GEOLOGY AND MINERAL DEPOSITS OF THE LUSHS BIGHT GROUP, NOTRE DAME BAY, NEWFOUNDLAND

by

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Abstract

Geological mapping in the Lushs Bight Group has shown that the Group is divisible into a number of fault-bounded blocks. Within these blocks, the group can locally be subdivided into different stratigraphic and/or lithological units. The major stratigraphic subdivisions are sheeted dikes and mafic pillow lava.

The stratigraphic top of the Lushs Bight Group is marked locally by hematization and the occurrence of interpillow jasper and jasper lenses with common magnetite. This is overlain by a distinctive unit of chocolate brown argillite and minor interbedded red chert.

The Lushs Bight Group is involved in regionally developed, northeast trending folds with an associated axial planar foliation. These structures are folded around open folds, flexures and kinks with a north striking axial plane.

Sulfide mineralization in the Lushs Bight Group is syngenetic and occurs as disseminations and stringers and as massive sulfides. It occurs at different stratigraphic levels and in different lithologies. The mineralization is discussed under four major headings: (1) in the sheeted dikes, (2) near the sheeted dike - pillow lava interface, (3) within pillow lava and intercalated pyroclastics at an assumed higher stratigraphic level, and (4) in sediments at the top of the Lushs Bight Group.

Introduction

This report summarizes the results of the second field season of a project designed to investigate the regional geology and mineral deposits of the Lushs Bight Group. The reader is referred to Kean (1983) for a summary of the results of the first year. The objectives of this project are to establish a stratigraphic and structural framework for the Lushs Bight Group, to study the deposits in the area, to evaluate their economic significance, and to develop a model that will be useful in the search for economic mineral deposits.

Access to the area is from the Trans Canada Highway via the Springdale, King's Point, Little Bay and Robert's Arm roads, and via boat from any of the coastal communities. Bedrock exposure along the coast is excellent and nearly continuous; elsewhere, it is good to poor.

Much of the area was extensively mapped and explored by BRINEX during the 1960's and early 1970's. Several thesis studies (e.g. Donohoe, 1968; Fleming, 1970; Marten, 1971a; DeGrace, 1971; West, 1972; Kean, 1973; O'Brien, 1975) supported by BRINEX have been done on the area and these add to a voluminous data base. Espenshade (1937), MacLean (1947), Neale et al. (1960) and Williams (1962) produced regional maps of the area, and Dean and Strong (1975) compiled the geology of the area on a scale of 1:63,360.

Despite this large amount of earlier work, the Lushs Bight Group has generally been mapped as an undivided sequence of pillow lava, chlorite schist and basic intrusive rocks. Consequently, the main objective of this project has been to elucidate the stratigraphy and structure of the Lushs Bight Group and to establish whether the stratigraphy and/or structure has any control on mineralization in the group.

The main findings of the 1983 field season are the following:

(1) A distinctive unit of chocolate brown argillite and common jasper marks the stratigraphic top of the Lushs Bight Group.

(2) Banded pyrite, pyrrhotite and magnetite are commonly interbedded with these sediments.

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(3) Rocks assigned to the Lushs Bight Group on Pilley's and Triton Islands are lithologically different from the Lushs Bight Group elsewhere and are, therefore, removed from that group.

(4) The volcanic rocks of the Lushs Bight Group are locally subdivisible into different lithological units.

(5) Sheeted dikes are widespread in the Lushs Bight Group; several new areas of dikes were discovered.

(6) The sequences on Pilley's and Triton Islands display monoclinal folding.

(7) Highly variolitic and quartz amygdaloidal pillow lavas are generally associated with mineralization.

(8) Sulfide mineralization occurs in chlorite schist derived from pillow lava and/or intercalated tuff.

(9) Most sulfide mineralization occurs as disseminations and stringers; banded or bedded sulfides occur in a few showings.

Regional Geology

The regional geology of the Springdale Peninsula was previously described by a number of workers, including MacLean (1947), Williams (1962) and Peters (1967). The area is also included in a 1:250,000 scale geological compilation of the Newfoundland Central Volcanic Belt (Kean, 1977). Dean (1978) summarized the regional geology of Notre Dame Bay, including the map area. The following discussion is adapted from Kean (1983).

The Lushs Bight Group occurs in western Notre Dame Bay, north of the Lobster Cove Fault. It outcrops between Southwest Arm in the west and Badger Bay in the east. It is faulted against the Silurian-Devonian Springdale Group and the Ordovician-(?)Silurian Roberts Arm Group along the Lobster Cove Fault to the south. Local outliers of the Springdale Group occur within the Lushs Bight Group north of the Lobster Cove Fault. These rocks are generally fault-bounded; however, an unconformity may exist on the Lushs Bight Group in the Davis Pond area (McGonigal, 1970). The Lushs Bight Group is conformably overlain by the Lower Ordovician Western Arm Group and, presumably, by the Lower Ordovician Catchers Pond Group to the north and west. It is faulted against the Cutwell Group on the northeast coast of Sunday Cove Island. This fault is presumed to continue underwater between Long Island and Pilley's Island and to juxtapose these groups in that area.

The Lushs Bight Group is considered to be of ophiolite affinity. However, as defined by Espenshade (1937) and used by MacLean (1947), it also included sedimentary and volcanic rocks now considered to be of island arc affinity. These rocks were subsequently assigned to the Western Arm Group (Marten, 1971a,b) and the Cutwell Group (Kean, 1973, 1983). Thus, the group now includes only mafic pillow lava, breccia and agglomerate, sheeted diabase dikes, gabbro dikes and sills and small bodies of ultramafic rock of ophiolite type. These rocks are low potash tholeiites with chemical similarities to modern oceanic crust (Papezik and Fleming, 1967; Smitheringale, 1972; Strong, 1973).

The Lushs Bight Group is folded into major northeast trending folds with the limbs displaced or cut off by northeast trending wrench faults. Later deformation resulted in folding about a north-south axis, resulting in southeast strikes.

The Lushs Bight Group is intruded by various bodies of probable Ordovician age, including the Colchester Pluton, the Cooper Cove Pluton and many small stocks and plugs interpreted to be contemporaneous with volcanism. It is also interpreted to be intruded by the Brighton Gabbro Complex, which gives an $^{40}Ar/^{39}Ar$ radiometric age of 495 ± 5 Ma (Stukas and Reynolds, 1974). A Late Cambrian age is thus suggested for most of the group.

MacLean (1947) reported a single Lower Ordovician brachiopod, *Discotreta* sp., from the lowermost part of the conformably overlying Western Arm Group.

The Lushs Bight Group and overlying volcanic sequences are correlative on the basis of age and stratigraphy with the Snooks Arm Group, which includes the Betts Cove ophiolite. The two sequences are interpereted to lie on opposing limbs of a major syncline.

Lushs Bight Group

General Statement

Geological mapping conducted during this project has shown that the Lushs Bight Group is divisible into a number of fault-bounded blocks (Figure 1). Within these blocks, the group can be subdivided into scanned image

LEGEND

Carboniferous

14 Reddish brown to greyish red conglomerate and sandstone; grey shale and siltstone and minor limestone.

Silurian to Devonian

SPRINGDALE GROUP (Unit 13)

13 Red and brown conglomerate, sandstone and siltstone; minor volcanic rocks.

12 Pink to red granite, granodiorite and quartz-feldspar porphyry.

Ordovician or Silurian

ROBERTS ARM GROUP (Unit 11)

11 Undivided mafic and felsic volcanic rocks.

Lower to Middle Ordovician

10 10A, Colchester Pluton: medium grained diorite, quartz diorite and minor granodiorite. 10B, Coopers Cove Pluton: fine to coarse grained diorite, granodiorite and granite, common diabase. 10C, Wellmans Cove Pluton: medium grained diorite and quartz diorite with mafic and ultramafic inclusions. 10D, Bob Head Pluton: medium to coarse grained diorite, gabbro and quartz monzonite.

WESTERN ARM/CUTWELL GROUPS (Unit 8)

8 Massive and pillow basalt and andesite, locally feldsparphyric. Lithic and pyroxene crystal-lithic tuff, lapilli tuff, breccia and agglomerate. Epiclastic and sedimentary rocks.

9 Highly vesicular pillow basalt and feldsparphyric andesite. Lithic and pyroxene crystal-lithic tuff, lapilli tuff and breccia. Interbedded red and green argillite and tuff.

CATCHERS POND GROUP (Unit 7)

7 Silicic lava, agglomerate and tuff; massive basalt, pillow lava and agglomerate; thin beds of fossiliferous limestone and limestone conglomerate.

Lower Ordovician and Earlier

LUSHS BIGHT GROUP (Units 1-6)

6 Brighton Gabbro: medium to coarse grained, hornblende clinopyroxenite, hornblendite, gabbro, diorite and quartz diorite.

5 Black, locally hematitized, pillow lava with common interpillow and lenses of jasper. Overlain by thinly bedded, chocolate-brown argillite and interbedded red chert.

4 Thinly bedded, grey green and black, mafic tuff and volcanic sediment; minor red argillite and chert. Magnetite lenses and magnetite rich tuff locally present.

3A Fine grained to aphanitic, gray to green, epidotized, pillow lava with common diabase and gabbro dikes.

3B Fine grained to aphanitic gray to green, commonly epidotized pillow lava with extensive pillow breccia and isolated pillows in places. Intercalated mafic tuff, locally extensive.

3C Fine grained to aphanitic, gray to green, commonly epidotized pillow lava and extensive chlorite schist; highly variolitic and quartz amygdaloidal in places. Mafic agglomerate, breccia and tuff; minor dacitic rocks. Extensive diabase dikes in places and locally sheeted.

2A Fine grained to aphanitic, gray-green to green, epidotized pillow lava with extensive diabase and gabbro dikes. Minor agglomerate and breccia. Chlorite schist extensive in places.

2B Undivided sheeted dikes and pillow lava with extensive dikes; locally variolitic. Minor mafic agglomerate, breccia and tuff. Minor dacitic rocks.

1 Sheeted diabase dikes; locally with gabbro and pillow lava screens.

Variolitic and quartz amygdaloidal pillow lava

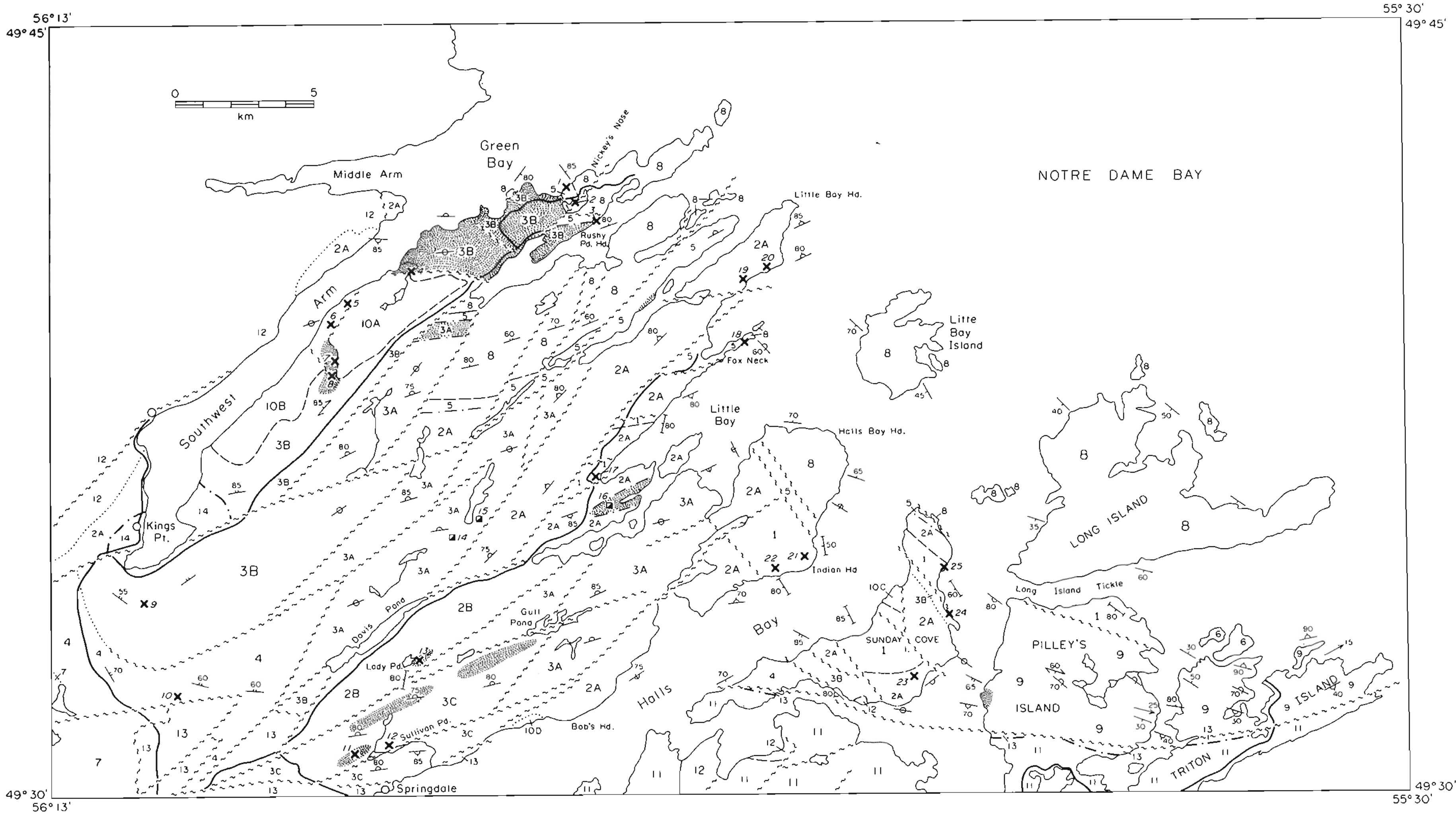

Figure 1: *Simplified geological map of the Lushs Bight Group, Notre Dame Bay, Newfoundland.*

different stratigraphic units and/or different lithological units. The major subdivisions are sheeted dikes (Unit 1) and mafic volcanics (Units 2 to 5). The most common rock type is fine grained to aphanitic, gray-green and green pillow basalt. The volcanic rocks, locally, can be subdivided into different stratigraphic and/or lithologic units. Pillow lava with extensive diabase dikes and dikes with pillow screens constitute Unit 2A. Unseparated areas of sheeted diabase dikes and pillow lava with diabase dikes are included in 2B.

The stratigraphic position of Unit 3 is not clear; it may in part be equivalent to Unit 2. It is lithologically subdivided on the basis of the presence of extensive pillow lava with common diabase and gabbro dikes (Unit 3A), extensive pillow breccias (Unit 3B), and/or extensive intercalated mafic tuff (Unit 3C). Unit 4 consists mainly of mafic tuff, agglomerate and volcaniclastic sediments with intercalated pillow lava.

The mafic volcanics (Unit 5) at the top of the Lushs Bight Group are generally black rather than the usual green color, are often hematized and contain common interpillow jasper, jasper lenses and locally magnetite lenses. The mafic volcanics are overlain by a distinctive unit of thinly bedded, chocolate brown argillite and red chert. These sediments are in turn overlain by green-gray and yellow-green tuff, argillite and pyroxene crystal tuffs (see also Kean, 1983).

Areas with extensive variolites and quartz amygdules are shaded on the map.

The sequence north of the Lobster Cove Fault on Pilley's and Triton Islands consists of pyroclastic rocks with intercalated vesicular pillow lava (Unit 9), and is lithologically different from the main portion of the Lushs Bight Group. This sequence is lithologically and stratigraphically similar to the rocks of the Cutwell and Western Arm Groups (Unit 8).

The rocks of the map area have been folded about northeast trending axes. These early or first phase(?) structures have been openly folded or kinked about north trending axes, resulting in southeast strikes. North facing monoclinal folding is developed in the sequences on Pilley's and Triton Islands. Major northeast trending faults cut the major fold structures.

The present large area of exposure is a result of structural repetitions, the true thickness of the Lushs Bight Group is probably between 3 and 4 km.

Lithologies of the Lushs Bight Group

Unit 1 - Sheeted Dikes

Sheeted diabase dikes occur in the Little Bay and Indian Head areas, along the west side and at Paddox Bight on the east side of Sunday Cove Island, and along the north coast of Pilley's Island. Areas entirely underlain by dikes also occur north of St. Patricks in the Lady Pond area, and east of the Little Bay road.

The dikes trend slightly east of north with slight variation, and dip to the west. Pillow and gabbro screens are locally present.

The sheeted dikes average 0.5 m thick and vary from less than 0.25 m to 2 m thick. The sheeted dikes consist predominantly of diabase with common gabbroic dikes and rare dikelets of aphanitic diabase (basalt) less than 2 cm in width. The diabase dikes are fine to medium grained, green and equigranular.

The gabbro dikes are medium grained, equigranular and locally porphyritic. Dikes completely replaced by epidote are locally present. The dikes generally display chilling on one margin, but locally both margins are chilled against gabbro screens and larger gabbro dikes. The dikes generally grade into areas of dikes with pillow screens and, in the Little Bay area, into pillow lava with extensive dikes. Dikes along the west shore of Sunday Cove Island, in particular the northern unit, are highly schistose and are often chlorite schist. Variolites are locally developed in the dikes.

The sheeted dike zones commonly develop rusty weathering scree slopes because of the abundant disseminated pyrite in them.

Unit 2 - Pillow Lava and Diabase Dikes

In places, this unit can be demonstrated to directly overlie the sheeted dike unit with a gradational contact. The unit then varies from dominantly sheeted dikes with pillow lava screens at its base to pillow lavas with extensive to common dikes at higher stratigraphic levels. These rocks are assigned to Unit 2A.

Extensive dikes in pillow lava characterize the Little Bay Head and north side of Little Bay areas. In the Little Bay Head area, there are sections more than 50 m thick that consist of multiple intrusions of medium grained gabbro and diabase dikes which are individually as wide as 2 m. Locally, these extensive dike sections are sheeted, i.e. they possess one chilled margin. The dikes strike slightly east of north at a high angle to the enclosing pillow lava.

The area between Lady Pond and the Little Bay road consists of pillow lava and associated tuff with common to extensive diabase dikes and extensive areas of sheeted dikes. These rocks are unseparated on the accompanying map and are indicated as Unit 2B. Fine grained to aphanitic, cleaved, green dacitic tuff also constitutes a minor portion of this subunit.

The pillow lavas in Unit 2 are fine grained to aphanitic, green to gray-green and equigranular. They are variably epidotized, commonly with their cores completely replaced by epidote and enveloped by chlorite schist. There are local areas where chloritic alteration predominates, in particular in shear zones. Quartz and calcite veining is common. The pillows are characterized by thin rims and are generally nonvesicular. They are closely packed, and interpillow material is minor, although locally white, gray, green and red interpillow chert is present, in particular, near the Little Bay and Sleepy Hollow mines. Interpillow aquagene tuff is rare. Minor breccia, pillow breccia and agglomerate occur intercalated with the pillow lava. The pillows vary in size from 15 cm to 1 m and in shape from round to elliptical. They are commonly flattened and moderately elongated in the plane of deformation. In the shear zones, the pillow lavas become chlorite schist, often enveloping epidote knots. Quartz, calcite and epidote veins are common. Quartz veining is locally extensive.

Whitish green, leached and silicified pillow lava and minor breccia occur on the coast along strike from the Little Bay and Sleepy Hollow mines.

Rocks constituting Unit 2B consist of sheeted dikes similar to Unit 1 and pillow lavas and dikes similar to Unit 2A. Chlorite schist is common as is mafic tuff, agglomerate and breccia. Fine grained green dacitic (field term based on estimated SiO_2 content) tuff is locally present, particularly near the Lady Pond prospect. Magnetite chert and rare magnetite lenses are also present in this area.

Varioles and quartz amygdules are extensive in the pillow lavas in places, particularly in areas of sulfide mineralization. The variolites are altered to epidote and disseminated throughout the pillows but are locally concentrated either in the cores or near the rims of the pillows. In places, they are up to 1 cm across.

The related dikes are fine to medium grained, green, equigranular diabase and gabbro. Epidote veins and patches are scattered throughout. The dikes vary from a few centimetres to about 2 m wide. They are commonly highly pyritic. The dikes are generally boudinaged in the shear zones.

Unit 3 - Pillow Lava, Pillow Breccia and Tuff

Unit 3 is subdivided into a sequence of dominantly pillow lava with common diabase and gabbro dikes (Unit 3A), a sequence of pillow lava, isolated pillows and pillow breccia and tuff (Unit 3B), and a sequence of pillow lava with intercalated tuff and common chlorite schist (Unit 3C). The exact stratigraphic position of Unit 3 is not clear.

Unit 3A does not differ substantially from Unit 2A and the distinction is arbitrary in many places. The unit is probably in part equivalent to Unit 2A. There generally appear to be fewer dikes of diabase and gabbro (see also Fleming, 1970); however, in the St. Patricks area, massive flows and large gabbro dikes and sills are common. The unit generally grades into the "black facies" of Marten (1971a,b) and minor red chert is locally present.

The pillow lavas are gray to green, fine grained to aphanitic and locally medium grained. They are generally epidotized, with the epidote occurring as veins, veinlets, patches and commonly completely replacing the pillow cores. The pillows vary in size from 15 cm to 1 m across and are closely packed. Small interpillow pillows and pillow fragments are common. Gray and whitish green chert is locally common, in particular northeast of the Whalesback mine. The pillows are generally nonvesicular, nonamygdaloidal and nonvariolitic. Minor variolitic variations occur over the Whalesback mine and locally along the north side of Little Bay.

In the St. Patricks area, fine to medium grained, green, equigranular mafic flows with poorly developed pillow structures are intercalated with the pillow lava. Numerous gabbro dikes and sills 1 to 40 m wide are common. These rocks consist of saussuritized yellow-green feldspar and a chloritized mafic mineral. Locally vesicular and scoriaceous zones are developed. Fine grained diabase dikes intrude these rocks. Feldspar porphyritic dikes are locally present.

The associated gabbro and diabase dikes and sills are fine to medium grained, green and equigranular. Minor feldspar-phyric phases are present.

Porphyritic dikes are locally common in this unit, in particular in the Whalesback - Little Deer mines area. They can be classified into four types containing phenocrysts of feldspar, amphibole and feldspar, and pyroxene in a green, aphanitic matrix. The dikes vary in width from several centimetres to several metres and trend generally either northwest or slightly east of north.

The pillow lava sequence (Unit 3B) exposed south of King's Point and along Southwest Arm is characterized by extensive pillow breccia and isolated pillow units and thin units of finely bedded mafic tuff and minor agglomerate. Altered and silicified pyroclastic breccia is present in the McNeily propect area (#8 on map). The sequence along Southwest Arm is characteristically highly variolitic. Numerous diabase and gabbro dikes intrude the sequence.

Mafic volcanics of Unit 3C consist of pillow lava, locally variolitic and rich in quartz amygdules, or vesicular chlorite schist and locally sheeted diabase dikes. The pillow lavas are aphanitic to fine grained, green, closely packed and commonly have associated breccia and tuff. Rare jasper is present. Within this unit there are extensive areas of fine grained, highly cleaved, green mafic volcanics and/or chlorite schist. In places, bedding is obvious and the rock is probably tuff. In other areas, in particular north of Springdale, it is hard to determine the protolith. Green dacitic tuff is locally present, in particular in the area west of the Sterling prospect (#11 on map).

Diabase and gabbro dikes are common in this unit. Aphanitic, green, felsic dikes are also locally common.

Unit 4 - Tuffs and Pillow Lava

Bedded mafic tuffs predominate in Unit 4. They are gray, green and black in color and fine grained. Black and red argillite beds are locally interbedded with the tuffs. Red chert lenses are locally present. Gray magnetite-rich cherts and magnetite lenses are present in places, in particular in the area south of King's Point. Gray, aphanitic to fine grained pillow lavas are intercalated with these rocks.

Graded bedding and crosslamination are locally developed, and the unit appears to interdigitate with pillow lavas of Unit 3A to the east. The contact with Unit 3B is interpreted to be a fault; however, the unit is also considered to be at a higher stratigraphic level.

Unit 4 on Sunday Cove Island consists of red and green argillite, green sandstone and mafic tuff. Thin pillow lava units are intercalated with the sediments.

Rocks of this unit resemble the sequence overlying the Lushs Bight Group and should perhaps be considered a part of it.

Unit 5 - Pillow Lava and Argillite

The top part of the Lushs Bight Group is characterized by black, fresh or chloritic, commonly hematized, pillow lava with common to extensive jasper lenses and interpillow jasper. These features are irregularly developed in the upper part of the group; although they indicate the top of the group, they are not restricted to a stratigraphic unit. Immediately overlying this sequence, there is a distinctive sequence of chocolate brown argillite and minor interbedded red chert of about 50 m thickness. Pyrite-, pyrrhotite- and magnetite-rich black argillite is commonly interbedded with this sequence, in particular near the top of the sequence. Pyroxene crystal - lithic tuff and well bedded green, gray and yellowish sediments and tuff overlie the chocolate brown argillite and are assigned to overlying volcanic sequences.

Overlying Volcanic and Sedimentary Sequences (Units 7, 8, 9, 11, 13 and 14)

The Lushs Bight Group is directly overlain by pyroclastic and extrusive volcanic rocks of the Catchers Pond (Unit 7) and Western Arm / Cutwell Groups (Unit 8). These rocks were thoroughly described by Marten (1971a,b) and Kean (1973) and will not be discussed here. However, many of the rocks underlying Pilley's and Triton Islands and previously assigned to the Lushs Bight Group are herein considered to be part of the overlying volcanic sequences. This unit (Unit 9) is as yet unnamed. It consists of large, bulbous and highly vesicular, black pillow basalt and lesser amounts of feldspar-phyric green pillow andesite. The lower pillow basalts of the unit contain extensive interpillow red chert and breccias rich in red chert. Sequences of intermediate composition, green breccia, lapilli tuff, and tuff grading upwards into well bedded green and red argillite are interbedded with the pillow lavas.

The Roberts Arm Group (Unit 11) is in fault contact with the Lushs Bight Group. The Springdale Group (Unit 13) and the Carboniferous sedimentary rocks (Unit 14) unconformably overlie the Lushs Bight Group.

Intrusive Rocks

Unit 6 - Brighton Gabbro

A small patch of the Brighton hornblende gabbro complex intrudes sheeted diabase dikes of the Lushs Bight Group on the east coast of Pilley's Island; however, the main exposures occur on Brighton Island and the smaller surrounding islands.

This unit is generally a very coarse grained hornblende gabbro with a complex history of multiple intrusion, with each phase being progressively less mafic. It is generally interpreted to be related to the ophiolitic magmatism.

Units 10 and 12 - Gabbro, Diorite and Granite

A number of bodies assigned to Unit 10 are intrusive into the Lushs Bight Group. They are considered to be of pre- Middle Ordovician age and comagmatic with the overlying Ordovician volcanic sequences. They vary in composition from gabbro and diorite to granodiorite and minor granite. They contain xenoliths and rafts of ultramafic rock varying in size from a few centimetres to >100 m.

Granitoid rocks (Unit 12) intrude the Lushs Bight Group and probably range in age from Silurian to Devonian. They consist of pink and red granite, alaskite, granodiorite and quartz-feldspar porphyry.

Structure

Early Structures

The Lushs Bight Group contains a single foliation which trends to the northeast or to the southeast and dips steeply, generally to the northwest or northeast. This fabric is commonly nonpenetrative in the pillow lavas where it is restricted to the pillow margins or the interstices. It is an L-S fabric associated with a steep stretching lineation and is defined by fine grained chlorite and fibrous amphibole. This foliation is axial planar to the regionally developed folds.

In the Pilley's Island and Triton Island areas, shallow northeast to southeast plunging folds with steep, locally overturned, northerly limbs and flat lying to shallowly south dipping limbs are well developed. These monoclinal folds are also considered to be related to the main deformation.

Chlorite schist shear zones are widely developed in the Lushs Bight Group. They form elongated or lenticular zones, from a few metres to more than 100 m wide, of coarse chlorite schist. These zones of chlorite schist pass into the normally weakly deformed host rocks with gradational contacts. This gradation occurs over a distance of one metre to tens of metres depending on the width and intensity of the shear zone. The rocks in these shear zones are totally schistose so it is generally difficult to determine the protolith. Dikes in these zones are transposed into the plane of deformation and in places boudinaged. The schist zones are not lithologically controlled, although they parallel stratigraphy, and are both mineralized and barren. However, the schist zones are generally more highly pyritized than the country rocks.

The intensity of deformation and the development of chlorite schist zones gradually die out to the east, i.e. higher in the stratigraphy.

Kennedy and DeGrace (1972) demonstrated that the foliation in the chlorite schist zones is a composite fabric derived by folding and transposition of an earlier chlorite foliation. They further demonstrated that the chlorite schist zones resulted from the superimposing of a homogeneous deformational fabric on an older inhomogeneously developed fabric in shear belts. The regionally developed foliation in the Lushs Bight Group is thus the result of a second deformation (D_2).

Marten (1971b) mapped a series of faults having sinistral displacements subparallel to the regional foliation in the Western Arm area. He interpreted them to be slides related to the regional deformation. Kennedy and DeGrace (1972) also noted gently inclined faults, parallel to the trend of the regional formation, separating various units of the Lushs Bight Group in the King's Point area. Similar faults can be seen in the Lushs Bight Group in the study area.

Late Structures

Crenulations of the regional foliation (S_2) are present locally. These crenulations are folded by kinks/flexures and by major open folds. The axial planes dip steeply and trend approximately north-south. They are steeply plunging. The open folds do not affect the kinks/flexures and are interpreted to be contemporaneous with the kinks. These kinks/flexures and open folds are best developed in the chlorite schist zones, where they fold the schist. The regional structure (fabric and folds) is also folded about these late folds; this accounts for the change in regional trends from northeast to southeast.

A number of postfolding major faults transect the Lushs Bight Group in this area. The most prominent are the Deer Pond Fault, the Little Deer - Davis Pond Fault system, the Gull Pond Fault and the Sullivan Pond Fault. Numerous splays and subsidiary faults are related to these. Similar faults in the Western Arm area are believed to have mainly dextral strike-slip movements because of their large horizontal components, straightness and lateral continuity (MacLean, 1947; Marten, 1971b). Similar dextral strike-slip movement is inferred for the faults in this area on the basis of evidence along the Davis Pond Fault and the 4 km dextral offset of the Lobster Cove Fault (MacLean, 1947; Neale and Nash, 1963); however, a component of dip-slip movement is also present. Many of the faults appear to have removed the axial zones of the major folds in the region. Narrow, less intense shear zones, breccia zones and brown carbonate breccia zones accompany the faulting.

Metamorphism

The Lushs Bight Group is characterized by epidote alteration which commonly completely replaces the cores of the pillow lava. This alteration predated or accompanied the regional deformation. It decreases upwards in the sequence and generally dies out near the top of the Lushs Bight Group, which is generally characterized by black, commonly hematized basalt, with epidote occurring only as minor veins and irregular patches.

Marten (1971a,b) referred to the two different types of lava within the Lushs Bight Group as the "main facies" and the "black facies". The "main facies" is composed of green and gray-green, epidotized mafic lavas and is characteristic of the lower parts of the Lushs Bight Group. The "black facies" is composed of black, fresh to chloritic lava with epidote as veins and irregular patches. It is concentrated in the upper parts of the Lushs Bight Group but has no formational status. Marten (1971b) suggested a correlation with the "Whalesback type" and "St. Patricks type" lava divisions, respectively, proposed by Papezik and Fleming (1967) for the volcanic rocks in the Whalesback mine area.

Studies of metamorphism in ophiolites (e.g. Spooner and Fyfe, 1973) indicate that the intense alteration and metamorphism of lower pillow lava units prior to deposition of upper pillow lava units is a common phenomenon. This is postulated to result from subseafloor hydrothermal metamorphism at active spreading ridges. The alteration facies developed in the Lushs Bight Group is thus interpreted to be a 'primary' alteration feature developed during the formation of the ophiolite.

Metamorphism related to the regional deformation was mainly limited to growth of chlorite and fibrous amphibolite along the foliation. It decreases upwards in the stratigraphy and had little effect on the overlying sequences.

Mineralization

The Lushs Bight Group contains more base metal sulfide showings per square kilometre than any other group of rocks in Newfoundland (Dean, 1978). The group has been extensively prospected, and has seen the development of two mines, Little Bay and Whalesback, and about two dozen prospects.

The many deposits differ greatly in size but most have several features in common which were noted by earlier workers. All are roughly ellipsoidal, with their long axes approximately coplanar with bedding. They occur almost exclusively in chlorite schist shear zones developed in pillow lavas (Peters, 1967) and associated tuff. These zones of schist and parallel sulfide lenses are conformable with the stratigraphy. They consist mostly of pyrite with lesser amounts of chalcopyrite, pyrrhotite and sphalerite and minor values of gold and silver.

Douglas et al. (1940) and MacLean (1947) considered the deposits to be replacements of chlorite schist in the shear zones during the late stages of faulting, and thus to have a common origin. MacLean also suggested a genetic relationship between the sulfides and granodiorite in the area. Williams (1963) concluded that a genetic relationship to volcanism might exist but that the final emplacement and distribution of the sulfides postdated the volcanism and resulted from structural deformation. Kanehira and Bachinski (1968) concluded that the sulfide mineralization at least in part predated deformation and metamorphism but also must have postdated the volcanism. West (1972) concluded that the mineralization at the Little Deer mine was postvolcanic.

Kennedy and DeGrace (1972) considered the deposits to predate the main regional deformation (D_2) because pyrite bands are commonly folded about the associated folds and chalcopyrite is concentated in fold hinges. In the Whalesback area, the sulfides are cut by the predeformation porphyry dikes (Fleming, 1970). Kennedy and DeGrace (1972) observed that, in most showings, banding resembling layering is present and that, with the exception of the Whalesback and Little Bay mines, the deposits occur in layered tuffaceous rocks. They thus concluded that the mineralization was synvolcanic.

Twenty-one volcanogenic sulfide showings and prospects visited during the 1983 field season are described in this report. They are described under four headings: (1) in the sheeted dikes; (2) near the sheeted dike - pillow lava contact; (3) within pillow lava and intercalated tuff of assumed higher stratigraphic position; (4) in sediments at the top of pillow lava.

(1) Mineralization in the sheeted dikes

A number of small showings, including the Indian Beach and Head (Keatons Adit), occur within narrow chlorite schist zones within sheeted dikes.

The *Indian Beach prospect (#21)*, located near Indian Head, Halls Bay, occurs in a sequence of northwest trending, southwest dipping sheeted diabase dikes. An old shaft and a dump with one to two tonnes of hand-sorted ore are present at the prospect. MacLean (1947) reported that a sample from about twenty pieces of this ore assayed 3.86% Cu, trace Au and 0.07 oz. Ag per short ton (2.4 g/t). The mineralization occurs in a northwest trending, steeply northeast dipping chloritized shear zone in narrow bands over a width of 2 to 3 m; it consists of disseminated and stringer pyrite, chalcopyrite and pyrrhotite.

The *Indian Head* or *Keatons Adit showing (#22)* occurs in the same sheeted dike sequence approximately 1 km southwest of the Indian Beach prospect. The showing consists of disseminated pyrite and minor chalcopyrite in a narrow, chloritized and minor silicified shear zone. Malachite staining is present in the cliffs along the coast. There are no grade or tonnage data available for this prospect.

The *Hearn gold prospect (#17)* at Little Bay, described by Kean (1983), also occurs within the sheeted dike zone and a number of small showings occur in the sheared sheeted dike sequences on Sunday Cove Island.

(2) Mineralization near the sheeted dike - pillow lava contact

Four major deposits occur in pillow lava within a few hundred metres of the sheeted dike - pillow lava contact. They are the *Little Bay* and *Sleepy Hollow deposits (#16)* (see Kean, 1983), and the Lady Pond and Miles Cove Mine deposits. The *Little Bay Head (#19)* and *Shoal Arm (#20) showings* are small prospects that probably occur in a similar setting. They occur in pillow lava with common to extensive diabase dikes. The *Paddox Bight showing (#25)*, located on the north side of Paddox Bight, Sunday Cove Island, occurs in dikes with minor pillow screens; it consists of a cluster of shafts and pits with small ore dumps. Howse and Collins (1979, Table II) reported a grab sample assay of 12.0% Cu, 25 g/t Pb, 0.12% Zn, and 0.2 g/t Au. The mineralization consists of pyrite and chalcopyrite as stringers and disseminations in altered and chloritized diabase dikes with a few pillow lava screens.

The *Lady Pond prospect (#13)*, consisting of seven or more shafts, is situated at the east end of Lady Pond approximately 1.5 km south of Davis Pond. MacLean (1947) described the old mine workings. Mineral deposit files at the Newfoundland Department of Mines and Energy describe the history of exploration and development, and report assays of 0.62% to 2.59% Cu in drill core. Traces of gold and silver were noted in some holes.

The prospect is in variolitic and quartz amygdaloidal pillow lava and breccia with extensive diabase dikes, approximately 200 m above the sheeted dike - pillow lava interface. In places, diabase dikes constitute up to 60% of the exposure. Intense silicification and possibly minor felsic tuff are also present in the mineralized zone. Shearing is locally well developed.

Very little mineralization is exposed on the surface, except for thin lenses of magnetite and magnetite-rich black interpillow chert and disseminated pyrite in chloritic mafic volcanics. Samples from the dumps vary from massive magnetite with minor quartz and chalcopyrite to stringers and disseminations of pyrite, chalcopyrite and pyrrhotite in chlorite schist. There are no massive sulfides exposed or in samples in the dump. However, MacLean (1947) reported that the ore was evidently in the form of individual, small lenses.

The *Miles Cove Mine prospect (#23)* is located at Miles Cove, Sunday Cove Island. The prospect has had a long and varied exploration history extending from the late 1800's to the late 1960's (see Howse and Collins, 1979). Three shafts, several pits and an old dump mark the abandoned workings. The prospect was estimated by Howse and Collins (1979) to contain 199,800 metric tonnes of 1.45% Cu. The prospect also assayed 0.34 g/t Au and 12.0 g/t Ag (Ten Cate, 1957).

The deposit is located in chlorite schist within pillow lavas and dikes a few hundred metres above the sheeted dike - pillow lava interface. Surface exposures consist of a 20 to 25 m wide, intensely chloritized schist zone with disseminated and stringer pyrite and minor chalcopyrite. Extensive quartz veins and knots cut the schist and are generally coplanar with the foliation. Small quartz eyes, possibly amygdules, are common in the top part of the chlorite schist. The chlorite schist grades into deformed basaltic pillow lava. The schist is kinked and crenulated about a vertical north-south axial plane. Narrow beds or lenses of tuff are also reported from this sequence. The sequence is intruded by diabase dikes and a felsic quartz-feldspar porphyry dike.

The mineralization consists of disseminations, blebs and stringers of pyrite, chalcopyrite and minor gold, silver and magnetite in the chlorite schist. Howse and Collins (1979) determined from drill sections that the mineralized shear zone has a strike length of 100 m and an average width of approximately 8 m.

There is no evidence of exhalative mineralization in the surface exposures and trenches. However, reports of the early workings indicate bands and lenses ranging in thickness from 0.3 to 1.0 m and up to 20 m long (Douglas et al., 1940). They also reported the presence of massive, banded, cupriferous pyrite on the ore dumps.

(3) Mineralization within pillow lava and tuffs

Much of the mineralization in the Lushs Bight Group that occurs in pillow lava and intercalated tuffs does not appear to have a close spatial association to the sheeted dikes. The most prominent of this type of mineralization is in the *Whalesback (#15)* and *Little Deer (#14)* mines (see Kean, 1983), and the Rendell-Jackman, Colchester, and McNeily prospects. The Sterling prospect is also grouped with these but it may be close to the sheeted dike - pillow lava interface. There are numerous other smaller prospects and showings that also occur in chlorite schist.

The *Sterling prospect (#11)* is located about 1.5 km northwest of Springdale. The property was developed in the 1880's and has been the subject of geological and exploration investigations ever since. The property has two shafts and several test pits. The reader is referred to McArthur (1973) for further details. There is no reliable estimation of tonnage. McArthur (1973) gave grades and widths for a number of holes cutting the mineralization. He noted the lack of continuity from hole to hole and the generally narrow width (<2 m) of the mineralization. He reported the best section as 1.7% Cu over 14 m.

The Sterling prospect occurs in mafic volcanics with an intercalated felsic tuff unit. The mafic volcanics are locally highly amygdaloidal and variolitic. The mafic volcanics consist of chloritic and epidotized basalt, pillow basalt, isolated pillows and pillow breccias and minor tuffs. The felsic tuffs are fine grained to aphanitic, green, dacitic-looking rocks, with or without quartz amygdules. A number of smaller showings occur in similar felsic or intermediate composition rocks in Unit 3C. Chert and jasper occur as small patches and lenses ranging from a few millimetres to 60 cm.

Numerous bodies of diabase and gabbro intrude the sequence. It is not uncommon for dikes to constitute 40 percent of one outcrop. Locally, to the southwest of the prospect, sheeted diabase dikes are present in isolated outcrops. Therefore, the Sterling prospect may in fact be closely associated with the sheeted dike - pillow lava interface.

Surface exposures of the mineralization consist of disseminated and stringer pyrite and chalcopyrite in chlorite schist. McArthur (1973) described two separate zones of pyrite and chalcopyrite mineralization with minor pyrrhotite and sphalerite. He described the sulfide bodies as massive or nearly massive lenses and pods and as stockworks of stringers and disseminations. The mineralized zones are in steeply dipping chlorite schist layers that are generally conformable with the regional trend. Quartz and carbonate veins are generally present. McArthur (1973) interpreted the Sterling prospect to be a stockwork zone.

The *Sullivan prospect (#12)* lies approximately 1 km to the east of the Sterling prospect. It consists of disseminations and stringers of pyrite and chalcopyrite and extensive veinlets of quartz in chlorite schist. The mineralized zone has a strike length of 1.5 km and varies from 70 to 140 m wide.

The *Rendell-Jackman prospect (#9)* is located approximately 1.2 km south of the bottom of Southwest Arm. It has been the subject of intense investigations since its discovery in the early part of this century. Three shafts have been sunk in the prospect, one in the northern zone and two in the southern zone. There are no up-to-date estimates of grade and tonnage. However, in 1912, proven reserves in the northern lens amounted to approximately 11,000 tonnes at an unspecified grade. Grades from the early production averaged 4% Cu. Since then, assays of grab samples from the dump and of drill core have varied from 1 to 5% Cu. An average grade of 0.72% Cu and 0.03 oz./ton Au over 61 feet (1.0 g/t over 19 m) was reported by MacLean (1947) for the government drilling on this property. The reader is referred to DeGrace (1971) and Douglas et al. (1940) for more details.

The prospect consists of two lenses or mineralized zones within chlorite schist. The chlorite schist is developed in tuff within a pillow lava - pillow breccia sequence. Minor jasper lenses occur in the mineralized schist zones. Surface exposures consist of chlorite schist with disseminations and stringers of pyrite. Diabase and gabbro dikes are common. Quartz veins and knots are present but not extensive. MacLean (1947) noted two types of mineralization. Massive banded pyrite with minor chalcopyrite and rare sphalerite and magnetite are characteristic of the southern zone; 'nodular' massive chalcopyrite and minor pyrite in chlorite schist are characteristic of the northern zone. The banding is defined by sulfide composition and by grain size. The banding is on a scale of 1 cm or less. Boudinaged jasper lenses occur in the mineralized zones. MacLean (1947), however, reported beds up to 6 feet (1.8 m) in thickness. The 'nodular' mineralization consists of nodules or lenses of chalcopyrite up to 10 cm in diameter in the chlorite schist. Tiny veinlets of chalcopyrite also cut the chlorite schist. Granular and cubic pyrite are not extensive. This suggests that the northern, more chalcopyrite-rich, mineralization is of stockwork type, while the southern, banded, pyritic mineralization represents the exhalative facies.

A few kilometres to the south of the Rendell-Jackman, several small showings occur in a predominantly bedded tuff and argillite sequence with intercalated mafic volcanics (Unit 4). These showings are best represented by the *Yogi Pond - Yogi Pond North* and *Nolan prospects (#10)*. They all occur in chlorite schist or mafic volcanics. The mineralization occurs as bands of disseminated pyrite and locally minor chalcopyrite. In places, banded or bedded pyrite with magnetite bands up to 2.5 cm thick are well developed. Magnetite chert and magnetite-rich sediment/tuff are locally developed throughout the unit in which this mineralization occurs.

The *Jerry Harbour prospect (#24)*, located at the bottom of Jerry Harbour, Sunday Cove Island, consists of a series of trenches. Two chip samples taken from a 1 m wide sulfide vein average 2.52% Cu, 0.26% Zn and 0.85 g/t Au (Howse and Collins, 1979).

The mineralization occurs in schistose tuffs, agglomerates and minor red chert within pillow lava. The mineralization consists of bands, stringers and disseminations of pyrite and minor chalcopyrite. In one trench, a 1 m wide band of massive sulfide and stringers of pyrite and chalcopyrite are associated with quartz veinlets in chlorite schist. Magnetite is also present. Quartz veining, silicification, pyritization and minor sericite is commonly developed in the surrounding mafic volcanic sequence. The pillow lava is also quartz amygdaloidal and locally variolitic.

A number of small showings, e.g. *Swatridge and Swatridge East (#4)*, *Old English (#5)*, and *South Naked Man (#6)*, occur in chlorite schist adjacent to the Colchester Pluton. The mineralization occurs mainly as disseminations and stringers in chlorite schist and in quartz veins cutting the schist. Pyrite, chalcopyrite and pyrrhotite are the main sulfide minerals. All of these showings have shafts and/or trenches on them. The most significant of these showings is probably the Old English. Copper values vary from <0.50% to >2.0% over short distances. The reader is referred to Gibbs (1967) and McArthur (1971) for further details.

The *McNeily (#8)* and *Colchester (#7) prospects* occur along the southwest side of the Colchester Pluton and are somewhat more significant than the other showings. These prospects were developed in the last century and have been subject to a number of exploration and geological studies since then (see McArthur, 1971).

The Colchester Main Zone comprises an 85 m wide chlorite schist zone mineralized over a distance of 485 m. Three shafts and an adit have been developed on the property. Gibbs (1967) estimated the tonnage at 1 million tons of 1.3% Cu. The West Zone has a shaft and a number of trenches sunk on it. No significant tonnage or grades have been reported for this prospect.

The Colchester Main and West Zones consist of pyrite and chalcopyrite mineralizaion in a chlorite schist zone. The mineralization occurs as disseminations, blebs, stringers, veins and irregular masses in the chlorite schist. Quartz-carbonate veins also carry sulfide mineralization. Pyrrhotite and magnetite are present. The chlorite schist occurs in pillow lava, breccia and agglomerate. Extensive dikes ranging from gabbro and diabase to felsite and quartz porphyry are common in the area.

The McNeily prospect occurs approximately 1000 m southwest of the Colchester Main Zone. Three shafts have been sunk on this prospect and it has been extensively diamond drilled. However, no significant tonnage has been outlined and grades vary from <0.5% to about 4% Cu over short intervals. Chalcopyrite and pyrite occur in a chlorite schist zone from 30 to 100 m wide. The schist zone occurs within a distinctive mafic breccia/agglomerate unit within the pillow lava. Magnetite-rich black chert and small magnetite pods are present in the chlorite schist. The agglomerate and breccia clasts are generally highly variolitic and quartz and/or calcite amygdaloidal. Extensive pyrite is locally present in the matrix. Intense leaching and silicification to a white felsic breccia appearance is developed in the vicinity of some of the mineralization. Dikes of gabbro, diorite, felsite, and feldspar porphyry are common. Quartz and quartz-chlorite veins are locally common.

McArthur (1971) reported the mineral assemblages as follows: pyrrhotite-pyrite-chalcopyrite, banded pyrite-chalcopyrite-sphalerite-magnetite.

(4) Mineralization in sediments at the top of Lushs Bight Group

Several significant showings occur in sediments at the top of the Lushs Bight Group. They are the *Nickey's Nose (#1)*, *Rushy Pond (Wheelers Shaft) (#2)*, *Rushy Pond Head (#3)* and *Fox Neck (#18)*.

The top part of the Lushs Bight Group is characterized by being black rather than green, and less altered and/or more chloritic than epidotized. Epidote occurs as veins and fracture fillings. Interpillow red chert or jasper is common and forms large lenses in places. Magnetite is common as disseminations and discrete bands in the chert. In places, the magnetite forms lenses up to 0.5 m thick. Overlying these jasper-rich pillow lava, breccia and agglomerate sequences is a sequence of chocolate brown argillite with interbedded thin jasper lenses and black argillite-mudstone. This sedimentary sequence can, in places, be as much as 150 m thick; however, thickness is complicated by faulting and folding.

Bands of massive pyrite and pyrrhotite with minor magnetite occur within the black argillite-mudstone. At Nickey's Nose, the mineralized zone is approximately 10 m wide and is exposed for about 100 m. The mineralization in the Nickey's Nose area occurs at two different places (Nickey's Nose North and South) that are interpreted to be structurally repeated. A shallow shaft was sunk on this showing and about 25 short tons (22.7 tonnes) of massive sulfide ore were extracted (Lundberg, 1936). Douglas et al. (1940) reported 0.02 oz./ton (0.7 g/t) Au in a grab sample from all over this showing. Mineralization at Rushy Pond (Wheelers Shaft) and Rushy Pond Head occur at the same stratigraphic level and is of the same type. The Rushy Pond Head showing is traceable almost to Rushy Pond, a strike length of about 0.5 km. Old trenches and shallow shafts were sunk on these prospects; however, no grades or tonnages were reported.

The mineralization at Fox Neck occurs in the same stratigraphic position and consists of a 30 cm thick bed of pyrite and pyrrhotite and a band of magnetite a few centimetres thick with a strike length of about 10 m.

Immediately overlying this chocolate brown argillite are pyroxene crystal lithic tuffs and bedded tuffs of the Western Arm Group.

Summary and Conclusions

The Lushs Bight Group consists of a number of fault-bounded blocks, some of which contain an identifiable ophiolite stratigraphy. Chlorite schist zones within this sequence are early structures, not lithologically controlled, and are locally mineralized. The mineralized zones may have acted in part as zones of weakness along which shear zones developed.

The major sulfide deposits and showings in the Lushs Bight Group occur within chlorite schist zones. The schist zones are generally within pillow lava and/or intercalated pyroclastics, and are conformable with the enclosing rocks. The sulfide lenses are in turn conformable with the schist zones, although sulfide veins crosscut the chlorite schist.

The mineralogy is simple, and commonly there is a sharp hanging-wall contact and a gradational footwall contact. Deformation obliterated primary structures in most deposits, and the sulfides were remobilized and recrystallized. Therefore, any interpretation of paragenesis or mineral zoning is suspect.

Significant pyrite, pyrrhotite and magnetite mineralization occurs in the sediments at the top of the Lushs Bight Group.

There are several theories for the origin of the deposits in the volcanics, but the following evidence from this study suggests a syngenetic volcanic origin for the deposits: (a) they have an early, predeformational origin; (b) they are essentially conformable bodies in mafic volcanics of ophiolite affinity, i.e. they are strata-bound; (c) they possess a simple mineralogy that is similar to volcanogenic ophiolite deposits; and (d) the chlorite schist shear zones are interpreted as early tectonic features that did not control mineralization. However, there is no doubt that the deposits have been remobilized and recrystallized.

The chlorite schist shear zones have generally been considered as "controls" for mineralization. However, chlorite schist zones also occur in the pillow lavas that overlie the sheeted dikes of the Betts Cove Ophiolite Complex (Douglas et al., 1940; Upadhyay and Strong, 1973). Primary volcanogenic sulfide mineralization at the pillow lava - sheeted dike contact has been remobilized and redistributed along the schist zones (Kennedy and DeGrace, 1972). Duke and Hutchinson (1974) also described chloritic shear zones in the York Harbour mine area. They attributed them to late movement along a synvolcanic fault-fissure that controlled the distribution of ore deposition. However, the chlorite schist shear zones are conformable with stratigraphy and as such were probably subhorizontal zones at the time of their formation. The schist zones are thus interpreted as early shear belts which were initiated at points of greatest mechanical weakness, commonly, but not exclusively, the sulfide bodies and associated alteration zones. A similar conclusion was reached by DeGrace (1971) and Kennedy and DeGrace (1972) for the Lushs Bight Group in the King's Point area.

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B.F. Kean

MAJOR SULFIDE MINERALIZATION IN THE AREA

1. *Nickey's Nose:* Banded pyrite, pyrrhotite and magnetite in black mudstone interbedded with chocolate brown argillite and minor red chert.

2. *Rushy Pond:* same as Nickey's Nose.

3. *Rushy Pond Head:* same as Nickey's Nose.

4. *Swatridge and Swatridge East:* Disseminated and stringer pyrite and chalcopyrite in narrow chlorite schist zones in pillow lava.

5. *Old English:* Stringer and disseminated pyrite and chalcopyrite with minor sphalerite in chlorite schist and quartz veins along the contact with the Colchester Pluton.

6. *South Naked Man:* Pyrite and chalcopyrite in chlorite schist.

7. *Colchester and Southwest Colchester:* Disseminations, stringers and lenses of pyrite, chalcopyrite and pyrrhotite with minor sphalerite in altered pillow lava and breccia.

8. *McNeily:* Disseminations, stringers and bands of pyrite, chalcopyrite and pyrrhotite with minor sphalerite in chlorite schist.

9. *Rendell-Jackman:* Pyrite, chalcopyrite, minor sphalerite and magnetite in chlorite schist derived from tuff.

10. *Yogi Pond and Nolan:* Banded massive pyrite and magnetite in schistose tuff.

11. *Sterling:* Pyrite and chalcopyrite with minor sphalerite as massive lenses, pods, stringers and disseminations in chloritic pillow lava and felsic tuff.

12. *Sullivan Pond:* Disseminated and stringer pyrite and chalcopyrite in chlorite schist.

13. *Lady Pond:* Disseminations, stringers and lenses of pyrite, chalcopyrite and magnetite in pillow lava, altered breccia and schist with extensive diabase dikes.

14. *Little Deer:* Pyrite, chalcopyrite, pyrrhotite and sphalerite as disseminations, stringers, lenses and pods in chlorite schist in pillow lava.

15. *Whalesback:* Pyrite, chalcopyrite, pyrrhotite and sphalerite as disseminations, stringers and banded lenses and pods in chlorite schist in pillow lava.

16. *Little Bay and Sleepy Hollow:* Pyrite, chalcopyrite, pyrrhotite and magnetite as massive lenses and pods, as stringers and disseminations in chlorite schist within pillow lavas and diabase dikes.

17. *Hearn:* Pyrite, chalcopyrite, sphalerite, arsenopyrite, galena and gold in quartz veins and as stringers and disseminations in sheared sheeted dikes with minor pillow screens.

18. *Fox Neck:* Banded pyrite, pyrrhotite and magnetite beds in chocolate brown argillite and red chert.

19. *Shoal Arm:* Pyrite, chalcopyrite, pyrrhotite, sphalerite and arsenopyrite in chlorite schist in pillow lava and diabase dikes.

20. *Little Bay Head:* same as Shoal Arm.

21. *Indian Beach:* Pyrite, chalcopyrite and pyrrhotite in chlorite schist within sheeted diabase dikes.

22. *Indian Head (Keatons Adit):* same as Indian beach.

23. *Miles Cove:* Pyrite and chalcopyrite in chlorite schist in pillow lava above sheeted dike contact.

24. *Jerry Harbour:* Pyrite and chalcopyrite in chlorite schist derived from tuff intercalated with pillow lava.

25. *Paddox Bight:* Pyrite and chalcopyrite disseminations and veins in sheeted dikes with pillow screens.