An Update of Bedrock Mapping in the Eastern Cobequid Highlands, Northern Mainland Nova Scotia

T. G. MacHattie, C. E. White, V. Beresford[1] and M. Reid[1]

Introduction

The Cobequid Highlands of northern mainland Nova Scotia form part of the southern margin of Avalonia (Hibbard *et al*., 2006), a fault-bounded terrane positioned inboard from Meguma and outboard of Ganderia (Fig. 1). Previous studies have shown that the area predominantly comprises Late Neoproterozoic to Late Devonian to Early Carboniferous volcanic, sedimentary and intrusive rocks (e.g. Murphy *et al*., 2001; Pe-Piper and Piper, 2002).

Investigations conducted in the eastern Cobequid Highlands by the Department of Natural Resources between 2010 and 2011 highlighted the mineral potential of the area through the discovery of a significant granite-related high-field-strength/rare earth element (HFSE/REE) prospect (MacHattie, 2011) and widespread volcanic-related epithermal Au-style mineral occurrences (MacHattie, 2012, 2013). In addition, new U-Pb zircon ages indicate the presence of some of the oldest Neoproterozoic crust found in Avalonia, as well as previously unrecognized Ordovician and Devonian intrusive units (MacHattie and White, 2012; MacHattie *et al*., 2012). As a result of the newly identified economic potential of the area and possibility for significant improvements to the geological framework, the Nova Scotia Department of Natural Resources initiated a bedrock mapping program in the eastern Cobequid Highlands in the summer of 2012 (MacHattie and White, 2012; MacHattie and White, 2013).

This report summarizes the important results of the 2013 mapping initiative and the types of digital products expected to be released as part of this program. A preliminary bedrock geological map product with accompanying lithogeochemistry and U-Pb zircon geochronology conducted to date can be found in MacHattie *et al*. (2013a, b).

Regional Geology

The eastern Cobequid Highlands are an uplifted crustal block composed of Late Neoproterozoic volcanic, sedimentary and plutonic rocks; significant amounts of Late Devonian to Early Carboniferous volcanic, plutonic and lesser sedimentary rocks; and minor Silurian sedimentary rocks. The southern boundary of highlands is marked by the Cobequid-Chedabucto Fault Zone, and to the north the highlands are unconformably overlain by Late Carboniferous sedimentary rocks of the Cumberland Basin (Fig. 2). The highlands are part of Avalonia, a composite terrane within the Appalachian Orogen that extends from the Boston area, through southern New Brunswick and northern Nova Scotia, to southeastern Newfoundland (Fig. 1).

The Neoproterozoic sedimentary and volcanic sequences preserved in the eastern Cobequid Highlands are interpreted to reflect deposition and extrusion in a rifted continental-arc environment (Pe-Piper and Murphy, 1989; Murphy, 2002). These sequences are intruded by Late Neoproterozoic plutonic rocks that are interpreted to have formed in a continental volcanic-arc environment (Pe-Piper *et al*., 1996; Murphy *et al*. 2001) along the northern margin of Gondwana (e.g. Nance *et al*., 2002). The voluminous Late Devonian to Early Carboniferous volcanic and plutonic rocks in the eastern Cobequid Highlands are bi-modal, contain within-plate geochemical signatures, and are interpreted to have formed in a plume-related intra-continental rift setting (e.g. Dessureau *et al*., 2000). Minor Early Carboniferous siliciclastic sedimentary sequences devoid of

[1]Department of Earth and Environmental Science, Acadia University, Wolfville, Nova Scotia B4P 2R6, Canada

MacHattie, T. G., White, C. E., Beresford, V. and Reid, M. 2014: *in* Mineral Resources Branch, Report of Activities 2013; Nova Scotia Department of Natural Resources, Report ME 2014-001, p. 145-156.

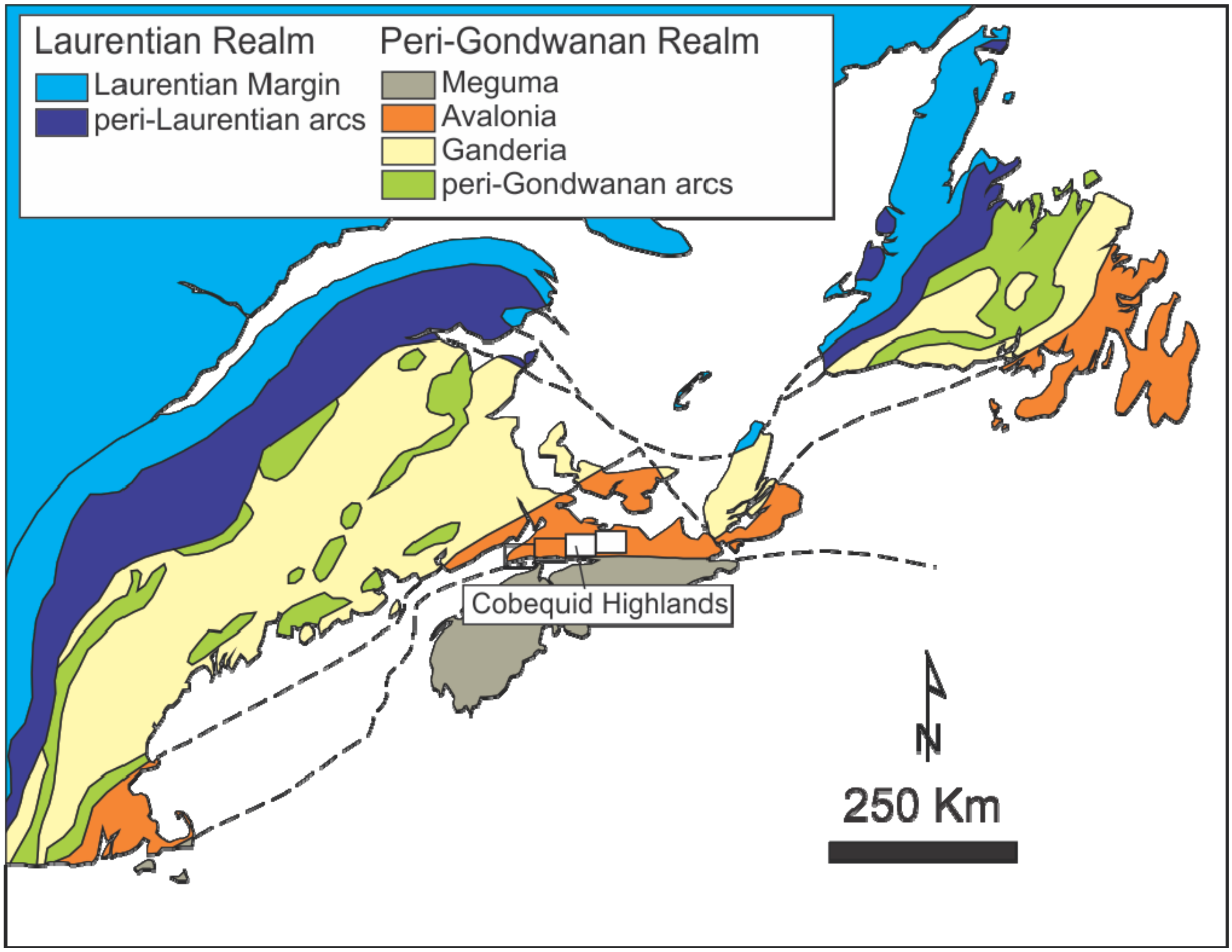


Figure 1. Lithotectonic elements of the northeastern Appalachian Orogen, modified from Hibbard *et al*. (2006). The four boxes labeled Cobequid Highlands are the outlines of the four 1:50 000 scale bedrock geology maps of Pe-Piper and Piper (2005a, b, c, d). The two filled boxes are the areas mapped in 2012 and 2013 (Fig. 2).

volcanic rocks are interpreted to have formed in more isolated fault-bound basins (e.g. Pe-Piper and Piper, 2002).

Geology of the Eastern Cobequid Highlands

Introduction

The 2013 bedrock mapping in the eastern Cobequid Highlands was undertaken at a scale of 1:10 000 and continued westward from the mapping conducted in 2012. The 2013 program included the highland areas surrounding the Wentworth Valley to the east (Highway 4), and extended as far west as the Economy River/Pleasant Hills (southwest) and Farmington areas (northwest), respectively (Fig. 2). This area is equivalent to the 1:50 000 scale bedrock map area of Pe-Piper and Piper (2005a; Wentworth), whereas mapping conducted in 2012 was concentrated on the 1:50 000 scale bedrock map area of Pe-Piper and Piper (2005b; Earltown).

As discussed in MacHattie and White (2013), the eastern Cobequid Highlands can be subdivided into two distinctive geological packages or blocks (Bass River and Jeffers Blocks), each with several stratigraphic formations and plutonic units. The Bass River Block is defined as the area between the Cobequid Fault to the south and the Rockland Brook Fault to the north, and the Jeffers Block is bounded to the south by the Rockland Brook Fault

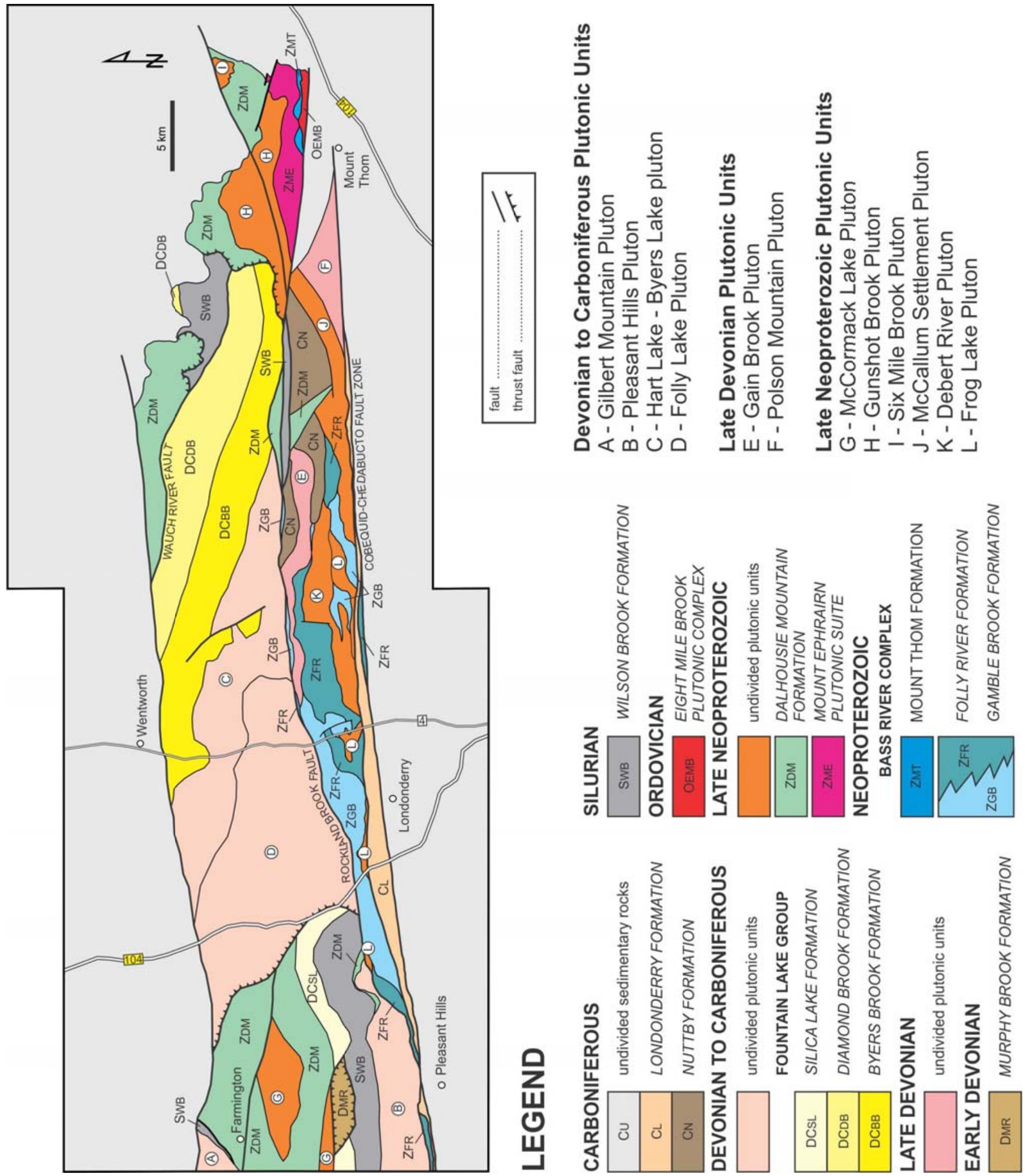


Figure 2. Simplified bedrock geological map of the eastern Cobequid Highlands modified from MacHattie *et al*. (2013a). The figure border is equivalent to the surrounds of the 1:50 000 scale maps of the eastern Cobequid Highlands of Pe-Piper and Piper (2005a and b).

and to the north by unconformably overlying Carboniferous sedimentary rocks (Fig. 2). The following is a brief description of some of the major geological units encountered within the Jeffers and Bass River blocks in the 2013 map area and their relationships to one another. Some of the units encountered were described in detail in MacHattie and White (2013) and the reader is referred to that work where applicable.

Important, first-order features of the bedrock geology of the 2013 map area include (1) an east to west thinning of the Bass River Block and convergence of the Cobequid and Rockland Brook faults, and (2) a newly recognized thrust within the Jeffers Block that separates intrusive rocks of the Folly and Hart Lake–Byers Lake plutons to the east from a complex collage of Neoproterozoic, Silurian, Devonian, and Late Devonian to Early Carboniferous supracrustal and plutonic rocks to the west (Fig. 2).

Jeffers Block Stratified Rocks

The majority of the 2013 map area is north of the Rockland Brook Fault and is thus underlain by the Jeffers Block. Stratified rocks found within the 2013 map area include Neoproterozoic, Silurian, Middle Devonian, and Late Devonian to Early Carboniferous units.

Neoproterozoic rocks are found within the northwestern portion of the Jeffers Block (Fig. 2). These rocks are predominantly composed of mafic to intermediate crystal-lapilli tuffs (Fig. 3a), well laminated felsic crystal-tuffs (Fig. 3b), and lesser siltstone and fine sandstone (Fig. 3c). Distinctively magnetic and commonly strongly epidotized basalt-flow units are also common (Fig. 3d). Closely associated with the volcanic rocks are numerous sub-volcanic mafic porphyries. Based on lithological similarities to Neoproterozoic volcanic rocks of the Dalhousie Mountain Formation to the east, these volcanic and related rocks are included within that formation (Fig. 2). Several fine-grained and vesicular mafic dykes cut the Dalhousie Mountain Formation volcanic rocks. These dykes closely resemble vesicular basalts recognized within the Silica Lake Formation (see below) and are interpreted to represent feeder dykes to these flows.

Silurian rocks of the Wilson Brook Formation west of Highway 104 crop out predominantly within a 20 km long and < 5 km wide belt situated to the north of the Late Devonian to Early Carboniferous Pleasant Hills Pluton (Fig. 2). A Silurian age is provided by numerous reported fossil occurrences (see Donohoe and Wallace, 1982). The formation is dominated by well bedded, grey siltstone and sandstone (Fig. 4a). Although locally cleaved, well preserved sedimentary structures and locally pervasive bioturbation (Fig. 4b) are diagnostic features of the formation within this east-west-trending belt. These rocks are intruded and contact metamorphosed by the Pleasant Hills Pluton along their southern margin. To the north, a porphyritic rhyolite unit occurs within the formation in close proximity to its northern contact with the Late Devonian to Early Carboniferous Silica Lake Formation. The rhyolite unit closely resembles rhyolites of the Silica Lake Formation, suggesting it may be a dyke or sill of the latter.

Silurian rocks also occur in a narrow wedge of rocks located just north of the Farmington area, in the far northwest portion of the 2013 map area (Fig. 2). A Silurian age is suggested from reported fossils of Late Landoverian age (see Donohoe and Wallace, 1982) and locally bioturbated siltstones similar to those found elsewhere in the Wilson Brook Formation. Siltstones in this wedge are intruded by fine-grained aplitic granite dykes interpreted to be related to the Late Devonian to Early Carboniferous Gilbert Mountain Pluton to the west (Fig. 2). In addition, numerous fine- to coarse-grained diorite dykes and sills of unknown age also occur in this wedge. A faulted contact with volcanic rocks of the Neoproterozoic Dalhousie Mountain Formation to the east is interpreted based on regional aeromagnetic data. This fault-bound wedge of Wilson Brook Formation rocks is host to the Arsenic Brook gold occurrence (Fig. 4c).

Devonian sedimentary rocks of the Murphy Brook Formation occur in the central Jeffers Block map area (Fig. 2). Control on their age is based on fossil evidence (see Donohoe and Wallace, 1982). Grey siltstones and conglomerates containing numerous grey siltstone and fine sandstone clasts predominate (Fig. 4d). All units possess well

Figure 3. (a) Heterolithic crystal-lapilli tuff of the Dalhousie Mountain Formation. (b) Finely laminated felsic tuff of the Dalhousie Mountain Formation. (c) Tuffaceous siltstone (pale grey unit at base of photo) overlain by well laminated volcanogenic sandstone of the Dalhousie Mountain Formation. (d) Strongly epidotized basalt of the Dalhousie Mountain Formation.

developed and distinctive cleavage that strikes to the north-northeast and dips shallowly to the east (20–35 degrees). This package of rocks is interpreted to be in thrust contact with bounding lithological units (Fig. 2).

Late Devonian to Early Carboniferous volcanic, volcaniclastic and related sedimentary deposits are found predominantly within the central Jeffers Block map area and collectively these constitute the Silica Lake Formation (Fig. 2). A Late Devonian to Early Carboniferous age assignment is

Figure 4. (a) Well laminated siltstone and sandstone of the Wilson Brook Formation. (b) Intensely bioturbated siltstone of the Wilson Brook Formation. (c) Adit exposed on tributary of Arsenic Brook within the Silurian Wilson Brook Formation. (d) Grey pebble-conglomerate of the Devonian Wilson Brook Formation. (e) Welded, fiamme-bearing ignimbrite of the Silica Lake Formation. (f) Vesicular basalt of the Silica Lake Formation.

based on lithological and geochemical similarities to dated volcanic rocks to the east that form the Byers Brook and Diamond Brook formations. Felsic volcanic rocks include fiamme-bearing welled ignimbrites (Fig. 4e), crystal-lapilli tuffs, finely laminated tuffs, as well as coherent flow-banded and porphyitic rhyolite flows. Basaltic rocks include vesicular flow units (Fig. 4f).

Jeffers Block Intrusive Rocks

Neoproterozoic Intrusive Rocks

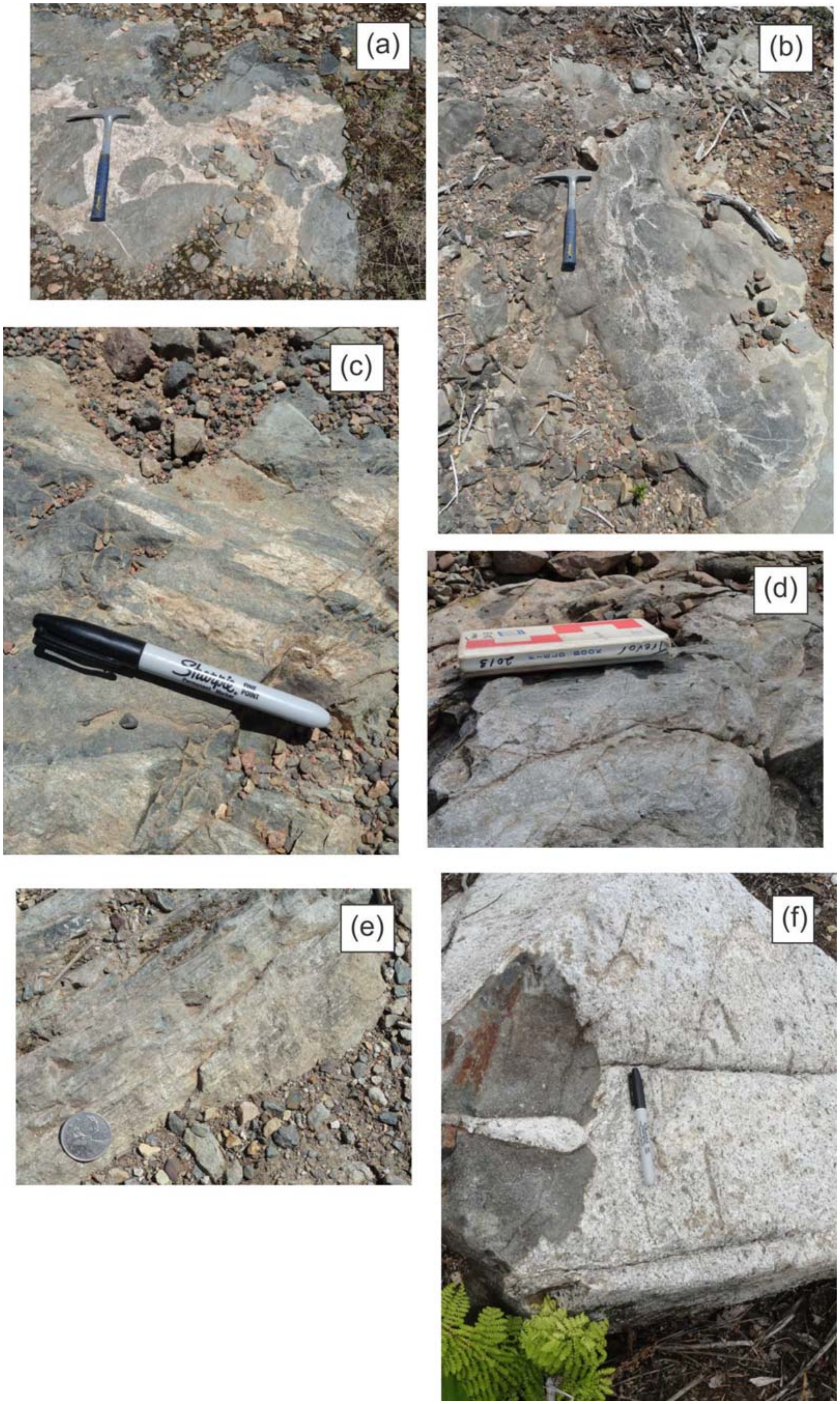
Neoproterozoic intrusive rocks ranging in composition from diorite to granodiorite and granite occur sparsely throughout the Jeffers Block and collectively they are referred to as the McCormack Lake Pluton (Fig. 2). A Neoproterozoic age is inferred based on lithological similarities to intrusive rocks found within the Bass River Block. These intrusive rocks are undeformed to foliated and relationships to other geological units within the Jeffers Block are uncertain due to poor exposure.

Late Devonian to Early Carboniferous

The Folly Lake Pluton is the most volumetrically significant intrusive body found in the Jeffers Block, and it underlies a significant region north of the Rockland Brook Fault. Throughout the Folly Lake pluton, an easily recognizable and predictable relationship exists between its three principal intrusive phases. The oldest phase, which is the majority of the pluton, comprises medium- to coarse-grained, largely equigranular gabbro and diorite. This early phase is cut, in a brittle manner, by thin stingers and dykes of fine- to medium-grained alkali-feldspar granite. The latter develop into larger bodies and sheets that locally attain tens of metres in apparent thickness. Proximal to the contact zone with the Hart Lake–Byers Lake pluton, granite sheets attain thicknesses of several hundreds of metres (not shown in Fig. 2). Coeval with emplacement of the alkali-feldspar granite phase, injections of fine- to medium-grained diorite consistently co-mingle with the granite, and both cut the early gabbro and diorite (Fig. 5a). Locally, mingling between granite and coeval diorite has progressed to the point of magma mixing and the production of a variety of 'hybrid' intrusives intermediate in composition between the two end-members. Fine-grained diorite dykes cross-cut all the main intrusive phases.

The southern and western margins of the Folly Lake Pluton are defined by complex shear zones, the Rockland Brook Fault to the south and a newly recognized, but as yet unnamed, thrust to the west (Fig. 2). Along the southern margin of the pluton, the steeply dipping, east-northeast-striking Rockland Brook Fault is characterized by a well developed mylonite zone. Importantly, proximal to this southern margin, the orientation of syn-plutonic micro-diorite inclusions and flow-foliation in alkali-feldspar granite (Fig. 5b) parallel the mylonitic fabric developed in the pluton within the shear zone (Fig. 5c). This indicates that deformation along the Rockland Brook Fault was synchronous with the later stages of pluton development, that is the coeval emplacement of granite and diorite. The western margin of the pluton displays a remarkably similar relationship between deformation and magmatism to that observed along the Rockland Brook Fault. Mylonitic fabrics developed within both the Folly Lake Pluton intrusives (Fig. 5d) and adjacent Dalhousie Mountain Formation volcanic rocks (Fig. 5e) strike northwest, dip moderately to the east (20–40 degrees) and possess stretching lineations that plunge shallowly to the north-northeast (10–20 degrees). Proximal to the shear zone along its northern extent, foliations are variably developed within the Folly Lake Pluton rocks. Importantly, some clearly represent flow-foliations developed during the later phase of pluton development synchronous with coeval granite and diorite emplacement (Fig. 5f).

North of the Rockland Brook Fault and west of the Folly Lake Pluton, Late Devonian to Early Carboniferous plutonism is represented by the Pleasant Hills Pluton and the Gilbert Mountain Plutons, respectively. The Pleasant Hill Pluton is dominated by variably textured alkali-feldspar granite, ranging from coarse-grained and equigranular to fine- to coarse-grained porphyritic, as well as fine-grained aplitic phases along its margins. Hybridization and magma mingling between alkali-feldspar granite and diorite occur


(a)
(b)
(c)
(d)
(e)
(f)

locally (Fig. 6a). The southern margin of the pluton possesses well developed east-west-trending, southerly dipping fabrics (Fig. 6b). This deformation may represent a northern splay of the Rockland Brook Fault that merges with the Cobequid Fault to separate the Pleasant Hills Pluton from the Bass River Block (Fig. 2). The pluton intrudes the Silurian Wilson Brook Formation to the north.

The Gilbert Mountain Pluton is poorly exposed in the northwestern portion of the map area. It consists predominantly of medium- to coarse-grained, equigranular alkali-feldspar granite. Fine-grained aplitic phases intrude the narrow wedge of Silurian Wilson Brook Formation exposed along its eastern margin (Fig. 2).

Bass River Block

Bedrock mapping conducted in the Bass River Block in 2013 has extended units defined in the block following the 2012 mapping initiative, and the reader is referred to MacHattie and White (2013) for detailed descriptions of the various geological units depicted in Figure 2. The Neoproterozoic Folly River and Gamble Brook formations continue west of Highway 104 along with minor Neoproterozoic dioritic rocks of the Frog Lake Pluton. Concomitant with the westward thinning of the Bass River Block, mylonitic intrusive and supracrustal rocks are complexly interleaved at a variety of scales. Importantly, the ductile deformation associated with the Rockland Brook Fault, which was confined to the northern margin of the Bass River Block further east, widens considerably to the west. In addition, the grade of metamorphism appears to increase to the west. The Londonderry Formation also tapers considerably toward the west as the Londonderry and Cobequid faults converge (Fig. 2). The new mapping has identified narrow, fault-bound slivers of Londonderry Formation farther west than previously recognized.

Economic Geology

A recently renewed interest in the geology and metallogeny of the Cobequid Highlands has been spurred by the discovery of new granite-related rare earth element and epithermal Au-style mineral prospects and occurrences in the northeastern highlands. In addition to these new exploration plays to the northeast, the southern flank of the Cobequid Highlands has long been a target for iron-oxide-copper-gold (IOCG) exploration (e.g. Belperio *et al*., 2008). Exploration efforts for rare metals, gold, copper and other base metals in the central and eastern Cobequid Highlands is at an all-time high, and a considerable amount of the region is held under mineral licence (Nova Scotia Department of Natural Resources, n.d.).

Important highlights of the new mapping conducted in 2013 relevant to mineral exploration in the area include the recognition that significant portions of the northwestern portion of the Jeffers Block are underlain by volcanic and volcaniclastic rocks of the newly defined Dalhousie Mountain Formation. These volcanic sequences are more widespread than previously recognized and, importantly, locally display significant amounts of silicification and sulphidization (MacHattie *et al*., 2013b). In the Late Devonian to Early Carboniferous Byers Brook and Diamond Brook formations, similar zones are sometimes associated with anomalous gold (MacHattie, 2013).

The new mapping has also recognized that the Londonderry Formation, host to the historic Londonderry iron deposits and hallmark of IOCG-style deposits, extends farther west than previously recognized, and thus has potential for an extension of the mineralization recognized to the east.

Figure 5. Intrusive rocks of the Folly Lake Pluton. (a) Alkali-feldspar granite mingling with coeval fine-grained diorite (top of image) and cutting older diorite phase (bottom of image). (b) Alignment of diorite inclusions in flow-foliated granite. (c) Mylonitic diorite and granite bands developed near the Rockland Brook Fault. (d) Mylonitic diorite developed on the western margin of the Folly Lake Pluton. (e) Mylonitic crystal tuff of the Dalhousie Mountain Formation. (f) Inclusion-rich flow-foliated granite containing quenched diorite blow cut by unfoliated granite stringer.

Figure 6. (a) Hybrid porphyritic intrusive mingling with diorite, Pleasant Hills Pluton. (b) Strongly foliated alkali-feldspar granite of the Pleasant Hills Pluton.

Future Work and Products in Preparation

The primary digital products in preparation from the new bedrock mapping initiative in the Cobequid Highlands include updated 1:50 000 scale bedrock geology maps. Associated with the production of these maps, several databases are currently under construction. These will include new laser-ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) U-Pb zircon age dates for intrusive, volcanic and sedimentary rocks (e.g. MacHattie *et al*., 2012). They will also include lithogeochemical data. The latter includes the current dataset of over 3400 mobile x-ray fluorescence (XRF) analyses of rock slabs collected as part of the 2012–2013 mapping initiative. As part of his M.Sc. research at Acadia University in Wolfville, Nova Scotia, V. Beresford is conducting a detailed petrological and geochemical study of Neoproterozoic plutonic rocks of the Bass River Block. His thesis is expected to be completed in the spring of 2014.

Continuation of the bedrock mapping initiative westward is planned for the summer and fall of 2014. The area to be investigated is approximated by the 1:50 000 scale bedrock geology map of the Parrsborro area (Pe-Piper and Piper, 2005c).

Acknowledgments

S. Barr, B. Murphy and J. Waldron are thanked for numerous discussions regarding the geology of the Cobequid Highlands. Special thanks to J. Drummond for assistance in the field during the previous summer's exploits in the area. Thanks to the land owners who allowed us to cross their properties. Special thanks to T. Lenfesty and J. Brenton for providing assistance in the departmental library.

References

Belperio, T., Morris, G. and O'Sullivan, J. 2008: Exploration for iron oxide copper-gold along the Cobequid-Chedabucto structure, Nova Scotia: assessment report covering main blocks of licences with July renewal dates; Nova Scotia Department of Natural Resources, Assessment Report ME 2008-181, 393 p.

Dessureau, G., Piper, D. J. W. and Pe-Piper, G. 2000: Geochemical evolution of earliest Carboniferous continental tholeiitic basalts along a crustal-scale shear zone, southwestern Maritimes basin, eastern Canada; Lithos, v. 50, p. 27-50.

Donohoe, H. V. and Wallace, P. I. 1982: Geological map of the Cobequid Highlands, Colchester, Cumberland, and Pictou counties, Nova Scotia, Sheet 3 of 4; Nova Scotia Department of Mines and Energy, Map 1982-8, scale 1: 50 000.

Hibbard, J. P., van Staal, C. R., Rankin, D. W. and Williams, H. 2006: Lithotectonic map of the Appalachian orogen, Canada-United States of America; Geological Survey of Canada, Map 02096A (2 sheets), scale 1:1 500 000.

MacHattie, T. G. 2011: Nature and setting of Late Devonian-Early Carboniferous rare earth element mineralization in the eastern Cobequid Highlands, Nova Scotia; *in* Mineral Resources Branch, Report of Activities 2010; Nova Scotia Department of Natural Resources, Report ME 2011-1, p. 75-92.

MacHattie, T. G. 2012: Report on the investigations into a newly discovered gold occurrence at Warwick Mountain in the Cobequid Highlands, Nova Scotia; Nova Scotia Department of Natural Resources, Open File Report ME 2012-001, 4 p.

MacHattie, T. G. 2013: Newly recognized epithermal-style gold occurrences associated with Late Devonian to Early Carboniferous bi-modal volcanism in the northeastern Cobequid Highlands; *in* Mineral Resources Branch, Report of Activities 2011; Nova Scotia Department of Natural Resources, Report ME 2012-1, p. 31-39.

MacHattie T. G., Murphy, J. B., White, C. E. and McFarlane, C. 2012: Tectonomagmatic history of the eastern Cobequid Highlands of Nova Scotia: implications for Avalonian lithospheric evolution and correlations within the Appalachian Orogen; *in* Program with Abstracts, GAC-MAC-AGC-AMC Joint Annual Meeting, St. John's Newfoundland, p. 82-83.

MacHattie, T. G. and White, C. E. 2012: A new geological interpretation of the eastern Cobequid Highlands, northern Nova Scotia; Nova Scotia Department of Natural Resources, Mineral Resources Branch, Open File Illustration ME 2012-018.

MacHattie, T. G. and White, C. E. 2013: Preliminary Geology of the Eastern Cobequid Highlands, Northern Mainland Nova Scotia; *in* Mineral Resources Branch, Report of Activities 2012; Nova Scotia Department of Natural Resources, Report ME 2013-001, p. 27-43.

MacHattie, T., White, C. E., Beresford, V. and Reid, M. 2013a: The eastern Cobequid Highlands: redefined geology and economic potential: Part 1; Nova Scotia Department of Natural Resources, Minerals Resource Branch, Open File Illustration ME 2013-016.

MacHattie, T., White, C. E., Beresford, V. and Reid, M. 2013b: The eastern Cobequid Highlands: redefined geology and economic potential: Part 2; Nova Scotia Department of Natural Resources, Minerals Resource Branch, Open File Illustration ME 2013-017.

Murphy, J. B. 2002: Geochemistry of the Neoproterozoic metasedimentary Gamble Brook Formation, Avalon Terrane, Nova Scotia: evidence for a rifted-arc environment along the west Godwanan margin of Rodinia; The Journal of Geology, v. 110, p. 407-419.

Murphy, J. B., Pe-Piper, G., Piper, D. J. W., Nance, R. D. and Doig, R. 2001: Geology of the eastern Cobequid Highlands, Nova Scotia; Geological Survey of Canada, Bulletin 556, 61 p.

Nance, R. D., Murphy, J. B. and Keppie, J. D. 2002: A Cordilleran model for the evolution of Avalonia; Tectonophysics, 352, p. 11-31.

Nova Scotia Department of Natural Resources (n.d.): NovaROC: Mineral Rights Online Registry

System; http://novaroc.novascotia.ca, accessed December 1, 2013.

Pe-Piper, G. and Murphy, J. B. 1989: Geochemistry and tectonic setting of the late Precambrian Folly River Formation, Cobequid Highlands, Avalon Terrane, Nova Scotia: a continental rift within a volcanic-arc environment; Atlantic Geology, v. 25, p. 143-151.

Pe-Piper, G. and Piper, D. J. W. 2002: A synopsis of the geology of the Cobequid Highlands, Nova Scotia; Atlantic Geology, v. 38, p. 145-160.

Pe-Piper, G. and Piper, D. J. W. 2005a: Bedrock geology map of the Wentworth area (parts of NTS sheets 11E/05, 11E/06, 11E/11 and 11E/12), Cobequid Highlands, Nova Scotia; Nova Scotia Department of Natural Resources, Mineral Resources Branch, Open File Map ME 2005-116, scale 1:50 000.

Pe-Piper, G. and Piper, D. J. W. 2005b: Bedrock geology map of the Earltown area (parts of NTS sheets 11E/06, 11E/10 and 11E/11), Cobequid Highlands, Nova Scotia; Nova Scotia Department of Natural Resources, Mineral Resources Branch, Open File Map ME 2005-117, scale 1:50 000.

Pe-Piper, G. and Piper, D. J. W. 2005c: Bedrock geology map of the Parrsboro area (parts of NTS sheets 11E/12, 21H/08 and 21H/09), Cobequid Highlands, Nova Scotia; Nova Scotia Department of Natural Resources, Mineral Resources Branch, Open File Map ME 2005-115, scale 1:50 000.

Pe-Piper, G. and Piper, D. J. W. 2005d: Bedrock geology map of the Cape Chignecto area (parts of NTS sheets 21H/07 and 21H/08), Cobequid Highlands, Nova Scotia; Nova Scotia Department of Natural Resources, Mineral Resources Branch, Open File Map ME 2005-114, scale 1:50 000.

Pe-Piper, G., Piper, D. J. W. and Koukouvelas, I. 1996: Precambrian plutons of the Cobequid Highlands, Nova Scotia, Canada; *in* Avalonian and Related Peri-Gondwanan Terranes of the Circum-North Atlantic, eds. R. D. Nance, and M. D. Thompson; Geological Society of America Special Paper 304, p. 121-132.