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STRATIGRAPHY AND METALLOGENY OF THE COD ISLAND AND CALM COVE FORMATIONS, MUGFORD GROUP, NORTHERN LABRADOR[1]

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ABSTRACT

The Lower Proterozoic Mugford Group represents a relatively undeformed cover sequence developed on the Archean crust of the Nain craton, northern Labrador. The unit is a 40 by 12 km sequence of lower sedimentary and upper volcanic rocks well exposed over a vertical thickness of up to 1200 m. Based on evidence from lithological, sedimentological, structural and chronological parameters, the sequence represents a prospective target for SEDEX-type massive sulphide mineralization.

The basal sedimentary sequence, the Sunday Run Formation, was deposited in a high-energy environment and occurs only on northwest exposures of the Mugford Group. The overlying Cod Island Formation consists of mixed shale, chert, dolostone and siltstone and contains thin coal seams within a shale and chert sequence at one locality. On the northwest side of Mugford Tickle, a debris flow containing angular, poorly sorted sedimentary and basaltic fragments is exposed. Massive sulphide fragments are also present in the flow and indicate synsedimentary sulphide deposition. Some fragments are of laminated sulphide and resemble the typical laminated horizons that occur in SEDEX deposits.

Sulphide mineralization in the Mugford Group consists of four types: 1) massive dominantly pyrrhotitic–pyritic ± sphalerite–galena material, 2) chalcopyrite–pyrrhotite amygdule and void-fillings in volcanic rocks, 3) pyrite–pyrrhotite laminations and concretions in shale, and 4) pyrite associated with coal seams. Overall, the sequence has interesting potential for SEDEX mineralization.

INTRODUCTION

This study is part of a larger project examining the metallogenic potential of Lower Proterozoic supracrustal sequences developed on the Archean Nain craton of northern Labrador. Wilton (1990) and Swinden *et al.* (1991) had previously suggested that these sequences contain the elements of sedimentary exhalative (SEDEX) mineralization. In 1991, the Snyder Group was examined (Wilton and Phillips, 1992) and the Ramah Group will be surveyed in 1993.

Laboratory investigations of samples from the Mugford Group, including detailed geochemical analyses of sedimentary rocks and sulphide horizons, as well as petrogenetic investigations (whole-rock geochemistry and isotopic studies) of volcanic rocks, are in progress.

The Mugford Group (Figure 1) is exposed over the 40 by 12 km area of the Kaumajet Mountains. Rocks of this unit consist of a lower sedimentary sequence overlain by a thick mafic volcanic succession; all of which have shallow dips (< 35°) and are exposed in spectacular cliff sequences with up to 710 m relief. The highest peaks in the Kaumajet Mountains, the Bishop's Mitre and Brave Mountain (named after Daly's 1902 vessel) are 1080, and 1200 m above sea level, respectively.

The Mugford Group was first mapped by Daly (1902) who defined the unit as the Kaumajet Mountain Group. At the southwest end of Cod (Ogualik) Island, he found that the Archean gneiss was overlain by 15 m of intrusive diabase and thence by slates, quartzites, limestone and sandstones with interbedded trap layers. Daly (*op. cit.*) noted a small pit and rusty tools indicating that 'attempts had been made to test the rock for either gold or copper' (page 221 of Daly, 1902).

Coleman (1921) made a reconnaissance visit to the Mugford area and termed the volcanic, sedimentary and intrusive rocks, the Mugford Series.

Kranck (1939) measured a sequence through the Mugford Series on the south side of Grimmington Island, presumably just south of Section 4 (Figure 1). As shown on Figure 2, Kranck (*op. cit.*) did not find sedimentary rocks at the base of his sequence, but suggested that such rocks could be covered by talus at the base of the section.

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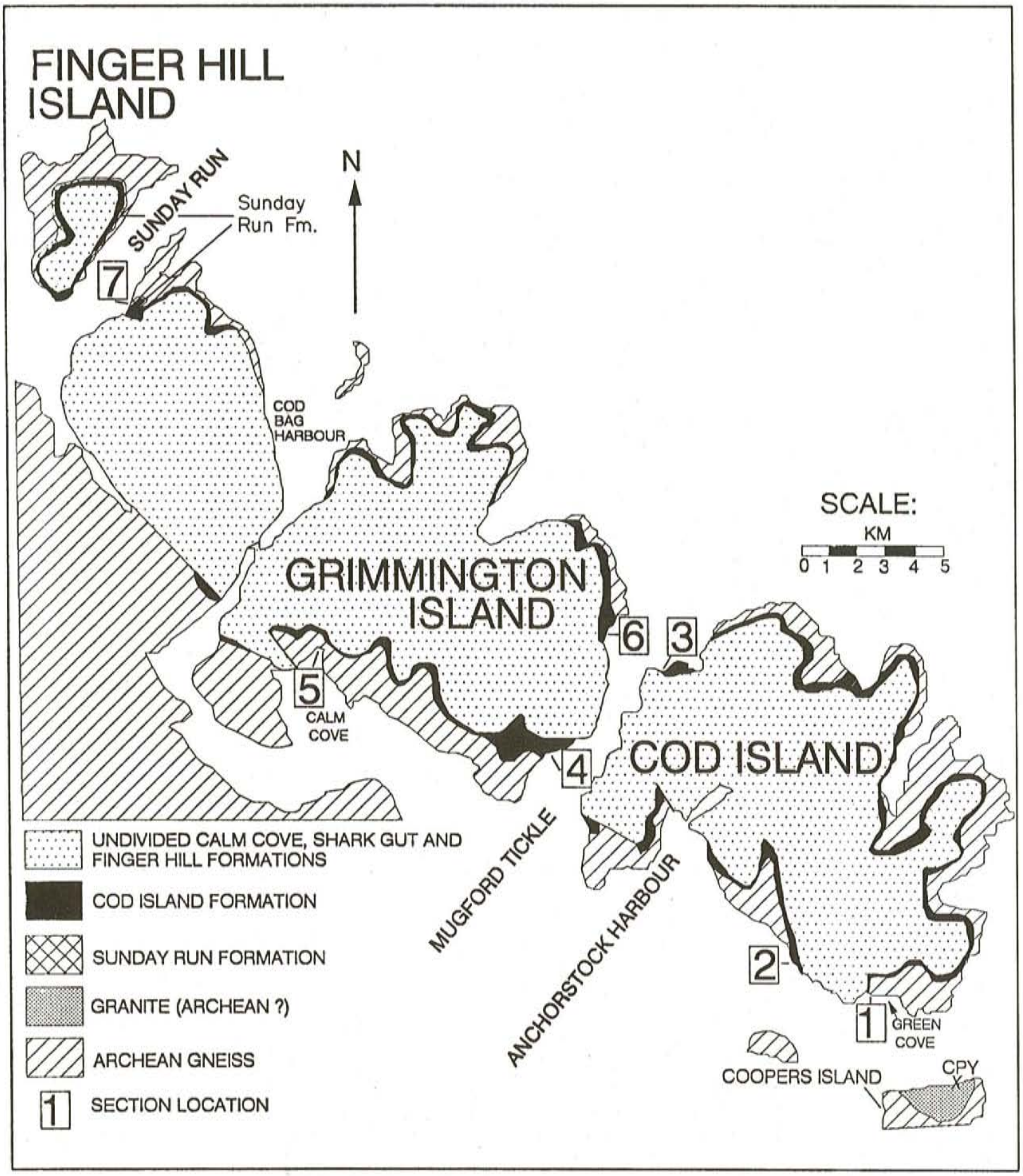

Figure 1. *Geological and section location map of the Mugford Group. The geology is from Smyth (1976).*

Douglas (1953) completed detailed mapping at Green Cove and Anchorstock Harbour. At Green Cove (Section 1—Figure 1), he mapped slates, of what he termed the Ramah Series, as overlying Archean gneiss. He designated the Mugford Series as volcanic rocks that overlie the Ramah Series slate with angular unconformity. According to Douglas, a quartz-porphyry dyke, which cut what he termed Ramah Series rocks, was truncated by the unconformity. He noted the presence of two pyritized chert beds in the slates with 'an occasional speck of galena' (page 44 of Douglas, 1953). On the northern shore of Coopers Island (identified by Douglas as Green Island), 4 km southeast of Green Cove, he found sulphides in quartz veins cutting a granite. Assays of the veins yielded nil values for gold or silver. Along the eastern shore of Anchorstock Harbour, Douglas (*op. cit.*) mentioned mineralized zones consisting of silica, pyrite and lesser chalcopyrite.

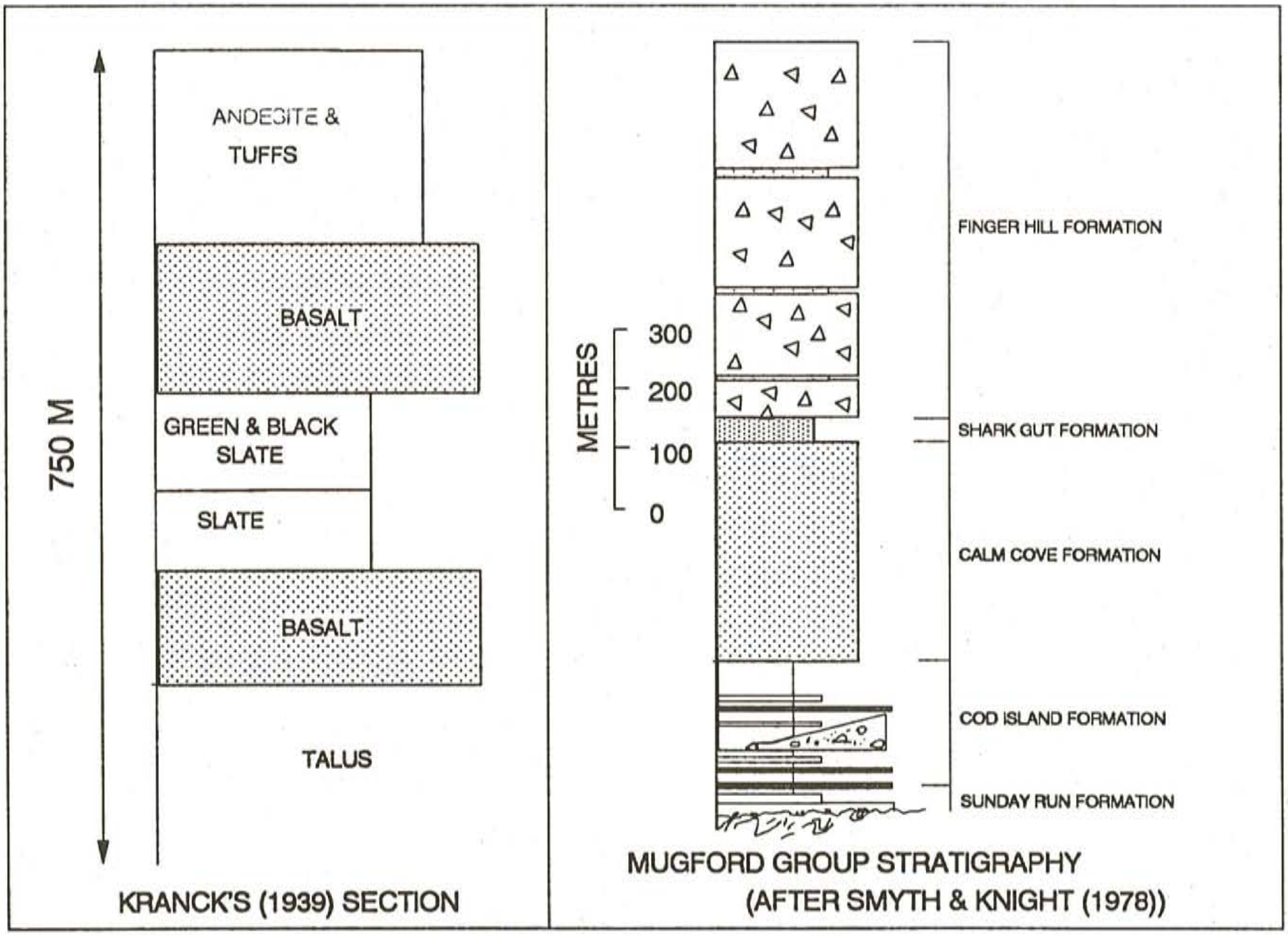

Figure 2. *Stratigraphic columns for the Mugford Series from Kranck (1939) and for the Mugford Group from Smyth and Knight (1978).*

Taylor (1970) briefly described the rocks and modified the name to the Mugford Group. He disagreed with Douglas' (1953) delineation of an unconformity at Green Cove and defined the sedimentary rocks as members of the Mugford Group.

Barton (1975) used geochemical data to define the presence of three magma types in the Mugford Group; tholeiitic basalts, komatiitic basalts and greenstones. He noted the presence of basal euxinitic shales that were up to 100 m thick, but made no comment upon them. An Rb–Sr whole-rock isochron for the volcanic rocks indicated an age of 2369 ± 55 Ma, but the isochron was dependent upon a sample of komatiite. Removing the komatiitic sample from the data produced a poorly defined age of ca. 2100 Ma for the remaining data.

Smyth (1976) produced the most detailed map of the Mugford Group and identified four units, which he termed the Lower Sedimentary Unit, the Lower Volcanic Unit, the Middle Sedimentary Unit, and the Upper Volcanic Unit. He described mudflows within the Lower Sedimentary Unit that contained pebble to block-sized clasts of shale, basalt, chert and argillite and established that the quartz-feldspar porphyry dyke, which Douglas (1953) had reported to mark the unconformity between the Ramah and Mugford series, actually cut both sedimentary and volcanic rocks. Also, he described Barton's (1975) komatiitic flow as an 'ultramafic sill (?)' (page 76 of Smyth, 1974).

Smyth (1976) reported pyrite as thin laminations in shale, local chalcopyrite–pyrite veins and disseminations within the contact zone between basaltic sills (Lower Volcanic Unit) and Lower Sedimentary Unit argillites and cherts, and chalcopyrite–pyrite in veins and disseminations with posttectonic granite on the north shore of Coopers Island.

In the most recent subdivision of the Mugford Group, Smyth and Knight (1978) defined five conformable formations (Figure 2). At the base is the thin (30 m thick) Sunday Run Formation, which these authors described as consisting of lower crossbedded sandstones, pebbly sandstones and conglomerate lenses, a middle sequence of purple laminite and an upper dolostone. This unit pinches out to the southeast. The Cod Island Formation overlies the Sunday Run Formation and comprises 200 m of black shale, chert, mudstone, argillite, sandstone, tuff and agglomerate. These sedimentary rocks are overlain by the basaltic pillow lavas, flows and volcanic breccias of the Calm Cove Formation (375 m thick). Overlying the Calm Cove Formation is argillite and tuff of the 40-m-thick Shark Gut Formation. The uppermost unit is the 600-m-thick Finger Hill Formation, which consists of volcanic breccias, tuffs and diabase sills.

Lazenby (1980) described the petrography of chert from Green Cove, which she termed Cod Island Chert, a member of Smyth's (1976) Cod Island Formation. Lazenby's interest in the chert stemmed from its use by prehistoric peoples as lithic materials.

PRESENT STUDY

The Cod Island Formation, and local parts of the Sunday Run and Calm Cove formations were the predominant focus for this study. On the basis of the reports by Daly (1902), Douglas (1953) and Smyth (1976), the Cod Island Formation was deemed to have the best potential for sedimentary exhalative massive sulphide (SEDEX) mineralization; a supposition that was subsequently strengthened as a result of the new work.

In order to evaluate the metallogenic potential of the lower sequences within the Mugford Group a series of stratigraphic sections (Figure 1) were measured through the group, and all the rocks were sampled in detail. In particular, a debris flow along the northwest side of Mugford Tickle was examined upon the advice of R. Smyth (personal communication, 1992). The sections were completed at Green Cove (Section 1), the east side of Anchorstock Harbour (Section 2), East Mugford Tickle (Section 3), Southeast Mugford Tickle (Section 4), Calm Cove (Section 5), Northwest Mugford Tickle (Section 6) and Sunday Run (Section 7). These sections are illustrated on Figure 3, Sections 1 to 7. Other samples were collected throughout the basal Mugford Group and locally within the basement.

ARCHEAN BASEMENT

These rocks are quartzofeldspathic gneisses and were observed in all sections except 2 and 3. The most notable feature of these high-grade rocks is the preponderance of ultramafic patches, xenoliths and interlayers. The ultramafic segments are particularly abundant in the basement at Sections 1, 4, 5, and 6. Douglas (1953) noted the presence of a green mineral in gneisses at Green Cove that proved to be chrome mica. At Section 1 (Green Cove), two large ultramafic zones were found within the basement gneiss. One has a width of > 30 m and consisted of blocks of sheared ultramafic rocks 0.5 m to > 4 m in size that contain talc, magnesite and Cr mica. At Section 4, contorted ultramafic pods and slivers are caught up in the gneiss. The ultramafic rocks have a strong green, chrome mica alteration and near the unconformity there is intense carbonate alteration.

Near Calm Cove (Section 5) the basement consists of interlayered gneiss and ultramafic rocks. The ultramafic rocks have a strong green colouration due to chrome mica content and are generally massive with relict pyroxene crystals visible locally.

Undeformed granite is also present within the basement and is best exposed on the north side of Cooper's Island. Smyth (1976) could not define an age for this granite and simply suggested that it was posttectonic. On Cooper's Island, the granite is a coarse-grained, red potassium feldspar-rich rock. On the east side of Mugford Tickle, rare patches of red potassium feldspar and intergrown quartz are present in pillow breccias of the Calm Cove Formation. These patches may represent xenoliths of the granite caught up in the Mugford Group, and therefore suggest that the granite pre-dates the Mugford Group.

SUNDAY RUN FORMATION

This unit is only exposed on Finger Hill Island, the east side of Sunday Run (Figure 1) and on the northwest side of Cod Bag Harbour (Smyth, 1976). This study examined the unit solely along Section 7 (Figure 3) on the east side of Sunday Run. As exposed in this section, the base of the unit is black chert or black sandstone containing quartz fragments; purple laminites, the most distinctive member of this formation as described by Smyth and Knight (1978), were not observed. Regolithic weathering of the basement gneiss was not apparent below the sandstone, although the sandstone itself appears to contain weathered basement material. Conglomerate interlayers, containing round, white quartz pebbles (ca. 1 cm in diameter) are present in the sandstone and suggest a high-energy depositional environment.

The sandstone is overlain by grey-green siltstone that contains shale laminae and layers. The siltstone is in turn overlain by massive weathering dolostone and then by a silicious, possibly tuffaceous, sandstone member that has an unusual columnar jointing pattern. The dolostone also contains shale laminae, which typically exhibit ripple marks.

The silicious sandstone is overlain by an irregular breccia zone (<0.5 to 1 m thick) containing mixed basalt and sedimentary fragments. The volcanic fragments are amygdaloidal and the amygdules are filled with carbonate, quartz and/or sulphide. The mixed nature of lithotypes in this zone, and the amygdaloidal and glassy, microlite-bearing nature of the magmatic fragments, suggest that the overlying mafic igneous rock represents a flow rather than a sill.

Overlying the basalt is an enigmatic 17-m-thick layered mafic to ultramafic unit that has an upper 2-m-wide ultramafic layer having green chrome mica alteration. Small relict pyroxene (?)crystals have been weathered out of this rock.

Shales and cherty siltstone typical of the lower Cod Island Formation lie stratigraphically above the ultramafic layer.

COD ISLAND FORMATION

The lowermost members of this formation, which directly overlie the Archean basement, are lithologically variable.

Thickness varies from 10 m at Section 4 to > 150 m at Section 6, and in general, seems to increase toward the northwest. In Section 1 (the farthest east), shale directly overlies the Archean basement (although the contact is unexposed) and grades upward through massive dolostone into shale and finally pyritiferous chert immediately below the Calm Cove Formation. In Section 2, > 20 m of shale are overlain by 16.5 m of interbedded chert, breccia and siltstone. Section 3 consists of 10 m of dolostone overlain by 35 m of shale and capped by dolostone and chert.

Dolostone forms the base of Section 4 and is overlain by interlayered siltstone and dolostone and then a 1-m-thick shale bed, which in its upper 0.3 m, is interbedded with four thin seams of coal. The lower seams are only 2 to 3 mm thick and occur within a 5-cm-thick chert layer, whereas the upper seams (2.5 and 1 cm thick) are present within the shale (Plate 1). The coal seams have thin (1 to 3 mm thick) pyrite selvages. Given the presumed ca. 2000 Ma age of the Mugford Group, this coal would have to have been derived from algal material and as such would represent some of the earliest coal known worldwide.

In Section 5 at Calm Cove, chert and dolostone rest directly on Archean gneiss. Between the dolostone, chert and shale, there is > 30 m of vesicular mafic igneous rock that may represent either a flow or sill.

Section 6 passes from a basal dolostone-cemented regolith into a chert layer cut by two diabase dykes. The chert passes up into a 130-m-thick diamictite, which is capped by a 10-m-thick gossanous shale–chert layer. The diamictite consists of a poorly sorted shale matrix in which the clasts range from 5 to 7 m (Plate 2) to 2 cm in diameter. The clasts are ovoid to angular and consist of shale, gossanous shale, interlayered shale and siltstone, massive sulphide, chert, dolostone and grey, amygdaloidal basalt. The presence of bedding in the shale–siltstone clasts (Plate 3), amygdules in basalt clasts and quartz veins in chert clasts indicate that the fragments were at least partially lithified prior to incorporation in the diamictite. The chaotic and disorganized nature of the rock type seems to indicate an origin as a debris flow, possibly as the result of volcanism and associated tectonic instability represented by the overlying Calm Cove Formation.

The Cod Island Formation sections appear to indicate a significant facies change in which dolostone is prevalent at the base of the formation in the northwest, whereas shale is more typical toward the southeast. This, together with the restriction of the high-energy sandstone-conglomerate unit of the Finger Hill Formation to the northwest, suggests that the basin edge and source area lay in that direction.

The debris flow was only examined at Section 6, but the thin breccias overlying chert at Section 2 seem to be distal stratigraphic equivalents; further suggesting that the eastern and basal parts of the Mugford Group represent deeper water, more distal conditions. The restriction of basaltic flows(?) or sills to Sections 5 and 7 of the Cod Island Formation also implies a proximal magma source toward the northwest.

CALM COVE FORMATION

A continuous shoreline exposure of this unit between Sections 4 and 6 on the eastern side of Grimmington Island, was examined and sampled in detail. The unit consists of individual, 8 to 10 thick layers of columnar-jointed basalt flows, pillow basalts, and pillow breccia with 1- to 3-m-thick tuffaceous chert and siltstone interbeds. The tuffaceous beds are more common near the base and gradually disappear up through the sequence. As described by Douglas (1953), superb examples of pillow basalt occur along the coast between Sections 1 and 2; including a magnificent 6-m-diameter lava tube.

DYKES–SILLS

We found, as had Smyth (1976) previously, that Barton's (1975) komatiitic basalt from the west side of Mugford Tickle is not a flow but actually an intrusive sill. In the upper contact zone, small dykelets of the ultramafic rock invade and surround the host sedimentary rock. The fact that this ultramafic rock is not a primary flow means that it should not have been used in conjunction with volcanic rocks in Barton's (*op. cit.*) Rb–Sr age determination for the Mugford Group. The age of ca. 2100 Ma (which excludes the sill data) is therefore preferred over the composite isochron age of 2369 + 55 Ma.

Along the southeast corner of Cod Island (4 to 5 km north of Green Cove) two types of dykes cut the Archean basement and Cod Island Formation and appear to feed the Calm Cove Formation volcanic rocks. One is a 7-m-wide diabase dyke, the other a 10-m-wide quartz-feldspar porphyry dyke (previously reported by Smyth, 1976). The porphyry dyke is grey, having about 30 percent phenocrysts (80 percent plagioclase and 20 percent quartz). The feldspar phenocrysts are up to 2 cm across and the quartz crystals are 5 to 10 mm in diameter. This porphyry is different from the porphyry dyke at Green Cove as the latter is lighter in colour and contains more quartz.

Another diabasic dyke having intersertal texture and plagioclase phenocrysts up to 2 to 3 cm across was sampled on the west side of Anchorstock Harbour. Better definition of these various dykes awaits geochemical data.

STRUCTURAL GEOLOGY

Structural fabrics and attitudes were not examined in the Archean basement, but the gneisses obviously underwent significant deformation and metamorphism prior to deposition of the Mugford Group. The Archean basement, as a composite unit, is block-faulted beneath the Mugford Group, a feature that probably accounts for the local variation in thickness of the Cod Island Formation. Good examples of block faulting are visible on coastal exposures near Section 4, where a small horst appears to be developed, and on the southwest side of Finger Hill Island in Sunday Run (Plate 4). In the latter exposure, the sedimentary rocks of the Sunday Run Formation(?) drape over a normal fault scarp. An

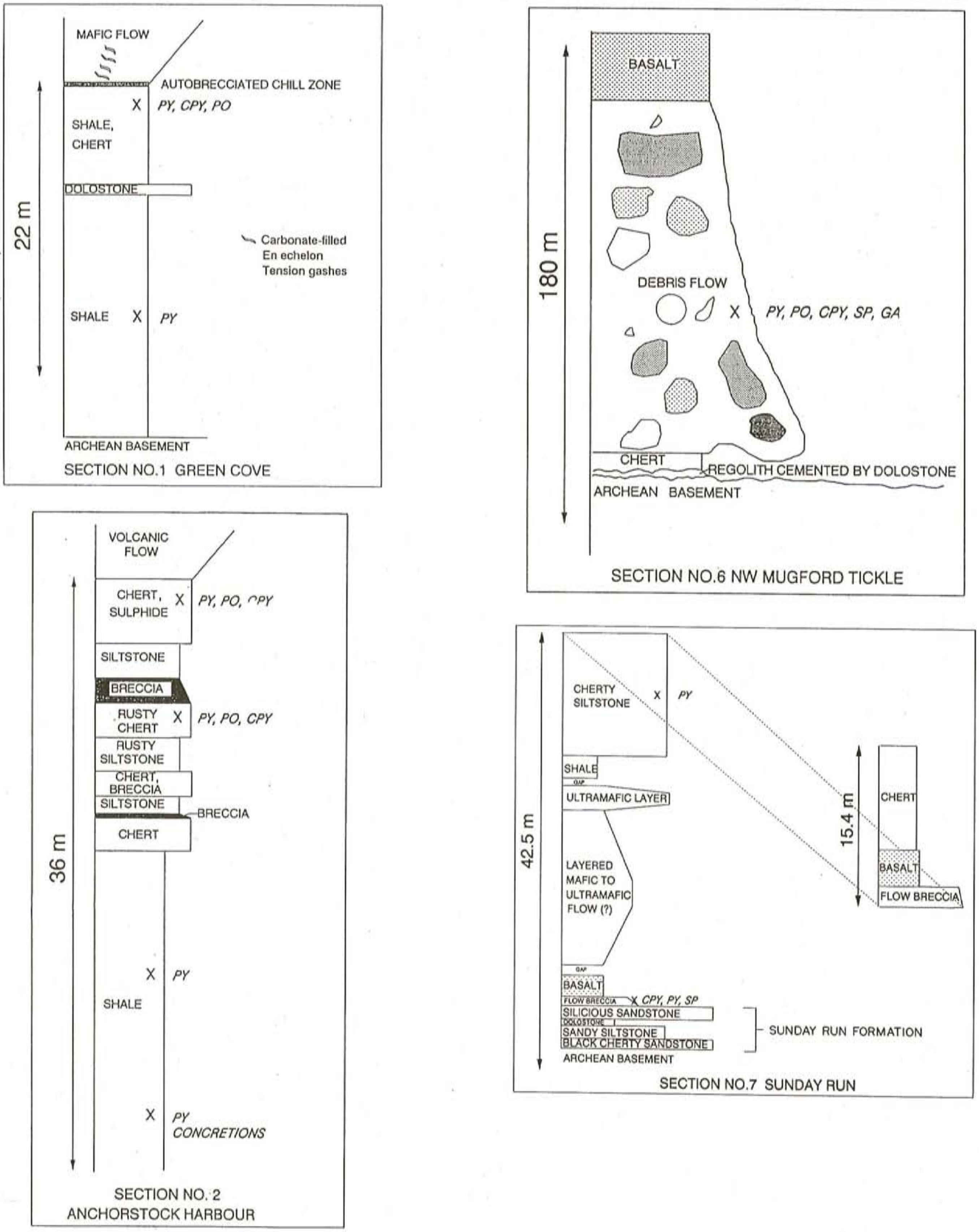

Figure 3. *Schematic stratigraphic sections through the lower Mugford Group; locations as on Figure 1. CPY = chalcopyrite, GA = galena, PO = pyrrhotite, PY = pyrite, SP = sphalerite.*

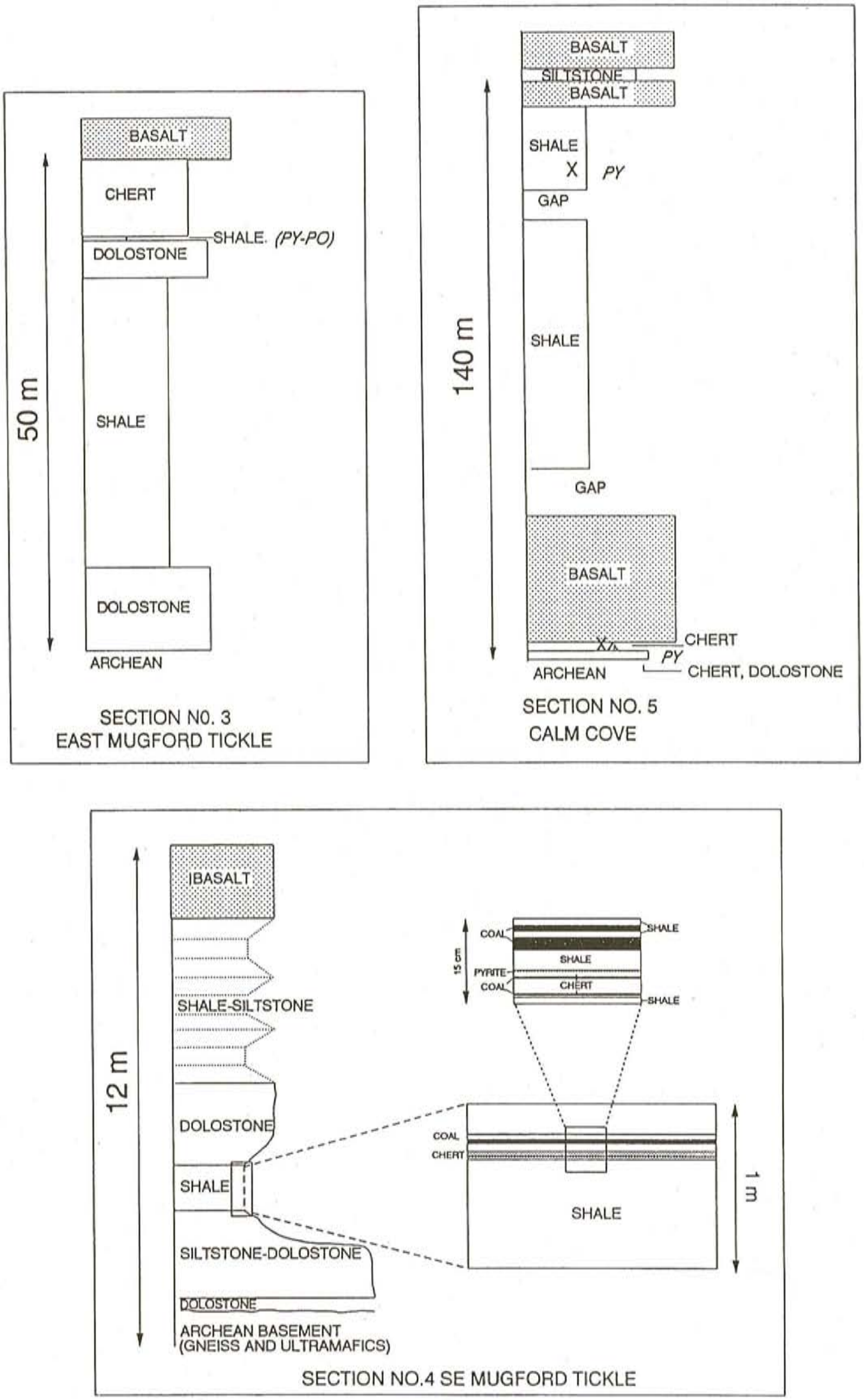

Figure 3. *Continued.*

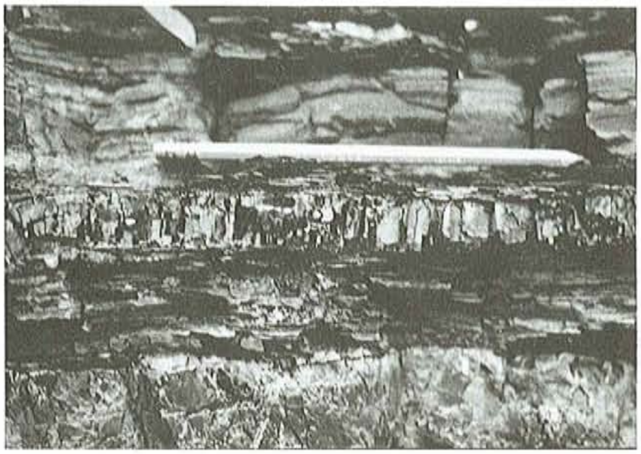

Plate 1. *Thin (2.5 cm thick) coal seam interbedded with shale, Section 4; the seam is underneath the pencil. A chert layer is present as the lower quarter of the plate.*

Plate 2. *Large gossanous shale block (underneath and to the right of Jeff) in debris flow, Mugford Tickle.*

Plate 3. *Various sedimentary rock fragments in Mugford Tickle debris flow; the layered siltstone–shale fragment (centre, layered) indicates at least partial lithification of the sediments had taken place prior to incorporation in the flow.*

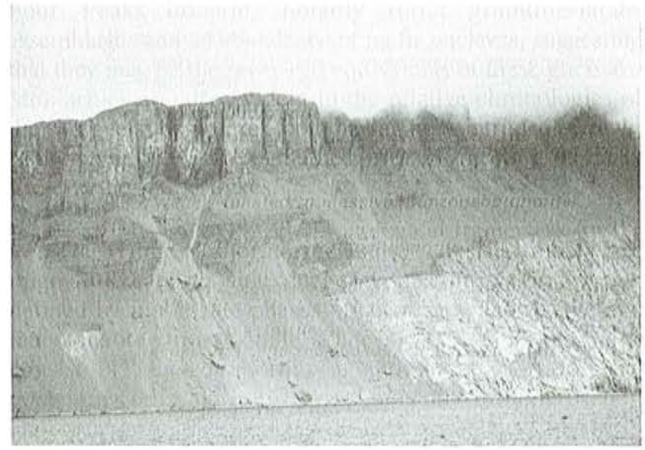

Plate 4. *Block-faulted Archean basement (white at base) and Sunday Run Formation and Cod Island Formation sedimentary rocks (layered in middle) draped over fault scarp (right centre) and volcanic rocks of Calm Cove Formation at top. Southeast side of Finger Hill Island along Sunday Run.*

argument could be made that the 'sediment draping' may actually postdate deposition of the sedimentary rocks (i.e., represents a competency contrast); in such a scenario, the present fault would have been a reactivation of a pre-existing fault structure. The essential feature is that listric faults are present in the basement.

Smyth (1976) described the Mugford Group as forming a large, open, northwest-trending syncline. The Calm Cove Formation, in general, is only minimally deformed and exhibits the broad open folds characteristic of the Mugford Group as a whole. A large fold limb in the volcanic rocks is particularly well exposed along the western side of Mugford Tickle between Sections 4 and 6.

East-facing recumbent folds are well developed in the shales and chert beds within the Cod Island Formation. A very large example of one such fold is exposed just to the southeast of Section 6 in a cliff face (Plate 5). The fold limbs are defined by shale and debris-flow layers; hence, the debris flow predates the deformation. A smaller recumbent fold in shale is displayed on the west side of Green Cove. This fold has very well-developed axial-planar cleavage (Plate 6) dipping 20/35°W from a fold axis that trends 118° and plunges 11°. A later fracture cleavage, with pyrite fillings, cuts the axial-planar cleavage at 160/55°E.

The presence of these folds in the lower sedimentary unit of the Mugford Group indicates either an earlier deformation that affected the Cod Island Formation, or reflects competency contrasts, and hence that there is a detachment (or decollement), between the massive volcanic rocks of the Calm Cove Formation and the lower layered sedimentary rocks. Because debris-flow layers containing volcanic clasts are folded near Section 6, it seems that the latter, competency contrast–detachment model, may have some validity. Further structural analyses will be needed to substantiate the relationships between the sedimentary and volcanic rocks.

Plate 5. *Large recumbent fold in shale and debris-flow layers (lower left third of plate—hinge disappears into talus); facing to east.*

Plate 6. *Recumbent east-facing fold nose at Green Cove (Section 1), note the prominent axial-planar cleavage.*

In Section 1, the lowermost portions of the Calm Cove Formation mafic volcanic rocks, immediately above the contact with lower sedimentary rocks, are transected by subvertical *en échelon* tension gashes. These gashes are filled with carbonate. The orientation of these gashes suggests a subhorizontal direction for maximum shortening (σ_1) and thus indicates the possibility of detachment between the recumbently folded sedimentary rocks and the tension gash-bearing volcanic rocks.

Sedimentary structures present within the Cod Island Formation include (1) ripple marks developed in interlayered chert and shale; in exposures at Section 3, ripples are up to 10 cm deep, (2) water-escape structures in shale defined by thin sandstone Neptunian dykelets cutting through the shale laminae, and (3) styolites developed with chert beds.

SULPHIDE MINERALIZATION

Sulphide minerals, overwhelmingly pyrite and pyrrhotite, occur throughout the Cod Island Formation and lower portions of the Calm Cove Formation. In general, sulphide occurrences can be classified into four main groups: (1) massive pyrite—pyrrhotite ($\pm$ chalcopyrite, sphalerite and galena), (2) pyrite—pyrrhotite—chalcopyrite in amygdules and other void fillings associated with volcanic rocks, (3) pyrite associated with coal seams, and (4) pyrite within shales.

The potentially most important economic occurrences are those of massive sulphide that are best seen as fragments and blocks within the debris flow at Section 6. Generally the blocks consist of massive pyrrhotite intergrown with fine pyrite and lesser chalcopyrite. Some other fragments are formed of thinly (1 to 3 mm) laminated shale and pyrrhotite ($>$ 60 percent) layers reminiscent of the type of laminated sulphide seen in sedimentary stratiform ore deposits (cf. Morganti, 1988). These blocks are large enough in places to resemble complete stratigraphic horizons within the debris flow.

Pyrite and pyrrhotite are so abundant in most shale fragments (Plate 2) that the entire debris flow has an overall rusty gossanous aspect. In most of these fragments, the sulphide seems to have formed contemporaneously with the host.

Small, very sparse ($<$ 5 to 20 mm diameter) patches of sphalerite and galena occur in the matrix adjacent to chert fragments. The sulphides have the appearance of soft components in the debris flow that were disaggregated and hence poorly preserved during mobilization of the flow.

Lead isotope ratios were analyzed for two galena separates and the data are listed in Table 1. Stacey and Kramers' (1975) model ages of 1585 and 1554 Ma for these samples are obviously much too young for ca. 2000 Ma mineralization (assuming it is syngenetic with the host rocks). The calculated μ values for the samples are, however, rather low and indicative of derivation from a uranium-depleted source; as such, the model ages are probably younger than they should be. On Figure 4, the isotope data of the Mugford samples are compared to those reported by Wilton (1991) for galena occurrences in the Moran Lake Group of the Central Mineral Belt (350 km to the south). Based on the Pb isotope data for these latter occurrences, Wilton (*op. cit.*) suggested that the lead in the galena was derived from the Archean

Table 1. Lead isotope data for galena separates from Mugford Group debris flow, Mugford Tickle, Labrador

Sample No.	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	Model* Age (Ma)	μ*
40094-001A1	15.248 ± 0.06%	15.001 ± 0.06%	34.754 ± 0.06%	1585	8.2
40094-001B	15.277 ± 0.05%	14.999 ± 0.05%	34.785 ± 0.06%	1554	8.2

* calculated using Stacey and Kramers' (1975) growth model

basement that represented a U-depleted (low μ) source. A similar case for derivation from the Archean basement can be made for the lead in the Mugford Group galena.

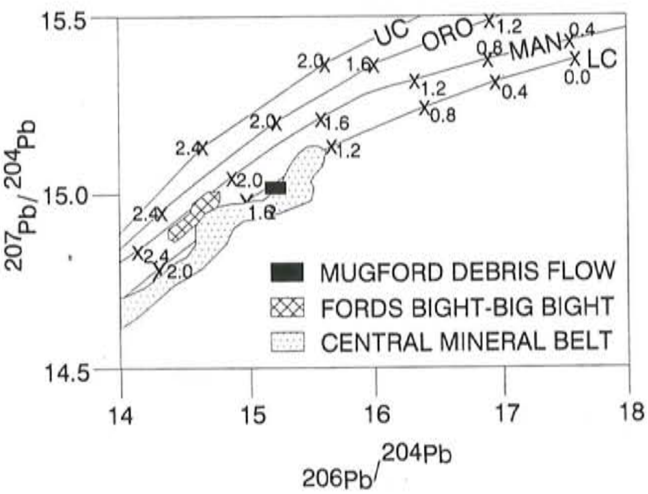

Figure 4. The *$^{207}Pb/^{204}Pb$ vs. $^{206}Pb/^{204}Pb$ isotope diagram with fields for samples from Fords Bight–Big Bight and other Central Mineral Belt data (from Wilton, 1991). Curves are Zartman and Doe's (1981) Version II plumbotectonics model; LC = lower crustal curve, MAN = mantle curve, ORO = orogene curve, and UC = upper crustal curve; numbers on curves are ages in Ga.*

Other evidence for the presence of Pb and Zn in the Mugford sedimentary basin is provided by preliminary LAM-ICP-MS analysis of coal from Section 4. These analyses indicate Pb and Zn concentrations considerably above background in the coal. Such anomalous values suggest that fluids, which flowed through the basin, and from which metals were adsorbed on the coal, contained appreciable dissolved Pb and Zn.

There are some pyritic massive sulphide horizons at Section 2. Abundant pyrite–pyrrhotite–chalcopyrite is also present as fracture-fillings within chert associated with these sulphide horizons, hence, a syn-sedimentary origin for sulphide deposition cannot be unequivocally confirmed. These cherts are presumably the jasper described by Douglas (1953).

The second type of occurrence, amygdaloidal sulphide, is well represented at Sections 6 and 7. At Section 6, grey basalt fragments contain pyrite–pyrrhotite–chalcopyrite-filled amygdules. At Section 7, along the flow-bottom breccia zone, chalcopyrite–pyrrhotite (+ sphalerite) occur within amygdules and voids.

The remaining two types, pyrite in shale and pyrite associated with coal, are locally interesting, but economically insignificant. Pyrrhotite and lesser chalcopyrite typically form intergrowths with pyrite. Superb examples of folded concretions, layers and pods are present in the lowermost shale at Section 2. The pyrite exhibits well-developed replacement textures of the shale, resembling microfluid fronts.

On the northeast corner of Coopers Island, the undeformed granite within the Archean basement contains quartz-vein sets containing abundant cubiform pyrite ± chalcopyrite and thin pyrite stringers. The veins and stringers have a general 188° trend and a near vertical dip. Individual quartz veins are up to 5 cm wide and also contain tourmaline crystals and possible rare fluorite. The veins may be magmatic–hydrothermal in origin.

CONCLUSIONS

The Sunday Run Formation forms the base of the Mugford Group and is composed of sandstone and conglomerate, probably representative of a high-energy depositional environment. The unit is only present under the northwestern edge of the Mugford Group.

The Cod Island Formation comprises various sedimentary rocks including shale, chert, siltstone and dolostone. The basal sedimentary rocks seem to define a lateral facies change from dolostone dominated in the northwest to siltstone dominated in the southeast. This facies variation suggests that the source region for detritus shed into the lower Mugford basin lay to the northwest and that the basinal margin was likewise in this direction.

Thin seams of coal are interbedded with chert and shale at one locality near Mugford Tickle. Based on the suggested ca. 2000 Ma age of the host rocks, these coal horizons must have been derived from algal material and represent some of the oldest known occurrences of such material.

A debris flow exposed along the west side of Mugford Tickle contains fragments of gossanous shale, amygdaloidal basalt, chert, and massive sulphide (pyrrhotite–pyrite). Distal equivalents of this debris flow are present 14 km to the southeast on the eastern shore of Anchorstock Harbour. These flows indicate periodic basinal instability within and during the depositional environment and also the probability of an eruptive/exhalative centre somewhere toward the northwest.

Sulphide occurrences range from secondary open-space fillings and shale replacements to syn-volcanic massive sulphide mineralization. Very rare galena and sphalerite have been observed within the massive sulphide material. The massive sulphide blocks are presumably fragments of more extensive exhalative sulphide horizons developed on the basin-floor.

The basement rocks exhibit block faulting and listric faults over which sedimentary rocks are draped. These faults could have provided the conduits for the circulation of basinal brines and as such may be analogous to equivalent structures described for SEDEX models (e.g., Large, 1983).

Taken altogether, these observations suggest that the Mugford Group may have some considerable potential as a SEDEX target, especially if the source region of the massive sulphide material can be ascertained.

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