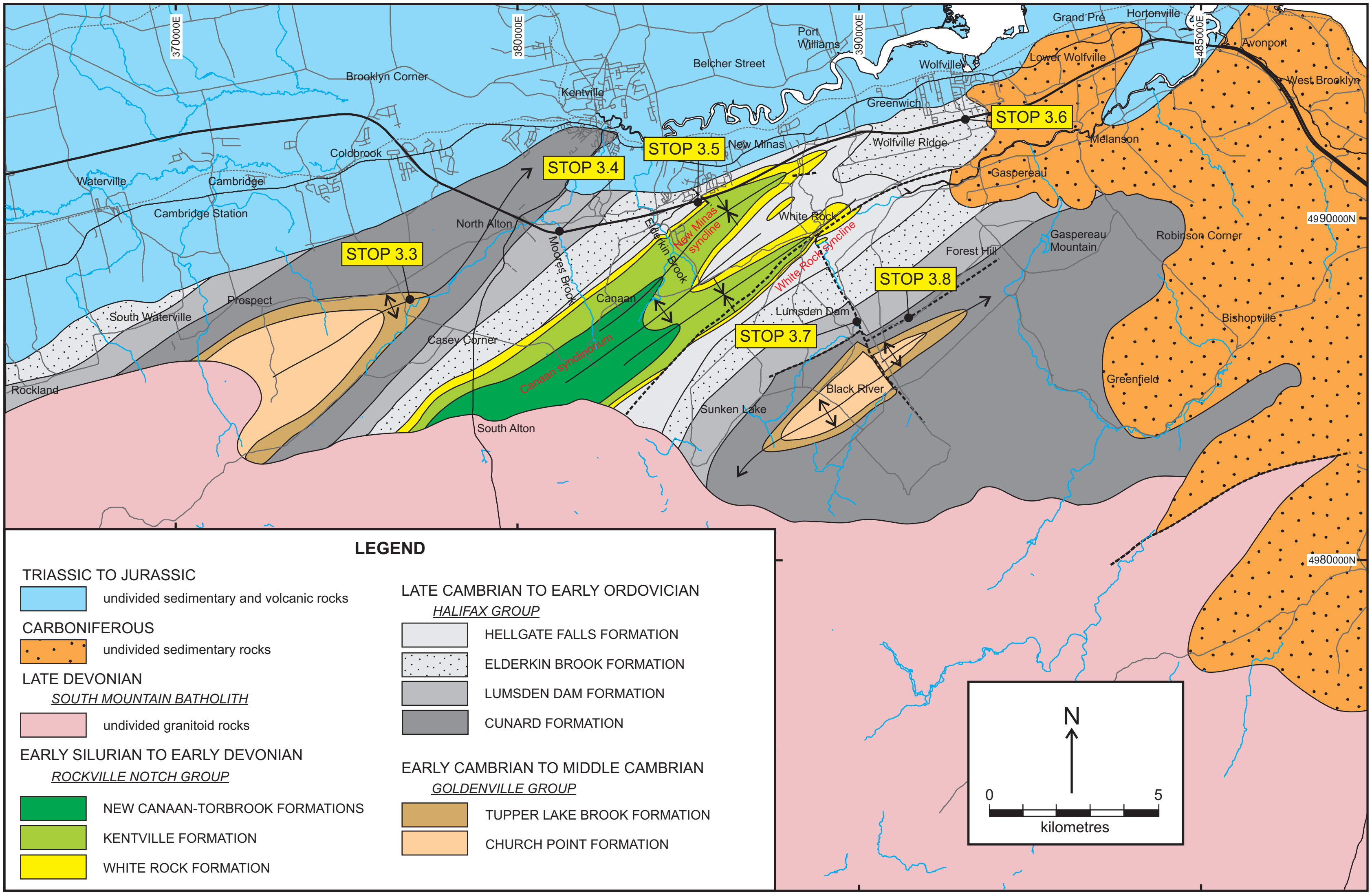


Figure 15. *Geological map of the Wolfville area showing Stops 3.3 to 3.8 on Day 3. Map is modified from White (2010b).*

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ST. JOHN'S 2012

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GAC®-MAC JOINT ANNUAL MEETING · AGC®-AMC CONGRÈS ANNUEL CONJOINT | MAY 27-29 MAI, 2012

The following are field trips organized for the GAC – MAC Meeting, St. John's 2012.

PRE-MEETING TRIPS

FT-A1 **Accreted Terranes of the Appalachian Orogen in Newfoundland: In the Footsteps of Hank Williams**
Cees van Staal and Alexandre Zagorevski
FT-A2 **The Dawn of the Paleozoic on the Burin Peninsula**
Paul Myrow and Guy Narbonne
FT-A4 **Mistaken Point: A Potential World Heritage Site for the Ediacaran Biota**
Richard Thomas
FT-A5 **Neoproterozoic Epithermal Gold Mineralization of the Northeastern Avalon Peninsula, Newfoundland**
Sean J. O'Brien, Gregory W. Sparkes, Greg Dunning, Benoît Dubé and Barry Sparkes
FT-A9 **Cores from the Ben Nevis and Jeanne d'Arc Reservois: A Study in Contrasts**
Duncan McIlroy, Iain Sinclair, Jordan Stead and Alison Turpin

POST-MEETING TRIPS

FT-B1 **When Life Got Big: Ediacaran Glaciation, Oxidation, and the Mistaken Point Biota of Newfoundland**
Guy M. Narbonne, Marc Laflamme, Richard Thomas, Catherine Ward and Alex G. Liu
FT-B2 **Peri-Gondwanan Arc-Back Arc Complex and Badger Retroarc Foreland Basin: Development of the Exploits Orocline of Central Newfoundland**
Brian O'Brien
FT-B3 **Stratigraphy, Tectonics and Petroleum Potential of the Deformed Laurentian Margin and Foreland Basins in western Newfoundland**
John W.F. Waldron, Larry Hicks and Shawna E. White
FT-B4 **Volcanic Massive Sulphide Deposits of the Appalachian Central Mobile Belt**
Steve Piercey and John Hinchey
FT-B5 **Meguma Terrane Revisited: Stratigraphy, Metamorphism, Paleontology and Provenance**
Chris E. White and Sandra M. Barr
FT-B6 **The Grenville Province of Southeastern Labrador and Adjacent Quebec**
Charles F. Gower
FT-B7 **Geotourism and the Coastal Geologic Heritage of the Bonavista Peninsula: Current Challenges and Future Opportunities**
Amanda McCallum and Sean O'Brien