THE BETTS COVE SULPHIDE DEPOSIT

by

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Introduction

During the 1982 field season detailed mapping and sampling of the abandoned Betts Cove Mine was carried out as part of a masters thesis on the controls of mineralization there. The thesis will concentrate on the alteration surrounding the mine and its relationship to the mineralization, and on the ore mineral paragenesis. Upadhyay (1973) mapped the entire Betts Cove ophiolite and Riccio (1972) mapped the area between Burton's Pond and Betts Big Pond. The thesis area is within the region mapped at 1:50,000 by DeGrace *et al.* (1976). This study was confined to detailed mapping on a grid spaced in part at 50 x 25 m intervals and in part at 100 x 25 m intervals over the mine area and the Fault Cove Fault (Fig. 1), and relied on previous mapping when sampling showings away from the grid. Many geographical names were taken from Upadhyay's (1973) map as these names are on file with the Mineral Occurrence Data System.

The Betts Cove ophiolite, which is exposed in an arc extending from Betts Cove to Tilt Cove (Fig. 1), is a part of the Lower Ordovician Snooks Arm Group. The ophiolitic rocks are conformably overlain by volcanic and sedimentary rocks of disputed affinity which complete the Snooks Arm Group. The latter sequence has been interpreted as an early arc assemblage (DeGrace *et al.*, 1976; Strong, 1977) and as having formed in a marginal basin (Upadhyay and Neale, 1979). Jenner and Fryer (1980) favoured the latter interpretation or an oceanic island setting but were unable to distinguish between the two. The Snooks Arm Group is 5.7 km thick and has a southeasterly dip that varies from about 35° to 85° (Upadhyay, 1973). Rocks of ophiolitic affinity which outcrop further south from Nippers Harbour to Stocking Harbour are considered to be an extension of the Betts Cove ophiolite (Riccio, 1972; Upadhyay, 1973; DeGrace *et al.*, 1976). Upadhyay (1973) has divided the Snooks Arm Group into five formations, of which the lowermost is the Betts Cove ophiolite, and he has divided the ophiolite into four members - a layered Ultramafic Member, an irregular, poorly developed Gabbroic Member, a Sheeted Dike Member and a Pillow Lava Member. A complete section is exposed at Betts Cove but throughout most of the ophiolite the Pillow Lava Member is faulted against the Ultramafic Member and most of the two intervening members are missing.

The mine is located at Betts Cove in the contact zone between the pillow lava and sheeted dike units. Access is generally available by boat from Nippers Harbour, 7 km to the southwest. The Betts Cove Mine was in operation from 1875 to 1883 when it was closed as the result of a cave-in. During that time 130,682 tons of ore and regulus plus 2,450 tons of pyrite were produced, of which 95,999 tons of ore were shipped. The grade is said to have averaged nearly 10% copper. No estimate of reserves is available (Snelgrove and Baird, 1953).

Snelgrove (1931) and Baird (1948) described the sulfides at Betts Cove, and Upadhyay and Strong (1973) interpreted the deposits as comparable with those in Cyprus. In addition there are various unpublished company reports on the deposit.

Gabbro Member (Unit 1)

The largest mass of gabbro outcrops in the area northwest of Joey's Pond where it is faulted in part against

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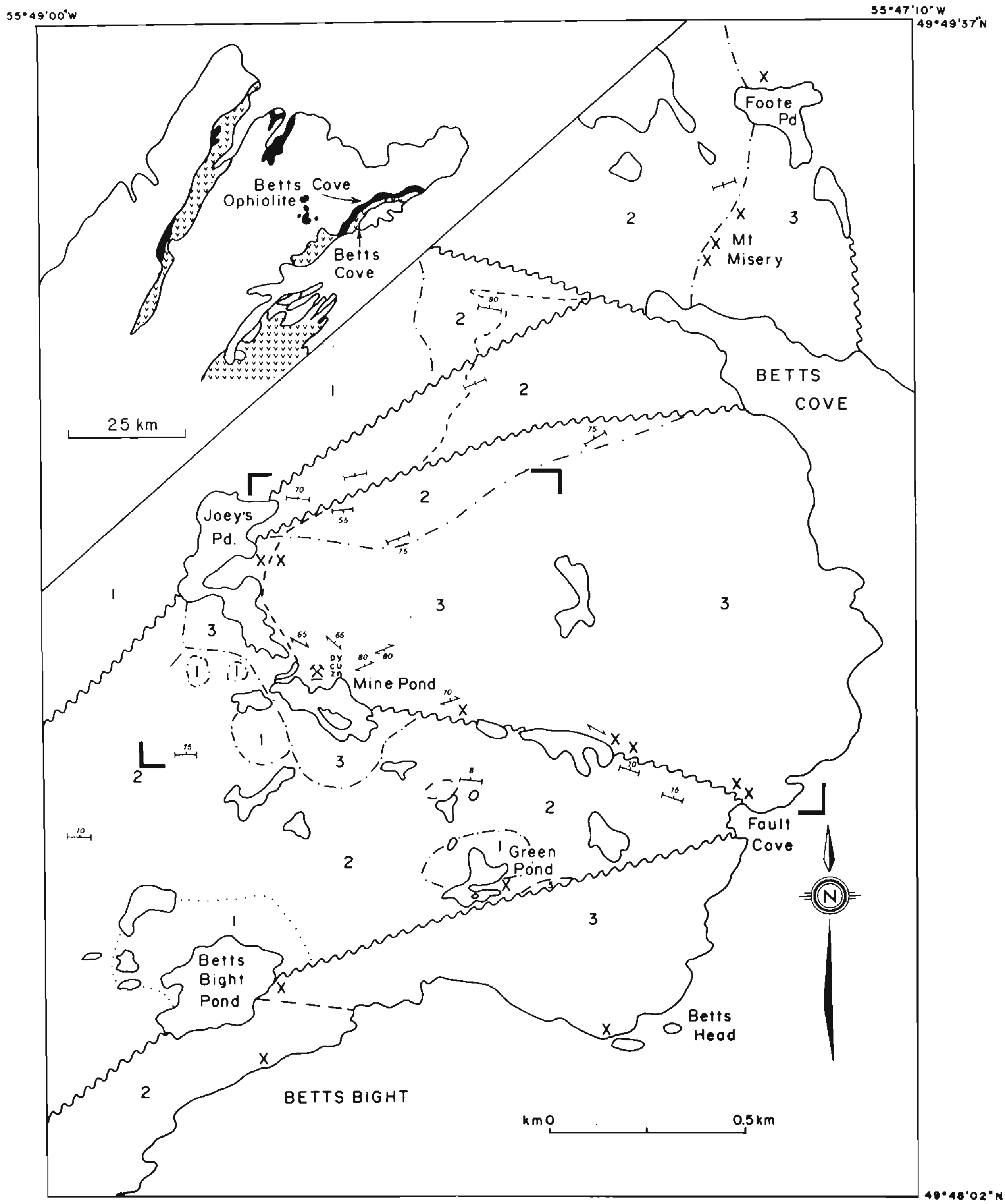
55°49'00"W
55°47'10"W
49°49'37"N
49°48'02"N
Betts Cove
Ophiolite
Betts
Cove
25 km
Foote
Pd
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Joey's
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Mine Pond
Fault
Cove
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Pond
Betts
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Head
BETTS BIGHT
km 0
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Figure 1: Geology of the Betts Cove area, northern Newfoundland. Index map of Figure 1 shows location of the Betts Cove ophiolite and other ophiolites of the Burlington Peninsula (Strong, 1982).

3 Variolitic pillow lavas, pillow breccia.

2 Sheeted dikes with gabbro screens and minor pillow lava screens, minor dike breccia.

1 Fine grained gabbro and leucogabbro.

Corners of grid

Betts Cove mine trail

sheeted dikes. However, to the northeast it is in gradational contact with the sheeted dike unit. Here, screens of gabbro and banded ultramafic rocks are found between the dikes. This gabbro, which was not mapped in detail, consists of approximately 50% plagioclase, 40% mafic minerals and up to 10% quartz. Grain size averages 1 to 2 mm.

To the west and south of the mine area, numerous screens and several large pods of gabbro occur within the sheeted dikes. The largest pods outcrop west of Mine Pond and along the north side of Green Pond. They are cut by dikes which become more numerous towards the edges of the gabbro pods until they become sheeted. The large mass north of Betts Bight Pond, mapped by Upadhyay (1973), and Riccio (1972), was not mapped by the author. Generally the gabbro contains about 50% mafic minerals and variable amounts of plagioclase and quartz. The plagioclase is translucent to opaque, and forms white, irregular patches which surround and enclose the pyroxenes. Most of the plagioclase has been variably altered to sericite. Plagioclase from gabbro near Fault Cove has been extensively altered, (probably saussuritized). The gabbro near Green Pond is leucocratic, containing about 80% plagioclase and quartz and 20% highly altered pyroxene. In places subhedral 2 mm crystals of plagioclase are partly surrounded by patches of altered chloritic pyroxene.

These gabbro pods may have intruded the sheeted dike and pillow lava units and been subsequently cut by dikes. The only definite intrusive contact was found on the shoreline at Betts Cove. There, a quartz-rich calcareous gabbroid rock intrudes the sheeted dike unit. In a sample taken from a boulder in which the contact is displayed, the gabbroid rock is chilled against the diabase. It contains 2 mm to 1 cm size xenoliths of diabase. In two places, screens of gabbro and pillow lava are found in close proximity within the dikes, suggesting that the gabbro may have intruded the pillow lavas.

Sheeted Dike Member (Unit 2)

The Sheeted Dike Member outcrops north, west and south of the central block of pillow lavas. The dikes strike generally east-west and dip steeply north, but their attitude varies locally, especially where there is a high percentage of gabbro screens. The dikes northeast of Joey's Pond are mostly sheeted, although there are numerous gabbro screens near the gradational contact with the gabbro unit. Dikes west of Joey's Pond and south of the Fault Cove Fault contain numerous screens and pods of gabbro. The dikes average 20 to 30 cm in width and weather red, red-brown, gray and green. Many of the red-weathering dikes are rich in mafic minerals (relative to the green weathering dikes) and the mafic minerals in places are aligned parallel to the dike margins. These dikes are fine grained and may be black on fresh surface but more commonly are olive green. The gray and green weathering dikes are generally fine grained and dark green to black on fresh surface, and plagioclase can be distinguished in most. Several thin, aphanitic, green-weathering dikes are also seen. These are commonly chilled against the other dikes which they generally cut at low angles.

Several east-west trending, very fine grained, siliceous dikes cut the pillow lavas north of Fault Cove. These dikes weather white and are pale green on fresh surface.

There are several orange-red weathering, variolitic dikes outcropping on Mount Misery. The variolites average 3 to 5 mm, weather white, and are prominent on weathered surfaces. They are translucent brownish green, have diffuse margins and are of a more felsic composition than the matrix which is fine grained and black. Some of the variolites are zoned such that the rims are richer in quartz and, therefore, more resistant than the centers. This gives rise to a doughnut effect on weathered surfaces.

A late siliceous dike cuts, at right angles, sheeted dikes along the Betts Cove mine trail. This dike is 40 cm wide, aphanitic, brownish yellow and has approximately 1%, 1 mm patches of white calcite.

Most dikes have at least one chilled margin although the contacts are commonly obscured by fracturing and shearing. The red weathering dikes are in places chilled against the green-gray weathering dikes but the reverse is also common.

Dike breccia outcrops in several areas. It commonly follows the trend of the dikes and consists of subrounded to subangular fragments which average a few millimetres to a few centimetres across, but in places are up to 30 cm across. The degree of brecciation varies, and in places fragments are all diabase and are difficult to see on fresh surface. Where brecciation has been more intense there is a higher proportion of matrix, and fragments of gabbro have been incorporated into the breccia. Some of the diabase fragments have chilled margins indicating that the dike had cooled before it was brecciated. The matrix is composed of smaller fragments and a yellow epidote cement.

Pillow Lava Member (Unit 3)

The pillow lavas are found in three areas; Mount Misery, to the immediate north of Betts Cove; south of Betts Cove, in the vicinity of and to the east of the mine; and on the coast near Betts Head. They generally dip moderately eastward. They average 10-30 cm in diameter, but may be 50 to 100 cm wide in places. Most are round or ellipsoidal; tubular pillows are also found, especially about 1 km east of the mine. Near the mine the pillows are tightly packed and there is little interpillow material. Away from the mine area there is interstitial green to pale brown and, less commonly, red chert. Red chert is more common on Mount Misery. Brecciated and broken pillows and hyaloclastic material are found in interstices where pillows are less tightly packed. Pillows are generally variolitic throughout the area, although in the vicinity of the mine at the gradational contact with the dikes they may contain only a few variolites. Variolites average 2 to 4 mm in diameter, but range from 1 to 7 mm. Commonly, variolitic texture begins 2 to 4 cm from the pillow rim and variolites increase in size and abundance towards the pillow centre until they coalesce. The variolites are lighter colored than the matrix, and most are pale green although they may also be cream, gray or brown. In places they are composed of acicular crystals (possibly amphibole) arranged in radial clusters. The matrix to the variolites is usually fine grained and gray to black. In places pillows are pale green to gray and this may be the result of alteration or may represent completely coalesced variolitic material. The pillows are locally amygdaloidal, and vesicles are filled with calcite, chlorite or quartz.

Near the mine and the nearby ponds the contact between the pillow lavas and the dikes is gradational. The pillows are small, poorly developed and tightly packed. They contain few variolites and are cut by pyrite and chalcopyrite-bearing stockwork quartz. Outcrops along the lake shores and the old road are generally unpillowed, fine grained black basalts. In places, dikes with pillow screens are seen.

Pillow breccia occurs locally in the area. It consists of subangular fragments up to several centimetres across, in a chloritic, epidotitic or siliceous matrix. Locally hyaloclastic texture is well developed. Pillow brecciation is in places confined to interstices, but is also developed on a larger scale.

Throughout the area the pillows are cut by late vuggy quartz veins which commonly contain epidote and calcite.

Economic Geology

Rocks outcropping in the vicinity of the mine contain only minor sulfides and the underground workings are now inaccessible. Much of the immediate area is covered by debris from the rockfall that resulted in mine closure, and by ore and waste dumps. At the mine site most of the sulfide in outcrop is stringer pyrite and chalcopyrite in stockwork quartz, and pyrite disseminations in the pillow lavas. These occurrences are concentrated in chloritic shear zones striking southeast and dipping 60° to 70° northeast. In places the pillows are sheared and flattened. Pyrite and chalcopyrite, associated with sugary white quartz, are locally concentrated in the interstices.

Massive sulfide outcrops at only one place; a 1.5 m thick unit of massive banded sulfide intercalated with sheared chloritic pillow lavas outcrops at the entrance to, and for the length of, a 20 m long adit. The shear zone is 3 to 4 m wide, strikes 060° and dips 70°N to 80°S. The banding in the ore, which parallels the foliation of the shear zone, may be of sedimentary origin, but no unequivocal sedimentary features were seen. The bands are 1 to 5 mm thick and are composed of pyrite, very fine grained sugary quartz, and minor chalcopyrite. The sulfide zone is very soft, crumbly and porous. This is not a result of surface weathering as the rock is not rusty. The banding appears to be the result of differing grain sizes and textures of pyrite and differing proportions of quartz and pyrite. The sulfide zone has a sharp contact with the sheared pillows and contains lenses and fragments of them. The pillows are variolitic and near the sulfides have well developed hyaloclastic texture. Red chert is found in the interstices and is in places remobilized in stringers which parallel the foliation.

Several showings were visited other than those in the immediate vicinity of the mine. All are either stockwork quartz with pyrite and chalcopyrite, calcite veins with chalcopyrite, or minor disseminations of chalcopyrite and pyrite. The most important showings occur at Mount Misery, along the Fault Cove Fault, at Betts Head and at Betts Bight Pond. An abandoned shaft or test pit is located at each of these showings. Most have only minor sulfides in outcrop, but strewn about there are mineralized boulders and rubble from inside the shafts. All of these showings except the one at Betts Head are near the pillow lava - sheeted dikes contact, but at Betts Head there are numerous dikes cutting the pillows.

Upadhyay (1973) estimated the proportion of dikes here to be 10% to 30%. Chloritic shear zones were seen in outcrop at only a couple of places along the Fault Cove Fault and at Betts Head but boulders from other showings are chloritic and sheared. Many barren shear zones, as well, are found in the pillow lava unit along the Fault Cove Fault. The shear zones strike generally east-southeast, parallel to the fault, and dip steeply north. The shear zones range from a few centimetres to a couple of metres in width and die out rapidly across their strike. Upadhyay and Strong (1973) interpreted them as being later than the mineralization and thought that the mineralized zones were structurally weak areas that were preferentially sheared.

Samples (especially of massive sulfide) were collected from ore dumps in the area. Many massive sulfide samples are composed of bands of pyrite, chalcopyrite and sphalerite. In many samples the sulfides are sheared and the banding appears to be overprinted by secondary subhedral pyrite cubes. Chalcopyrite is also found as irregular bands in chlorite schist. These samples contain only minor subhedral pyrite. Most of the stringer and disseminated sulfides were sampled from outcrops around the mine and the showings previously described. The quartz stringers are generally thin (<5 mm across) and contain stringers and disseminations of chalcopyrite. Pyrite is also commonly present in the stockwork and disseminated in the rock as subhedral to euhedral cubes up to 5 mm across. In places, stringers and patches of pyrite are found without chalcopyrite or quartz as accessories. Chalcopyrite and malachite are found in later, thin calcite veins which cut the massive ore.

The showing at Burton's Pond, which is about 1 km west of the area shown in Fig. 1, was examined briefly. It is in the sheeted dike unit but there are a large number of gabbro and ultramafic screens in the area. The rock around the showing is extensively chloritized and is cut by quartz and calcite veins. The sulfides occur as stringers and disseminations in quartz veinlets.

The showing was described briefly by Douglas *et al.* (1940). Arsenopyrite was tentatively identified and a grab sample was analyzed with the following results: Cu 1.21%, S 3.36%, As 2.68%, Ag 10.6 g/t and Au 14.4 g/t. The high arsenic value was interpreted as a confirmation of the presence of arsenopyrite (Douglas *et al.*, 1940).

The present author was influenced by this report and wrongly identified the most common sulphide at the showing as arsenopyrite (reported in the Newfoundland Department of Mines and Energy Preliminary Reports for 1982). It was later identified in polished section and by electron microprobe as non-magnetic pyrrhotite. A few microscopic grains of cobaltite (CoAsS) were identified by microprobe analysis. Other sulphides present are chalcopyrite and minor sphalerite.

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