4. MARBLE-HOSTED DEPOSITS: MEAT COVE & LIME HILL

High grade massive sphalerite zone at Lime Hill deposit.

4.1 INTRODUCTION

Hill (1989) recognized two major categories of base metal deposits within the marble-hosted (George River Group) metallic deposits in the pre-Carboniferous rocks of Cape Breton Island.

Polymetallic skarn mineralization is related to a discrete contact metamorphic or metasomatic event and may be hosted both in the carbonates and the intrusives. Further subdivision may be made based on metal association.

Stratabound mineralization is generally restricted to a discrete carbonate unit, is not related to a definable contact metamorphic event, and the associated calc-silicate assemblages are interpreted as reflecting regional rather than local contact metamorphism. Further subdivision of this class may be made based on morphology and metal association.

Earlier investigators (Milligan, 1970 and Chatterjee, 1980) had suggested that the carbonate-hosted deposits of the George River Group of Cape Breton were all skarn-type deposits. The more recent documentation of analogies with the marble-hosted deposits of Quebec and New York State opens up exploration potential. Briefly, these deposits are hosted within the "Marble Belt" of the Grenville Structural Province (Gauthier & Brown, 1986). This belt hosts one major producer, the Balmat-Edwards mine in New York State, and many similar though smaller deposits, several of which have been mined in a small way, occur within the belt. Sulphide mineralization is characteristically hosted in regionally metamorphosed calc-silicate-bearing dolomite marble as coarse-grained, massive to banded, disseminated concentrations of sphalerite ± galena, pyrrhotite, pyrite and chalcopyrite. The deposits are considered to originate from remobilized sediments and display a stratiform control to mineralization. Metamorphism and tectonism have subsequently caused remobilization of the ore into high grade shoots and lenses and orebodies are described as "rod- or pencil-like" because they can continue for long distances along plunging fold axes.

4.2 LOCATION AND ACCESS

The marble-hosted deposits at Meat Cove and Lime Hill, in Cape Breton Island, are similar to the Grenville deposits and have been selected to illustrate this base metal environment, which would appear to be confined to Cape Breton Island (Fig. 12).

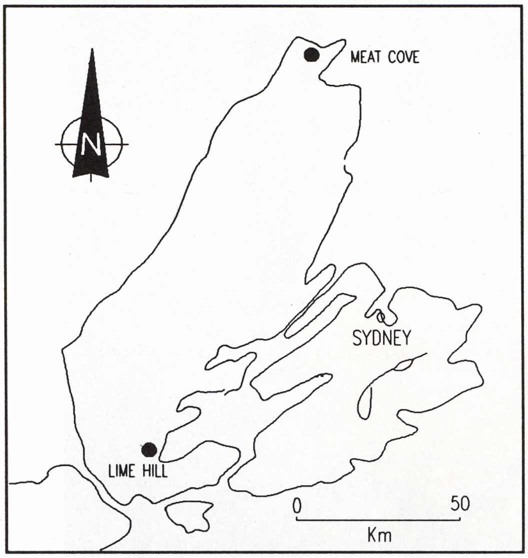

Figure 12. *Proterozoic stratabound carbonate-hosted base metal deposits in Cape Breton.*

The **Meat Cove** Zn, Pb, Cd, Ge, Cu deposit is located in Inverness County, at the northern tip of Cape Breton Island, at longitude 60° 35'W and latitude 47° 00 N and on NTS map sheet 11N-2A.

The **Lime Hill** Zn, W, wollastonite deposit is located at 61° 09'W and 45° 47'N on NTS map sheet 11E-14A in Inverness County. The deposit is located on North Mountain, on the northern shore of the West Bay of Lake Bras d'Or, and approximately 25 km northeast from Port Hastings.

4.3 PREVIOUS WORK

Fletcher (1881) designated the term George River Group to describe the Precambrian metacarbonates of Cape Breton Island. Historically, both the Lime Hill and Meat Cove deposits have been regarded as contact metasomatic skarn-type deposits (Keating, 1960; Chatterjee, 1977, 1979 & 1980) but more recent workers (Hill, 1987 & 1989; Sangster and Thorpe, 1988; and Sangster, 1990) have drawn analogies with the base metal deposits hosted in Grenville Supergroup marbles in southeastern Ontario, southwestern Quebec and northern New York State.

4.4 EXPLORATION HISTORY

Both deposits were discovered in the mid 1950s and have been subjected to several exploration programs in the intervening years.

4.4.1 Meat Cove

Diamond-drilling to test an aeromagnetic anomaly in 1953 led to the discovery of the Meat Cove deposit in northern Cape Breton Island. The initial drilling program, by Mineral Exploration Corp., comprised 5 holes totalling 443 m, and intersected "good" sphalerite mineralization (Nova Scotia Department of Mines, Annual Report 1953).

Between 1953 and 1956, a further 3111 m of surface and 1300 m of underground drilling were completed. The deposit was accessed by a 171 m long adit (Fig. 13) from which some 70 m of crosscuts were developed. This program, under the direction of McPhar Geophysics Ltd., included extensive geological mapping, geochemical surveys, geophysical surveys and the excavation of 62 pits.

By 1957 two zones totalling 3.18 million tonnes grading between 2% to 3% Zn, with Cd and Ge values, were outlined. In 1965 ore reserves were estimated as 4.0 million tonnes grading 4% Zn, and 0.15 to 0.47 lbs. Cd/t.

A trenching program in 1968 reported grades of 5.65% Zn over a length of 77 m, and included a 31 m section averaging 10.15% Zn (Chatterjee, 1979). Huston and Associates (1972) estimated 3.18 million tonnes grading 2.08% Zn in the Adit zone with a further 0.36 million tonnes at 2.76% Zn in a second zone (Dunbar, 1965).

Belore Mines (Houle et al., 1989) examined the deposit in 1988-89 and reported a total of 6380 m in 67 surface drillholes and 1306 m in 24 holes from underground as being on file at Nova Scotia Department of Natural Resources. The Belore exploration program included line cutting, soil sampling, a magnetometer survey, geological mapping and sampling of outcrops and trenches, and some mapping and sampling of the old adit.

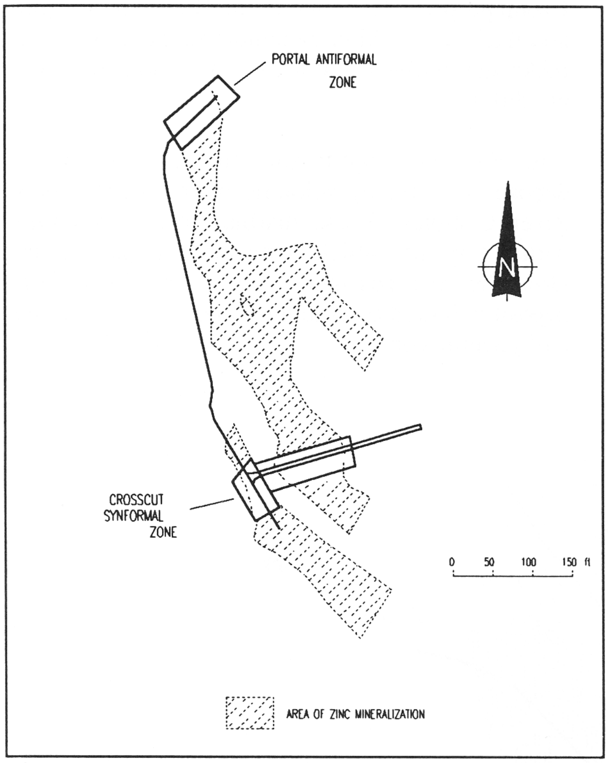

Figure 13. *Meat Cove, Cape Breton Island, mineralized zone (after Houle et al, 1989).*

4.4.2 Lime Hill

Follow-up of a regional geochemical stream sediment survey in the mid 1950s by Dr. B. Keating led to the discovery of zinc sulphide outcrops in McCuish Brook in 1957. Subsequently named the Lime Hill showing, the deposit was investigated with various trenching and drilling programs by Belcher Mining Corp., Conwest, Cominco, Lura Corp., Patino, Silvermaque and Brascan in the period between 1957 and 1976.

Eighty-two surface diamond-drill holes, totalling in excess of 4600 m, have been completed on the property. Mineralization has been encountered in many holes and ranges from short, high grade (38.8% Zn/ 1.2 m) intersections through medium grade (10.17% Zn/ 7.6 m) to longer sections of low grade mineralization. Four zones of sulphide mineralization have been recognized and Chatterjee (1977) estimated 2 million tons @ 2.5% Zn for the deposit as a whole.

Thirty-eight trenches were completed during 1974 and 1975 but the variable depth of weathered bedrock and excessive water flows caused many problems.

In 1977 Chatterjee reported tungsten and wollastonite on the property and in the early 1980s, Bluestack Resources made a geological compilation (Patterson, 1984) of the base metal potential.

In 1986 Bluestack Resources commenced an investigation of the wollastonite potential of the property. Examination of all available drill core at the DNR core storage facility at Stellarton disclosed previously unrecognised sections of wollastonite. A mapping program yielded new showings and a program of 19 trenches was completed (Pegg, 1987).

4.5 REGIONAL GEOLOGY

The carbonate-bearing metasedimentary rocks of the pre-Carboniferous of Cape Breton Island have historically been correlated with the George River Group which Milligan (1970) describes as a loosely-defined lithostratgraphic unit comprising interbedded carbonate and clastic metasedimentary rocks and minor volcanic rocks.

Hill (1989) describes the carbonate units as ranging in composition from relatively pure limestone and dolostone of very low metamorphic grade to highly metamorphosed, calcareous, dolomitic or siliceous marble. Associated metasedimentary rocks include quartzite and feldspathic sandstone which enclose carbonate members and are also of variable metamorphic grade. Argillaceous and volcanic rocks are more limited in distribution.

Going northward in Cape Breton Island, correlation of the highly metamorphosed and deformed carbonate-clastic metasedimentary sequences with the George River Group rocks is more difficult than previously implied and carbonate units form a very small component of the clastic sedimentary sequence.

Barr and Raeside (1986) have subdivided the pre-Carboniferous geology of Cape Breton Island based predominantly on intrusive age relationships. Four main tectonostratigraphic divisions are proposed (Fig. 14), namely the "Grenvillian" Blair River Complex, and the Aspy, Bras d'Or and Avalon Terranes. The George River Group rocks, comprising metasediments and metavolcanics, dominate the Bras d'Or zone and are widespread in the Aspy Terrane and in the Blair River Complex. Keppie (1992) suggests that

Cape Breton Island comprises one terrane only - the Avalon Terrane, and maintains that the divisions recognized by Barr and Raeside are really tectonic features within one single terrane rather than major terrane boundaries. Hill (1989) has discriminated the marble-bearing sequences on the basis of carbonate composition, metamorphism, and structural and stratigraphic relationships. Historically these Precambrian carbonates have all been arbitrarily assigned to the George River Group. Sangster (1990) quotes recent work which shows that the George River Group proper is restricted to the Bras d'Or Terrane and that areas of high metamorphic grade gneissic rocks and marble (as at Meat Cove and Lime Hill) are different.

Thus Sangster (1990) states that the Meat Cove deposit is hosted by dolomite marble of the Blair River Complex. These marbles form a xenolith within a syenite which is regarded as part of the Grenville age basement rocks. The Lime Hill deposit is hosted by dolomitic marbles of the Lime Hill gneissic complex.

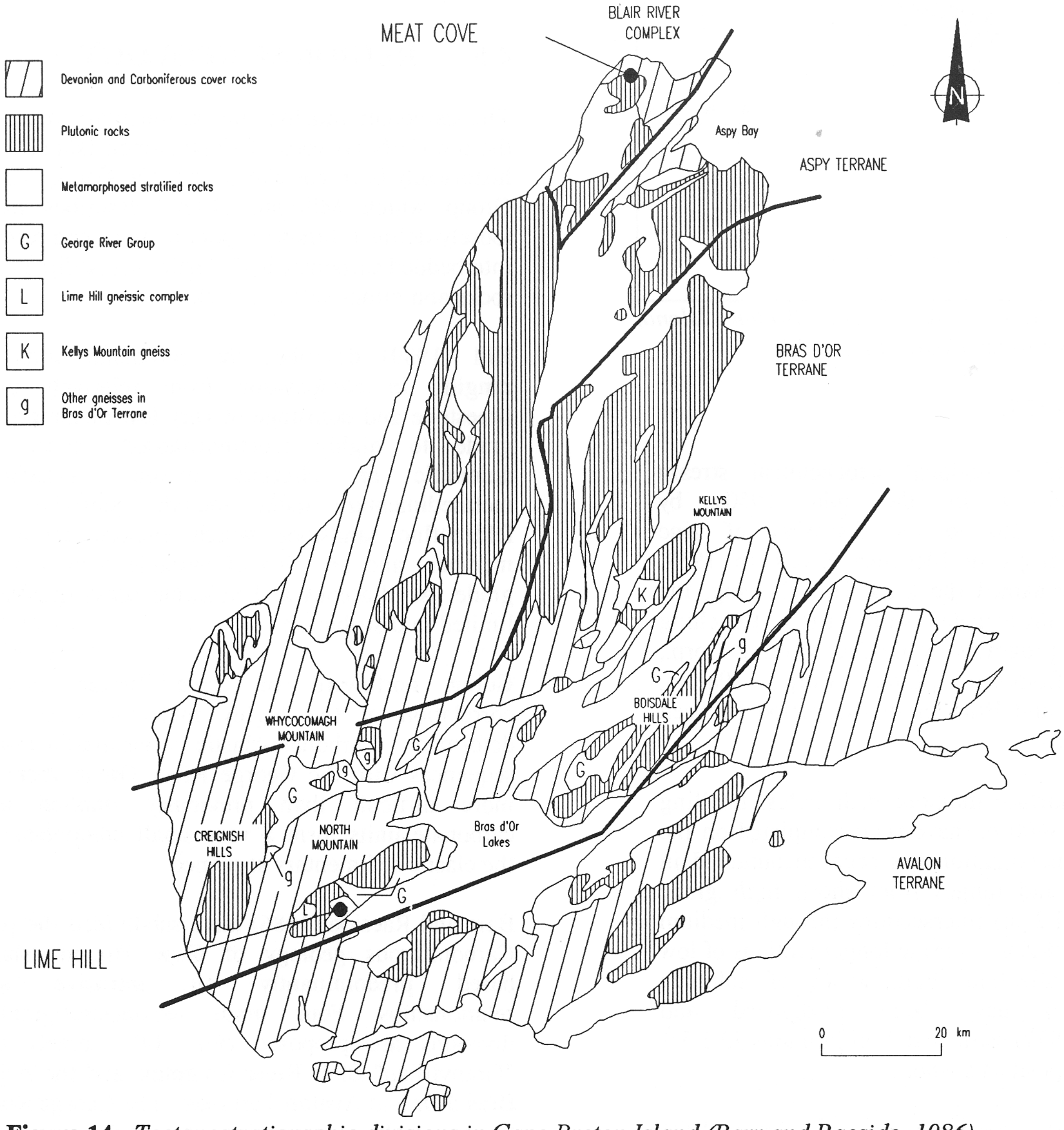

Figure 14. *Tectonostratigraphic divisions in Cape Breton Island (Barr and Raeside, 1986).*

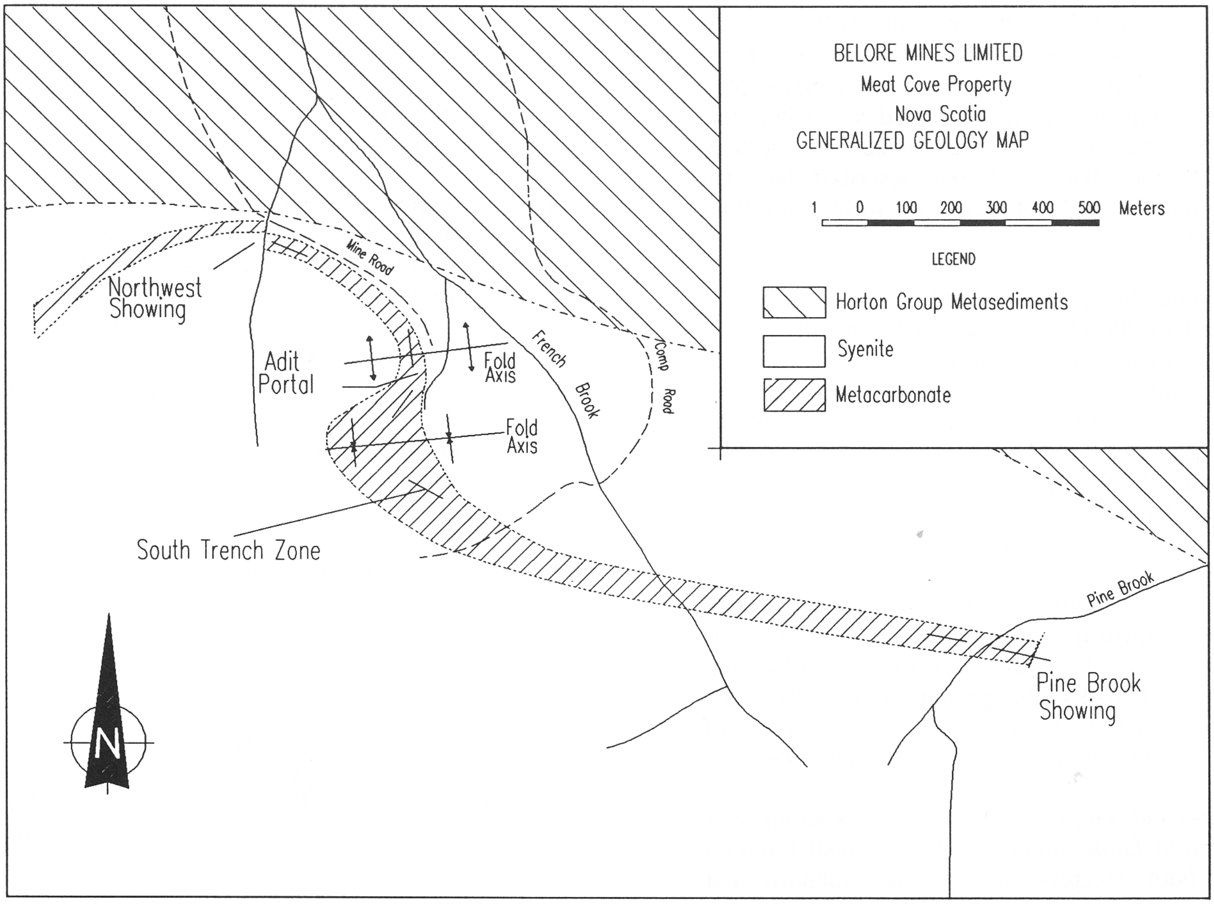

Figure 15. *Meat Cove deposit - geology and mineralization (after Houle et al., 1989).*

4.6 LOCAL GEOLOGY

4.6.1 Meat Cove

The host-rock marble is interpreted as a large xenolith within the Lowland Brook hornblende syenite which has intruded a high grade gneiss of the Blair River Complex (Fig. 15). The syenite, which carries minor magnetite, shows clear intrusive contacts with the carbonate host rock. Previous workers had included these gneisses with rocks of the late Precambrian George River Group, but more recent work (Barr et al., 1987), based on geological relationships, has assigned a much older Grenvillian age. Unconformably overlying both the metacarbonate and the syenite are the Carboniferous age Horton Group clastics.

Houle et al. (1989, for Belore Mines) describe the host carbonate xenolith as a convex tabular body dipping moderately to the NE and striking NW to WNW for some 2 km. The youngest rocks on the property are NE-trending, mafic diabase dykes which intrude all the above noted lithologies.

Two large scale fold styles are described by Houle et al. (1989). A northeast-plunging open anticline is present in the northern part of the property and an open Z-shaped structure occurs within the host metacarbonate and displays a NE- to ENE-striking axial trace. The plunge of these folds follows the footwall syenite contact which dips at 50 - 60^{o} NE. Subsurface mapping in the adit by Houle et al delineated a set of isoclinal structures attributed to a second deformational phase.

Two major fault trends have been identified. The ENE fault shows a dominantly sinistral displacement of up to 100 m and with an unknown vertical component. The N- to NE-trending fault has a horizontal offset of about 20 m and appears to throw to the east.

4.6.2 Lime Hill

The mineralized marble at Lime Hill has been historically assigned to the George River Group, which is present at much lower metamorphic grade immediately to the northeast (Sangster, 1990). This difference was noted by Guernsey (1928), and Chatterjee (1980) described the Lime Hill marble as "roof pendants within granitoid rocks".

Mapping by Justino (1985) and Justino and Sangster (1987) has defined the Lime Hill gneissic complex (including the mineralized carbonates) to be separate and distinct from the George River Group rocks. Marble accounts for < 10% of the exposed area of the gneissic complex, which Raeside (1990) supported as being older than the George River Group rocks.

At Lime Hill (Fig. 16), the gneissic complex consists predominantly of a metacarbonate rock suite comprising dolomite marble and siliceous dolomite marble, with lesser calcite marble and calc-silicate rocks. This gneissic body was intruded by a small tonalite body and a large number of later granitic and mafic dykes (Sangster, 1990).

Justino and Sangster (1987) defined a strong N-S structural fabric containing the regional foliation and both steeply-plunging and subhorizontal minor fold axes. Sangster (1990) states that the outcrop pattern suggests N-S isoclinal folding, and other structural data suggest that the gneissic rocks structurally overlie the mineralized marble. A major WNW-striking sinistral fault is present and Sangster (1990) suggests that this has offset the mineralization into the present configuration. Several small N-S faults have been mapped.

4.7 MINERALIZATION

4.7.1 Meat Cove

The mineralized carbonate unit at Meat Cove (Fig. 15) strikes southeast for approximately 2 km, is up to 35 m wide and dips moderately to the northeast (Fig. 17). Four styles of sulphide mineralization have been identified as follows:

(i) Banded sphalerite (blackjack variety) - pyrrhotite-pyrite-chalcopyrite as fine cm-scale bands defining bedding in the metacarbonate.

(ii) Semi-massive disrupted bands and massive pods of sphalerite-pyrrhotite-pyrite-chalcopyrite in the metacarbonate. This is the previously known "zinc ore" type and most commonly occurs on fold hinges.

(iii) Massive sulphide veins of sphalerite-pyrrhotite-bornite occurring both in the syenite and the metacarbonate unit. These veins occupy faults and/or fractures and are commonly associated with the semi massive type near deformation zones. Houle suggests that they may represent the "ore leading channels" of Chatterjee (1977) or may be remobilized banded sulphides.

(iv) Disseminated pyrite-chalcopyrite (plus magnetite) within foliated syenite.

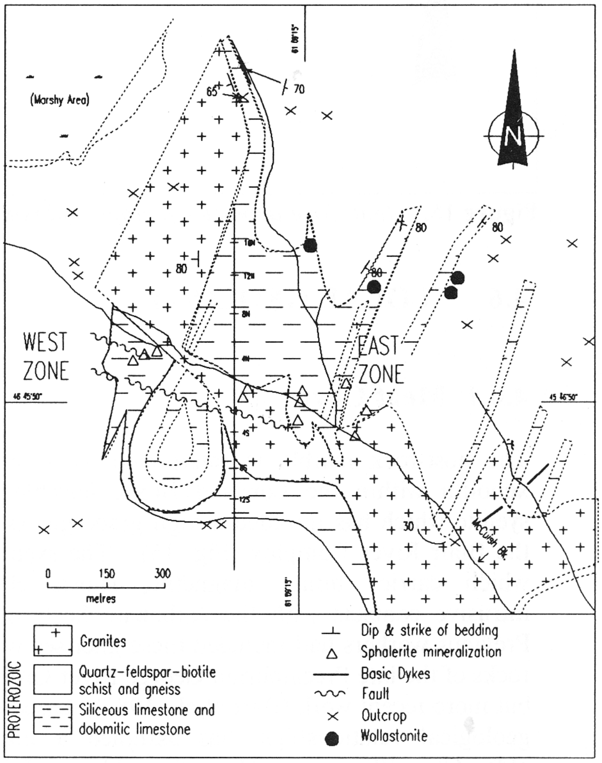

Figure 16. *Lime Hill deposit - geology and mineralization (after Cominco, 1960, and Sangster, 1990).*

Four zones of "significant" sphalerite mineralization have been outlined as follows (Fig. 15);

(i) the Adit (underground),
(ii) The Northwest,
(iii) the Road Cut and
(iv) The South Trench.

Sampling by Belore Mines (Houle et al., 1989) in the Adit zone returned values of 3.13% Zn/3 m; 6.87% Zn/6 m and 9.52% Zn/3m with the higher values corresponding to areas of structural grade enhancement. The Northwest showing, the focus of the original work in the mid 1950s and in 1968, returned values of 11.3% Zn/17 m and 6.1% Zn/4.6 m in metacarbonates. Belore reported the highest Zn and Cd assays from this zone with 14.98% Zn/3.5 m and 17.35% Zn/4 m, with best Cd values up to 0.06%.

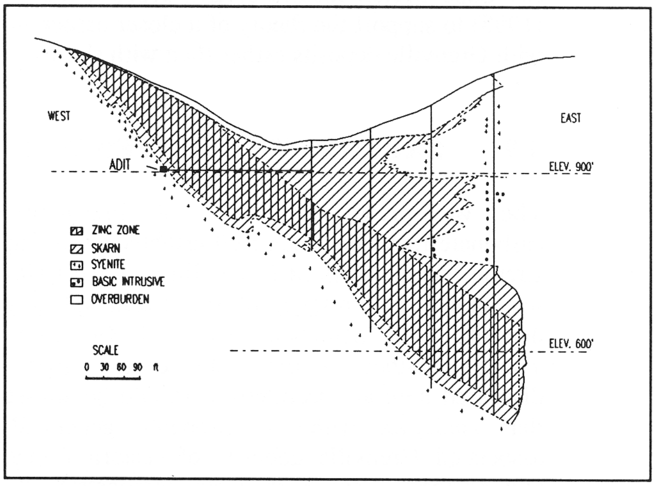

Figure 17. *Meat Cove deposit - vertical section (Houle et al., 1989).*

The South Trench zone, 200 m south of the adit portal, was sampled in 1968 and values of 2.9% Zn/31 m and 10.5% Zn/33.5 m were reported within the metacarbonate.

Several estimates have been made over the years as to 'ore reserves' within the two main zones - the Adit zone and the Northwest showing. In 1965, possible reserves of 4.0 million tonnes grading 4% Zn, and 0.15 to 0.47 lbs. Cd/t were reported. Huston and Associates (1972) estimated 3.18 million tonnes grading 2.08% Zn in the Adit zone with a further 0.36 million tonnes at 2.76% Zn in a second zone (Dunbar, 1965).

Chatterjee (1979) reported germanium values up to 160 ppm in the sphalerite and Patterson (1987, unpublished data) reported mercury values up to 2.4 ppm in a sample of massive sphalerite assaying 30% Zn.

Metallurgical tests carried out in the 1960s (as reported by Belore Mines, (Houle et al., 1989) on a bulk sample from the Adit zone showed recoveries ranging from 80% for the low grade (<2%Zn) material to 85-90% for a 3.6% Zn head grade. The 18 ton bulk sample returned a concentrate grading "5.2%" (this should probably be 52% Zn) plus 0.16% Cd.

4.7.2 Lime Hill

The sphalerite mineralization is exposed in two zones that parallel the lithological layering and foliation within the marble host rock. The **East zone** (Fig. 16) comprises three sub-zones, namely the Main, "C" and #2 zones; while the **West zone** lies 370 m west of the #2 sub-zone. Assay data from previous operators show mineralized intersections ranging from 25 cm to 10 m with grades varying from a few percent to 10% Zn /10 m. Silver values are low and Hg up to 4.32 ppm has been reported (Patterson, unpublished data, 1987) from a high grade (30% Zn) sample.

Patterson (1984) suggested that the sub-zones within the East zone might be all one zone due to folding. The zone has been traced by trenching and diamond-drill holes over a strike length of 300 m. Within the Main zone, sphalerite occurs as tabular bands ranging from 1 to 30 cm thick, striking 010^o and dipping steeply to the west. The mineralization, averaging 4.5 m in thickness, pinches and swells down dip and along strike from 2 - 7.5 m and has been estimated to contain 227,000 tonnes at 8.9% Zn (Patterson, 1984). The "C" zone mineralization occurs in a synclinal structure plunging about 30^o to the north and also displays wide variation in thickness and grade. The zone averages 2.5 m thick, is 200 m long and has been drilled to a depth of 75 m. Patterson (1984) estimates 112,000 tonnes at 5.46% Zn. The #2 zone is narrow, averaging 1.7 m, and is estimated to contain 36,000 tonnes at 3.49% Zn.

The West zone comprises a series of bands and disseminations of sphalerite in westerly-dipping, tabular bodies of dolomitic limestone. The zone strikes N-S for 200 m, averages 1.8 m in thickness, has been traced down dip for 50 m, and is estimated to contain 50,000 tonnes @ 6.25% Zn.

Chatterjee (1977) estimated 2 million tons @ 2.5% Zn for the deposit as a whole, but Patterson (1984) estimated a geological reserve of 425,000 tonnes @ 7.22% Zn over an average thickness of 2.8 m.

The stratabound carbonate-hosted mineralization occurs in both disseminated and massive forms. Medium- to coarse-grained sphalerite is present in bands that vary from 1 cm to several metres in thickness and parallel the lithological layering in the carbonate. Minor disseminated pyrrhotite and/or pyrite, with rare chalcopyrite, occur. Massive sphalerite layers, from 10 - 50 cm thick, occur parallel or subparallel to the disseminated sphalerite layers (Sangster, 1990). Pyrite can be dominant in these massive layers, which can truncate bedding-parallel bodies of disseminated sphalerite. Sangster equates this texture with the "spangle ore" as seen in the Balmat-Edwards deposits in New York State and which are interpreted as the result of mobilization of sulphides during metamorphism.

Chatterjee (1977) identified scheelite and wollastonite and the most recent work on the property, by Bluestack Resources, has concentrated on examining the wollastonite potential (Pegg, 1987).

4.8 GENESIS

The Precambrian carbonate-hosted deposits at Lime Hill and Meat Cove have been presented as classic examples of "skarn type" deposits by earlier workers (Keating, 1960, and Chatterjee, 1977, 1979 & 1980). Patterson (1984) suggested that the mineralization might be remobilized syngenetic material and suggested that analogies could be drawn with the Grenville carbonate-hosted deposits in eastern Canada and New York State.

Sangster (1990) presents evidence suggesting that the Lime Hill and Meat Cove deposits are metamorphosed Mississippi Valley type (MVT) or Sedimentary Exhalative (Sedex) type deposits formed from MVT basin brines. The high Hg content of the ore at Meat Cove (Patterson, unpub. data) and the high Hg geochemical dispersion halo (Rogers) would create difficulties for this proposed origin. Interpretation of the lead and sulphur isotope data from Lime Hill caused Sangster and Thorpe (1988) to conclude that the origin of the deposit was very similar to that for the Grenville carbonate-hosted deposits. Examination of the composition of pyroxenes in the Cape Breton metacarbonate deposits led Hill (1988) to support the theory of a closer association with Grenville deposits rather than with skarns.

4.9 EXPLORATION POTENTIAL

The widespread occurrence of Precambrian carbonate rocks has been well established in Cape Breton Island. Work at Lime Hill and Meat Cove has shown the presence of significant sphalerite deposits with associated Cd and Ge values. Though neither of the Cape Breton deposits discussed here are economic it should be stressed that analogies with the probably genetically-associated Grenville deposits of eastern Canada and northern New York State demonstrate that viable deposits may be found. The classic type example of this class is the Balmat-Edwards deposit in New York State, from which 23 million tonnes at 10% Zn were mined between 1915-1979 with a further 23 million tonnes of the same grade in reserve. The former producers in the eastern Canadian Grenville were much smaller tonnage operations but displayed many features similar to the Balmat-Edwards deposit. Typically, these are coarse-grained stratiform sulphides occurring as tabular, pod-like or lenticular bodies, usually elongate in a down plunge direction of fold hinges. The deposits have been described as pencil- or rod-like and are structurally complex.

These analogies with the Grenville type deposits and the widespread distribution of the metacarbonates in Cape Breton (Hill, 1989) suggest that continuing exploration for this type of sulphide deposit, and its associated industrial minerals, could be worthwhile.