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METALLOGENY OF THE CONNAIGRE BAY GROUP, SOUTHERN NEWFOUNDLAND

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ABSTRACT

The Late Precambrian Connaigre Bay Group is host to several small, massive sulphide occurrences and showings. They are located within a limited stratigraphic horizon, consisting of the upper section of the Tickle Point Formation and the conformably overlying and predominantly mafic volcanic lower section, of the Sam Head Formation.

The major showing located at Winter Hill is situated in a carbonate–calc-silicate lens, which is in turn located within mafic volcanics. Sphalerite, galena and chalcopyrite are the main ore minerals whereas pyrite, sphalerite and pyrrhotite are the dominant sulphides. Epidote and chlorite alteration are widespread in the mafic volcanics around the mineralized zone, and within the mineralized lens sericite, calc-silicate and chlorite alteration assemblages dominate.

Most of the other minor occurrences appear in the upper Tickle Point Formation and generally consist of massive pyrite lenses containing only trace amounts of base-metal sulphides. An exception to this is at Frenchman Head, where base-metal sulphides locally make up 5 percent of the rock.

A volcanogenic–exhalative genesis is suggested by most of the macroscopic and microscopic observations. The lithological setting, alteration assemblages and ore mineral abundances, are a few of the criteria that conform to a volcanic origin.

INTRODUCTION

The Connaigre Bay Group lies in the Gaultois (1M/12) map area and is accessible by a paved road (Route 360) to Harbour Breton and an unpaved road (Route 364) to Hermitage.

The 1988 field season was devoted to a metallogenic study of the Connaigre Bay Group. Known and newly found base-metal occurrences were sampled and mapped in detail. Emphasis was placed on the more extensively worked Winter Hill and Frenchman Head occurrences (Figure 1).

The area was first mapped by Widmer (1950). Greene (1975) mapped the Harbour Breton map area, and Greene and O'Driscoll (1976) mapped the Gaultois map area, southeast of Hermitage Bay on a 1:50,000 scale. The area was also the subject of an M.Sc. thesis study by O'Driscoll (1977), the results of which were reported by O'Driscoll and Strong (1979).

The topography is quite rugged, having steep valley walls grading into undulating upland regions. Bedrock exposure is good in the upland areas except in places where bogs fill the topographic lows. The valley slopes are generally covered with a thin veneer of vegetation near the top and the lower sections are usually tree covered.

GENERAL GEOLOGY

The Hermitage Peninsula is located along the southwestern margin of the Avalon Zone (Williams, 1979). It is separated from the metamorphosed and polydeformed rocks of the Gander Zone by the Hermitage Bay Fault.

The oldest rocks on the peninsula are silicic–mafic volcanics and sedimentary rocks of the Late Precambrian Connaigre Bay Group (O'Driscoll and Strong, 1979). The Late Precambrian age is inferred from a lithological correlation with the Long Harbour Group to the east (Greene and O'Driscoll, 1976). All the rocks of the Connaigre Bay Group are separated from other sedimentary sequences by either faults or igneous intrusions (O'Driscoll, 1977).

The Connaigre Bay Group is intruded by the Hermitage Complex, which consists of diorite, gabbro and granite (O'Driscoll, 1977), and outcrops along the southwestern portion of the Hermitage Peninsula. Numerous felsic and mafic dykes associated with the Hermitage Complex cut and appear to feed the volcanics of the Connaigre Bay Group. The Straddling Granite is a small intrusion associated with the Hermitage Complex (O'Driscoll, 1977), and is located near the head of Hermitage Bay.

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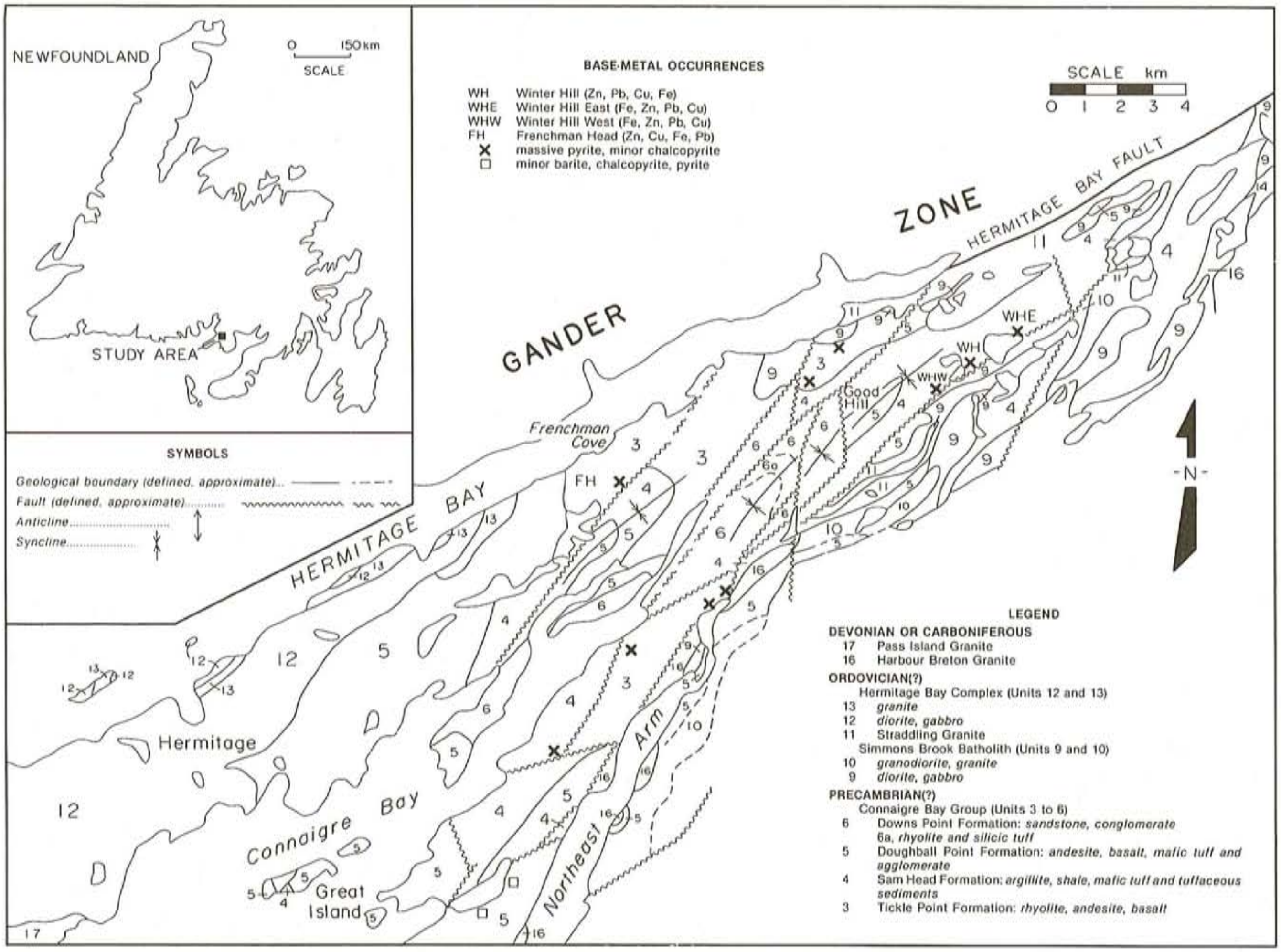


Figure 1. *Geology of the Hermitage Peninsula area (after Greene and O'Driscoll, 1976).*

The Hermitage Complex is intruded by the Pass Island Granite, which is similar to the Ackley Granite (Widmer, 1950) and considered to be about the same age (Devonian).

The Connaigre Bay Group

The Connaigre Bay Group is divided into four formations (O'Driscoll, 1977; Colman-Sadd *et al.*, 1979).

The basal formation is the Tickle Point Formation, which outcrops between the upper reaches of Connaigre Bay and Northeast Arm (Harbour Breton) and between Frenchman Cove and the head of Hermitage Bay (Figure 1). It consists of purple to pink, massive flow-banded and autobrecciated rhyolite and interbedded massive green andesite and basalt (O'Driscoll, 1977). The base of the Tickle Point Formation is not exposed, but, from outcrop exposures, the thickness of the formation is estimated to be at least 500 m.

The Sam Head Formation (Colman-Sadd *et al.*, 1979) conformably overlies the Tickle Point Formation. Close to Connaigre Bay, the Sam Head Formation consists of laminated green and grey argillite and has purple conglomerate, sandstone and shale at the base (O'Driscoll, 1977). Limestone lenses and limy argillite layers are rare. Southeast of upper Hermitage Bay it consists of interbedded mafic tuffs and tuffaceous sedimentary rocks (O'Driscoll, 1977). Carbonate–calc-silicate lenses are locally present and are important as a site for base-metal mineralization (see below). The total thickness of the Sam Head Formation is estimated to be at least 300 m (O'Driscoll, 1977).

The Doughball Point Formation conformably overlies the Sam Head Formation. It outcrops around Connaigre Bay and the Northeast Arm (Harbour Breton). It also appears as small conformable and fault-bounded lenses in the Good Hill area. The formation comprises green to grey massive andesite and basalt, fine to coarse, mafic tuff and agglomerate and minor interbedded silicic flows and tuffs. The Doughball Point Formation is the thickest formation in the Connaigre Bay Group (O'Driscoll, 1977) and is about 1500-m thick.

The Downs Point Formation is the uppermost sequence in the Connaigre Bay Group and conformably overlies the

Doughball Point Formation. This formation consists of red, purple and grey, graded and cross-bedded sandstone and pebble to cobble conglomerate. It also contains red, thinly laminated argillite and pink to purple massive rhyolite and silicic tuff (O'Driscoll, 1977). It outcrops along the northwest shore of upper Connaigre Bay and to the northeast of the head of Connaigre Bay. The estimated thickness of the Downs Point Formation is 1000 m, but faulting within the thickest exposed section (southwest of Good Hill) may have caused repetition or omission of some of the unit (O'Driscoll, 1977).

MINERALIZATION

Sam Head Formation

Field Relationships. The Sam Head Formation hosts the Winter Hill showings (Winter Hill (main showing), Winter Hill East and Winter Hill West) near a faulted contact with the Simmons Brook Batholith (Figure 1). The three showings occupy the same stratigraphic position along approximately 3 km of strike length. The Winter Hill showing occurs in a carbonate—calc-silicate lens, within mafic tuff, near the top of the Sam Head Formation (Figure 2). The Winter Hill East and Winter Hill West showings are in silicified argillite or fine grained tuffaceous rocks. All the showings are cut by felsic and/or mafic dykes or sills.

Sphalerite, pyrite, pyrrhotite, galena and chalcopyrite are the main sulphide minerals at the Winter Hill showing. There are also minor to trace amounts of magnetite. The mineralized zone, approximately 2- to 4-m thick, consists of disseminated to massive banded sulphides (Plate 1) underlain(?) by a zone of disseminated to massive pyrite and minor chalcopyrite, which has a maximum thickness of 4 to 5 m, but is irregular in shape. Bands of sphalerite (up to 10-cm thick) (Plate 2) occur discontinuously along the upper contact of the carbonate—calc-silicate unit. These sphalerite bands are overlain by either felsic or mafic intrusives or mafic tuffs. Magnetite also occurs along this upper contact, but only where the carbonate—calc-silicate lens is in contact with felsic intrusives.

The sphalerite bands grade downward into a calc-silicate facies containing thin laminae of sphalerite and increasing amounts of other sulphides. Underneath this is a discontinuous breccia unit (Plate 3) having fragments up to 0.5 m in diameter that are locally enveloped by thin bands of sphalerite. Gossanous material is common where sphalerite and other sulphides are present in the breccia. The gossan is generally rich in pyrite, chalcopyrite and sphalerite and has pervasive malachite and smithsonite staining. Carbonate having lesser calc-silicates underlie the breccia unit. Generally, the carbonate is unmineralized and exhibits contorted banding (Plate 4) (alternating carbonate- and sericite-rich layers), but near the breccia unit there is a thin (approximately 10 cm) bed of massive layered pyrite, sphalerite and galena. The attitude of this bed conforms with the local bedding.

Outcrop exposures at Winter Hill indicate that the carbonate—calc-silicate lens is at least 120 m in length, and between 5- and 10-m thick. Intersections in drill core indicate the unit, which dips between 30 and 40° to the northwest, is continuous, but is thinner about 150 m down dip.

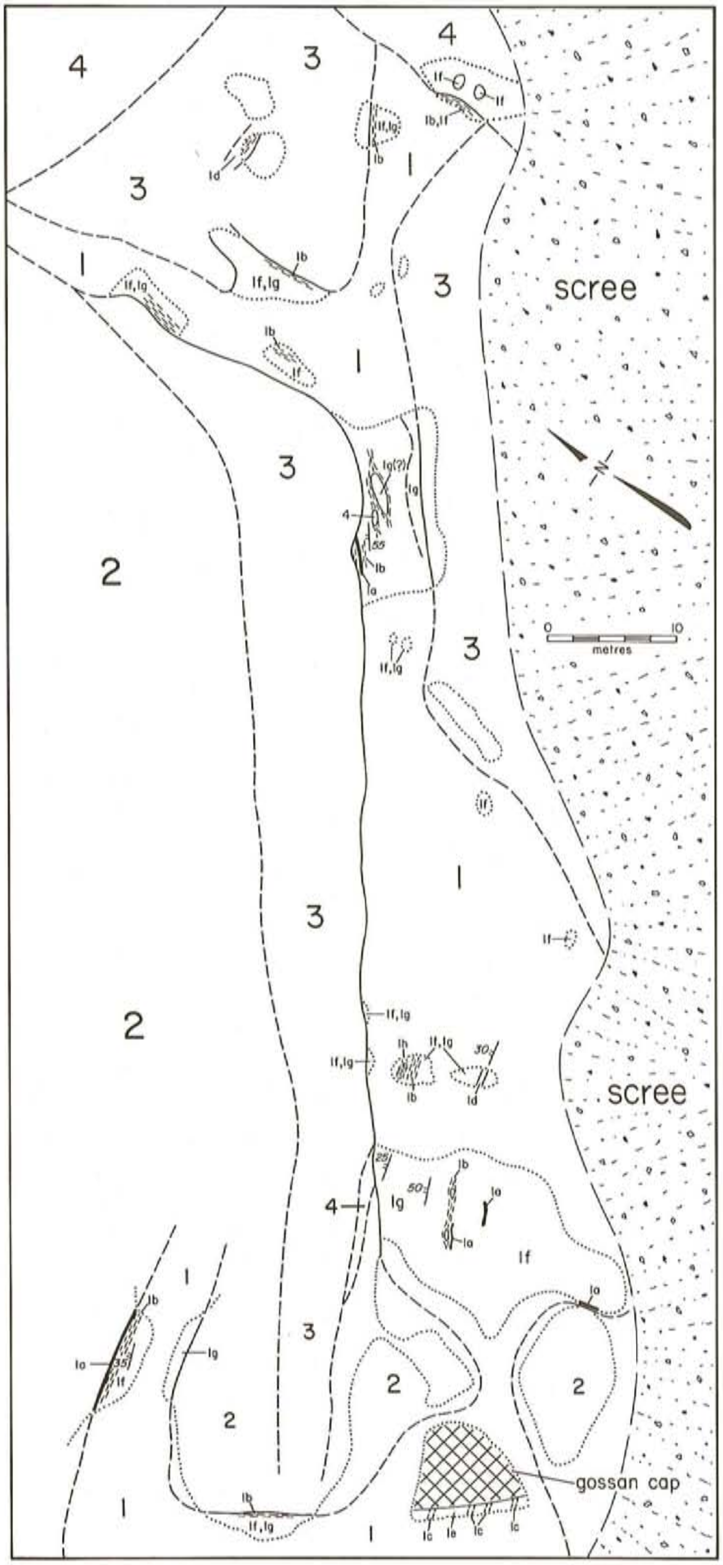
Winter Hill East and Winter Hill West are two small base-metal showings approximately 2 km northeast and 1.2 km southwest of Winter Hill, respectively. Both showings are hosted by silicified argillites or fine grained tuffaceous rocks. Mineralization at Winter Hill East consists of disseminated, semi-massive and massive pyrite and minor amounts of sphalerite and galena. The trench here is almost 30-m wide, but the best sulphide mineralization occurs over 5 to 10 m in the central portion of the trench. The host rock is bounded by a vesicular mafic flow or dyke along the western extension of the trench. The eastern section of the trench is mainly sheared argillite and disseminated pyrite.

The mineralized zone at Winter Hill West is smaller than the zone at Winter Hill East and consists almost entirely of semi-massive to massive pyrite. There is some banded pyrite and locally, disseminated sphalerite and galena are present.

Petrography. The mineralogy of the mineralized zones in the Sam Head Formation was studied from outcrop specimens and drill core samples. The local mafic lithic-crystal tuffs contain abundant fine grained plagioclase and lesser amounts of carbonate, pyroxene, and opaques as matrix components. Potassium feldspar, along with minor quartz, plagioclase, and hornblende and/or pyroxene make up the crystals, whereas the lithic clasts, generally, have the same mineralogy as the tuff.

Alteration is quite extensive within the tuffs. The matrix appears to be the least altered, but the fine grained crystals are cloudy and in places altered to assemblages of epidote, chlorite, and carbonate. Generally, the lithic clasts are more altered and contain similar assemblages. The K-feldspar crystal fragments are anhedral to subhedral and are commonly saussuritized. In a few cases, crystal overgrowths of a fibrous mineral obscures contacts between the crystal and the surrounding matrix. Plagioclase crystals show albite twinning and are also partly saussuritized. The hornblende and/or pyroxene crystals are altered to a combination of epidote and chlorite, whereas the quartz crystals are essentially fresh but show undulose extinction. Epidote and chlorite alteration is more prevalent closer to the ore zone, whereas sericite, carbonate and albite (?) alteration is more abundant farther away from the ore zone. This may be a direct result of the increase in mafic crystals as the ore zone is approached.

The carbonate—calc-silicate lens, which hosts the base-metal mineralization at Winter Hill (main showing) consists mainly of calcite and/or dolomite and lesser amounts of tremolite, diopside, sericite and quartz. Pyrite, sphalerite and rutile (hematite?) locally constitute between 1 and 2 percent



LEGEND

ORDOVICIAN OR OLDER

Hermitage Bay Complex

4 MAFIC DYKES/SILLS

3 FELSIC DYKES/SILLS

LATE PRECAMBRIAN

Sam Head Formation (Connaigre Bay Group)

2 MAFIC TUFF

1 CARBONATE/CALC-SILICATE LENS

- 1a semi-massive to massive sphalerite
- 1b thin sphalerite bands
- 1c semi-massive to massive pyrite (± cpy, po, gn, sph)
- 1d semi-massive to massive banded sulphides
- 1e semi-massive to disseminated pyrite
- 1f carbonate/marble
- 1g calc-silicate
- 1h breccia

Symbols

Geological boundary (known, approximate)..

Major outcrops..

Sulphide/Carbonate banding.......................... 50

Figure 2. *Geology of the Winter Hill showing.*

Plate 1. *Thinly banded massive sulphides (subunit Id).*

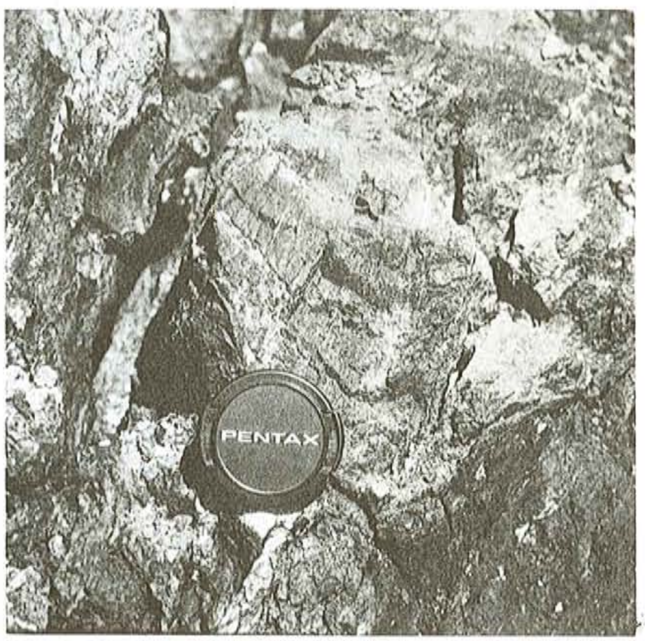


Plate 2. *Band of semi-massive to massive sphalerite (subunit Ia).*

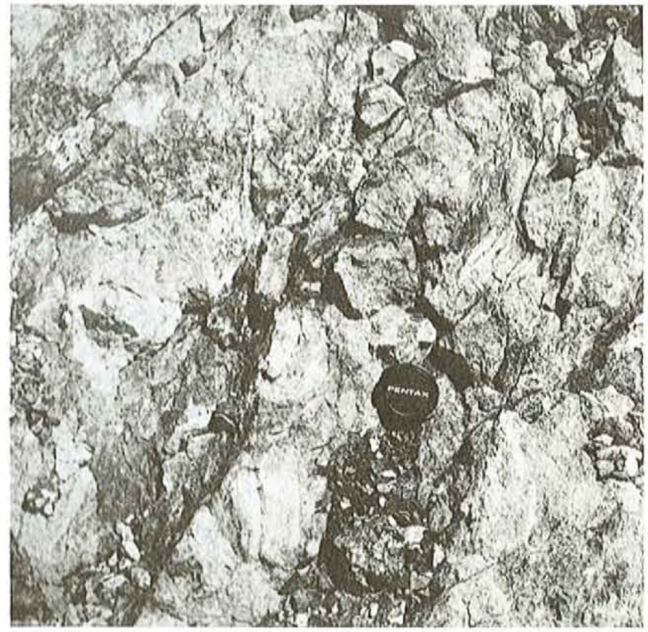


Plate 3. *Carbonate breccia unit at Winter Hill.*

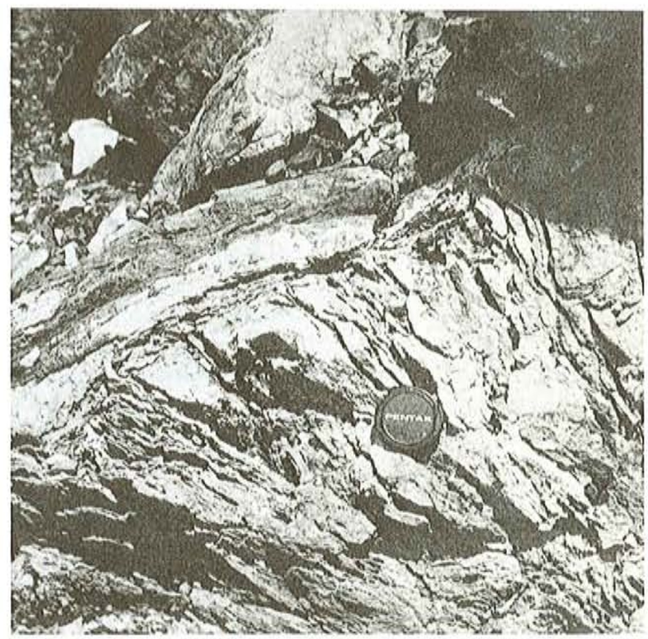


Plate 4. *Contorted banding within the carbonate lens.*

of the rock. Near the lower contact with the mafic tuff, there is secondary serpentine, chlorite, epidote and possible talc. Relict olivine crystals, now mostly serpentine, are also present.

Tremolite and diopside are the major constituents of the calc-silicate facies associated with smaller percentages of quartz, carbonate and sericite. Epidote and chlorite are common alteration products and sericite, plagioclase and rutile are rare.

Sphalerite and pyrite are the most abundant and widespread opaque minerals present in the Winter Hill showing. Chalcopyrite is usually present, associated with sphalerite and pyrite, but only in minor amounts. Galena, pyrrhotite and magnetite are also present in small quantities but are more localized. Digenite and chalcocite(?) occur as rare disseminated grains.

Sphalerite and pyrite occur in all mineralized areas, but sphalerite tends to be concentrated near the top of the carbonate–calc-silicate lens and pyrite is more common below the sphalerite-rich layers. Sphalerite, generally, occurs as medium- to coarse-grained anhedral crystals commonly containing chalcopyrite inclusions. Pyrite is usually present as subhedral to euhedral, fine- to medium-grained cubes, but rarely displays a colloform-like texture. Some of the pyrite cubes show evidence of fracturing along their boundaries whereas others are partially replaced by pyrrhotite(?). Sphalerite cores are also present within some of the pyrite crystals.

Chalcopyrite, present as inclusions in sphalerite, also occurs as fine grained crystal masses normally in close proximity to pyrite. Fine grained digenite and chalcocite, where present, are associated with chalcopyrite. Galena and pyrrhotite tend to be concentrated near the upper contact with the felsic unit. Galena occurs as anhedral, fine- to medium-grained crystals usually concentrated in thin (millimetre scale) layers. Pyrrhotite is present as small disseminated crystals and as a possible alteration product of pyrite.

Magnetite is almost solely limited to the contact zone between the carbonate–calc-silicate unit and the upper felsic unit. It occurs as thin discontinuous layers or as small crystal aggregates.

Tickle Point Formation

Field Relationships. Mineralization at Frenchman Head is contained in felsic volcanics of the lower Tickle Point Formation. The showings contain only minor disseminated and banded base-metal sulphides (up to 5 to 10 percent). The silicified host rocks in the mineralized area commonly contain quartz 'eyes' in a matrix of fine grained quartz, sericite and chlorite. Pyrite, sphalerite, galena and chalcopyrite, generally, occur as disseminated grains, but are rarely concentrated in thin bands. Pyrite is the dominant sulphide in these thin bands. Chalcopyrite, pyrite and galena ± chalcocite also occur along some fractures. The mineralized zone is commonly overlain by carbonatized and chloritized mafic volcanics.

On the surface, the sulphide-rich zones are exposed in three lateral mineralized outcrops that apparently occupy the same stratigraphic level; these zones are between 5- and 7-m thick and probably up to 400 m long. The sulphide mineralization is cut by porphyritic mafic dykes.

Massive and massive-banded pyrite occur at several other localities in the Tickle Point Formation. These occurrences are commonly barren of base-metal sulphides but chalcopyrite is present as a minor to trace constituent in some localities. The massive pyrite lenses are up to 2- to 3-m thick and may be continuous for 500 to 1000 m along strike. They are hosted by fine grained felsic volcanic rocks, felsic tuffs, silicified argillites and/or cherts. Minor amounts of mafic tuff are not uncommon at most occurrences.

Petrography. Sulphide-rich zones in the Tickle Point Formation are contained essentially within fine grained felsic rocks. These rocks are characterized predominantly by fine grained quartz. Aggregates of quartz crystals commonly form small spheres and may indicate a spherulitic texture. Plagioclase is present as phenocrysts and in the matrix. Fresh plagioclase normally displays albite twins, whereas some show oscillatory zoning (possible sanidine). However, the majority of the plagioclase is altered to either chlorite, sericite, or epidote. Potassium feldspar is also present but may be difficult to distinguish from untwinned and singularly twinned plagioclase. Pyroxene and hornblende occur rarely and are usually partly or wholly altered to epidote or chlorite.

At Frenchman Head, pyrite comprises approximately 80 percent of the total opaque mineralogy; sphalerite and chalcopyrite constitute the remainder. The pyrite is present as fine- to medium-grained disseminated crystals. Sphalerite grains are usually larger than the pyrite grains and commonly contain inclusions of chalcopyrite. Chalcopyrite also occurs as small discrete crystals.

Away from the Frenchman Head showing, pyrite is essentially the only opaque mineral. Some areas locally contain 1 to 2 percent sphalerite and chalcopyrite combined. The pyrite occurs as semi-massive to massive-layered, fine grained subhedral crystals. Sphalerite and chalcopyrite are generally anhedral and smaller in size. Hematite is present as coatings around pyrite crystals or as thin veinlets (possibly oxidized pyrite veins), in places containing rutile.

Doughball Point Formation

Field Relationships. In the Doughball Point Formation there is a minor occurrence of chalcopyrite and barite. Chalcopyrite is present as isolated patches in and around some mafic dykes whereas both barite and chalcopyrite are present in carbonate and quartz–carbonate veins cutting the mafic tuffs. Barite is limited mainly to the calcite–quartz veins, but only two veins in two different localities contain barite. Semi-massive pods of hematite are also located in some veins.

Petrography. The mafic dykes are composed essentially of equigranular plagioclase and pyroxene. Some of the pyroxenes are altered slightly to chlorite and epidote. The larger plagioclase crystals are rimmed by small pyroxene crystals. Potassium feldspar is also a minor component. One mineralized vein contains garnet and pyroxene.

The intruded mafic tuffs have been altered to a fine grained assemblage of calcite, epidote and other calc-silicate minerals.

DISCUSSION

Massive sulphide showings and occurrences within the Connaigre Bay Group are concentrated near the top of the

Tickle Point Formation and at the base of the conformably overlying Sam Head Formation. Macroscopic and microscopic examinations of these mineralized zones suggest a volcanic–exhalative origin. The criteria leading to this conclusion are as follows:

- a close association with volcanic and volcaniclastic rocks, fine grained sedimentary rocks and chemical precipitates (i.e., carbonates and cherts);
- the sulphide lenses are restricted to a limited stratigraphic package and were probably formed over a short interval of time;
- the common occurrence of thin sequences of massive pyrite, with or without base-metal sulphides;
- sulphide mineralogy dominated by pyrite and lesser amounts of sphalerite, pyrrhotite, galena and chalcopyrite;
- sphalerite and galena are the dominant ore sulphides in the upper section of the carbonate–calc-silicate lens at Winter Hill, whereas pyrite and minor chalcopyrite are more abundant in the lower section of the lens;
- local sericite and chlorite alteration; and
- granular texture displayed by much of the sulphides and some pyrite grains displaying rare colloform texture.

All the above criteria have not been found together, at any one occurrence or showing, but are a culmination of observations made during the study. At many localities, younger events (i.e., formation of skarnoid(?) minerals within the carbonate–calc-silicate lens at Winter Hill) have obscured original textures and also, possibly, have altered the primary mineral assemblages.

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REFERENCES

Colman-Sadd, S.P., Greene, B.A. and O'Driscoll, C.F.
1979: Gaultois, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Map 79-104.

Greene, B.A.
1975: Harbour Breton map area. *In* Report of Activities. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 75-1, pages 3-9.

Greene, B.A. and O'Driscoll, C.F.
1976: Gaultois map area. *In* Report of Activities. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 76-1, pages 56-63.

O'Driscoll, C.F.
1977: Geology, petrology and geochemistry of the Hermitage Peninsula, southern Newfoundland. Unpublished M.Sc. thesis, Memorial University of Newfoundland, St. John's, Newfoundland, 144 pages.

O'Driscoll, C.F. and Strong, D.F.
1979: Geology and geochemistry of late Precambrian volcanic and intrusive rocks of southwestern Avalon Zone in Newfoundland. Precambrian Research, Volume 8, pages 19-48.

Widmer, K.
1950: Geology of the Hermitage Bay area, Newfoundland. Unpublished Ph.D. thesis, Princeton, New Jersey, 439 pages.

Williams, H.
1979: Appalachian Orogen in Canada. Canadian Journal of Earth Sciences, Volume 16, pages 792-807.