GEOLOGIC SETTING AND VOLCANOGENIC SULFIDE MINERALIZATION OF THE EASTERN WILD BIGHT GROUP, NORTH-CENTRAL NEWFOUNDLAND

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Abstract

The Wild Bight Group in north-central Newfoundland is a thick sequence of volcaniclastic, volcanic and related intrusive rocks deposited during the development of an Early-Middle Ordovician island arc. Volcanic flows, which comprise up to 20% of the sequence, are dominantly basaltic and occur at several stratigraphic levels. Rhyolitic flows and pyroclastics are locally developed in the central part of the succession. Volcaniclastic rocks consist of fine grained sandstone, siltstone and chert interbedded with thick conglomerate units. Sedimentary structures suggest a northerly flow. The environment appears to have been one of quiet sedimentation on the flanks of a volcanic edifice to the south, punctuated by periodic debris flows and local eruptive activity.

Four volcanogenic sulfide deposits are known in the Wild Bight Group. The largest of these, the Point Leamington deposit, comprises a massive sulfide body underlain by a zone of pervasive quartz-sericite and chlorite alteration. The Lockport deposit outcrops as a stockwork zone but there is evidence of a small massive cap in the subsurface. The Indian Cove and Long Pond prospects are pyrite-chalcopyrite-bearing stockwork zones. All are spatially and stratigraphically associated with felsic volcanism.

Introduction

The Wild Bight Group comprises a thick sequence of volcanic and sedimentary rocks which outcrop across Notre Dame Bay between Shoal Arm, Badger Bay and Osmonton Arm, New Bay (Figure 1). The sequence is overlain by Caradocian chert and shale and is considered by most workers (e.g. Dean, 1978) to form part of an Early-Middle Ordovician island arc, remnants of which are preserved throughout central and southern Newfoundland (Kean et al., 1981; Swinden and Thorpe, in press).

The general distribution of lithologies and their stratigraphic sequence within the Wild Bight Group was first investigated in detail in the 1930's. Heyl (1938) mapped the sequences immediately adjacent to New Bay as part of his comprehensive examination of the stratigraphy of the Bay of Exploits area, and Espenshade (1937) included part of what is now considered to be the western side of the Wild Bight Group in his study of the Pilleys Island area. Each worker erected a local stratigraphic nomenclature in his area, and Espenshade appears to have been the first to coin the term "Wild Bight volcanics" for the sequences exposed in Wild Bight, Badger Bay. Hayes (1951) later mapped part of the western Wild Bight Group, assigning these rocks to the "Exploits Series" but retaining the term "Wild Bight Formation" for the sequences in Wild Bight.

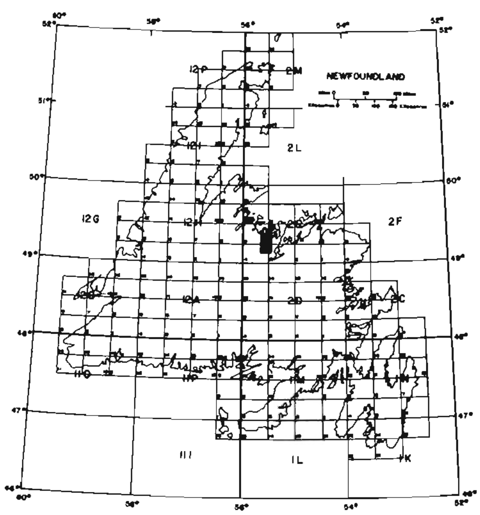

Figure 1: *Location of the study area. Black square is the area shown in Figure 2.*

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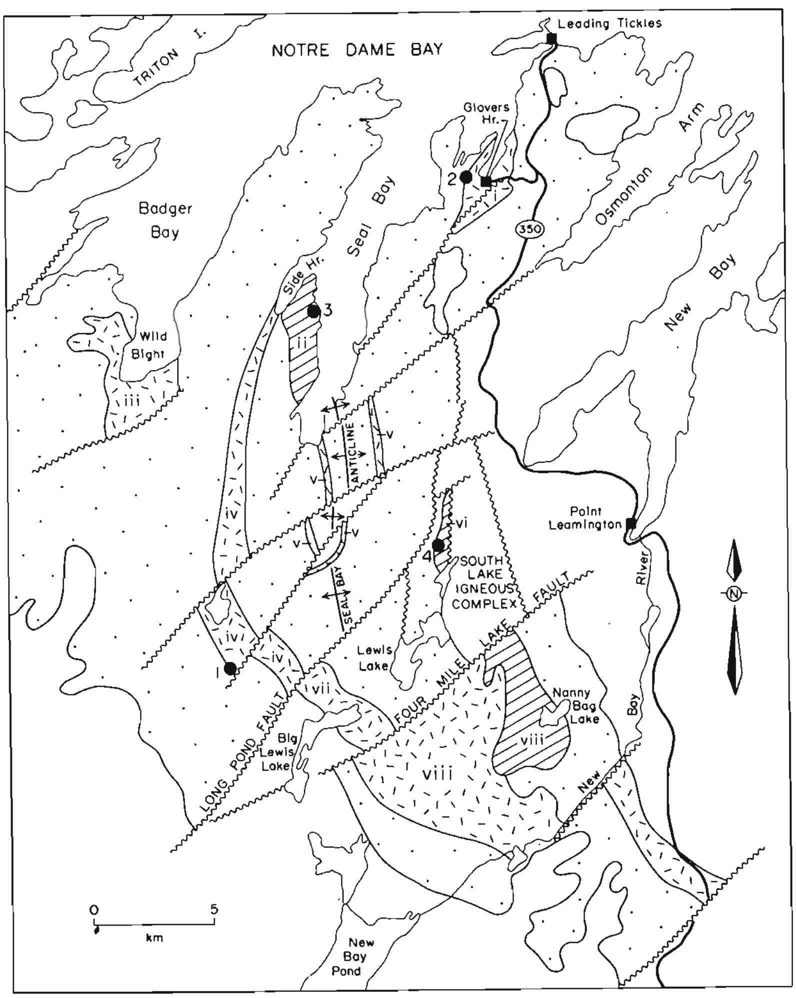
The "Wild Bight Group" in its present form was defined by Williams (1963) during his 1:250,000 mapping of the Botwood (2E) map area.

The most detailed published maps of the Wild Bight Group are those compiled by Dean (1978) at a scale of 1:50,000. Wild Bight Group data on these maps were drawn principally from the workers cited above and from unpublished exploration company maps. Dean's (1978) contribution to the geology of the Wild Bight Group was two-fold. Firstly, and perhaps most importantly, he provided the first detailed published account of the distribution of the group. Secondly, he subdivided it into five informal formations, providing a stratigraphic framework within which the distribution of the various volcanic sequences could be interpreted.

Volcanogenic sulfide mineralization in rocks presently assigned to the Wild Bight Group was first discovered in the late 1800's near Lockport. The deposit there was worked briefly around the turn of the century, yielding the only recorded production from the Wild Bight Group. Since that time, three other deposits of volcanogenic origin have been recognized in the sequence, the Indian Cove and Long Pond prospects and the Point Leamington deposit (Figure 2).

The present study was designed to investigate the regional geologic and tectonic setting of the Wild Bight Group, with emphasis on the volcanic rocks which occur principally in the eastern part of the group, and the four volcanogenic sulfide deposits which they host.



LEGEND

Mainly volcaniclastic and sedimentary rocks.

Mainly mafic volcanic rocks.

Mainly felsic volcanic rocks.

KEY TO VOLCANIC SEQUENCES
(see text; most designated names are informal)

- i Glovers Harbour basalts.
- ii Indian Cove volcanics.
- iii Wild Bight, Badger Bay volcanics.
- iv Side Harbour formation north of Long Pond fault.
- v Sparrow Cove Point formation.
- vi Long Pond volcanics.
- vii Big Lewis Lake basalts.
- viii Volcanic rocks between Four Mile Lake fault and New Bay River

KEY TO VOLCANOGENIC SULFIDE DEPOSITS

1 Point Leamington
2 Lockport
3 Indian Cove
4 Long Pond

Figure 2: *Simplified distribution of lithologies in the eastern Wild Bight Group. Location of volcanogenic sulfide occurrences is indicated by solid circles.*

Geologic Setting of the Eastern Part of the Wild Bight Group

Dean (1978) showed that the Wild Bight Group occupies a broad anticlinal structure, the axis of which trends approximately north-south through the center of Seal Bay (the Seal Bay anticline, Figure 2). The base of the sequence is not exposed in this area: the stratigraphic succession youngs more or less continuously to the east and west (although crossing numerous minor folds) and eventually passes conformably upward into fossiliferous Caradocian shale and chert of the overlying Shoal Arm Formation. Two virtually complete cross-sections of Wild Bight Group stratigraphy are exposed on the coastline between Shoal Arm and the Leading Tickles peninsula on both sides of the Seal Bay anticline, and well washed exposures display the essential features and critical relationships of the sequence. The author feels that systematic mapping of this area will ultimately result in considerable revision of Dean's (1978) informal stratigraphic nomenclature. Accordingly, this nomenclature will be used sparingly in the following discussions.

In general terms, three rock types are present in the eastern Wild Bight Group: (1) volcaniclastic and sedimentary rocks, (2) volcanic rocks, and (3) mafic intrusive rocks. These are briefly described below; because of the economic significance of the volcanic rocks, they are treated in more detail.

(1) Volcaniclastic and Sedimentary Rocks

Volcaniclastic and sedimentary rocks comprise up to 80% of the Wild Bight Group succession. In the eastern Wild Bight Group, these are principally of two types: (i) fine grained, planar bedded, laminated graywacke, siltstone, argillite and chert with local conglomerate beds; and (ii) massive, generally unbedded, medium to coarse grained volcaniclastic conglomerate. The latter is generally matrix-supported, often poorly sorted, and contains subrounded to angular fragments of locally derived volcanic and sedimentary rocks.

Some general comments can be made concerning the stratigraphic development of sedimentary rocks in the eastern Wild Bight Group. The oldest unit, exposed in the core of the Seal Bay anticline, consists of up to 500 m of fine grained argillite, siltstone and chert with minor amounts of pebble sandstone and rare fine grained conglomerate. This stratigraphic unit, referred to as the Omega Point formation by Dean (1978), is characterized by abundant green to buff chert and particularly by red chert and argillite. It contains a single 6 m thick black shale horizon exposed on a small island in Seal Bay bottom, and appears to record the most extensive interval of quiet water sedimentation in the Wild Bight Group. Along the eastern shore of Seal Bay, this unit passes upward into a volcaniclastic succession containing increasing amounts of coarse volcaniclastic sandstone and conglomerate horizons. Immediately north of Sparrow Cove Point, these lithologies typically form 0.3 to 5 m beds separated by a similar thickness of fine grained, laminated chert and siltstone. The thickness and abundance of the coarse units increase northward along the east side of Seal Bay (i.e. upsection); in the area north of Locks Harbour, individual layers of coarse volcaniclastic conglomerate commonly attain thicknesses greater than 60 m, separated by 1 to 10 m layers of fine grained siltstone and chert. These coarse sediments form a major part of the sequence up to its exposed top on the Leading Tickles peninsula. A similar progression from fine grained, apparently quiet water sedimentation through environments of progressively more coarse deposition by debris flows and turbidite currents is also recorded in sequences on the west side of the Seal Bay anticline, although local structural complications and probable facies changes make detailed correlation difficult.

The environment recorded by the Wild Bight Group succession appears to have changed from initial quiet water sedimentation to quiet sedimentation punctuated by periodic turbidity currents and debris flows. Current ripples, crossbeds and slump structures indicate a generally northerly flow, suggesting a topographic high to the south. Therefore, the sediments were probably deposited on the middle flanks of a volcanic edifice situated to the south.

(2) Volcanic Rocks

Volcanic accumulations are present at several localities and various stratigraphic levels within the eastern Wild Bight Group (Figure 2). All the known volcanogenic sulfide deposits in the Wild Bight Group are hosted by volcanic rocks, although not all volcanic accumulations are known to be mineralized. Each major volcanic sequence is described briefly below; names for these sequences are for convenience only and do not represent formally proposed stratigraphic nomenclature.

(a) Descriptions

(i) *Glovers Harbour volcanics:* The Glovers Harbour volcanics, host to the Lockport deposit, were included in the Pennys Brook Formation by Dean (1978). They

consist predominantly of pillow basalts, which comprise 60 to 70% of the section. The pillows are generally 0.7 to 1.5 m long, bulbous to somewhat flattened and highly vesicular, the vesicles commonly filled with chlorite, calcite or epidote. Most pillows have well developed rinds, and minor hyaloclastic material occurs in the interstices. Well washed coastal outcrops provide good three dimensional exposure of pillows and allow top determinations to be made with confidence.

Most of the remaining lithologies in this unit are volcaniclastic and hyaloclastic. Well bedded volcaniclastic sandstones are locally interbedded with the pillow lavas. The eastern part of the sequence contains a 200 m thick lens of basaltic pyroclastic rock containing abundant fragments of basalt in a chloritic matrix; the lens outcrops on islands and headlands in the central and eastern parts of Glovers Harbour. Pillow breccias are locally developed throughout the sequence.

A single felsic volcanic member outcrops on several rocky hills about 700 m south-southwest of the Lockport mine. This unit consists of gray to bluish, quartz-feldspar crystal tuff and possibly represents a single ash flow. It appears to lie at approximately the same stratigraphic horizon as the Lockport mine.

Minor amounts of red chert are present in the sequence. One particularly persistent bed up to 1 m thick can be traced for more than 800 m along strike immediately north of the Lockport mine.

The Glovers Harbour volcanics are faulted against well bedded chert, argillite and sandstone to the west along a fault which is apparently dextral strike-slip. Adjacent to the fault, the basalts are intensely cleaved and hematized, and face northwest. To the east, the volcanics pass conformably upward into coarse volcaniclastic debris-flow deposits; the contact is exposed on the shoreline northeast of Glovers Harbour.

Structural relationships within the volcanics have not been mapped in detail. They appear, however, to occupy a broad anticlinal structure, the axis of which trends north-northwest immediately west of Glovers Harbour.

(ii) Indian Cove volcanics: The Indian Cove volcanics, host to the Indian Cove prospect, were assigned to the Seal Bay Brook formation by Dean (1978). They occupy an area approximately 4 km long and 1 km wide between Side Harbour and Mill Cove and consist of a complex assemblage of volcanic flows and pyroclastic rocks. The central and probably oldest part of the Indian Cove volcanics consists of a massive, buff to green rhyolite which outcrops on the north shore of Indian Cove and in the hills west of the cove. The rhyolite is massive and commonly displays intense hydrothermal alteration characterized by gas brecciation and closely spaced fractures filled with hematite and pyrite. The rhyolite is overlain by various types of felsic to mafic pyroclastic rocks displaying rapid lateral facies changes. These consist mainly of poorly sorted, angular fragments of felsic volcanic rock, chert and minor basalt set in a tuffaceous matrix varying from dark green to buff in color and mafic to felsic in composition. Spectacular breccias are present locally; they contain red chert fragments up to 5 m across chaotically distributed in a gray to reddish chloritic matrix. These appear to represent debris flows, possibly related to the development of the domal structure represented by the rhyolite. The debris-flow deposits seem to occupy the upper stratigraphic levels of the volcanic sequence and pass conformably upward into well bedded red and green chert, siltstone and sandstone which mark the top of the unit.

A single pillow basalt flow is present in the southern part of the unit. It may occur low in the stratigraphy but, due to structural complications, this is uncertain.

The Indian Cove volcanics appear to pass conformably upward into volcaniclastic but and conglomerate to the west, although this contact is not exposed; the eastern contact lies under the waters of Seal Bay.

(iii) Wild Bight, Badger Bay volcanics: Mafic volcanic rocks outcropping around the bottom of Wild Bight, Badger Bay, were assigned to the Pennys Brook Formation by Dean (1978). They are composed mainly of basaltic, highly vesicular pillow breccias in which pillow fragments commonly range from 5 to 30 cm in diameter and possess well developed rinds on rounded surfaces. Complete pillows, locally preserved within the breccias, are both clast- and matrix-supported. Interstitial material, consisting of chloritic (probably hyaloclastic) matrix with abundant small angular basalt fragments, generally comprises less than 20% of the rock.

Thin pillowed flows are present but appear to comprise less than 20% of the sequence. The pillow lava units are 10 to 30 m thick, consisting of 1 to 1.5 m long pillows which generally contain abundant calcite- and chlorite-filled vesicles; they probably represent single flows. Locally, pillow lava can be seen to grade upward into pillow breccia.

The Wild Bight, Badger Bay volcanics are bounded top and bottom by volcaniclastic rocks and apparently lie near the top of the Wild Bight Group; the top is marked by the Caradocian Shoal Arm Formation to the immediate northwest.

Previous maps of this area (e.g. Espenshade, 1937; Dean, 1978) indicated that mafic volcanic rocks also outcropped along the east shore of Badger Bay northeast of Wild Bight, forming a 500 m thick unit from Green Point north to Little Cove, Badger Bay. This unit, in fact, consists of massive, dark green volcaniclastic sandstone with chert and basalt fragments, locally cut by fine grained mafic sills.

(iv) Side Harbour formation north of Long Pond Fault: This laterally extensive basaltic sequence hosts the Point Leamington sulfide deposit. It was assigned to the Side Harbour formation by Dean (1978). It is well exposed immediately south of Side Harbour, where it consists mainly of pillow lava, with large (30 to 50 cm), bulbous pillows which are commonly quite vesicular.

This formation is relatively thin immediately south of Side Harbour but thickens steadily southward along strike to a maximum of more than 2 km near the Point Leamington deposit. The basalt unit was previously mapped as outcropping in the bottom of Side Harbour (Figure 1). However, outcrops there consist of fine to medium grained mafic intrusive rocks which display chilled margins and contain xenoliths of adjacent rocks. These intrusive rocks are along strike from and probably represent a subvolcanic phase of the basalts.

The only felsic volcanics noted were in the immediate vicinity of the Point Leamington deposit, where quartz-feldspar crystal tuff forms a lenticular unit approximately 200 m thick which has been traced for more than 1500 m along strike.

The Side Harbour formation is bounded above and below by typical volcaniclastic lithologies of the Wild Bight Group. The contacts appear to be conformable, but are not exposed.

(v) Sparrow Cove Point formation: This formation consists of a thin (generally less than 100 m) unit of pillowed basalts, originally defined by Dean (1978). These basalts are moderately vesicular and outcrop in a horseshoe-shaped belt around the bottom of Seal Bay. This formation is probably misnamed since it does not appear to outcrop at Sparrow Cove Point, where the equivalent stratigraphic level is occupied by volcaniclastic sandstone and chert, and diabase and gabbro dikes and sills. However, the basalt is well exposed south of Seal Bay and is generally thin enough that it could represent a single flow. The basalt is conformably bounded on both sides by laminated chert, siltstone and graywacke.

(vi) Long Pond volcanics: This narrow unit of mainly rhyolite, quartz-feldspar crystal tuff, felsic pyroclastic rocks and red chert outcrops in a narrow, north trending band north of Lewis Lake. It hosts the Long Pond prospect and includes a narrow (30 to 40 m) unit of pillow lava and pillow breccia. The stratigraphic facing direction of this unit is not known; it is conformably bounded to the west by red chert and gray to green argillites which are in turn faulted against volcaniclastic rocks. To the east, the volcanics are faulted against the South Lake Igneous Complex.

(vii) Big Lewis Lake basalts: This sequence outcrops between the Long Pond and Four Mile Lake Faults, and can be distinguished from the Side Harbour formation basalts which adjoin them across the Long Pond Fault (Figure 2) in two respects: (1) the Big Lewis Lake basalts comprise mainly pillow breccia and basalt-bearing volcanic breccia with relatively little pillow lava; (2) they pass conformably upward into the Caradocian chert-shale interval and are, therefore, stratigraphically higher in the section. Both lithologically and with respect to their stratigraphic position within the Wild Bight sequence, the Big Lewis Lake basalts closely resemble the basaltic sequences in the Wild Bight, Badger Bay section. There are no felsic volcanics in this unit.

(viii) Nanny Bag Lake volcanics: Volcanic rocks in this area, assigned by Dean (1978) to the Pennys Brook formation, consist of a felsic volcanic complex centered on the west end of Nanny Bag Lake, bounded to the south and west by basalts which extend south to the New Bay River. The thick basaltic sequence west of the felsic complex comprises mainly massive, unpillowed, generally nonvesicular rocks unlike those anywhere else in the Wild Bight Group. The massive basalts are separated from the felsic complex by a narrow volcaniclastic graywacke and conglomerate unit which passes conformably eastward into the felsic complex. The felsic volcanic complex consists mainly of black to dark blue quartz-eye rhyolite and rhyolitic crystal tuff, but also contains a considerable amount of volcaniclastic material. Detailed traversing is needed to fully define the nature of this complex.

Geologic maps compiled by Dean (1978) show basaltic rocks outcropping southeast and east of the felsic volcanic center. The present mapping suggests that the south end of this volcanic sequence near New Bay River is underlain, at least in part, by diorite and gabbro intrusions. To the east of the felsic complex, volcaniclastic turbidites form all the outcrops. North of the Four Mile Lake Fault, mafic rocks east of the volcanic sequence appear to be intrusive and may be related to the South Lake Igneous Complex.

(b) Stratigraphic relationships

Volcanic rocks appear to occupy several stratigraphic levels within the Wild Bight Group. In some cases, the relative position of the volcanic rocks can be stated with confidence. In most cases, however, structural disruption and the paucity of outcrops in critical areas render correlations more uncertain. Present evidence suggests the following relationships:

(1) The Sparrow Cove Point basalts (v) are the stratigraphically lowest volcanic rocks in the sequence, occurring near the exposed base of the Wild Bight Group in the core of the Seal Bay anticline.

(2) The Big Lewis Lake basalts (vii) are the stratigraphically highest volcanic rocks in the sequence and pass directly upward into Caradocian shale and chert. The Wild Bight, Badger Bay basalts are only slightly lower in the sequence, separated from the Caradocian shales of the Shoal Arm Formation by a thin volcaniclastic interval. These two basaltic sequences are very similar lithologically, consisting dominantly of pillow breccia and hyaloclastite with minor pillowed flows. They are probably lateral equivalents.

(3) The Side Harbour formation north of the Long Pond Fault (iv) is intermediate in the stratigraphic sequence. It is underlain by volcaniclastic rocks which apparently pass conformably downward into the core of the Seal Bay anticline, and it is overlain by similar rocks, the thickness of which is uncertain due to folding but which appear to pass upward into the Wild Bight, Badger Bay basalts. The formation may be more or less equivalent to the Glovers Harbour basalts, which appear to lie about 2 km stratigraphically below the Caradocian shale at Leading Tickles and to be separated from it by mainly volcaniclastic rocks. The base of the Glovers Harbour volcanics is not exposed. The Nanny Bag Lake volcanics appear to occupy a similar stratigraphic position as they pass upward through approximately 2 km of volcaniclastic rocks into Caradocian shale east of Nanny Bag Lake.

(4) The relative position of the Long Pond volcanics is not known as they are fault bounded on both the east and west. Likewise, the postion of the Indian Cove volcanics remains somewhat enigmatic as the upper and lower contacts are not exposed. If the western contact is conformable (suggested by the continuity of planar features across the contact area), the Indian Cove volcanics are slightly lower in the section than the Side Harbour formation.

In summary, there is evidence for multiple episodes of volcanic activity during deposition of the Wild Bight Group. The units which contain volcanogenic sulfide mineralization are generally intermediate in the stratigraphic sequence but not necessarily at the same stratigraphic horizon. Detailed structural mapping of the units is needed to clarify these relationships.

(3) Intrusive Rocks

The Wild Bight Group is extensively cut by mafic sills and, less commonly, by dikes ranging from fine grained, locally vesicular diabase to coarse grained, equigranular to somewhat porphyritic gabbro. Fine grained varieties are commonly highly vesicular, locally crosscutting, and some show evidence of intrusion into wet sediments. Most appear to be related to the Wild Bight volcanism and were probably intruded at relatively high levels.

Volcanogenic Sulfide Occurrences

Four principal volcanogenic sulfide occurrences are known in the Wild Bight Group. These were examined in detail on site and, where possible, in drill core. The locations of these deposits are shown on Figure 2 and brief descriptions are presented below.

(1) Point Leamington: This is the largest single massive sulfide deposit known in Newfoundland; it was discovered in the early 1970's by Noranda Exploration Ltd.. Previously published dimensions (Noranda Mines staff, 1974) suggest that more than 20 million tonnes of massive sulfide are present, grading approximately 0.5% Cu and 2% Zn with sporadic precious metal values. The deposit lies at the top of a thick volcanic sequence which is dominantly composed of pillowed basalts (the Side Harbour formation north of the Long Pond Fault, unit iv). In the vicinity of the deposit, the basalts are capped by a 500 m thick unit of felsic quartz-feldspar crystal tuff which has been traced for approximately 1500 m along strike. This unit is the only felsic volcanic member in the Side Harbour formation.

The rocks near the deposit are poorly exposed and the massive sulfide body lies under a bog. A few exposures of highly altered, pyritic, rhyolitic quartz-eye crystal tuff of the footwall outcrop immediately east of the deposit. Similarly altered and mineralized pillow basalt outcrops about 100 m further east. Unaltered volcaniclastic rocks outcrop in the hanging wall to the west of the deposit.

These outcrops summarize the environment; details of the setting are somewhat better displayed in drill core. The massive sulfide body consists mainly of fine grained pyrite with lesser chalcopyrite, and local enrichment of sphalerite as blebs and discrete beds. The contacts of massive sulfides with the hanging wall and the footwall are sharp, although the footwall displays a zone of pervasive alteration recognizable everywhere below the massive body. The alteration consists mainly of variably intense silicification and sericitization commonly accompanied by veinlets, blebs and disseminations of pyrite and lesser chalcopyrite. This pervasive alteration is locally cut by 5 to 30 cm wide crosscutting zones of intense black chlorite alteration which is generally accompanied by more intense sulfide mineralization. In some drill core, the chlorite alteration can be seen to be most intense in the immediate footwall to the massive sulfides and, locally, the lower parts of the massive sulfides have been brecciated, with chlorite introduced between the fragments. The chloritic alteration is believed to represent zones of more intense fluid flow during the alteration/mineralization episode. Where most intensely developed in the immediate footwall, it may record zones of discharge of the mineralizing fluids.

The massive sulfide body has been outlined by diamond drilling to a depth of approximately 260 m, and the nature of the massive sulfides is remarkably uniform from the surface to this depth. The total extent of the body has not yet been determined.

The massive sulfides and the host rocks are cut by numerous mafic dikes ranging from fine grained diabase to coarsely porphyritic gabbro similar to those observed in outcrop throughout the Wild Bight Group.

(2) Lockport: The Lockport deposit was discovered in the late 1870's or 1880's. Early workings on the deposit included a series of open cuts on the gossans which marked the original showings, and five shallow shafts from which a limited amount of ore was apparently shipped to the Tilt Cove smelter near the turn of the century. The property received sporadic attention throughout the early 1900's, but the first comprehensive exploration program did not take place until the 1950's, when NALCO did geological mapping, geochemistry, geophysics and some diamond drilling on the main prospect. Further diamond drilling has been carried out by other firms from the 1960's to the present: 15 holes totalling 2647 m have been drilled on the deposit. The core from these holes has been lost, although drill logs are on file with the Department of Mines and Energy. Grade and tonnage estimates by Fogwill (1965) suggest the presence of approximately 220,000 tonnes of material grading 1.21% Zn and a further 392,350 tonnes grading 0.75% Cu.

The property was the subject of an M.Sc. dissertation at Memorial University by DeZoysa (1969).

The Lockport deposit occurs near the center of the Glovers Harbour volcanics, and is partially exposed in the old open cuts and abundant nearby outcrops. The open cuts expose only the western side of the deposit, although the abundant mineralized material on the adjacent dumps may sample material from the unexposed eastern portion as well. The host rocks exposed in the open cuts comprise mainly intensely sheared, silicified pyroclastic rocks and basaltic flows. Felsic quartz-feldspar crystal tuff outcrops 700 m southwest of the deposit approximately on strike with the mineralized horizon. The mineralization exposed in the open cuts is of stockwork type, characterized by intense quartz-sericite alteration and pervasive disseminations and stringers of pyrite and lesser chalcopyrite. The deposit is highly sheared, and lenses up to 10 cm wide of massive pyrite are present, apparently boudins of what were previously relatively large stringers.

There are no exhalative massive sulfides exposed at the prospect; there are, however, numerous large boulders on the dumps which consist of massive, finely laminated pyrite-chalcopyrite with local concentrations of sphalerite. Logs of holes drilled by NALCO in the 1950's suggest that a massive sulfide zone up to 8 m wide was intersected at the eastern margin of the deposit, and that this zone is characterized by markedly elevated zinc grades (the zinc-rich reserves quoted above). It is possible that this zinc-rich zone represents the exhalative cap to the stockwork zone exposed in outcrop and that this zone was also the source of the massive boulders on the dump. According to the NALCO drill logs, this zone appears to have a strike extent of less than 130 m and to pass into massive pyrite at depth (less than 90 m below surface). The distribution of drill holes is inadequate, however, to delineate the body.

A preliminary interpretation of the relationships at the Lockport deposit, therefore, suggests that it represents a proximal stockwork - massive sulfide system which faces east and is hosted by basaltic flows and pyroclastic rocks of indeterminate original composition. The mineralization may be related to the felsic volcanic episode represented by laterally equivalent crystal tuffs, but this cannot be demonstrated at present.

(3) Indian Cove: The main showing in the Indian Cove volcanics is displayed in a series of outcrops approximately 300 m southwest of Indian Cove. The mineralization is also exposed in several trenches and a small adit. It consists mainly of disseminated and stringer pyrite and chalcopyrite in altered rhyolite and silicic breccia. The mineralized zone is better displayed in drill core from eight holes which were drilled by Texasgulf in 1975. This core is presently stored at the Department of Mines and Energy's core storage library in Pasadena.

The mineralization as seen in core comprises a stockwork zone with a small, central, intensely altered chlorite-pyrite chalcoyrite zone surrounded by less intense sericite-silica alteration containing abundant pyrite-chalcopyrite (sphalerite) stringers. The alteration which accompanies the mineralization is pervasive but uneven in intensity. Quartz-sericite alteration is widely developed and is commonly accompanied by disseminated and stringer pyrite with minor chalcopyrite. Locally, the host rock is almost completely silicified over widths up to 3 m; these zones grade into less altered rhyolite and felsic volcanic breccia in which original textures are preserved. The most intense sulfide mineralization commonly occurs in zones where black chlorite alteration is best developed. These zones are generally 5 to 20 cm wide but locally as wide as 20 m, and generally contain minor amounts of visible sphalerite as well as the ubiquitous pyrite and chalcopyrite. Grades are commonly low. The best mineralization intersected by diamond drilling assayed 1.04% Cu, 0.78% Zn and minor silver over 10 m.

There does not appear to be any truly exhalative mineralization at the Indian Cove prospect. The showing seems to be a particularly intense facies of the pervasive alteration which is present throughout the felsic flow and pyroclastic sequence of the Indian Cove volcanics, and is interpreted as hydrothermal alteration related to the formation of the rhyolite dome at the base of the sequence. The effects of this hydrothermal activity are well displayed at the previously described locality on the shores of Indian Cove; less intense, although ubiquitous, pyritization and sericitization are evident in the felsic volcanic rocks for several hundred metres along strike from the prospect. The alteration at the main prospect is the most intense yet discovered in the sequence and the only one to contain significant quantities of base metals. This may be partly because most exploration on the property has been in the immediate vicinity of the showing. The hydrothermal system, however, is in evidence over an area considerably wider than the showings, and it may well be that zones of base-metal-bearing stockwork as well as exhalative sulfides related to hydrothermal fluid discharge remain to be discovered.

(4) Long Pond: This prospect lies within a narrow belt of rhyolitic tuff and breccia, but is at least in part hosted by a thin basaltic pillow lava / pillow breccia unit which can be traced for several hundred metres along strike. The mineralization consists mainly of heavily disseminated pyrite and minor chalcopyrite; it is accompanied by chlorite-sericite-silica alteration, and is probably stockwork type. No drilling has been recorded from the prospect. This favorable environment deserves a thorough look for massive sulfide mineralization.

Conclusions

This report summarizes the preliminary phase of a project designed to investigate the geological and tectonic environments of volcanogenic sulfide mineralization in Early-Middle Ordovician island-arc sequences of central Newfoundland. Further work in the Wild Bight Group will focus on petrographic, geochemical and isotopic studies of the volcanic rocks and the associated mineralization. Tentative conclusions reached on the basis of field work to date include the following:

(1) The Wild Bight Group records a dominantly volcaniclastic environment, punctuated by brief episodes of volcanic activity. It appears to have been deposited on the middle flanks of a major volcanic edifice located to the south of the presently preserved sequence.

(2) Volcanic accumulations are present at various stratigraphic levels in the sequence. The accumulations display significant differences in lithology and setting. Volcanism was dominantly mafic, but with development of areally restricted felsic domes and possibly ash flows.

(3) Sulfide mineralization accompanied several of the volcanic episodes. Exhalative sulfides are well developed at the Point Leamington deposit and are underlain by stockwork alteration and mineralization. Mineralization exposed on the surface at the Lockport, Indian Cove and Long Pond prospects (and in drill core from Indian Cove) is mainly of stockwork type, although evidence suggests that the Lockport deposit has an exhalative cap which does not outcrop. The potential for the existence of related massive sulfide mineralization is good in all cases.

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