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NEW INSIGHTS INTO THE STRATIGRAPHY OF THE BLOW ME DOWN BROOK FORMATION, WESTERN NEWFOUNDLAND

E. Gillis and E. Burden
Department of Earth Sciences, Memorial University of Newfoundland,
St. John's, Newfoundland, A1B 3X5

ABSTRACT

Regional 1:50 000 mapping of coastal sedimentary strata from the community of Fox Island River, north to the Bay of Islands shows large continuous sections of Blow Me Down Brook formation rocks. These exposures, paired with a recently documented basal contact between Blow Me Down Brook red shale beds and the underlying Fox Island volcanics, have allowed development of a composite stratigraphy for the Blow Me Down Brook formation. The formation, herein estimated to be about 400 m thick, is formed of five distinctive stratigraphic units: Unit A is a massive red shale interbedded with volcanic rocks; Unit B is a thick-bedded, red (hematitic) and greenish micaceous sublitharenite and lithic subarkose; Unit C is a quartz and feldspar pebble conglomerate containing calcarenite boulders; Unit D is a coarse-grained, greenish quartzarenite and sublitharenite with minor subarkose, interbedded with red, green and grey shale, and; Unit E is a massive siliceous red and black shale.

Petrographic analyses show the sandstones are largely quartzose. In Units B, C and D feldspar is a common, but minor component. Mica is the most common lithic mineral in Units B and D, and glauconite pellets and calcite cement are commonly seen in Units C and D. In some rock samples, from the upper part of Unit D, dolomite grains occur with some calcite cements. By the careful recognition of strata and successions using the descriptions given, these rocks can be successfully mapped across this region.

INTRODUCTION

For almost 150 years, there has been passing mention of quartzose and feldspathic sandstones in the series of allochthonous beds found in western Newfoundland (Logan, 1863; Schuchert and Dunbar, 1934). In the early 1960s, significant new mapping was being conducted in western Newfoundland (*see* Brückner, 1966, and references therein). Brückner (1966), in a limited-edition conference field guide, compiled a series of student thesis studies and proposed a stratigraphy for many of these allochthonous beds. The hyphenated and lower case moniker Blow-me-down Brook formation was created to identify "greywacke and arkose, with some conglomeratic beds, interbedded with soft, red and green shales" in the allochthon. A posthumous paper by Lilly (1967), with editorial work by W.D. Brückner, is admittedly incomplete. In that paper, Lilly (*op. cit.*) declares his intention to formally propose Blow-me-down Brook formation as the name for these sandstone and conglomerate beds; this is a key element of the North American Stratigraphic Code. However, without a stratotype and other basic information provided from this or any other subsequent papers, the formation must remain informally designated. In recent years, and in keeping with the proper name for the brook, the formation has come to be spelled and known as the Blow Me Down Brook formation.

Extensive belts of deformed outcrop of the Blow Me Down Brook formation are found along Blow Me Down Brook, on Woods Island, along the shore of the Bay of Islands, and along the coast of the Gulf of St Lawrence (Figure 1). Typically, field descriptions show the formation to be a thick-bedded, grey-green, very coarse- to medium-grained, arkosic sandstone, interbedded with black, green and red shale. No clearly defined stratigraphic base or top has been identified from these deformed thrusts, but a number of researchers (Brückner, 1966; Lilly, 1967; Williams, 1973) indicate some form of stratigraphic contact might exist between Blow Me Down Brook strata and volcanic rocks.

Early descriptions of the Blow Me Down Brook formation considered strata to be Lower Ordovician flysch (Brückner, 1966; Lilly, 1967; Williams, 1973) lying upon

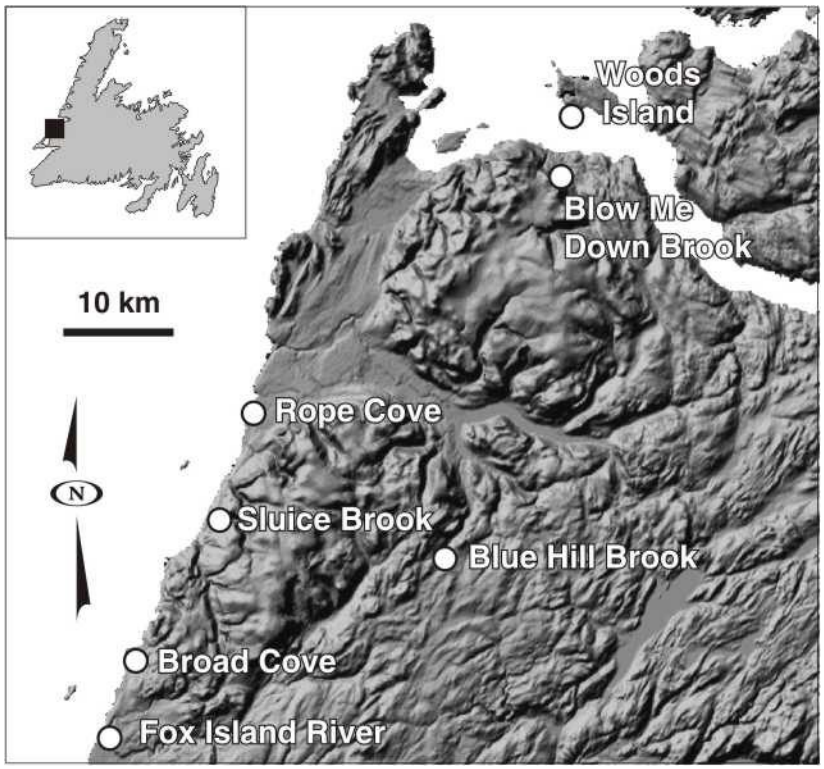

Figure 1. *Radar image (courtesy of Newfoundland and Labrador Geological Survey) showing localities and sections examined in this study.*

Middle Arm Point formation rocks and below Humber Arm Volcanics. More recent petrographic work by Quinn (1985) compared the Sellars formation (a Bonne Bay equivalent to the Blow Me Down Brook formation) with similar sandstone units of Precambrian–Cambrian age in the Appalachians. From these observations, Quinn (*op. cit.*) suggested that the Blow Me Down Brook formation had been misinterpreted as an Ordovician flysch, and is more likely related to Lower Cambrian rift deposits. This observation was later confirmed by discovery of the Early Cambrian trace fossil *Oldhamia* by Lindholm and Casey (1989).

To date, the only reported stratigraphic measurements from thick and continuously exposed Blow Me Down Brook strata come from an outcrop located on the south coast of Woods Island, Bay of Islands (Palmer *et al.*, 2001). Here, Palmer *et al.* (*op. cit.*) show a stratigraphic section of 372 m of the Blow Me Down Brook strata (Figure 2). Shallow faults, common in this section, are thought to have little offset (Palmer, *op. cit.*). Beds are mostly composed of grey-green sandstone and pebble conglomerate with very minor siltstone and shale. Sedimentary structures found throughout this section include planar laminations, crossbeds, graded beds and dish structures; all are thought to indicate high-energy gravity-flow deposits of an ancient deep-sea fan.

Regional field mapping (Figure 1) of coastal sections and river transects from Rope Cove to Fox Island River, and reconnaissance mapping on Blow Me Down Brook, Blue Hill Brook, and Woods Island, show that extensive deposits of Blow Me Down Brook strata contain a larger variety of rock types, bedding features and lithologic successions than that has been reported in the literature. Re-assembly of strata and successions across fault panels shows a composite stratigraphy that is, on one hand, more complicated than earlier views of these rocks, but fully in keeping with the rift margin origins suggested by Quinn (1985).

FIELD AND LABORATORY TECHNIQUES

Thrust panels of Blow Me Down Brook formation rocks are well exposed in coastal sea cliffs and river valleys from Fox Island River to Rope Cove. Additional outcrops measured or otherwise examined for this study are found on Blue Hill Brook, along Blow Me Down Brook, and on the west end of Woods Island (Figure 1). Critical elements to this stratigraphy include recognition of the distribution of feldspar and quartz pebbles and granules, calcarenite boulders, quartzose sandstones, thick shale successions, trace fossils and carbonate cements.

Individual thrust panels can show substantial accommodation faulting and folding generated from one or more episodes of regional deformation (Burden *et al.*, 2005). Depending upon the thrust history, and the style and degree of motion on normal and reverse faults, adjacent fault blocks may or may not carry a similar stratigraphy. By constructing and labelling a digital photographic mosaic of the coastline, and by completing onshore measurements and sampling, the strata has been re-assembled into a composite pattern of sedimentary successions; this has produced a regional stratigraphy for the Blow Me Down Brook formation.

To further characterize strata of the Blow Me Down Brook formation, a petrographic study of 61 thin sections was conducted with the Gazzi-Dickinson point count method. The primary grain parameters outlined by Dickinson (1970) include, quartz (both monocrystalline and polycrystalline), feldspar (plagioclase and potassium) and lithic fragments. In addition to these primary mineral grains, mica, dense minerals, miscellaneous and unidentified grains are counted according to guidelines established in the Gazzi-Dickinson technique. Matrix and cement are not counted

due to the fact that these are later diagenetic features (Dickinson, 1970).

For each thin section, a minimum of 300 counts was recorded using a point count stage with a 1 mm grid spacing. Once the counts were complete, the data was then plotted on a QFL ternary diagram where the sandstones were classified according to McBride (1963).

Carbonate cements present an interesting anomaly. To our knowledge, none have been reported in any earlier studies. Generally patchy in distribution, cathodeluminescence microscopy is used in conjunction with fluorescence microscopy to show the distribution of calcite and dolomite crystals and cements.

STRATIGRAPHY OF THE BLOW ME DOWN BROOK FORMATION

The Blow Me Down Brook formation contains five distinctive stratigraphic units, informally named Units A through E. Unit A (Plate 1), herein inferred to represent the base of the formation, is best exposed in small streams in the upper reaches of Blue Hill Brook. Here, 1 to 2 m beds, consisting of mostly red siliceous shale, with lesser amounts of grey and rarely black shale, lie interbedded with and conformably overlie thin beds of the Fox Island volcanics (Fowler, 2005).

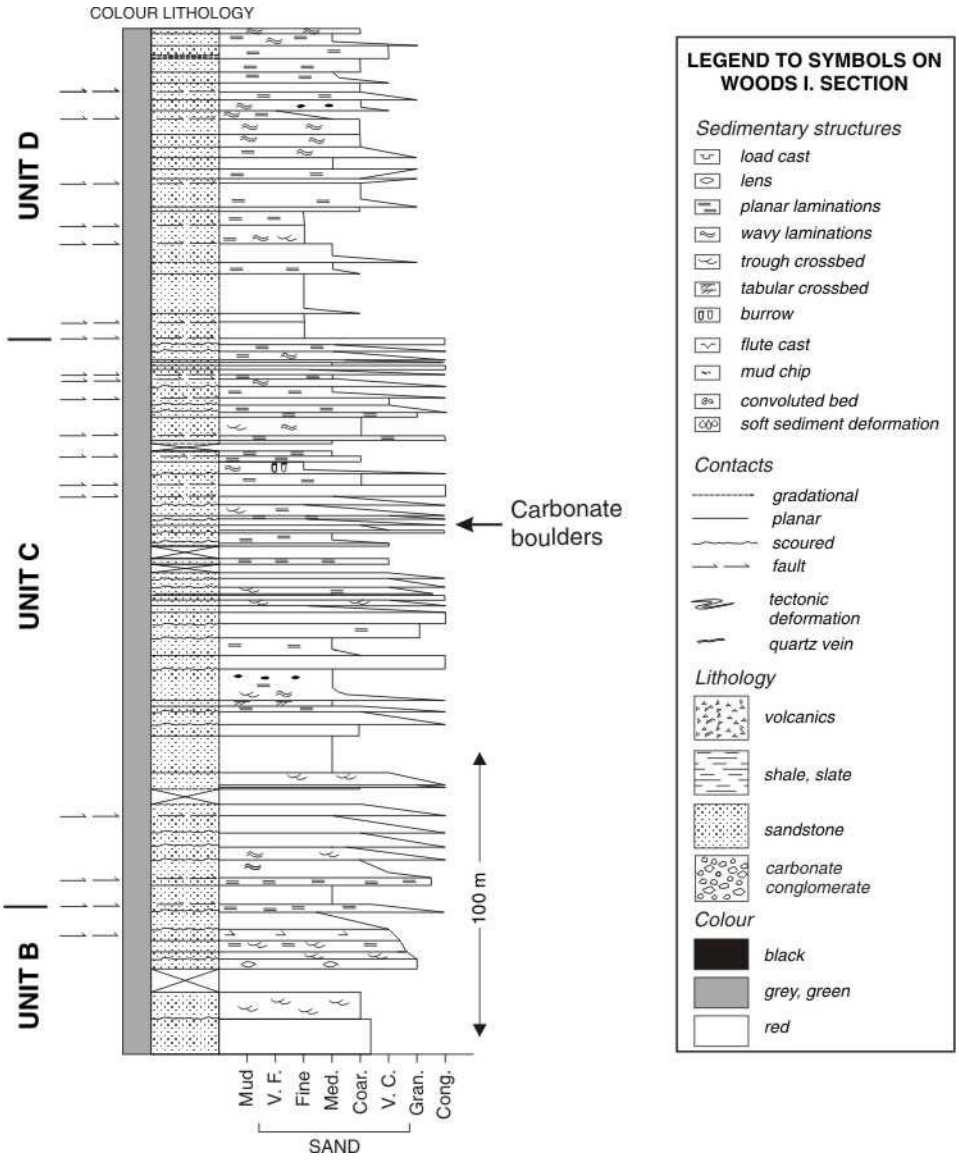

Figure 2. *Woods Island stratigraphic section from Palmer* et al. *(2001), refigured to highlight faults and to show the location of calcarenite boulder conglomerate beds.*

Unit B, of the Blow Me Down Brook formation (Figure 3) is generally located at the base of some thrust panels. In one section, along the coastline near Fox Island River, the maximum thickness for Unit B is at least 75 m. Strata are dominated by greenish grey and red coarse-grained to granular sandstone beds ranging from 25 cm to 14 m in thickness (Plate 2). Scattered throughout this interval is a succession of 1 to 2 m beds of red, green and dark-grey shale beds. Shaly strata are largely devoid of trace fossils; the first *Oldhamia* trace comes from the last and highest dark grey shale near the contact with Unit C.

Point counts for Unit B sandstones (Figure 4) show these rocks to be sublitharenites with less than 80% subangular quartz, more than 15% lithics (mostly mica), and less than 15% feldspar. Other detrital or secondary minerals include abundant interstitial hematite in the red-coloured sandstones and unidentified opaques.

Unit C always lies in sharp contact with Unit B. It is easily recognized by an abrupt shift in grain size from coarse-grained and granular lithic sandstones of Unit B to

Plate 1. *Basal contact of Fox Island Volcanics and red shales of Unit A of the Blow Me Down Brook formation (UTM 399390, 5406725).*

Plate 2. *Red hematitic sandstones of Unit B, Broad Cove south (UTM 378647, 5400594).*

more quartzose beds containing clast- and matrix-supported pebble and boulder conglomerates. Pebble conglomerates are generally more than 80% quartz and less than 10% feldspar and other lithic minerals (Plate 3). Small, patches of calcium carbonate can be seen in thin sections of these quartzose sublitharenites and subarkoses, but when tested with hydrochloric acid the hand specimens do not effervesce.

One of the more distinctive elements found at, or near, the top of Unit C is a calcarenite boulder conglomerate horizon up to 12 m thick. Calcareous sandstone clasts 10 to 65 cm in diameter rest in a calcite-cemented matrix of quartz and feldspar pebbles (Plate 4). The clasts may be oblate to discoidal in shape and frequently contain parallel laminations and mud chips. For these rocks, the hydrochloric acid test generates significant effervescence.

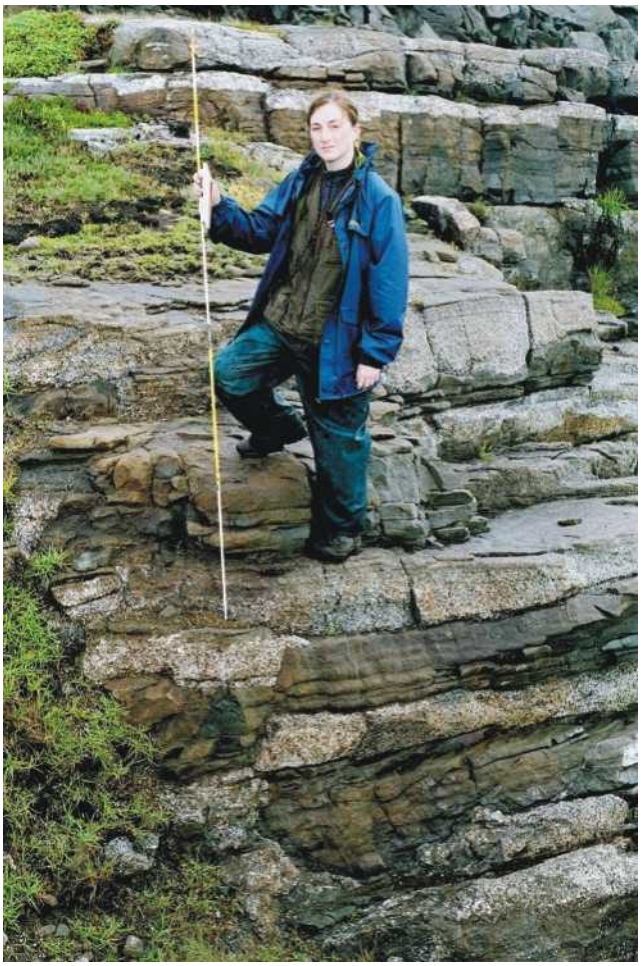

Plate 3. *Pebble conglomerate beds from Woods Island show prominent scours and synsedimentary normal faults (UTM 411084, 5438310).*

Unit C shows significant variations in thickness. On the southern shore of Broad Cove, near Fox Island River, tight folding and faulting make stratigraphic measurements difficult; here, beds of Unit C appear to be no more than 12 m thick (Figure 3). A more continuous section of conglomeratic strata located in sea cliffs north of Broad Cove contains more than 57 m of strata in a coarsening-upward succession, capped with 14 m of pebble conglomerate (Plate 5). Farther north in the Bay of Islands, the Blow Me Down Brook section measured by Palmer *et al.* (2001) on Woods Island contains more than 200 m of coarse-grained and conglomeratic strata (Figure 2) with clear evidence for repeated episodes of erosion and synsedimentary normal faulting (Plate 3). These east- and southeast-dipping beds are clearly deformed by a much later episode of normal faulting and therein present a maximum estimate for the thickness of this unit. The calcareous boulder conglomerate horizon is located near 170 m in the Palmer *et al.* (2001) section and in the hanging wall of a southeast-striking, west-dipping normal fault.

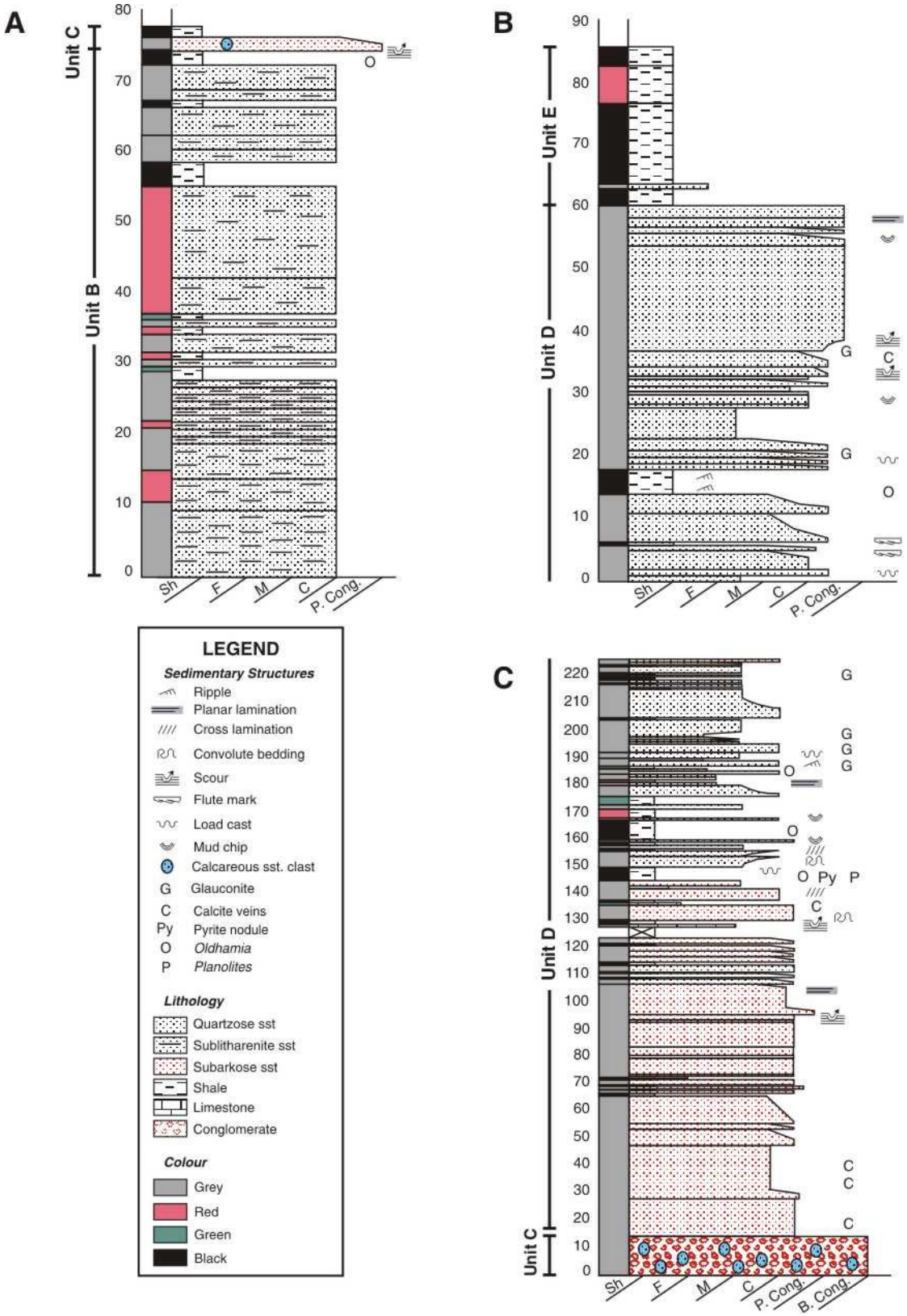

Figure 3. *Stratigraphic sections of Blow Me Down Brook formation. A) Units B and C in Broad Cove south (UTM 378647, 5400594). B) Units D and E, north of Sluice Brook (UTM 386609, 5413838). C) Units C and D, Broad Cove (UTM 378956, 5401202).*

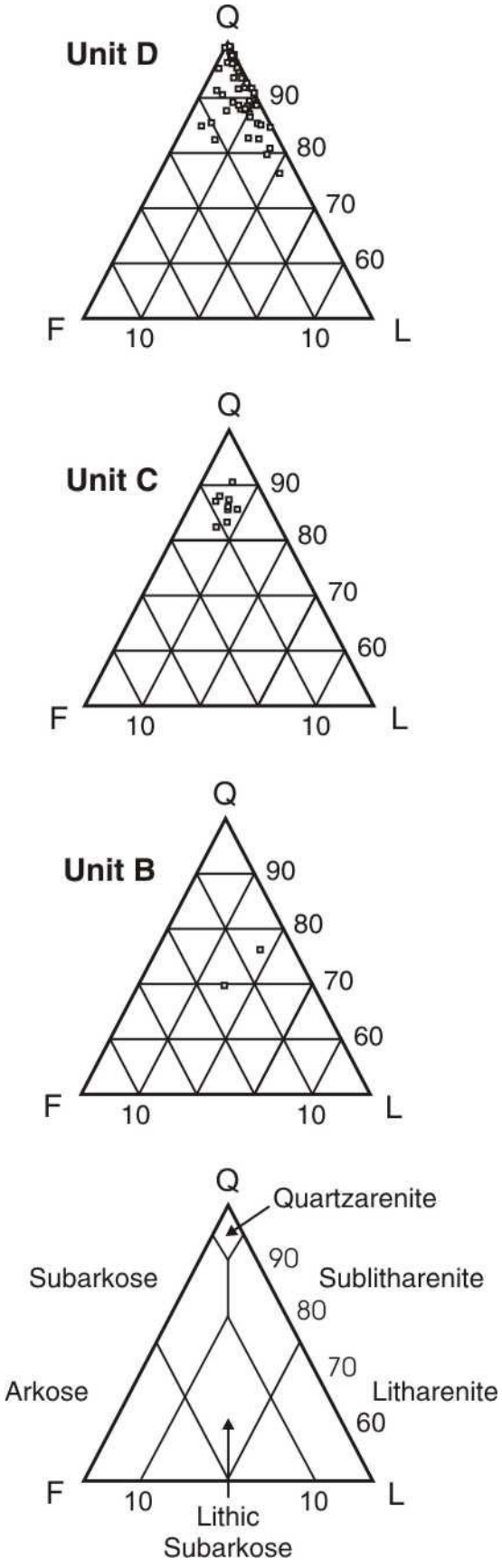

Figure 4 (opposite)**.** *Ternary plots based on point count data for Units B, C and D of Blow Me Down Brook formation.*

Plate 4. *Calcarenite boulder ~50 cm long and containing imbricated shale clasts (UTM 378740, 5401202).*

Unit D conformably overlies the conglomeratic Unit C. The unit measures 285 m total thickness; the basal 50 m of this unit are dominated by thick-bedded, greenish-grey, massive, subarkosic sandstone having rare, thin, interbeds of dark-grey shale. The middle of this unit between 100 to 200 m marks a transitional zone where there is a shift in the sediment composition from a subarkose to a sublitharenite and quartzarenite. Across this interval, the thickness of the sandstone beds decrease and fining-upward sequences capped with thin shale and siltstone beds become common. Grey shale beds are commonly bioturbated; *Oldhamia* is often found amongst other diverse trace fossils in these muddy successions. The upper 85 m of Unit D (Plate 6) is composed of 2- to 17-m-thick beds of coarse-grained to granular, grey quartzarenite having minor calcite veining. Dark-grey, *Oldhamia*-bearing shale beds, no more than 5 m thick, are less common in this part of the succession.

Sedimentary structures in the sandstones include planar lamination, crosslamination, common mud chips, rare ripples, load casts, convolute bedding, flute casts and scours. In thin section, many of these sandstones are seen to be slightly calcareous and rarely dolomitic (Plate 7). Amongst other common lithic minerals, glauconite pellets have also been found.

Plate 5. *Vertically exaggerated panoramic of about 500 m of cliff from Broad Cove north. Syncline is composed of a coarsening- and thickening-upward succession of Unit C strata capped with a prominent pebble conglomerate (UTM 379977, 5402419).*

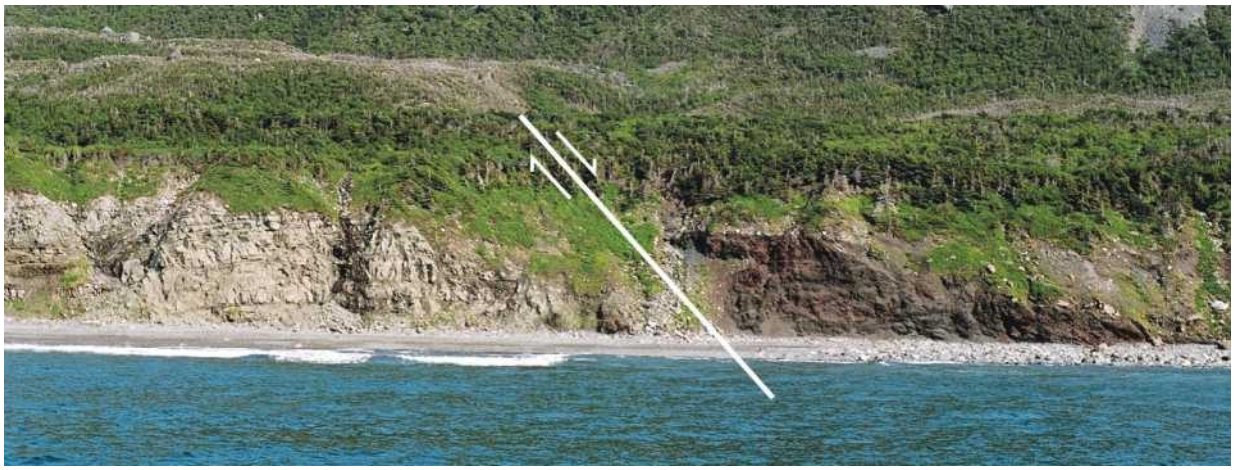

Plate 6. *Coastal section ~200 m long shows grey-green sandstones of Unit D and red and black shale of Unit E in a normal fault contact (UTM 386902, 5413424).*

Repeat sections of Unit D beds occur along the coastline from Rope Cove, south to Fox Island River. Commonly, the quartzose sandstones of Unit D are petroliferous (Burden *et al.*, 2005).

The final unit of the Blow Me Down Brook formation is Unit E (Plate 6). This unit consists entirely of massive red siliceous shale directly overlying strata of Unit D. Unit E is normally very deformed. The thickest representative section is less than 30 m thick (Figure 3).

DISCUSSION

From the very first geological observations of Logan (1863), the Blow Me Down Brook formation has been recognized for its greenish colour and feldspar content. Whereas the formation does contain some feldspar, it would be incorrect to describe it as arkosic. Empirical analyses of Units B, C and D, in outcrop or hand specimen, apparently focus on the seemingly abundant pink feldspar grains and pebbles; compositional estimates tend to err toward arkosic sandstone compositions for Blow Me Down Brook rocks. In contrast, the point count data presented here shows that the feldspar content is not high; much of the Blow Me Down Brook formation is very quartzose and appropriately described as a quartzarenite, a micaceous sublitharenite or a (quartzose) subarkose (Figure 4). Under a provenance and tectonic regime classification proposed by Dickinson *et al.* (1983), Blow Me Down Brook rocks fall into the Craton interior and the Recycled Orogenic (Quartzose Recycled) fields. This is entirely consistent with a rift margin origin for these rocks.

Blow Me Down Brook formation rocks along the shore of the Gulf of St Lawrence are much better exposed and apparently less deformed than strata lying farther inland and beneath the ophiolitic massifs. Distinctive stratigraphic units identified from grain-size, mineralogy and trace-fossil content occur in different thrusts in a regular repeating succession. In a sense, these rocks show a shift from red and hematitic, somewhat lithic sandstones lying on or near volcanics (Units A and B) to more quartzose sandstones near the top of the formation (Unit D).

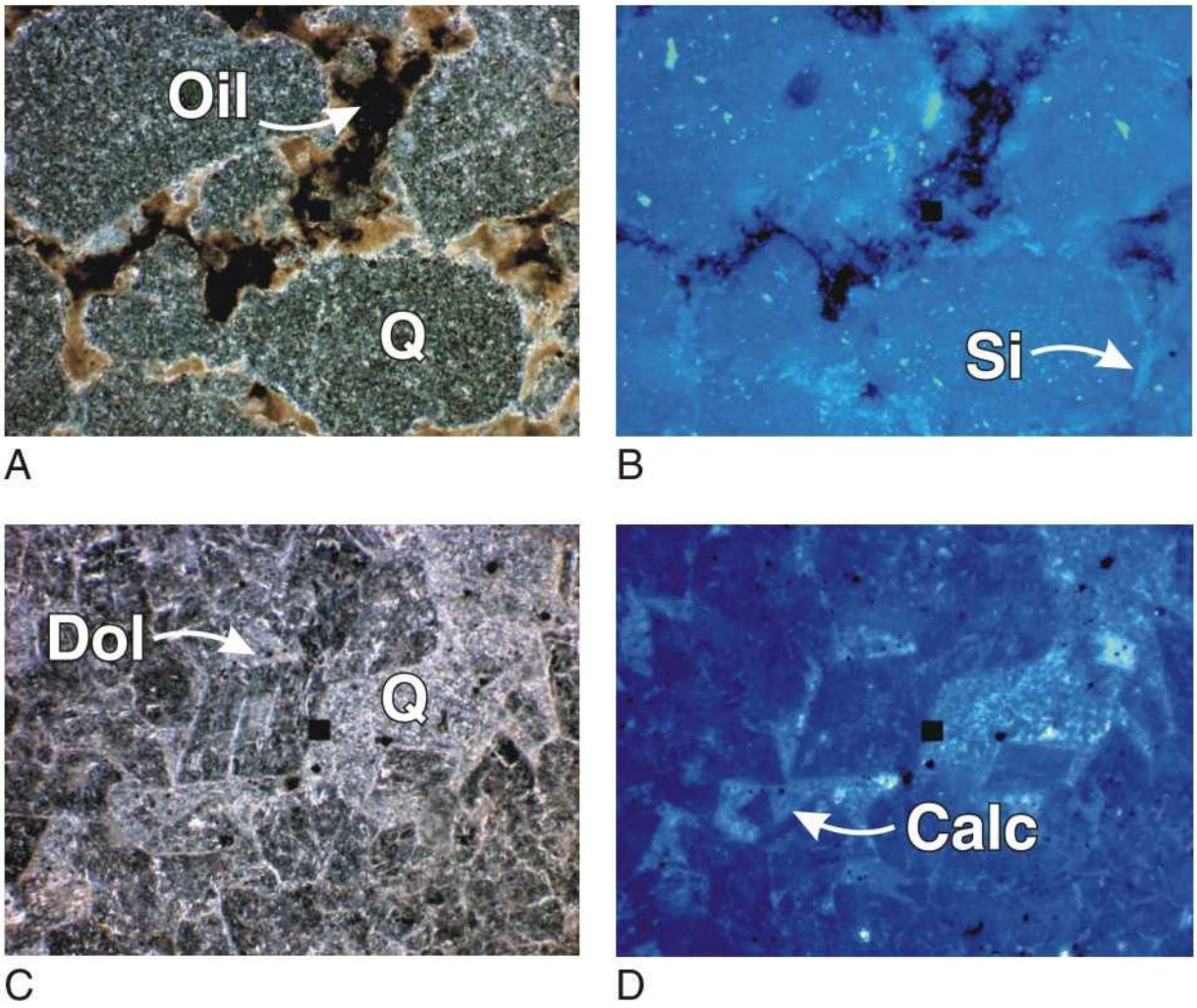

Plate 7. *A) Dark field photograph of quartz grains with surrounding pore space infilled by oil (EG99; UTM 384916, 5411056). B) Flourescence image of photograph A; Q - quartz; Si - silica cement. C) Dark field photograph of quartz and zoned dolomite grains (EG168; UTM 387518, 5416989). D) Flourescence image of photograph C; Dol - dolomite; Calc - calcite. Small black square is 10* μ*m. Both samples are from Unit D.*

In Unit C, the appearance of clean, quartz and feldspar pebble beds with calcarenite boulders marks a regional shift in sedimentary environments and provenance (Plate 3). Sedimentology indicates high energy deposits; petrography and mineralogy indicate that the source lies in exposed and eroded granitic crust. Rifting, with normal faulting, and development of horsts, can result in coarse sediment accumulating in adjacent grabens. So too, lowstand system tracts can generate a similar set of conditions for rapid transport and deposition of sediment from hinterland settings.

Just above the last pebble and boulder beds of Unit C, the Unit D strata become clean, moderately well-sorted, and subrounded quartzarenites punctuated with beds of shale containing trace fossils. A shift in provenance toward mature sediment with increased biological productivity suggests stable conditions indicative of a transgressive systems tract with highstand deposits.

For hydrocarbon exploration, the sediments of this unit can display grain to grain boundaries and porosity (Plate 7). A breached antiform near Sluice Brook on the Gulf of St. Lawerence contains significant hydrocarbon staining and a petroliferous odour (Burden *et al*., 2005). Similar structures buried and sealed may contain petroleum.

CONCLUSIONS

A composite picture of the Blow Me Down Brook formation is developed through measuring and sampling strata from multiple sections across different thrusts. The base of the formation is herein inferred to be red shale and sand-

stone beds lying upon Fox Island volcanics. From bottom to top, strata gradually become more quartzose in composition. A distinctive pebble and boulder conglomerate divides the formation along what may be an episode of rifting or a sequence boundary.

In outcrop, some of the quartzose sandstones from near the top of the formation are petroliferous. In the subsurface, these may be prospective exploration targets.

ACKNOWLEDGMENTS

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