CANADIAN TECTONICS GROUP WORKSHOP
CAPE BRETON ISLAND
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FIELD TRIP GUIDE

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INTRODUCTION

Cape Breton Island is made up of four tectonostratigraphic zones, named (from north to south) Blair River Inlier and Aspy, Bras d'Or, and Mira terranes (Figure 1). On this trip we will examine representative outcrops of various ages in three of these four zones (Figure 2, Figure 3).

The northernmost zone, the Blair River Inlier, is a fragment of Canada's Precambrian Shield, and contains syenitic, monzodioritic and anorthositic plutons (age 980-1100 Ma) intruded into amphibolite- to granulite-facies gneiss (age >1200 Ma). Many of these rocks were metamorphosed at about 1000 Ma, in common with other parts of the Grenville Province of the Canadian Shield in western Newfoundland, Labrador, Quebec and Ontario (Figure 1).

The Aspy terrane consists of ca. 620 and 570-500 Ma metamorphic and plutonic rocks in the western part (Mabou and Cheticamp areas) with uncertain relation to the younger mid-Paleozoic metamorphic rocks (and associated plutons) that dominate the rest of the terrane. The younger metamorphic rocks include metavolcanic, metasedimentary, and gneissic rocks of Ordovician and Silurian age (ca. 450-430 Ma). They were involved in high-pressure amphibolite-facies metamorphism in the late Silurian - early Devonian (ca. 400 - 420 Ma). These metamorphic units are intruded by abundant plutons with ages of ca. 440 Ma, 430 Ma, 400 Ma, and 375-365 Ma. The plutons range from I-type to S-type to A-type – quite a variety in a relatively small area!

The Bras d'Or terrane contains low-pressure amphibolite-facies gneissic "basement", greenschist-facies (and in places higher grade) quartzite, marble and meta-greywacke, and a large volume of late Neoproterozoic subduction-related dioritic, tonalitic, granodioritic, and granitic (I-type) plutons. In the eastern Cape Breton Highlands, the plutonic rocks are particularly abundant, and some of the plutons contain magmatic epidote, indicative of crystallization at pressures of over 800 MPa (25 km depth). The boundary between the Bras d'Or and Aspy terranes is the Eastern Highlands shear zone, and Bras d'Or terrane rocks near it have been affected by younger events associated with terrane collision. Away from the boundary, few events between the middle Cambrian and the Carboniferous are recorded in the Bras d'Or terrane.

Both Aspy and Bras d'Or terranes are considered to be part of Ganderia, whereas the Mira terrane which forms southeastern Cape Breton Island is part of Avalonia. The Mira terrane, like other parts of Avalonia, includes Late Neoproterozoic (680 Ma, 620 Ma, 575 Ma, and 560-550 Ma) mafic and felsic volcanic and volcaniclastic rocks, interstratified clastic sedimentary rocks, and compositionally expanded I-type granitoid plutons, overlain by Cambrian to Ordovician clastic units. In contrast to Bras d'Or terrane, regional metamorphic grade is very low to low. We do not see any Mira terrane rocks on this field trip.

During and following terrane amalgamation, Late Devonian & Carboniferous clastic and carbonate rocks were deposited on top of the older rocks. Faulting (including strike-slip faults, thrust faults, and extensional detachment faults) continued during the Late Paleozoic and Mesozoic.

On this trip, we will see typical rocks of the Bras d'Or and Aspy terranes, the boundary between the two terranes, and one outcrop of anorthosite of the Blair River Inlier. We will focus on the relationship between geology, geological history, and the spectacular scenery for which the Cape Breton Highlands are famous.

BRAS D'OR TERRANE

Bras d'Or terrane, like Mira, is dominated by Neoproterozoic and Cambrian rocks but they differ from those of Mira terrane in composition and age, and hence Bras d'Or is interpreted to be part of Ganderia, not Avalonia (Barr et al. 1998; Hibbard et al. 2006). Rocks similar to those in Bras d'Or terrane also have been recognized elsewhere in Ganderia (e.g., O'Brien et al. 1991; White and Barr 1996; Rogers et al. 2006; Barr et al. 2014b) but they are best exposed in Bras d'Or. Bras d'Or terrane contains fault-bounded blocks of Neoproterozoic low-pressure amphibolite-facies gneiss and much more extensive belts of greenschist-facies (and in places higher grade) quartzite, marble, meta-greywacke, and minor volcanic rocks (Raeside and Barr 1990, 1992). The relationship between the two suites of metamorphic rocks is unknown but recent work indicates that the two packages are the same rocks at different metamorphic grades (Barr et al. 2013, 2014b). Both metamorphic suites are intruded by a large volume of Late Neoproterozoic (mainly ca. 560-553 Ma) subduction zone-related dioritic, tonalitic, granodioritic, and granitic plutons. Plutonic rocks are especially abundant in the eastern Cape Breton Highlands, where several of the plutons contain high-alumina hornblende and magmatic epidote, indicative of crystallization at pressures of over 800 MPa (25 km depth) (Farrow and Barr 1989). These rocks are interpreted to represent the deep levels of an Andean-type continental margin subduction zone, whereas plutons (and in places co-magmatic volcanic rocks) in the southern part of the terrane represent higher level parts of the same subduction zone igneous assemblage. Post-orogenic Late Cambrian granitic plutons are also present, and Middle Cambrian to early Ordovician volcanic and sedimentary rocks are preserved in a down-faulted block known as the Bourinot belt in the Boisdale Peninsula. Despite some similarity to the Cambrian sequence on Mira terrane, the Bourinot belt is firmly linked to Bras d'Or terrane and hence Ganderia. Similar Cambrian-Ordovician rocks also occur in Ganderia in southern New Brunswick (Fyffe et al. 2009).

Barr et al. (1998) proposed that Neoproterozoic rocks of the Bras d'Or terrane and its equivalents exposed in southern New Brunswick and locally in central Newfoundland represent the "basement" on which Paleozoic rocks were deposited, and these Paleozoic rocks (e.g., the Gander Group in Newfoundland), which dominate Ganderia elsewhere, were assumed to have been derived from the Bras d'Or terrane.

A major mylonitic high-strain zone known as the Eastern Highlands shear zone (Lin, 1995, 2001) separates Bras d'Or terrane from Aspy terrane to the north. This boundary has a long and complex history, and the original relationship between Bras d'Or and Aspy terranes was likely as basement and cover (Chen et al. 1995). Bras d'Or terrane appears to have been thrust to the northwest over Aspy terrane, and much of the original terrane is missing - the part of Bras d'Or terrane now adjacent to Aspy was little affected by and hence probably far away during the Silurian-Devonian events which are so prominently recorded in Aspy terrane. These mid-Paleozoic events are not generally recorded in Bras d'Or terrane rocks, except near the Eastern Highlands shear zone, where $^{40}Ar/^{39}Ar$ dating revealed overprinting in Neoproterozoic rocks by younger thermal events associated with Bras d'Or-Aspy terrane collision (Reynolds et al. 1989).

ASPY TERRANE

Aspy terrane contains low- to high-grade metavolcanic and metasedimentary rocks and large areas of orthogneiss and less abundant paragneiss, all metamorphosed in the late Silurian - early Devonian (ca. 420 - 400 Ma) (Dunning et al. 1990; Reynolds et al. 1989; Barr et al. 1998; Price et al. 1999; Horne et al. 2003; Lin et al. 2007). The protolith ages for these metamorphic rocks are somewhat uncertain, but they appear to include both Neoproterozoic and Ordovician-Silurian components (Lin et al. 2007). Rocks with ages of ca. 620 and 550 Ma occur in the western part of the terrane (Mabou and Cheticamp areas) and have difficult-to-demonstrate relationships with the younger mid-Paleozoic metamorphic rocks (and associated plutons) that dominate in the rest of the terrane, but are likely to constitute their basement. The younger metamorphic rocks include metavolcanic, metasedimentary, and gneissic rocks of Ordovician and Silurian (ca. 450-430 Ma) age. They were involved in high-pressure amphibolite-facies metamorphism in the late Silurian - early Devonian (ca. 400 - 420 Ma). They are subdivided into map units separated by plutons, faults, or Carboniferous rocks and assigned local names because of the difficulty of making correlations throughout the area (e.g., Barr and Jamieson 1991; Barr et al. 1992; Lin et al. 2007). Metaconglomerate in the eastern part of the Aspy terrane yielded detrital zircon ages including ca. 495 Ma grains that suggest an original depositional link with Bras d'Or terrane which contains plutons of that age (Lin 1993; Chen et al. 1995).

Metamorphic units in the Aspy terrane are intruded by abundant plutons with igneous crystallization ages of ca. 442 Ma, 430 Ma, 400 Ma, and 375-365 Ma (Dunning et al. 1990; Horne et al. 2003). In simplistic terms, the plutons can be said to include all of "I-type, S-type, and A-type" (Barr 1990). The oldest plutons are orthogneissic/foliated dioritic, tonalitic, and granitic plutons with ages of ca. 440-425 Ma and petrological features consistent with formation in a subduction zone setting (Price et al. 1999). Together with volcanic rocks of similar ages, they may have formed in a Japan-type setting offshore from Bras d'Or terrane and on Bras d'Or terrane crust (Figure 4). Younger ca. 400 Ma plutons mainly occur within splays of the Eastern Highlands shear zone and may have formed in conjunction with the early stages of juxtaposition with Bras d'Or terrane. They also have volcanic-arc characteristics (Barr 1990). The most pervasive units in Aspy terrane are "S-type" granodioritic to granitic plutons and associated pegmatite/aplite with a minimum age of about 375 Ma, based on a U-Pb (monazite) age of 375+5/-3 Ma from the Black Brook Granitic Suite (Figure 3). However, based on the fact that they are older than the Bothan Brook Granite dated at 376 ± 3 Ma (U-Pb zircon; Horne et al. 2003) and that they are an intimate part of the Cheticamp Lake Gneiss where they have yielded a U-Pb age of 396 ± 2 Ma, their age is probably closer to 400 Ma than 375 Ma. These plutons have "syn-collisional" petrological characteristics, and may have formed as a result of increased compression between Aspy and Bras d'Or terranes during docking of Mira terrane in the mid-Devonian.

Metamorphic and $^{40}Ar/^{39}Ar$ studies indicate that the Aspy terrane cooled quickly from ca. 600°C through 400°C between 386 Ma and 370 Ma, and by ca. 375 Ma, bimodal volcanic rocks and nonmarine sedimentary successions were forming in rift basins, mainly in Aspy terrane but also locally in Bras d'Or terrane. The bimodal volcanic rocks have within-plate characteristics (e.g., Barr et al. 1995; Barr and Peterson 1998), as do the related granitic plutons. These granitic plutons include the megacrystic Margaree Pluton with its distinctive rapakivi texture, as well as widespread coarse-grained equigranular granitic plutons.

Such plutons are absent from Bras d'Or terrane, except in the easternmost highlands where the Eastern Highlands shear zone splays; one splay (the main one?) appears to be stitched by the Black Brook Granitic Suite (Yaowanoiyothin and Barr 1991), whereas the 402 Ma Cameron

Brook Granodiorite was emplaced in the southern splay and may also be a stitching pluton (Dunning et al. 1990).

The abundant plutonic components that characterize Aspy terrane also typify other parts of Ganderia. Van Staal et al. (2009) interpreted an equivalent range of granitoid rocks in New Brunswick and central Newfoundland mainly to slab break-off (Silurian) and flat-slab subduction (Devonian), and similar models may apply (in a simplistic way at least) to plutons in Aspy terrane. On the north, Aspy terrane is separated from the adjacent Blair River inlier by the steep Red River and Wilkie Brook fault zones which form a geometrically impossible-looking "V-shape", with the junction of the "V" cut and thus obscured by Devonian granitic plutons (Margaree and Andrews Mountain-type plutons). Such plutons "stitch" the bounding faults of the Blair River inlier, and show that juxtaposition with Aspy was completed by ca. 375 Ma (Barr et al. 1996). The configuration of the bounding faults at depth is unknown. No units equivalent to the peri-Laurentian arcs and back-arcs of western Newfoundland and Quebec have yet been identified in Cape Breton Island and offshore geophysical data indicate that those units are pinched out against major Carboniferous faults (Barr et al. 2014a).

BLAIR RIVER INLIER

The Blair River inlier forms the northwestern part of Cape Breton Island. It consists mainly of composite orthogneissic units, intruded by less deformed plutons of varied compositions including anorthosite, gabbro, syenite, and granite. Miller et al. (1996) and Miller and Barr (2000) reported U-Pb dates confirming that major units in the inlier are of Mesoproterozoic age, including the Sailor Brook Gneiss (>1217 Ma), Lowland Brook Syenite (1080 +5/-3 Ma), Red River Anorthosite Suite (>1095Ma), and Otter Brook Gneiss (978 +6/-5 Ma). They also showed that high-grade metamorphism of the Sailor Brook Gneiss occurred at 1035 +12/-10 Ma, and that the Red River Anorthosite Suite was metamorphosed at 996+6/-5 Ma.

Paleozoic igneous activity in Blair River inlier is demonstrated by the 435 +7/-3 Ma age of the Sammys Barren Granite (Figure 3). In addition, Paleozoic amphibolite-facies metamorphism is reflected in ca. 425 Ma titanite ages from the Proterozoic units, and subsequent cooling through hornblende, muscovite, and phlogopite $^{40}Ar/^{39}Ar$, and rutile U-Pb, closure temperatures lasted until ca. 410 Ma (Barr et al. 1996; Miller et al. 1996). Although similar in timing to events in adjacent Aspy terrane, these events are unlikely to reflect direct interaction of the Blair River inlier with the Ganderian Aspy terrane, but instead with peri-Laurentian elements incised by subsequent tectonic events. A later, probably Devonian, greenschist-facies overprint is most intense near chlorite-grade shear zones and brittle fault zones, and likely reflects juxtaposition with Aspy terrane.

The Mesoproterozoic units of the Blair River inlier are distinct in both age and composition from rocks in other parts of Cape Breton Island and in northern Appalachian outboard terranes in general. They contain rock types and ages similar to those characteristic of the Grenville Province of Laurentia and similar to those in other Grenvillian basement inliers in the Appalachian orogen, such as the Steel Mountain, Indian Head, and Long Range inliers in western Newfoundland (e.g., Heaman et al. 2002). Thus, the Blair River inlier is interpreted to be an exposure of Laurentian Grenvillian basement that was deformed, metamorphosed, and intruded by granite during Appalachian orogenic events (Miller et al., 1996; Barr et al. 1996, 1998).

The faults that bound the Blair River inlier are marked by steep mylonite zones mainly in Blair River lithologies; contacts between these rocks and Aspy terrane rocks are mainly brittle faults, although Aspy terrane rocks are also locally mylonitic, especially near the bounding faults. Offshore seismic profiles (e.g., Loncarevic et al. 1989) are not clear about the relationship of the Blair River inlier to Grenvillian basement in the Gulf of St. Lawrence. It is possible that the Blair River inlier is a “flake” that has been detached from its Grenvillian roots in the St. Lawrence promontory (Lin et al. 1994). However, geophysical modeling indicates continuity between Grenvillian basement in western Newfoundland and Cape Breton Island (Barr et al. 2014a).

MIRA TERRANE

Mira terrane is the only part of Cape Breton Island which belongs to Avalonia (Hibbard et al. 2006). In the northern Appalachian orogen, Avalonian rocks occur in southeastern New England (USA), the Caledonian Highlands of southern New Brunswick, the Cobequid and Antigonish highlands of northern mainland Nova Scotia, Mira terrane in Cape Breton Island, and the Avalon platform of eastern Newfoundland (Figure 1). Some authors refer to these areas collectively as West Avalonia, to distinguish them from the components of East Avalonia in the UK and elsewhere in Europe. In this guidebook, the term is used to refer only to the northern Appalachian orogen. The characteristic rocks of Avalonia are Middle to Late Neoproterozoic volcanic, sedimentary, and plutonic rocks, although specific ages vary from area to area. Most Avalonian areas also include overlying Cambrian to Lower Ordovician clastic sedimentary units.

In Mira terrane, Neoproterozoic rocks form three belts of mainly different ages (Figures 2, 3): ca. 680 Ma (Stirling), ca. 620 Ma (Sporting Mountain, East Bay Hills, and Coxheath Hills), and 575-550 Ma (Coastal). All three belts are dominated by mafic to felsic volcanic and volcaniclastic rocks and varying abundances of inter-stratified epiclastic and clastic sedimentary rocks. Barr (1993) and Macdonald and Barr (1993) interpreted the Stirling belt to represent an intra-arc or back-arc basin. In contrast, the ca. 620 Ma mainly volcanic, volcaniclastic, and plutonic rocks of the Coxheath Hills, Sporting Mountain, and East Bay Hills belts have petrochemical features typical of high-K calc-alkalic suites formed at continental margin subduction zones (Barr 1993; Barr et al. 1996). However, the presence of plutonic rocks of this age in the Stirling belt indicates that these two belts were juxtaposed by that time. These composite dioritic to granitic ca. 620 Ma plutons are the most extensive plutons in the Mira terrane.

The ca. 575 Ma mainly tuffaceous volcanic rocks of the Coastal belt (Fourchu Group) appear to be transitional between calc-alkalic and tholeiitic chemical affinity. They are inferred to represent magmas derived early in the development of a ca. 575 Ma northwest-dipping (present coordinates) subduction zone. High-level plutonic rocks are only a minor component. The other major component of the Coastal belt, the Main-a-Dieu Group, contains lava flows, tuffs, debris flows, and fine-grained epiclastic rocks interpreted to have been deposited in intra-arc basins developed adjacent to the stratovolcanoes represented by the tuffs and flows of the Fourchu Group (Barr 1993; Barr et al. 1996). The Main-a-Dieu Group is overlain by mainly clastic marine sedimentary rocks of Cambrian to Early Ordovician age (Barr et al. 1996). Devonian plutons are also present in the Mira terrane. They are shallow intrusions with associated porphyry-type, greisen-hosted, and vein-hosted Cu-Mo-Pb-Ag-Bi mineralization (Barr and Macdonald 1992). Petrological characteristics suggest that they are subduction-related plutons, but no other evidence of a Devonian magmatic arc occurs in southern Cape Breton Island. The apparent arc-signatures could reflect the nature of their source rocks in the roots of a Neoproterozoic arcs, or they could be associated with a more outboard subduction zone relating to juxtaposition of Gondwana with Meguma (e.g., Moran et al. 2007). Recent dating and other isotopic studies have clarified the timing and demonstrated a complex history of terrane amalgamation within the Mira composite terrane that is likely typical of Avalonia as a whole (Willner 2013a, b; 2015).

The boundary between Mira terrane and Bras d’Or terrane to the north is a “cryptic suture”, buried beneath Carboniferous sedimentary rocks or located under water in Bras d’Or Lake (Figure 2). On maps, it is rather arbitrarily placed at conveniently located Carboniferous faults through the Boisdale Peninsula. The presence of clasts derived from both Mira terrane and Bras d’Or terrane units in a Middle Devonian conglomerate (McAdams Lake Formation) south of this fault shows that the two areas were in proximity by that time (White and Barr 1998). Magnetic and gravity models across the boundary suggest that the Mira terrane has been thrust under Bras d’Or terrane at the boundary (King 2002).

Field Trip Stops

To get to the Cabot Trail from Sydney:
Go south on Kings Road – NS4 W
Use right lane to turn onto NS-125 W via ramp to North Sydney/Newfoundland Ferry
Take exit 1W for NS-105 W/Trans Canada Highway towards Baddeck/Canso Causeway
Merge onto NS-105 W/Trans Canada Highway
After Kellys Mountain turn onto NS-312 N (signs for Englishtown Ferry/Ingonish)
Turn left at Ferry turn-off ($7.50/car).

Stop 1: St. Anns Look-off (46.245716°N 60.514786°W)
From the look-off on Kellys Mountain you can see the eastern Highlands as far as Cape Smokey. This part of the Highlands is composed mostly of granitoid rocks, with quartzite and other metasedimentary rocks of the McMillan Flowage Formation making up the prominent ridge to the northwest in this view. The lower land is underlain by sandstone, limestone, and gypsum of the Carboniferous Horton and Windsor groups. At the look-off, you are standing on cordierite-bearing gneiss (Jamieson 1984) of Kellys Mountain, also part of the Bras d'Or terrane. These low-pressure gneissic rocks are characteristic of the Bras d'Or terrane. The gneiss is intruded by the late Cambrian (ca. 498 Ma) Kellys Mountain Granite, as well as by diorite and intermediate granitoid rocks with a probable age of ca. 560 Ma (based on comparisons to similar rock types elsewhere in the terrane).

Note: Distance measurements after this point are given for a start at the junction of the Cabot Trail with the Englishtown Ferry road. They do not include the turn-offs at Wreck Cove road or Bay St. Lawrence Road. If those are included, add 25 km to all measurements.

Stop 2: Wreck Cove Road - Birch Plain Granite (46.527842°N 60.431344°W)
(Left turn at Wreck Cove Hydro station (26 km), 1.4 km from turn.)
The Birch Plain Granite is medium-grained biotite granite, of Late Neoproterozoic age (ca. 570 Ma, unpublished data). It is texturally and mineralogically distinct from the younger (ca. 495 Ma) Cape Smokey Granite (Stop 3), and is inferred to be part of the same plutonic suite as the Indian Brook Granodiorite (Grecco and Barr 1999), in which it forms xenoliths. Mineralogy in the granite includes plagioclase, perthitic microcline, quartz, and biotite (no amphibole). Allanite and zircon are abundant accessory phases, together with titanite, apatite, and magnetite. It locally displays weak foliation, but whether it is the result of flow or tectonism is unclear. It is cut by mafic dykes of uncertain age which have sharp contacts and well developed

chilled margins; locally magma-mingling features suggest that they may be of similar age to the host granite.

Stop 3: Cape Smokey Granite (46.587714°N 60.381551°W)
(Stop at the picnic park look-off, 40 km)
Cape Smokey is underlain by pink leucocratic biotite granite of late Cambrian age (493 ± 2 Ma; Dunning et al. 1990). The granite is equigranular and unfoliated (post-tectonic), and consists of approximately equal amounts of plagioclase, orthoclase, and quartz. Biotite forms only 1-2% and is mainly altered to chlorite. Similar granite of similar age (498 ± 2 Ma; Dunning et al. 1990) forms much of Kellys Mountain where it intrudes Bras d'Or gneiss. The tectonic setting for these large plutons is enigmatic. They have volcanic-arc chemical signatures (Barr 1990). The only constraints on tectonic activity in Bras d'Or terrane at that time is in the Bourinot belt, where bimodal volcanic rocks and a syenogranite pluton have ages of 505 ± 3 Ma and 509 ± 2 Ma, respectively (White et al. 1994). These rocks have within-plate characteristics and have been linked to separation of Ganderia from Gondwana. The Kellys Mountain and Cape Smokey plutons may also be related to that event.

Pay CBHNP entrance fee on right turnoff lane.
NO rock collecting or hammers from here on in please.

Stop 4: Black Brook Granitic Suite, Green Cove
(Pull off the trail into the parking lot at Green Cove – 69 km.)
The spectacular roadside and shoreline outcrops through this part of the Cape Breton Highlands National Park are a mixture of biotite granite and cross-cutting granitic, aplitic, and pegmatitic dykes, all part of the Devonian (~375 Ma) Black Brook Granitic Suite. Also present are xenolithic blocks composed of biotite-rich pelitic material and megacrystic granodiorite. Collectively the latter two lithologies have been termed the "Neils Harbour Gneiss". The megacrystic orthogneiss yielded a U-Pb (zircon) age of 403 ± 3 Ma, the same as the age of the megacrystic Cameron Brook Granodiorite (402 ± 3 Ma) to the south. Hence, it is likely that the megacrystic component of the Neils Harbour Gneiss is the Cameron Brook Granodiorite. The biotite-rich schistose rocks could be remnants of the host rock (age unknown) of both the Black Brook Granitic Suite and the Cameron Brook Granodiorite.

Based mainly on an observed change in the nature of the xenoliths from the type seen here to gneissic lithologies clearly derived from Aspy terrane units Yaowanoiyothin and Barr (1991) drew the Aspy/Bras d'Or boundary as a "cryptic suture" through the Black Brook Granitic Suite, and interpreted the granitic suite to be syntectonic, emplaced during movement along the Eastern Highlands shear zone. The terrane boundary then stepped to the south with several branches. In contrast to the western and eastern margins of the Black Brook Granitic Suite where dykes associated with the pluton are numerous, the southeastern margin is sharp and no dykes derived from the Black Brook Granitic Suite occur in adjacent Bras d'Or terrane units and no xenoliths from those units (with the exception of the Cameron Brook Granodiorite) were recognized in the Black Brook Granitic Suite. These observations suggest that the Bras d'Or terrane units now juxtaposed with the Black Brook Granitic Suite along the Eastern Highlands shear zone were not in close proximity during intrusion of the suite.

Stop 5: Cabot Landing Provincial Park
At 95 km (just under 25 km from Green Cove), turn on to Bay St. Lawrence Road (slight right turn) for 9.9 km, turn right into Cabot Landing Provincial Park.
Looking north from Cabot Landing Provincial Park, the raised beaches are apparent, marking the trace of the Aspy Fault. The Aspy fault is a Carboniferous late brittle fault, with much less effect on the geology than its spectacular "trace" might suggest and has only a few kilometres of displacement. The offset raised beach indicates that motion on the fault occurred in the Quaternary, perhaps in response to isostatic adjustments.

Stop 6: Aspy Fault Look-off - MacGregor Brook (46.811444°N 60.642244°W)
From the look-off one can see the extent of the Carboniferous lowlands of the Aspy Valley. The prominent Aspy Fault follows the steep valley to the northeast toward Newfoundland where it connects with the Cabot or Long Range Fault, and to the southwest toward Margaree. The rocks across the road from the look-off are part of the metasedimentary Cape North Group, which here have been strongly sheared on the edge of the Wilkie Brook shear zone which marks the boundary with the Blair River Complex. Going up North Mountain after the look-off, the roadside sections expose sheared and locally mylonitic rocks of the 1½ km wide Wilkie Brook shear zone, with mylonitic layers and metasedimentary rocks of the Ordovician-Silurian Cape North Group, cut by abundant Devonian granitic sheets of the "Andrews Mountain type" (age ca. 375 Ma).

Stop 7: Anorthosite - North Mountain (46.808488°N 60.694025°W) (114 km)
Gneissic and plutonic rocks of the Blair River inlier form most of the roadside outcrops on North Mountain (elevation 445 m) but stopping anywhere during the ascent is both dangerous and illegal. These rocks are all strongly deformed and altered because of proximity to the margins of the inlier, and in fact, no outcrops that really do justice to the Blair River inlier occur along the Cabot Trail. Outcrops in the ditch on the south side of the highway near the summit of North Mountain are the best available.

These outcrops of the Red River Anorthosite have been quite strongly deformed by shearing associated with the margins of the Blair River inlier. Farther to the northeast, this anorthosite body has yielded a U-Pb (zircon) minimum igneous crystallization age of 1095 Ma, and a metamorphic age of ca. 996 Ma (Miller et al. 1996; Miller and Barr 2000). The massive anorthosite in this outcrop is typical of the core of the suite, and elsewhere it grades outward into gabbroic rocks. The anorthosite consists mostly of plagioclase of andesine-labradorite composition. These rocks are typical of "AMCG" suites of the Grenville Province of the Canadian Shield.

Stop 8: Scenic Look-off and Pleasant Bay Complex (46.789861°N 60.846676°W)
On a clear day, the ascent on MacKenzie Mountain (elevation 335 m) provides scenic views across Aspy terrane to the east, underlain in this area mainly by plutonic rocks ranging in age from ca. 442 Ma (or older) orthogneiss (Pleasant Bay Complex) to ca. 365 Ma megacrystic granite of the Margaree Pluton, but also including ca. 375 Ma granite (Pleasant Bay Granite) and schist of the Jumping Brook Metamorphic Suite. Far down in the valley, the MacKenzie River flows from the interior of Aspy terrane. Views far to the north show Andrews Mountain, composed of red Devonian granite (see pillars supporting the benches and display panels for nice examples), and across the Red River mylonite zone north of Andrews Mountain, the rugged shoreline of the Grenvillian Blair River inlier. The Lowland area around Pleasant Bay is underlain by Carboniferous sedimentary rocks. The body of water to the west is the Gulf of St. Lawrence. The roadside outcrop opposite the look-off is typical of the Pleasant Bay Complex. It includes paragneiss (foliation trending north and nearly vertical) cut by varied biotite and muscovite-biotite granodiorite and granite. These distinctive medium-grained peraluminous granitoid rocks are characteristic of Aspy terrane (as we also saw at Green Cove). Dykes of granitic pegmatite and associated aplite are also characteristic components of Aspy terrane and are well displayed in this outcrop (as they are at Green Cove).

Stop 9: Metasedimentary rocks of the Jumping Brook Suite - Cap Rouge Look-off
(46.735923°N 60.922690°W) 133 km
From this area to the east and uphill, metamorphic grade in the Jumping Brook Metamorphic Suite increases systematically from chlorite through biotite, garnet, staurolite, and sillimanite. Little outcrop occurs at the top of the highlands plateau (elevation ca, 450 m) and the relationship between the Jumping Brook Metamorphic Suite and overall higher grade Pleasant Bay Complex is uncertain (Jamieson et al. 1987). Many of these rock types are best seen here in the ornamental wall at the Cap Rouge look-off, which is a safer place to stop than on the descent down French Mountain. From this location you can get a good view of the western Highlands including the lowlands underlain by Carboniferous rocks and the highlands composed of metamorphic and granitic rocks of the Aspy terrane.

Stop 10: Cheticamp River tonalite in contact with Jumping Brook Metamorphic Suite
(46.726019°N, 60.924782°W)
Park at the Corney Brook Campground (150 km) and walk up the hill to the south, on the left side of the road, preferably in the ditch.
The Late Proterozoic Cheticamp River tonalite is visible on the north side of the road cut. The phyllites of the Dauphine Brook Formation (part of the Jumping Brook Metamorphic Suite) are sheared and folded. Barite veins occur throughout the phyllite near the top of the outcrop and into the next road cut. The Cheticamp River tonalite is interpreted as being 488 Ma (+4.90 - 3.90), and based on detrital zircon U-Pb dating, the Dauphine Brook Formation has to be younger than ~530 Ma (for details see White et al. 2015, this volume). Unfortunately these age constraints do not fully explain their contact relationship since there is no known minimum age for the Dauphine Brook Formation.

Stop 11: Pillar Rock
(Right turn off the trail into beach parking lot, 155 km)
The sea stack (Pillar Rock) is composed of Devonian (375 Ma) basalt of the Fisset Brook Formation. The narrow valley occupied by the lake is bounded by faults on both sides. One fault extends under the beach between Pillar Rock and the mainland and the other between Pillar Rock and the rocky headland (Presqu'ile) to the west. Along the beach between the parking place and the sea stack the shoreline consists of phyllites that are part of the Jumping Brook Metamorphic Suite. Such rocks form most of the outcrops along the Cabot Trail between here and French Mountain. The large boulders of granite along the beach were trucked here from a quarry near Dingwall to prevent erosion of the road above. On the headland west of the beach, Carboniferous sedimentary rocks dip out to sea. They contain purple fluorite veins and fracture coatings, deposited from water migrating through the rocks.

Stop 12: Cheticamp Pluton at Le Grand Falaise (46.675004°N 60.953092°W)
(Pull off to the left, into the parking lot at the Grand Falaise signpost, 157 km)
Note: The base of this cliff is **not** safe to approach.
As seen from the Grand Falaise Picnic Site, the bottom of the cliff consists mostly of dark green to black, shattered and strongly altered basalt (Devonian Fisset Brook Formation) with a prominent layer of brick-red sedimentary rocks. These red sedimentary rocks are associated with rocks of the Fisset Brook Formation elsewhere, and without them it would have been difficult to identify the basalt as belonging to that formation, as Silurian mafic volcanic rocks also occur in Aspy terrane. The upper part of the cliff is granite of the Cheticamp Pluton of Jamieson et al. (1986). This part of the Cheticamp Pluton is likely as old as ca. 565 Ma (see White et al. 2015, this volume).The contact between the Fisset Brook Formation below and the granite above is a thrust fault marked by a zone of intense shattering and alteration. The movement of fluids through the fractured rock deposited veins of calcite and gypsum near the

thrust fault. The granite is cut by mafic and felsic dykes; one of the felsic dykes in the cliff apparently yielded an age of 439 ± 7 Ma (Currie et al. 1982) and hence they are probably related to Silurian volcanic rocks elsewhere in the Aspy terrane.

Not-a-Stop A: Belle Côte area

As we drive south along the shore, you should note we are driving along a coastal ridge, underlain by Late Carboniferous sandstone. The older limestone and gypsum of the Windsor Group underlie the low ground to the east. Beyond them, the more resistant rocks of the Highlands plateau rise up, emplaced along fault zones (perhaps thrusts).

Not-a-Stop B: Middle River area

As we drive along the Cabot Trail in the Middle River area, we cut across the southern edge of the Highlands. The topography along this part of the Trail is dominated by alternating narrow valleys and flat open "intervales" that were lake beds during the end of the Ice Age. The valleys are mostly fault controlled, for example Lake O'Law goes well below sea level, and hints at glacial over-deepening.

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CAPE BRETON ISLAND

CTG 2015

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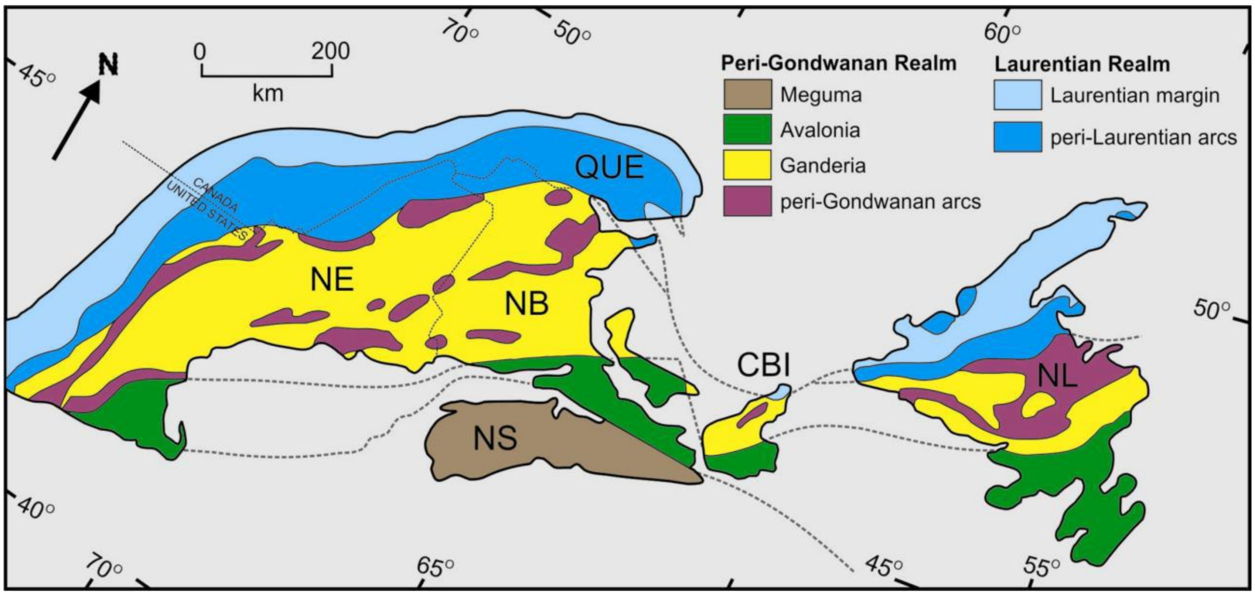


Figure 1. Divisions of the northern Appalachian orogen after Hibbard et al. (2006). Abbreviations: CBI, Cape Breton Island; NE, New England states of the USA; NL, Newfoundland, NS, Nova Scotia; NB, New Brunswick; Que, Quebec.

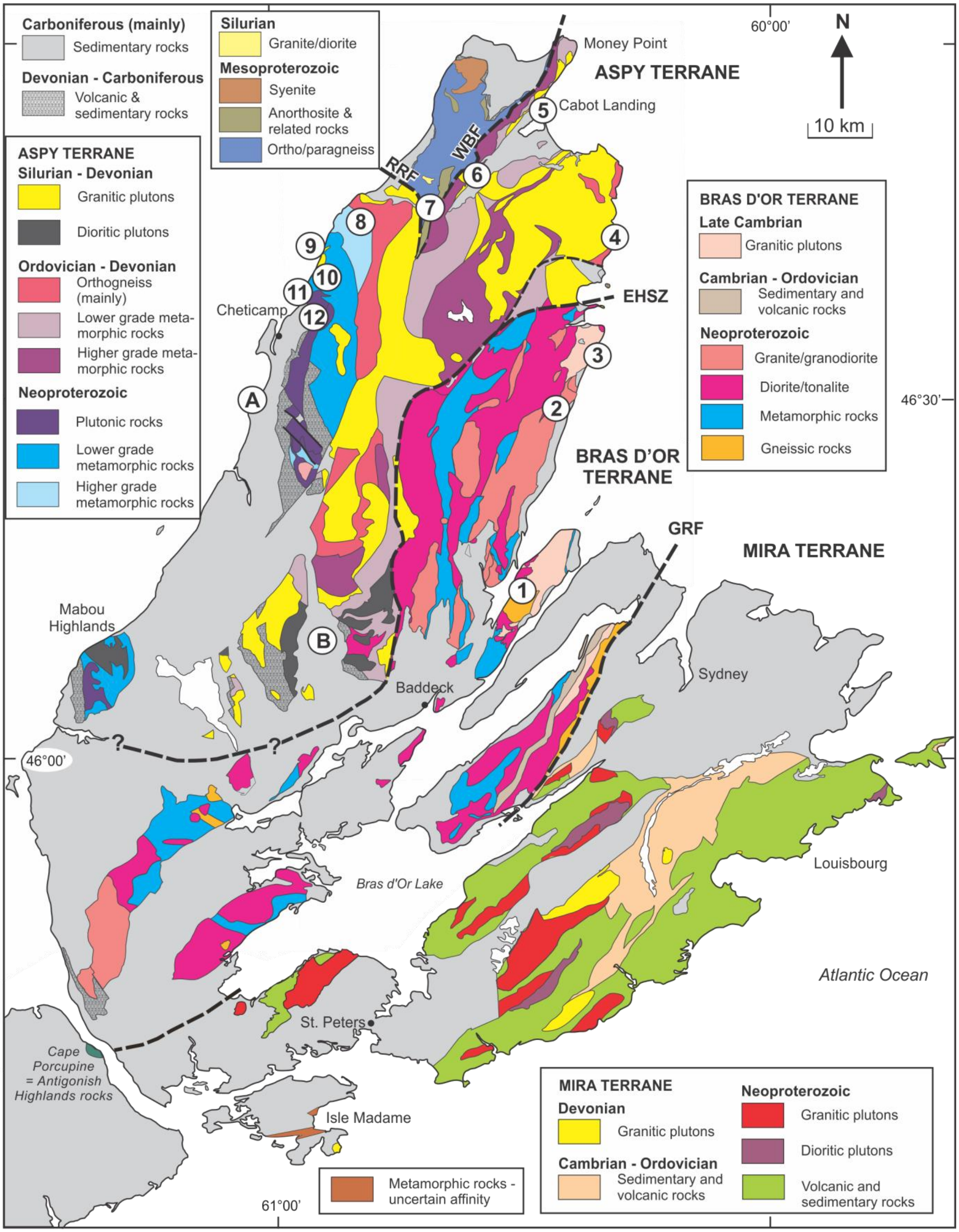
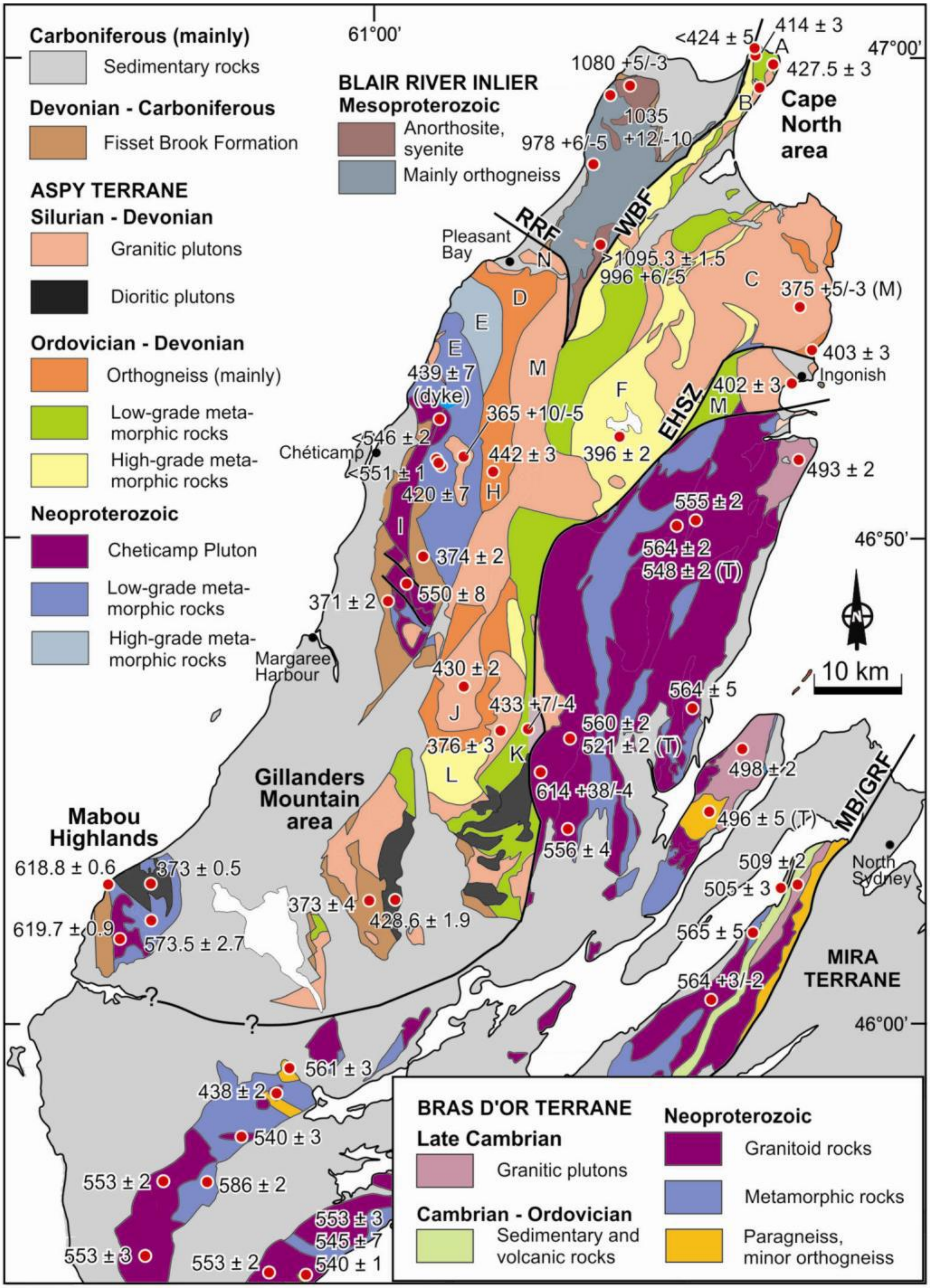


Fig. 2. Stop locations for CTG 2015 Cape Breton Highlands field trip.



Carboniferous (mainly)
Sedimentary rocks
Devonian - Carboniferous
Fisset Brook Formation
ASPY TERRANE
Silurian - Devonian
Granitic plutons
Dioritic plutons
Ordovician - Devonian
Orthogneiss (mainly)
Low-grade metamorphic rocks
High-grade metamorphic rocks
Neoproterozoic
Cheticamp Pluton
Low-grade metamorphic rocks
High-grade metamorphic rocks
BLAIR RIVER INLIER
Mesoproterozoic
Anorthosite, syenite
Mainly orthogneiss
61°00'
47°00'
46°50'
46°00'
Cape North area
Pleasant Bay
Chéticamp
Margaree Harbour
Ingonish
Gillanders Mountain area
Mabou Highlands
North Sydney
MIRA TERRANE
RRF
WBF
EHSZ
MB/GRF
10 km
BRAS D'OR TERRANE
Late Cambrian
Granitic plutons
Cambrian - Ordovician
Sedimentary and volcanic rocks
Neoproterozoic
Granitoid rocks
Metamorphic rocks
Paragneiss, minor orthogneiss

Figure 3: Compilation of U-Pb age data (in Ma) for the Bras d'Or and Aspy terranes and the Blair River inlier (modified from Lin et al. 2007). U-Pb ages are for zircon unless otherwise indicated: M, monazite; T, titanite. Lettered units (more or less from north to south) are: A, Money Point Group; B, Cape North Group; C, Black Brook Granitic Suite; D, Pleasant Bay Complex; E, Jumping Brook Metamorphic Suite; F, Cheticamp Lake Gneiss; G, Clyburn Brook Formation; H, Belle Cote Orthogneiss; I, Cheticamp Pluton; J, Taylors Barren Granite; K, Sarach Brook Metamorphic Suite; L, North Branch Baddeck River leucotonalite; M, Margaree Pluton; N, Andrews Mountain Granite. Abbreviations: RRF, Red River fault; WBF, Wilkie Brook fault; EHSZ, Eastern Highlands shear zone; MB/GRF, MacIntosh Brook/Georges River fault.

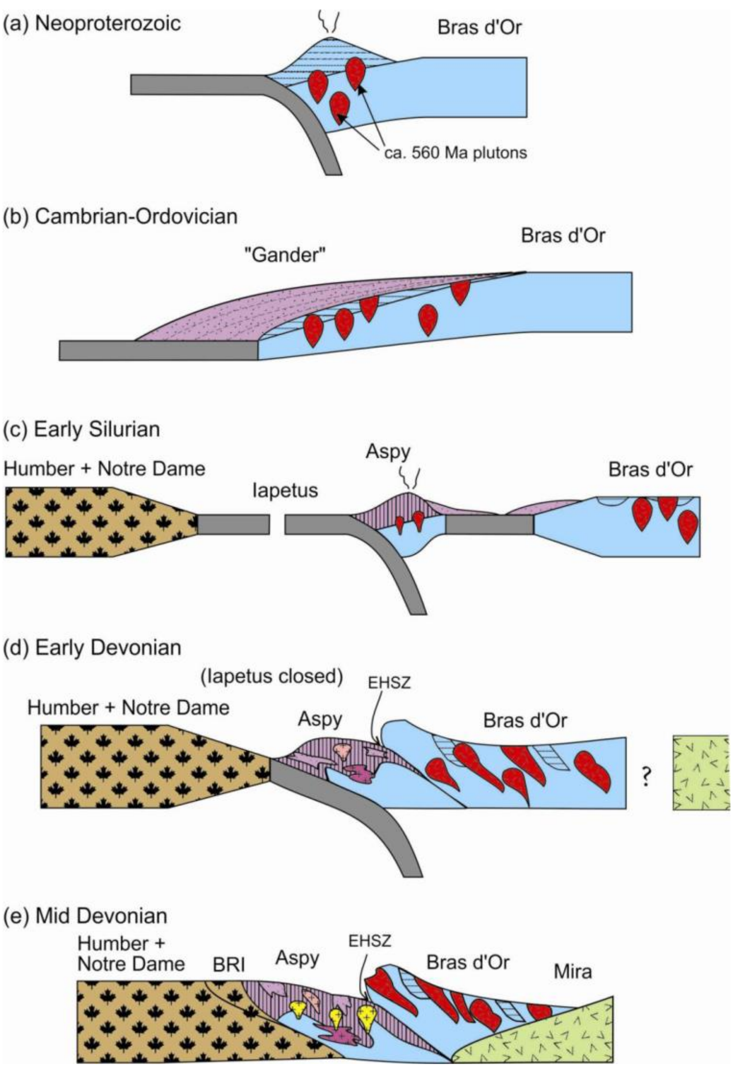


Figure 4: A possible tectonic model for the development of Bras d'Or and Aspy terranes after Barr et al. (1998). Abbreviation: EHSZ, Eastern Highlands shear zone.

Plate 1a: Exposure of the Devonian Black Brook Granititc Suite at Green Cove, Cape Breton Highlands National Park. (Stop 4)

Plate 1b: Looking north along the coast, in the Devonian Black Brook Granititc Suite at Green Cove, Cape Breton Highlands National Park. (Stop 4)

Plate 2: Looking north along the escarpment of the Aspy Fault towards Aspy Bay.

Plate 3a: Steeply dipping metamorphic rocks of the Jumping Brook Metamorphic Suite with a sea stack of Devonian basalt of the Fisset Brook Formation. (Stop 10)

Plate 3b, 3c: Purple fluorite deposited in veins in the Carboniferous sedimentary rocks overlying the Jumping Brook metamorphic Suite. (Stop 10)

Plate 4a: Contact between granite of the Cheticamp River tonalite and the Dauphine Brook Formation phyllites of the Jumping Brook Metamorphic Suite looking towards the Corney Brook campground to the north. The red granite in the background is the French Mountain syenogranite. (Stop 11)

Plate 4b: Contact between granite of the Cheticamp River tonalite (left) and Dauphine Brook Formation phyllites of the Jumping Brook Metamorphic Suite (right). (Stop 11)

Plate 5a: Cliff face exposure at Le Grand Falaise. The dark rocks at the base are basalts of the Devonian Fisset Brook Formation, overthrust by Neoproterozoic granite of the Grand Falaise Granite (formerly the Cheticamp pluton). (Stop 12)

Plate 5b: View of the cliff face exposure at Le Grand Falaise. The dark rocks at the base are basalts of the Devonian Fisset Brook Formation, overthrust by Neoproterozoic granite of the Grand Falaise Granite (formerly the Cheticamp pluton). Fault gypsum deposits mark the contact. (Stop 12)

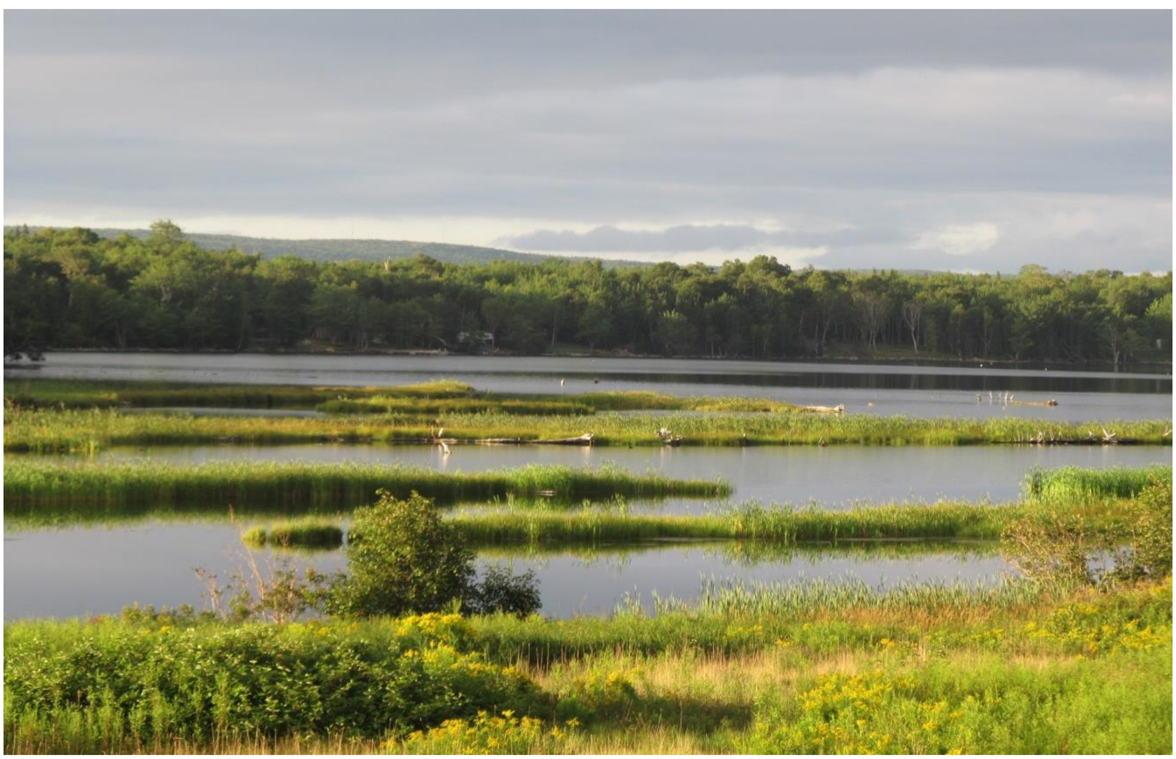


Plate 6: Lowlands of the Margaree – Middle River area. Intervales like these were lake bottoms during the last Ice Age. (Not-a-stop B)



Plate 7a, b, c: Exposure of the Eastern Highlands Shear Zone north of Hunters Mountain.

Plate 8: Why mapping in the Highlands is only for the brave and intrepid!

All photographs by Deanne van Rooyen.