Bedrock Geology in the Whycocomagh Mountain-Aberdeen Ridge Area (11F/14 and 11K/03), Central Cape Breton Island, Nova Scotia

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Introduction

The Whycocomagh Mountain-Aberdeen Ridge area is located along the northwestern margin of the Bras d'Or terrane (Barr and Raeside, 1989; Raeside and Barr, 1990) of central Cape Breton Island (Fig. 1) and includes exposures of varied Late Neoproterozoic metamorphic and plutonic rocks surrounded by younger Carboniferous sedimentary units (Armitage, 1989; White and Boehner, 2008). The area hosts significant skarn mineralization and placer gold showings. The Aspy terrane to the north is a belt of mainly Ordovician to Silurian volcanic, metasedimentary and plutonic rocks with minor Late Neoproterozoic plutonic and metamorphic units (Barr and Jamieson, 1991; Raeside and Barr, 1990; Barr *et al*., 1998). The boundary between the Bras d'Or and Aspy terranes is similar to that between the Exploits and Gander terranes in the Central Mobile Belt of Newfoundland, where it is the site of significant mesothermal gold mineralization (e.g. van Staal, 2007).

Contact relationships between the Bras d'Or and Aspy terranes are complex (e.g. Barr *et al*., 1998; Lin *et al*., 2007) and the strategic location of the Whycocomagh Mountain-Aberdeen Ridge study area may provide a better understanding of the original relationship between these two terranes and will have implications for understanding collisional tectonics and related mineralization in this part of the northern Appalachian orogen. This mapping project was designed to advance the understanding of the stratigraphy, structure and age of the units in the Whycocomagh Mountain-Aberdeen Ridge area to facilitate mineral exploration. The project is the subject of an M.Sc. thesis at Acadia University by the senior author (Swanton, 2010).

Geological Setting

Historically, all of Cape Breton Island was included in the Avalon zone or terrane (e.g. Williams, 1979; Keppie *et al*., 1998) and most metamorphic rocks were assigned to the George River Series or Group (e.g. Milligan, 1970; Keppie, 1979). Mapping and petrological studies during the past 30 years, however, combined with modern radiometric ages, have resulted in the recognition of several terranes and blocks (e.g. Mira, Bras d'Or and Aspy terranes, and the Blair River Inlier) in the former 'Avalon zone', each with its own unique and unrelated metamorphic and igneous units (e.g. Raeside and Barr, 1990). In the Bras d'Or terrane the metamorphic units are assigned now to either the George River Metamorphic Suite or the Bras d'Or Gneiss (Keppie, 2000; White and Boehner, 2008). The George River Metamorphic Suite includes mainly low to medium metamorphic grade clastic, carbonate and volcanic rocks, whereas the Bras d'Or Gneiss consists of mainly high-grade (low-pressure, high-temperature) metamorphic rocks. (Armitage, 1989; Campbell, 1990; White *et al*., 2003). Both units are intruded by ca. 565 Ma to 555 Ma plutons and less abundant Cambrian and younger plutons (Dunning *et al.*, 1990; Barr *et al*., 1998; White *et al*., 2003; White and Boehner, 2008). These units are unconformably overlain by clastic sedimentary rocks of the Horton Group (Keppie, 2000). All

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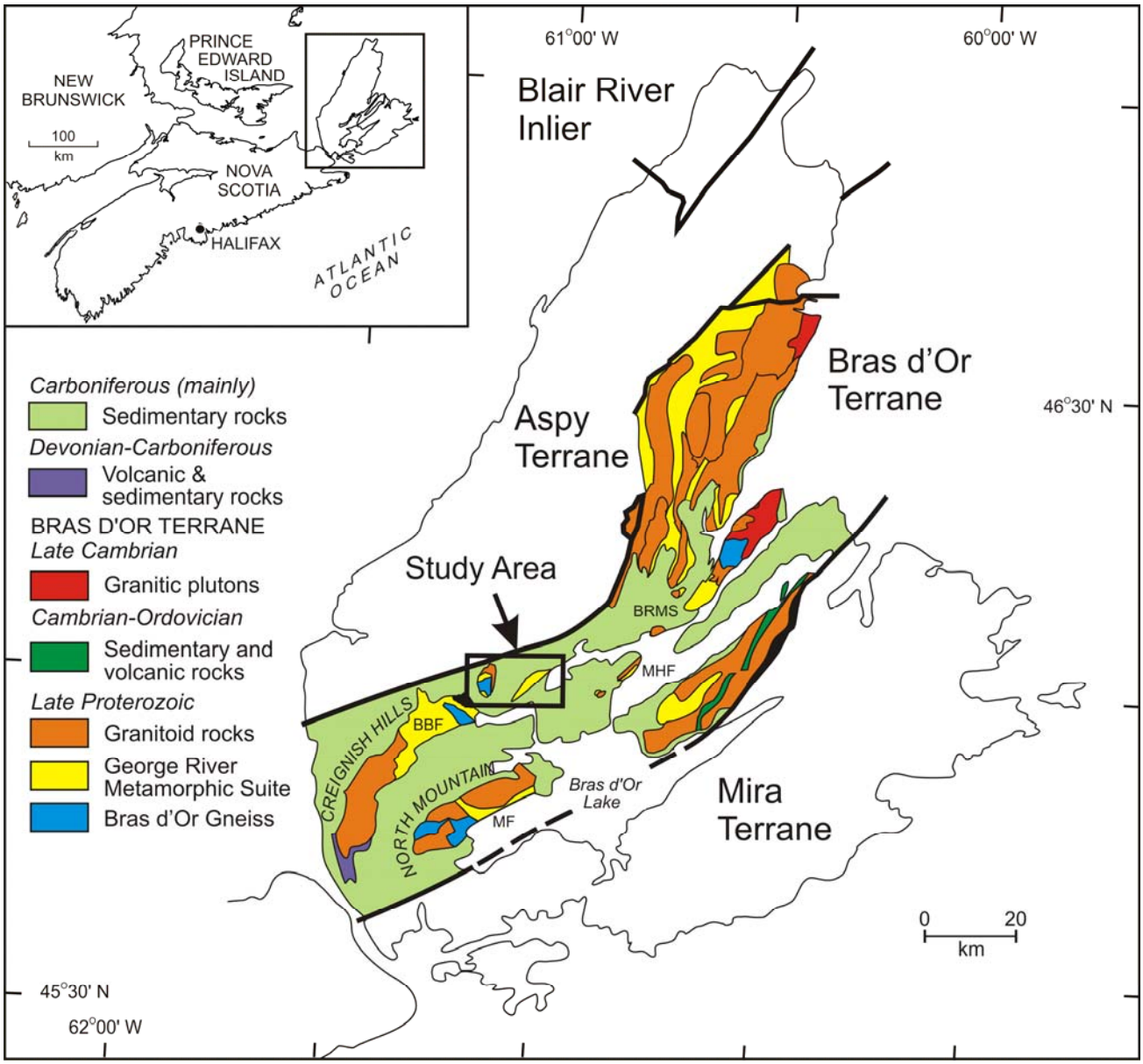

Figure 1. Location of the Whycocomagh Mountain and Aberdeen Ridge areas in the Bras d'Or terrane of central Cape Breton Island. Abbreviations: BBF, Blues Brook Formation; BRMS, Barachois River Metamorphic Suite; MF, Malagawatch Formation; MH, Maskells Harbour Formation.

these units have been interpreted to exist in the Whycocomagh Mountain-Aberdeen Ridge area (Armitage, 1989; Campbell, 1990; White *et al*., 2003; White and Boehner, 2008).

Previous Investigations

The earliest mapping in the Whycocomagh Mountain-Aberdeen Ridge area was conducted by Fletcher (1885). He recognized the rocks in Whycocomagh Mountain as a mixture of "Pre-Cambrian syenitic gneissoid and other feldspathic rocks and George River Limestone", whereas those in the Aberdeen Ridge area he considered as the "syenitic gneissoid" unit. The younger, sedimentary rocks he classified as Early Carboniferous or Devonian. Iron and copper were noted in the Whycocomagh Mountain area. The

northern part of the study area, on the Lake Ainslie map sheet, was mapped by Norman (1935) who divided the rocks into quartzite and minor limestone of the Precambrian George River Series, which were intruded by Precambrian diorite to granodiorite. These units were overlain by sedimentary rocks of the Mississippian Horton Series. Norman (1935) reported a magnetite and chalcopyrite occurrence in contact metamorphosed quartzite on Mullach Brook, but noted no other mineral occurrences. The southern part of Whycocomagh Mountain and southern and northeastern areas of Aberdeen Ridge (Whycocomagh and Baddeck map sheets) were mapped by Kelly (1967). Like Norman (1935), he recognized the George River Series (Group) but considered the igneous units to be Devonian or older. He also mapped a separate granitic body on Whycocomagh Mountain that he called quartz monzonite. Rocks in the northeastern part of the Aberdeen Ridge area he mapped as Devonian or younger granitoid rocks. Although Milligan (1970) did reconnaissance work in the study area his mapping concentrated on the Creignish Hills, where he noted the presence of gneissic units but included them with the George River Series.

In the late 1970s and early 1980s significant exploration was carried out in the Whycocomagh Mountain area for tungsten-associated skarns around the plutonic units (e.g. Black, 1978, 1982). Yip Choy (1982) conducted follow-up petrographic studies on the igneous units in the area. He recognized a younger granite porphyry (Whycocomagh Mountain pluton) and an older, possibly Precambrian dioritic pluton. Barr *et al*. (1984) dated the granite porphyry at 402 ± 20 Ma (K-Ar hornblende) and speculated that the Cu-Mo-W mineralization was related to emplacement of the pluton. Because of the historical placer gold occurrences, the area was staked by Noranda from 1985-1995 (e.g. Woods, 1991). No source area for the gold was defined but as a result of exploration significant Cu, Pb and Zn anomalies were identified (e.g. Woods, 1994).

After the initial work of Barr and Raeside (1989) in recognizing four distinct pre-Carboniferous lithotectonic divisions in Cape Breton Island, numerous detailed mapping projects were undertaken in the Bras d'Or terrane to better establish its regional continuity and place constraints on tectonic models. One of those projects was by Armitage (1989) who mapped (1:10 000 scale) the igneous and metamorphic units in the Whycocomagh Mountain-Aberdeen Ridge area. He recognized that the clastic and carbonate rocks of the Precambrian George River Group had been regionally metamorphosed to greenschist facies. He also mapped a gneissic unit with mineral assemblages typical of the amphibolites facies of metamorphism and considered these gneisses to be in faulted contact with the George River Group. He also mapped the northeastern part of the Aberdeen Ridge as George River Group, in contrast to granite as shown by Kelly (1967). The metamorphic rocks were intruded by the Precambrian to Early Cambrian Lewis Mountain Pluton and the Devonian Whycocomagh Mountain Pluton, and overlain by the Carboniferous Horton Group. Campbell (1990) mapped the Creignish Hills and correlated the George River Group in the Whycocomagh Mountain area to the Blues Brook Formation and assigned the gneissic units to the Skye Mountain Metamorphic Suite.

The area was mapped again at 1:50 000 scale by Lynch *et al*. (1993), Lynch and Brisson (1996), Lynch and Lafrance (1996) and Giles *et al*. (1997). All included the gneissic unit, as defined by Armitage (1989), in the George River Group. The compilation map of White and Boehner (2008) relied heavily on the work of Armitage (1989) and re-instated the Skye Mountain metamorphic suite in the Whycocomagh Mountain area, collectively under the name Bras d'Or Gneiss, and grouped the Blues Brook Formation under the George River Metamorphic Suite.

Geology of the Whycocomagh Mountain-Aberdeen Ridge Area

Introduction

Geological mapping on the Whycocomagh Mountain-Aberdeen Ridge area at 1:10 000 during August and September 2009 resulted in division of

the rocks into seven units: (1) Blues Brook and (2) Aberdeen Ridge formations of the George River Metamorphic Suite, (3) Lewis Mountain Pluton, (4) Bucklaw Pluton, (5) Whycocomagh Mountain Pluton, (6) Horton Group and (7) Windsor Group (Fig. 2).

Blues Brook Formation

The Blues Brook Formation of the George River Metamorphic Suite occurs in the Whycocomagh Mountain area and was assigned this designation because of its similarity to the package of varied quartzofeldspathic and pelitic rocks exposed in the Creignish Hills (e.g. Campbell, 1990; White and Boehner, 2008). The Blues Brook Formation in the Whycocomagh Mountain area can be divided into three informal members (Fig. 2). The northernmost member is best exposed in cliff sections on tributaries in the upper reaches of Mullach Brook, southern part of Freshwater Brook, and along Highway 104 (Fig. 2). It consists of grey, banded, quartzofeldspathic metasandstone and metasiltstone with minor thin beds of fine-grained quartzite, phyllite and schist. Metaconglomerate, amphibolite and calc-silicate rocks are rare. Foliation, defined by white mica, chlorite and locally minor biotite, is typically parallel to layering. The mineral assemblage indicates greenschist-facies regional metamorphism.

The southernmost member of the Blues Brook Formation is best exposed in cliff sections on tributaries in the upper part of Neil Gobhas, Freshwater and Saltwater brooks. It is generally more pelitic than the northern member of the formation and consists of pelitic schist interbedded with minor quartzite, marble and amphibolite. Banding is typically controlled by alternating biotite- and muscovite-rich, and quartz- and feldspar-rich layers. Interbedded quartzite layers are white to grey, fine grained and featureless, and best exposed around Saltwater Brook. Marble and calc-silicate rocks are common. They are typically white to light grey, fine- to medium-grained, and locally ‘skarnoid’ in appearance. Many of these carbonate rocks are dolomitic in composition (Armitage, 1989). Amphibolite is dark green to grey, fine- to medium-grained, massive to weakly foliated and may have originally been mafic sills or dykes. Outcrops around Churchview represent the third member in the Blues Brook Formation. These rocks consist of thickly bedded, white medium- to coarse-grained quartzite. These are cut by thin mafic sills and dykes with well developed chilled margins that resemble the amphibolite in the southern member, but are less metamorphosed. This unit is identical to the one established by White and Boehner (2008) to the west in the Creignish Hills.

The dominantly pelitic southern member was considered by Armitage (1989) and White and Boehner (2008) to be part of the Bras d’Or Gneiss. The present study indicates, however, that the metamorphic grade gradually increases from chlorite grade in the northwest to andalusite-garnet grade to the southeast. Hence, the area previously interpreted as “Bras d’Or Gneiss” is actually the Blues Brook Formation at a higher metamorphic grade. Work continues to assess if the higher metamorphic grade is a regional event or related to contact metamorphism. Preliminary pressure-temperature estimates for the peak metamorphic conditions are 2.5 kbar at 600°C, similar to those reported by Armitage (1989).

Bedding orientations in the Blues Brook Formation appear to be random in the field and this is somewhat reflected in the scatter of poles to layering (Fig. 3a). However, the poles define a moderately developed girdle distribution which suggests that the area was folded into moderately northeast-plunging, northwest-verging, asymmetric folds. The poles to foliation are also scattered, yet define a girdle distribution similar to bedding (Fig. 3b). This similarity suggests that foliation and bedding were parallel prior to deformation and later folded together. If so, the original folds were isoclinal to develop foliations parallel to bedding. Hence, the regional distribution of units is controlled by F_2 fold structures, and F_2 folds were noted in the field.

Aberdeen Ridge Formation

Metamorphic rocks in the Aberdeen Ridge area are termed the Aberdeen Ridge Formation (Fig. 2). Like the Blues Brook Formation, they are part of the George River Metamorphic Suite, but because

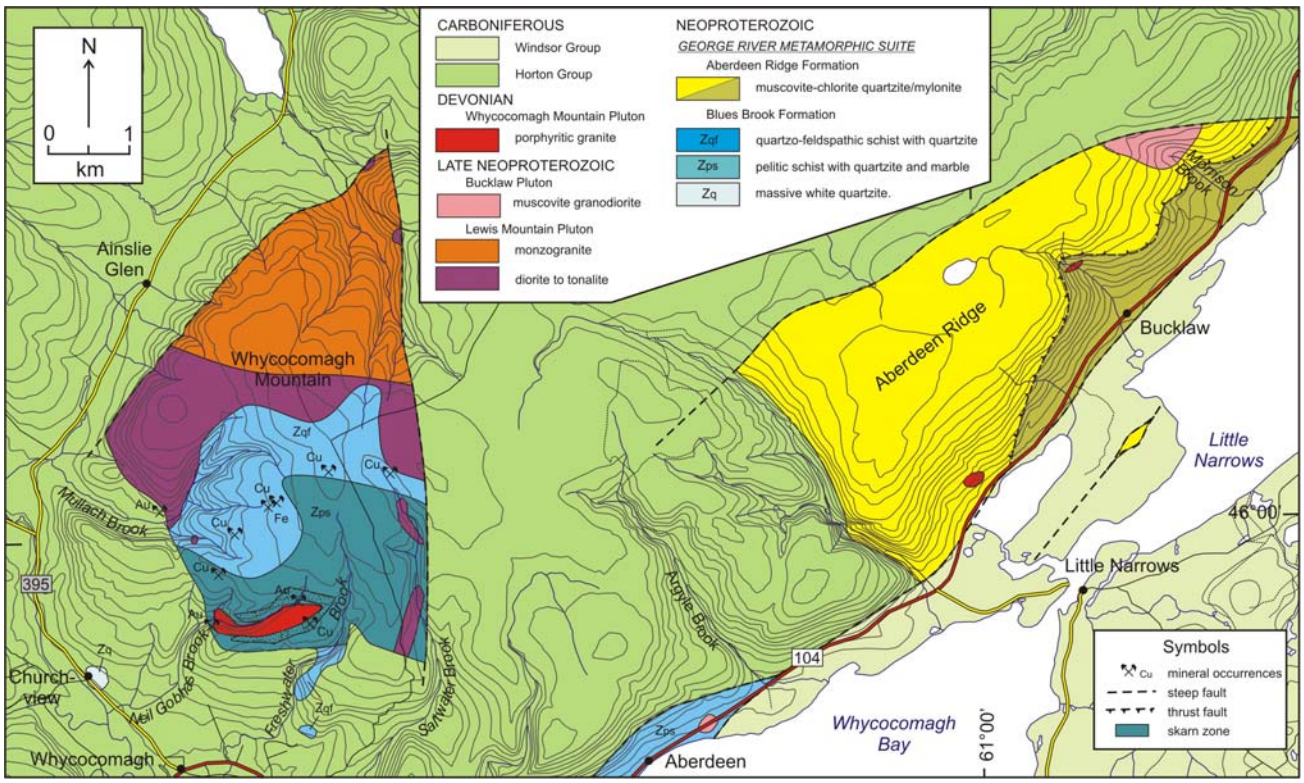

Figure 2. Geological map of the Whycocomagh Mountain and Aberdeen Ridge map area.

they differ somewhat from the Blues Brook Formation in the Whycocomagh Mountain area, they are given a new name.

The Aberdeen Ridge Formation is exposed in brooks draining Aberdeen Ridge. It is dominantly grey, fine- to medium-grained, well banded quartzite interlayered with minor metasiltstone. Foliation is not well developed but where present it is parallel to bedding and defined by white mica. The quartzite in the northeast part of the formation is cut by a wide mylonite zone. Amphibolite occurs in places and is generally dark grey-green and featureless, except in the mylonite zone where it is well lineated. As in the Whycocomagh Mountain area, the amphibolite bodies are interpreted to represent mafic sills.

Although fewer data are available due to less outcrop, structures in the Aberdeen Ridge Formation are similar to those at Whycocomagh Mountain. One difference, however, is that the F_2 folds plunge shallowly to the southwest and the folds verge to the southeast (Fig. 3c, d). Intersection lineations plunge to the west-southwest. A wide mylonite zone cuts across the regional fabric in the northeastern part of the Aberdeen Ridge Formation. The mylonite is dominantly an L-tectonite but in places L-S tectonite was observed. The stretching lineations are defined by quartz rods and dominantly plunge shallowly to the west-southwest, although a few plunge to the east, parallel to the intersection lineations (Fig. 3e). Poles to the mylonitic foliation defined a girdle distribution with a shallow west-southwest-plunging 'fold-axis', parallel to the average stretching lineation (Fig. 3e). Preliminary kinematic studies indicate sinistral sense of movement with tops to the east-northeast. The significance of this previously unrecognized mylonite zone is unclear but under investigation.

Lewis Mountain Pluton

The Lewis Mountain Pluton (Armitage, 1989) is best exposed in streams draining the northern part of Whycocomagh Mountain (Fig. 2). It is a composite pluton consisting of medium-grained, hornblende-bearing, diorite to quartz diorite and tonalite in the southern part, and medium-grained, hornblende- and biotite-bearing monzogranite in

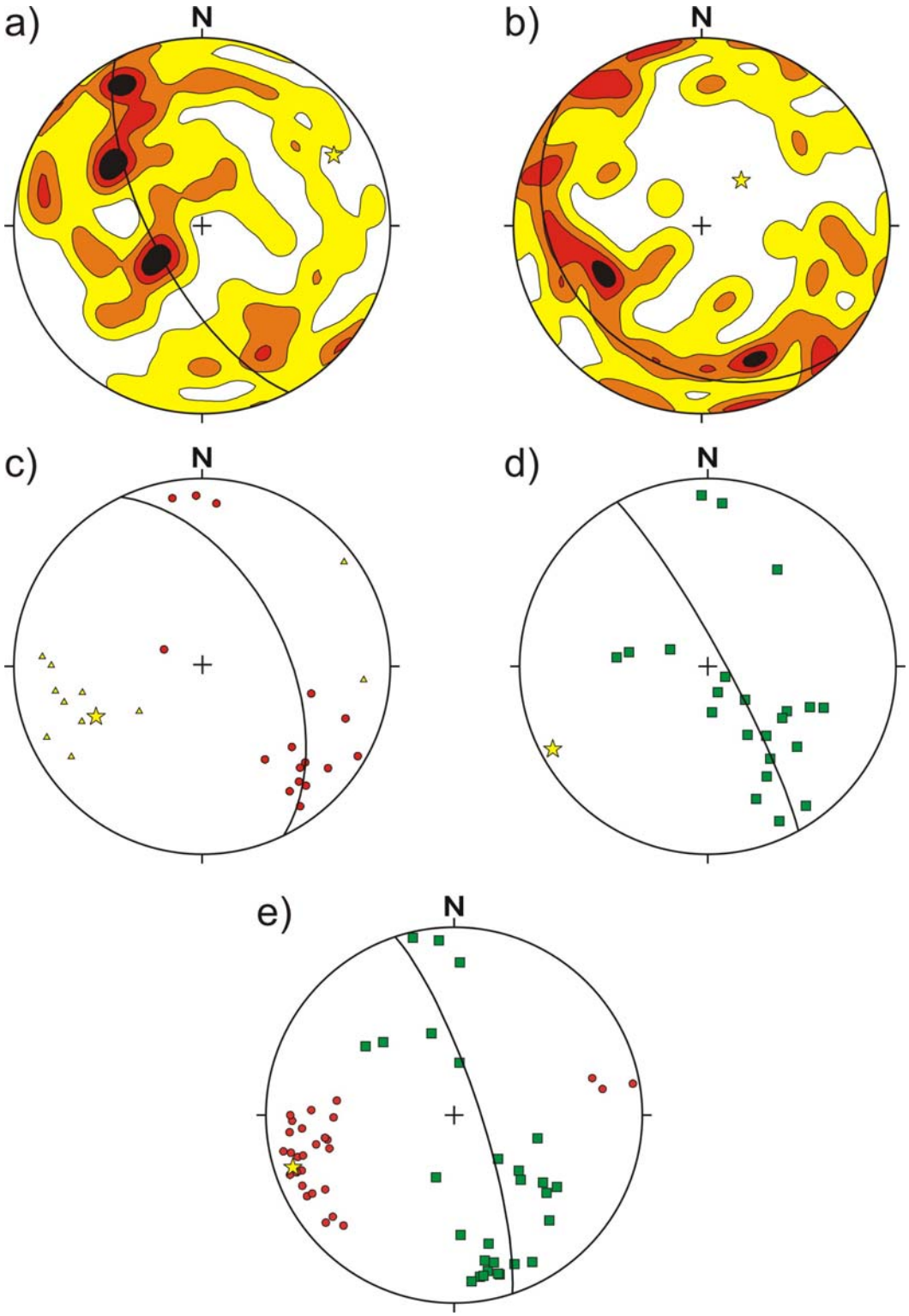

Figure 3. Structural data from the Whycocomagh Mountain and Aberdeen Ridge map area plotted on equal area stereonets. (a) Contoured poles to bedding (n = 100) in the Blues Brook Formation. Contours are at 1, 3, 5 and >7%. (b) Contoured poles to foliation (n = 79) in the Blues Brook Formation. Contours are at 1, 3, 5 and >7%. (c) Poles to bedding (n = 22) in the Aberdeen Ridge Formation and intersection lineation (yellow triangles, n = 11). (d) Poles to foliation (n = 16) in the Aberdeen Ridge Formation. (e) Poles to mylonitic foliation (green squares, n = 27) and stretching lineation (red circles, n = 33).

the north. Variations among these different rock types appear to be gradational. Locally, close to inferred faults, the pluton displays a shear fabric but overall the pluton is unfoliated and unmetamorphosed. Smaller dioritic bodies and dykes in the George River Metamorphic Suite are interpreted to be related to the Lewis Mountain Pluton. The pluton locally contains metasedimentary xenoliths with lithologies consistent with derivation from the Blues Brook Formation. Preliminary geochemistry suggests that the Lewis Mountain Pluton has an origin related to a continental margin subduction zone. The age of the pluton is not directly constrained, but its petrological and chemical characteristics are similar to ca. 565 to 555 Ma plutons exposed elsewhere in the Bras d'Or terrane (Dunning *et al.*, 1990; White *et al.*, 2003; White and Boehner, 2008).

Bucklaw Pluton

The Bucklaw Pluton (new name) outcrops in the northeastern part of the Aberdeen Ridge area, and also occurs as a small plug to the southwest in the Blues Brook Formation (Fig. 2). It consists dominantly of pink, unfoliated, medium-grained, equigranular, biotite-muscovite monzogranite. Chemically it displays peraluminous character, which is consistent with the observed presence of both muscovite and garnet. Its contact relationship with the Aberdeen Ridge Formation was not observed but is interpreted to be intrusive. The age of the pluton is not well constrained, but it may be similar to the ca. 556 Ma muscovite-bearing Bell Lakes Suite exposed father to the north in the Bras d'Or terrane (Conley, 1985; Dunning *et al*., 1990).

Whycocomagh Mountain Pluton

The Whycocomagh Mountain Pluton intrudes the Blues Brook Formation and is best exposed on Neil Gobhas Brook in Whycocomagh Mountain (Fig. 2). It also occurs as a small stock to the east in the Aberdeen Ridge Formation (Fig. 2) and as dykes in the Blues Brook Formation in Saltwater Brook. It consists of biotite-hornblende porphyritic granodiorite with phenocrysts of euhedral plagioclase (± quartz and potassium feldspar) in a fine- to medium-grained equigranular matrix. Porphyritic monzogranite with a fine-grained matrix occurs as pods and dykes in the granodiorite and locally displays magma-mingling textures. Hornblende from the porphyry yielded a 402 ± 20 Ma K-Ar age (Barr *et al*., 1984). The small intrusion of similar composition in the Aberdeen Ridge Formation cuts the mylonite zone and is undeformed. This indicates that deformation in the mylonite zone is pre-Devonian. Like the Lewis Mountain Pluton it has I-type petrographic and chemical features.

Horton and Windsor Groups

Sedimentary rocks assigned to the Carboniferous Horton Group unconformably overlie the metamorphic and plutonic units along the southwest margins of Whycocomagh Mountain and Aberdeen Ridge (Fig. 2). Elsewhere, the Horton Group is in faulted contact with the older units. The Creignish Formation, the basal unit in the Horton Group, is the dominant unit exposed. It consists of orange oligomictic conglomerate, arkosic sandstone and siltstone, with minor red sandstone and siltstone. Clasts in the conglomerate are dominantly granitic with minor quartzite and resemble units in the underlying Blues Brook and Aberdeen Ridge formations. The Windsor Group is poorly exposed in the study area and a string of sinkholes marks the faulted contact with the Aberdeen Ridge Formation.

The Horton Group around the Whycocomagh Mountain and Aberdeen Ridge areas has been folded into a series of upright, shallow southwest-plunging F_1 anticlines and synclines (Figs. 4a and b, respectively). This folding event may be responsible for the scatter in bedding and foliation orientations observed in the older rocks.

Regional Correlations

The Blues Brook and Aberdeen Ridge formations are similar to units elsewhere in the Bras d'Or terrane that make up the George River Metamorphic Suite, especially the Malagawatch and Maskells Harbour formations (Campbell, 1990; Justino and Barr, 1994; Wasylik, 2004; Wasylik *et*

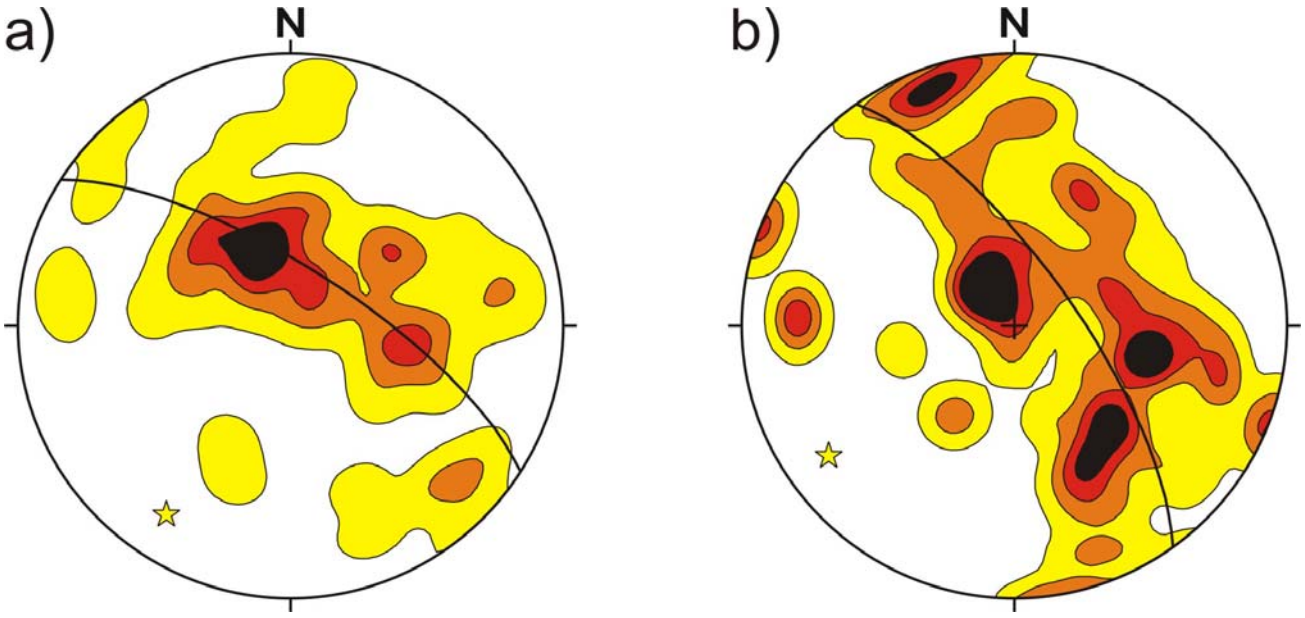

Figure 4. Structural data from the Carboniferous units around Whycocomagh Mountain and Aberdeen Ridge map area plotted on equal area stereonets. (a) Contoured poles to bedding (n = 71) in the Horton Group around Whycocomagh Mountain. Contours are at 1, 3, 5 and >7%. (b) Contoured poles to bedding (n = 79) in the Horton Group around Aberdeen Ridge. Contours are at 1, 3, 5 and >7%.

al., 2005; White and Boehner, 2008). All these formations consist of metapelite, calcitic and dolomitic carbonate-bearing rocks, and quartzite, as well as minor metavolcanic rocks not found in the Blues Brook and Aberdeen Ridge formations. The Barachois River Metamorphic Suite (Raeside and Barr, 1990) farther to north in the Bras d'Or terrane (Fig. 2) may be equivalent to the George River Metamorphic Suite but the Barachois River Metamorphic Suite lacks marble and calc-silicate rocks, so there may not be a direct correlation.

Late Neoproterozoic and Late Cambrian plutonic rocks are characteristic of the Bras d'Or terrane (Raeside and Barr, 1990). The Creignish Hills and related satellite plutons include tonalite-diorite, granodiorite-monzogranite and monzogranite units (White *et al*., 1990, 2003; White and Boehner, 2008), and the Marble Mountain, Big Brook, and West Bay plutons of the North Mountain area also include similar rock types (Justino and Barr, 1994). In addition, the plutonic units on Washabuck Peninsula are similar (Wasylik, 2004; Wasylik *et al*., 2005). All of these plutons show similar calc-alkalic trends and likely formed in a continental margin subduction zone setting (Raeside and Barr, 1990; Grecco and Barr, 1999). The Bucklaw pluton is similar to other S-type igneous units (e.g. Bell Lakes Suite of Conley, 1985) in the Bras d'Or terrane.

Most of the plutonic rocks in the Creignish Hills and North Mountain areas have yielded precise U-Pb ages of ca. 553 Ma (White *et al*., 2003). Hence, it is likely that the Lewis Mountain and Bucklaw plutons are of similar late Neoproterozoic age. The protolith age of the George River Metamorphic Suite is less well constrained, but likely to be ca. 650 Ma (Keppie *et al*., 1998; Barr *et al*., 2003). The mainly unfoliated character of the plutonic rocks indicates that they were emplaced after regional metamorphism and deformation of their host rocks.

The younger Devonian Whycocomagh Mountain Pluton has no other equivalent pluton in the Bras d'Or terrane. In the Avalon (Mira) terrane in southeastern Cape Breton Island, however, there are a number of Devonian, high-level plutons with similar petrographic and geochemical properties (Barr and Macdonald, 1992; Barr *et al*., 1996). In addition, these younger plutons in the Mira terrane are associated with Cu-Mo-Pb mineralization. On a regional scale, this implies that the terranes in Cape Breton Island were likely amalgamated by the

Devonian and experienced a significant episode of post-tectonic plutonism that occurred throughout the northern Appalachian orogen.

Summary

The Whycocomagh Mountain and Aberdeen Ridge areas are underlain by metasedimentary rocks of the Blues Brook and Aberdeen Ridge formations, part of the George River Metamorphic Suite of the Bras d'Or terrane. These formations are intruded by dioritic to granodioritic rocks of the Lewis Mountain Pluton, and muscovite- and garnet-bearing monzogranitic rocks of the Bucklaw Pluton, similar to ca. 565-550 Ma plutons in other areas of the Bras d'Or terrane. Their petrological features indicate that they are part of an expanded I- and S-type granitoid suite emplaced as a result of subduction at a continental margin. Carboniferous sedimentary rocks of the Horton and Windsor groups surround the exposed Precambrian units.

Acknowledgments

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References

Armitage, A. E. 1989: Geology and petrology of the crystalline rocks of the Whycocomagh area, Cape Breton Island, Nova Scotia; unpublished B.Sc. thesis, Acadia University, Wolfville, Nova Scotia, 120 p.

Barr, S. M. and Jamieson, R. A. 1991: Tectonic setting and regional correlation of Ordovician-Silurian rocks of the Aspy terrane, Cape Breton Island, Nova Scotia; Canadian Journal of Earth Sciences, v. 28, p. 1769–1779.

Barr, S. M. and Macdonald, A. S. 1992: Devonian plutons in southern Cape Breton Island, Nova Scotia; Atlantic Geology, v. 28, p. 101–113.

Barr, S. M. and Raeside, R. P. 1989: Tectonostratigraphic divisions in Cape Breton Island, Nova Scotia: implications for the configuration of terranes in the northern Appalachian Orogen; Geology, v. 17, p. 822–825.

Barr, S. M., Yip Choy, R. N., Colwell, J. A. and Oldale, H. S. 1984: Granitoid Rocks and associated copper skarn, Whycocomagh Mountain, Cape Breton Island, Nova Scotia; Maritime Sediments and Atlantic Geology, v. 20, p. 43–55.

Barr, S. M., White, C. E. and Macdonald, A. S. 1996: Stratigraphy, tectonic setting, and geological history of Late Precambrian volcanic-sedimentary-plutonic belts in southeastern Cape Breton Island, Nova Scotia; Geological Survey of Canada, Bulletin 468, 84 p.

Barr, S. M., Raeside, R. P. and White, C. E. 1998: Geological correlations between Cape Breton Island and Newfoundland, northern Appalachian orogen; Canadian Journal of Earth Sciences, v 35, p. 1252–1270.

Barr, S. M., Davis, D. W., Kamo, S. and White, C. E. 2003: Significance of U-Pb detrital zircon ages in quartzite from peri-Gondwanan terranes, New Brunswick and Nova Scotia, Canada; Precambrian Research, v. 126, p. 123–145.

Black, D. L. 1978: Tungsten, Whycocomagh, Inverness County, Nova Scotia; Report on rock, snow, stream sediment and soil geochemical surveys, geological mapping, a magnetic survey, drilling and drill core chemical analysis; Nova

Scotia Department of Natural Resources, Assessment Report ME 11F/14D 53-J-59(01).

Black, D. L. 1982: Tungsten, Whycocomagh, Inverness County, Nova Scotia; Report on drilling and soil geochemistry; Nova Scotia Department of Natural Resources, Assessment Report ME 11F/14D 53-J-59(03).

Campbell, J. E. M. 1990: The Geology of the northeastern Creignish Hills, Cape Breton Island, Nova Scotia; unpublished M.Sc. thesis, Acadia University, Wolfville, Nova Scotia, 164 p.

Conley. H. A. 1985: Petrography and geochemistry of the Bell Lakes Suite, Victoria County, Cape Breton Island; unpublished B.Sc. Thesis, Acadia University, Wolfville, Nova Scotia, 84 p.

Dunning, G. R., Barr, S. M., Raeside, R. P. and Jamieson, R. A. 1990: U-Pb zircon, titanite, and monazite ages in the Bras d'Or and Aspy terranes of Cape Breton Island, Nova Scotia; implications for igneous and metamorphic history; Geological Society of America Bulletin, v. 102, p. 322–330.

Fletcher, H. 1885: Report on the geology of northern Cape Breton; Geological and Natural History Survey and Museum of Canada, Report of Progress 1882-83-84, p. 1–98, 1:63 360 scale map.

Giles, P. S., Hein, F. J. and Allen, T. L. 1997: Bedrock geology of Port Hood-Lake Ainslie (11K/04, 11K/03, 11F/13), Cape Breton Island, Nova Scotia; Geological Survey of Canada, Open File 3253, 1:50 000 scale map with marginal notes.

Grecco, L. E. and Barr, S. M. 1999: Late Neoproterozoic granitoid and metavolcanic rocks of the Indian Brook area, southeastern Cape Breton highlands, Nova Scotia; Atlantic Geology, v. 35, p. 43–57.

Justino, M. F. and Barr, S. M. 1994: Petrology, petrogenesis and tectonic setting of plutonic rocks in the North Mountain area, west-central Cape Breton Island, Nova Scotia; Atlantic Geology, v. 30, p. 47–64.

Kelly, D. G. 1967: Baddeck and Whycocomagh map-areas with emphasis on Mississippian stratigraphy of central Cape Breton Island, Nova Scotia (11K/02 and 11F/14); Geological Survey of Canada, Memoir 351, 65 p.

Keppie, J. D. 1979: Geological map of the Province of Nova Scotia; Nova Scotia Department of Mines and Energy, Map ME 1979-4, scale 1: 500 000.

Keppie, J. D. (compiler) 2000: Geological map of the Province of Nova Scotia; Nova Scotia Department of Natural Resources, Map ME 2000-1, scale 1:500 000.

Keppie, J. D., Davis, D. W. and Krogh, T. E. 1998: U-Pb geochronological constraints on Precambrian stratified units in the Avalon composite terrane of Nova Scotia, Canada: tectonic implications; Canadian Journal of Earth Sciences, v. 35, p. 222–236.

Lin, S., Davis, D. W., Barr, S. M., van Staal, C. R., Chen, Y. and Constantin, M. 2007: U-Pb geochronological constraints on the evolution of the Aspy terrane, Cape Breton Island; implications for relationships between Aspy and Bras d'Or terranes and Ganderia in the Canadian Appalachians; John Rodgers Memorial Issue, part II, American Journal of Science, v. 307, p. 371–398.

Lynch, G. and Brisson, H. 1996: Bedrock geology, Whycocomagh (11F/14), Cape Breton Island; Geological Survey of Canada, Open File 2917, 1:50 000 scale map.

Lynch, G. and Lafrance, B. 1996: Bedrock geology, Baddeck (11K/02); Geological Survey of Canada, Open File 2488, scale 1: 50 000.

Lynch, J. V. G., Tremblay, C. and Rose, H. 1993: Geological map (1:50 000) of Lake Ainslie area, Cape Breton Island, Nova Scotia (11K/03 and west 11K02); Geological Survey of Canada, Open File Map 32613.

Milligan, G. C. 1970: Geology of the George River Series, Cape Breton; Nova Scotia Department of Mines and Energy, Memoir ME 7, 111 p.

Norman, G. W. H. 1935: Lake Ainslie map-area, Nova Scotia; Bureau of Economic Geology, Department of Mines, Geological Survey of Canada, Memoir 177, 103 p., map 282, scale 1:63 360.

Raeside, R. P. and Barr, S. M. 1990: Geology and tectonic development of the Bras d'Or suspect terrane, Cape Breton Island, Nova Scotia; Canadian Journal of Earth Sciences, v. 27, p. 1371–1381.

Swanton, D A. 2010: Field relations, petrology, tectonic setting and economic potential of the metamorphic and igneous rocks in the Whycocomagh-Aberdeen area, Cape Breton Island, Nova Scotia; M.Sc. thesis, Acadia University, Wolfville, NS, 207 p.

van Staal, C. R. 2007: Pre-Carboniferous tectonic evolution and metallogeny of the Canadian Appalachians; *in* Mineral Resources of Canada: A Synthesis of Major Deposit Types, Distinct Metallogeny, the Evolution of Geological Provinces, and Exploration Methods. ed. W. D. Goodfellow; Geological Association of Canada, Mineral Deposits Division, Special Publication 5, p. 793–818.

Wasylik, D. 2004: Geology of the Washabuck Peninsula, central Cape Breton Island, Nova Scotia; unpublished B.Sc. thesis, Acadia University, Wolfville, Nova Scotia, 78 p.

Wasylik, D., White, C. E. and Barr, S. M. 2005: Geology of the Washabuck Peninsula, Central Cape Breton Island, Nova Scotia; *in* Mineral Resources Branch, Report of Activities 2004, ed. D. R. MacDonald; Nova Scotia Department of Natural Resources, Report ME 2005-1, p. 117–128.

White, C. E. and Boehner, R. C. 2008: Bedrock geology map of the Whycocomagh area (NTS 11F/14), Inverness County, Nova Scotia; Nova Scotia Department of Natural Resources, Open File Map ME 2008-1, scale 1:50 000.

White, C. E., Barr, S. M. and Campbell, M. R. 1990: Petrology of the Creignish Hills Pluton, Cape Breton Island, Nova Scotia; Atlantic Geology, v. 26, p. 109–123.

White, C. E., Barr, S. M. and Ketchum, J. W. F. 2003: New age controls on rock units in pre-Carboniferous basement blocks in southwestern Cape Breton Island and adjacent mainland Nova Scotia; *in* Mineral Resources Branch, Report of Activities 2002, ed. D. R. MacDonald; Nova Scotia Department of Natural Resources, Report ME 2003-1, p. 163–178.

Williams, H. 1979: Appalachian Orogen in Canada; Canadian Journal of Earth Sciences, v. 16, p. 792–807.

Woods, G. A. 1991: Report of work licence no. 15864, Whycocomagh property, Inverness County, Nova Scotia (NTS 11F/14, 11K/03); Nova Scotia Department of Natural Resources, Assessment Report ME 1991-46, 59 p.

Woods, G. A. 1994: Report of work licence no. 579, Whycocomagh property, Inverness County, Nova Scotia (NTS 11F/14, 11K/03); Nova Scotia Department of Natural Resources, Assessment Report ME 1994-27, 23 p.

Yip Choy, R. N. 1982: Petrology of the Whycocomagh Mountain Pluton, Cape Breton Island, Nova Scotia; unpublished B.Sc. thesis, Acadia University, Wolfville, Nova Scotia, 83 p.