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A SULPHIDE DEPOSIT CONTAINING GALENA, IN THE LOWER DEVONIAN DISAPPOINTMENT BAY FORMATION ON BAILLIE HAMILTON ISLAND[1], CANADIAN ARCTIC ARCHIPELAGO

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Abstract

Baillie Hamilton Island is situated in a region noted for lead and zinc deposits similar in many respects to the Mississippi Valley-type ore deposits. A sulphide deposit that includes small amounts of galena occurs in porous and vuggy dolomite of the Disappointment Bay Formation near the southwestern extremity of Baillie Hamilton Island. Mineralized deposits are rare in the Disappointment Bay Formation, and the present deposit adds further interest to this formation as a potential host for lead and zinc ore bodies. Most lead and zinc occurrences in this region of the archipelago, including that of the currently operated Polaris Mine, are replacement deposits in carbonate rocks of the Ordovician Thumb Mountain Formation that were exposed to erosion and karstification in Early Devonian time, and subsequently overlain unconformably by the Disappointment Bay Formation. Structural evidence is presented here that suggests the Disappointment Bay in southwestern Baillie Hamilton Island may lie directly on the Thumb Mountain. This in turn raises the possibility, however tenuous, that the sulphide deposit in that region indicates the presence of an ore body at depth in Thumb Mountain strata.

Résumé

L'île de Baillie Hamilton est située dans une région connue pour ses gisements de plomb et de zinc, semblables sous de nombreux aspects à ceux de la vallée du Mississippi. Un gisement de sulfure qui comprend de petites quantités de galène se trouve dans une dolomite cristallisée et poreuse de la formation de Disappointment Bay près de l'extrémité ouest de l'île Baillie Hamilton. Les gisements minéralisés sont rares dans la formation de Disappointment Bay, et ce gisement rend cette formation plus intéressante si on la considère comme pouvant contenir des gisements de plomb et de zinc. La plupart des manifestations de plomb et de zinc dans cette région de l'archipel, incluant celle de la mine de Polaris en cours d'exploitation, sont des gisements de remplacement dans des roches carbonatées de la formation ordovicienne de Thumb Mountain qui ont été mis à découvert par l'érosion et la karstification au début du Dévonien puis ont été recouverts ultérieurement, de façon non concordante, par la formation de Disappointment Bay. On présente des données structurales qui suggèrent que la formation de Disappointment Bay dans le sud-ouest de l'île Baillie Hamilton pourrait reposer directement sur la formation de Thumb Mountain. A son tour, ceci suggère la possibilité même si elle est mince, que le gisement de sulfures de la région indique la présence d'un gisement en profondeur dans les couches de Thum Mountain.

Introduction

Baillie Hamilton Island is situated about 13 km north of Cornwallis Island, in what is approximately the geographic centre of the Canadian Arctic Archipelago. Near the southwestern extremity of Baillie Hamilton Island, a small, but rather spectacular sulphide deposit, consisting mainly of pyrite and marcasite with small amounts of galena, occurs along the crest of an anticline that is exposed at the base of northwest-trending sea cliffs (Fig. 30.1, 30.2). The metallic minerals occur as infillings of pores and vugs in dolomite in the upper part of the lower member of the Lower Devonian Disappointment Bay Formation. The deposit occurs at 94°44'08"W, 75°46'16"N.

The deposit was discovered in late August of 1983 during a geological mapping traverse using a helicopter for transportation. About 10 minutes were devoted to examining the rocks at this locality. Six specimens of the mineralized rocks were collected. They have been analyzed by X-ray diffraction, and the results are summarized in Table 30.1.

Acknowledgments

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Regional setting

Baillie Hamilton Island is part of the cratonic Boothia Uplift, a major geological province in the archipelago that extends north from Boothia Peninsula on the continental

[1] Baillie Hamilton Island was discovered in 1851 by Captain William Penny, commander of an expedition sent out by the British Admiralty to search for Sir John Franklin. Penny named the island Hamilton Island "after W.A.B. Hamilton, R.N., Secretary of the Admiralty" (Sutherland, 1952, v. 2, p. 127). However, the name of the island on the map that accompanied Sutherland's (op. cit.) narrative account of Penny's expedition was expanded to include Hamilton's commonly known christian name, and continued to appear as Baillie Hamilton Island on maps and in accounts of this region until the 1950s, after which time the name of this island has been almost invariably misspelled as Baillie-Hamilton Island.

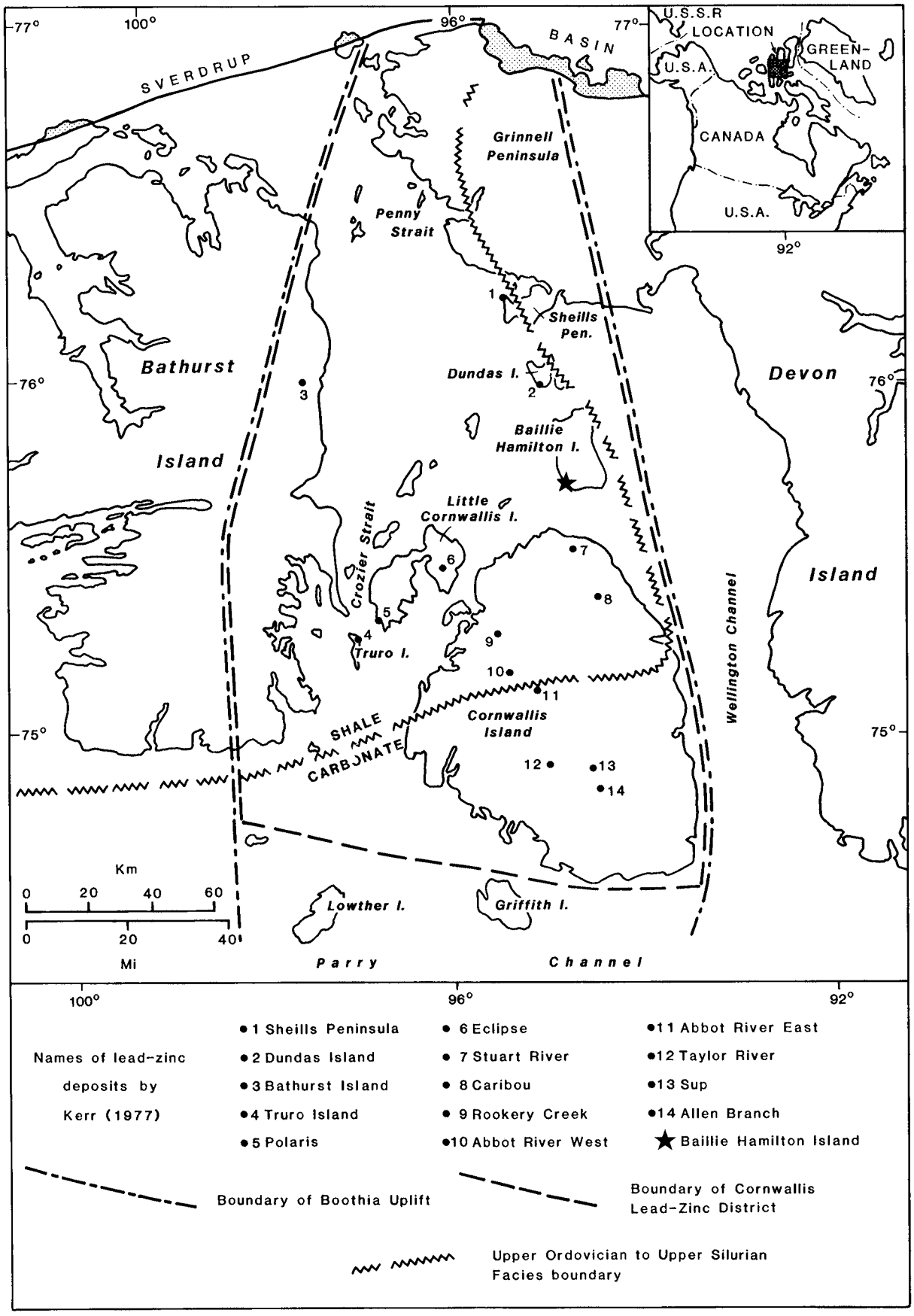

Figure 30.1. *Index map of the Cornwallis Lead-Zinc District (after Kerr, 1971).*

mainland to the north end of Grinnell Peninsula (see Thorsteinsson and Uyeno, 1981 and references contained therein). The uplift is about 800 km long and 150 km wide. South of Parry Channel, the uplift consists of Precambrian crystalline rocks and Proterozoic sediments which are flanked by mainly platform-type Cambrian to Late Silurian carbonate sediments, and Late Silurian to Early Devonian redbeds. North of the channel, the uplift includes mainly Cambrian to Lower Devonian miogeosynclinal carbonate sediments and lesser amounts of Lower Devonian redbeds. (Younger sequences of platform-type sediments that overspread this region are discussed below). The principal crustal movements by which the Boothia Uplift achieved its present areal extent and most of its present structural characteristics occurred in Late Silurian and Early Devonian times. The Late Silurian movements were limited to parts of the uplift situated south of Parry Channel, while Early Devonian movements occurred along the entire length of the uplift. The Upper Silurian and Lower Devonian redbeds mentioned above attest to these crustal movements. The structures in the Phanerozoic rocks of the uplift include mainly steeply dipping normal faults, generally broad, open synclines and more tightly folded anticlines (see for example, geological maps of the Cornwallis Island area by Thorsteinsson, 1973). The regional strike of these structures is northerly and thus aligned with the overall trend of the uplift.

North of Parry Channel, the Cambrian to Lower Devonian miogeosynclinal sediments that were deformed by the Early Devonian crustal movements are overlain unconformably by three sequences of sediments that are separated

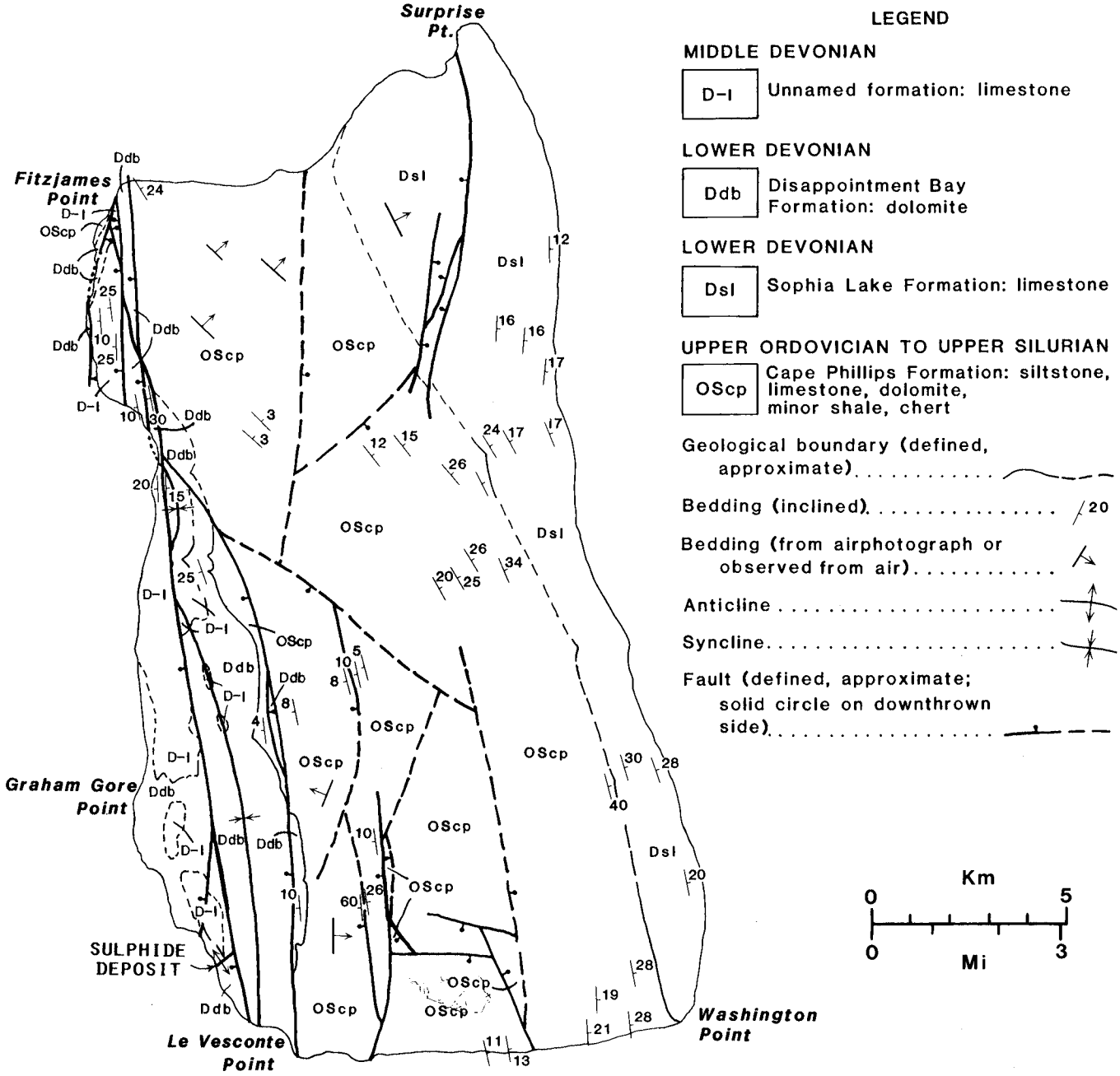

Figure 30.2. *Geological map of Baillie Hamilton Island.*

Table 30.1. Semi-quantitative X-ray diffraction analysis of samples

	#1	#2	#3	#4	#5	#6	#1	#6
Minerals	Whole-rock	Whole-rock	Whole-rock	Whole-rock	Whole-rock	Whole-rock	Metallic grain	Metallic grain
Metallic								
Galena	1.8	4.1	3.0				79.1	
Pyrite	18.3	32.0	55.5	23.2	4.7	13.7	4.1	29.9
Marcasite	20.7	57.0	27.3		4.0		4.1	
Goethite	1.8					1.3		6.9
Jarosite?		2.7	4.0					
Rock-forming								
Dolomite	1.2		10.1	71.4	81.0	82.2	2.5	56.3
Calcite	51.0			1.2	8.1			
Gypsum	2.5			1.8				2.3
Quartz	2.4			1.2				
Feldspar		4.1		1.2	2.0	2.7		
Clay							10.0	
Sulphur?								4.6

from one another by regional unconformities. These sequences occur mainly as downfaulted or downfolded outliers, and the regional trend of the folds and faults that affect them, is, like the earlier established Early Devonian trends, northerly. The sequences are described briefly from oldest to youngest as follows:

1. A conformable succession including in order upward:
   a. Disappointment Bay Formation; Lower Devonian dolomite.
   b. Unnamed formation, Middle Devonian limestone.
   c. Bird Fiord Formation; Middle Devonian sandstone and lesser amounts of limestone.
   d. Hecla Bay Formation; Middle and Upper Devonian mainly nonmarine sandstone.
2. Isachsen Formation; Lower Cretaceous nonmarine sandstone and siltstone.
3. Eureka Sound Formation; Upper Cretaceous to Lower Tertiary, mainly nonmarine sandstone and siltstone.

Stratigraphy and structural geology of Baillie Hamilton Island

The strata exposed on Baillie Hamilton Island are divisible into two structurally conformable sequences separated from one another by an angular unconformity (Fig. 30.2). The older sequence includes the Cape Phillips Formation and overlying Sophia Lake Formation. These formations outcrop in eastern parts of Baillie Hamilton Island, and together they constitute surface exposures for over more than three quarters of the island. The regional strike of these formations is northerly, and they generally dip eastward. The younger sequence is made up of the Disappointment Bay Formation and an overlying unnamed unit of limestone. These formations occupy a narrow strip of territory along the west side of the island. The regional strike and dip of these rocks is north and west, respectively. Both the older and younger sequence are cut by steeply dipping, mainly north-striking normal faults.

Cape Phillips Formation

The formation consists mainly of siltstone that is variably argillaceous, calcareous and dolomitic; limestone that is cryptocrystalline to finely crystalline and variably argillaceous, silty and dolomitic; and dolomite that is commonly finely crystalline and variably argillaceous, silty and calcareous. All of these rocks are typically dark grey, thin bedded and laminated. Also present are lesser amounts of shale and chert. Other notable features of the formation include mass-flow deposits, soft sediment deformation and abundant graptolites. The Cape Phillips ranges from Late Ordovician to Late Silurian in age. The lower part of the Cape Phillips is not exposed on Baillie Hamilton Island. However, the formation is about 3000 m thick as determined on neighbouring Cornwallis Island, and by far the greater part of it is exposed on Baillie Hamilton Island. To the east and southeast, the graptolitic beds of the Cape Phillips Formation pass laterally into a sequence of four shelf-type carbonate formations. These formations include, in upward stratigraphic order, Allen Bay, Cape Storm, Douro and Barlow Inlet (see Thorsteinsson and Uyeno, 1981). The line of facies change is shown in Figure 30.1.

Two widely distributed formations that underlie the Cape Phillips in the archipelago, though not exposed on Baillie Hamilton Island, are pertinent to the present discussions. They are the Irene Bay and Thumb Mountain formations. The Irene Bay is separated from the Cape Phillips by a sharp, yet conformable contact. It is a unit of Upper Ordovician greyish green shale with lesser amounts of limestone. It ranges in thickness from 35 to 45 m. The Irene Bay conformably overlies the Thumb Mountain Formation, which consists mainly of limestone and dolomite and subordinate amounts of shale. The Thumb Mountain is about 340 m thick on nearby Cornwallis Island, where, moreover, it appears to be variably dolomitized. In places, the formation appears to consist almost entirely of limestone; in others it is largely dolomite.

Sophia Lake Formation

The Sophia Lake Formation on Baillie Hamilton Island is represented by about 780 m of dominantly medium grey, aphanocrystalline to finely crystalline limestone. The contact of the Sophia Lake with the underlying Cape Phillips is gradational, and marked by a change from a thick unit of siltstone at the top of the latter formation to limestone in the former. The upper surface of the Sophia Lake Formation on the island is represented by the present day erosion surface so that the total thickness of the formation is unknown. The formation is dated as early Early Devonian by Thorsteinsson and Uyeno (1981).

The Sophia Lake exhibits a broad threefold subdivision on the island:

1. A lower unit, about 190 m thick, consisting mainly of thin and planar bedded limestone that passes upwards into medium bedded, nodular limestone. Minor amounts of shale and siltstone occur throughout this unit. The unit is rich in brachiopods, trilobites and conodonts.
2. A middle unit, about 140 m thick, consisting of thick-to mainly medium- and thin-bedded limestone with subordinate shale and siltstone beds. The unit is characterized by corals, stromatoporoids and brachiopods.
3. An upper unit, about 440 m thick, composed mainly of thin-bedded limestone with lesser amounts of dolomite, dolomitic limestone and siltstone. The rocks are rich in leperditicopod ostracodes. The upper 60 m or so of this unit are characterized by an increasing abundance of thin interbeds of siltstone and sandstone including a single unit of chert-pebble conglomerate about one metre thick.

Disappointment Bay Formation

The formation includes two distinctive members on Baillie Hamilton Island. The lower member is made up of resistant thin- to thick-bedded and massive dolomite that ranges from finely- to medium-crystalline, and from yellowish grey to medium grey. Porous to vuggy intervals are well developed in some sections, and are commonly impregnated with bitumen. The thickness of the member is estimated as 70 m. The upper member consists mainly of soft-weathering, variably silty and sandy dolomite that is finely crystalline, thin bedded and ranges from shades of brown to green. This member is about 140 m thick. The contact between the lower and upper members is sharply defined. The possibility that this contact may represent an unconformity is suggested by the fact that a unit of chert-pebble conglomerate, less than half a metre thick, is developed sporadically at the base of the upper member. The basal chert-pebble conglomerate that characterized the formation throughout much of the Cornwallis Island area is apparently absent on Baillie Hamilton Island. The formation has been dated as late Early Devonian on the basis of conodonts (Thorsteinsson and Uyeno, 1981).

Unnamed limestone formation

A unit of limestone, about 100 m thick, overlies the Disappointment Bay Formation with a sharp, yet conformable contact, and represents the youngest bedrock formation preserved on Baillie Hamilton Island. The top of the unit is not preserved on the island, but on neighbouring Cornwallis Island the unit is overlain by the Middle Devonian (Eifelian) Bird Fiord Formation.

The limestone unit, as developed on Baillie Hamilton Island, is typically variably silty and sandy, finely crystalline, and thin- to mainly medium-bedded. The colour of these rocks varies from shades of grey to shades of brown. Very thin interbeds of shale and greenish sandstone occur in some sections.

This unit of limestone has been referred to the Blue Fiord Formation (see for example Thorsteinsson and Kerr, 1968), but it is probably best considered as representing a new, and as yet unnamed formation. At its type section in southwestern Ellesmere Island the Blue Fiord is Early Devonian (Zlichovian to Dalejan; see Uyeno and Klapper, 1980), and therefore correlative with the Disappointment Bay Formation, whereas the limestone beds in question here are Middle Devonian (Eifelian) in age (Uyeno, personal communication). The limestone beds thus equate with the lower part of the type section of the Bird Fiord Formation, which also occurs on southwestern Ellesmere Island.

Significance of sulphide deposit

Baillie Hamilton Island is situated in the Cornwallis Lead-Zinc District, a name proposed by Kerr in 1977. The district coincides with the northern part of the Boothia Uplift (Fig. 30.1). Kerr described 14 lead-zinc deposits in the district, one of which is now in production (Polaris Mine) on the west coast of Little Cornwallis Island. According to Kerr most of these deposits are characterized by the following controls on mineralization:

1. The Middle to Upper Ordovician Thumb Mountain Formation is the host.
2. The mineralized part of this formation is brecciated dolomite.
3. The deposits occur within the distributive area of the graptolitic Cape Phillips Formation.
4. The lead-zinc deposits were at one time overlain unconformably by the Disappointment Bay Formation. Kerr has argued convincingly that the lead-zinc mineralization occurred as replacement deposits in karst caverns that developed in the Thumb Mountain Formation in places where that formation was structurally high and exposed during the Early Devonian interval of erosion marked by the unconformity at the base of the Disappointment Bay Formation.

The sulphide deposit in southwestern Baillie Hamilton Island is of interest for two reasons: 1. sulphide deposits in the Disappointment Bay Formation are rare (Kerr, 1977), and the present deposit adds further interest in this formation as a potential host for lead-zinc ore bodies in the Cornwallis district; and 2. there is a possibility, however tenuous, that the Disappointment Bay at the locality of this deposit lies directly on the Thumb Mountain Formation, and that the deposit represents the uppermost mineralized part of an ore body at depth in the latter formation. This possibility is based on the following lines of reasoning. The graptolites in the Cape Phillips indicate that all four series of the Silurian are represented in exposures of the formation, and furthermore that these series comprise north-trending belts of exposures. Thus, as one proceeds westward from any given point on the Cape Phillips-Sophia Lake contact one passes progressively, first across Pridolian beds, next across Ludlovian and Wenlockian beds, and lastly across late Llandoverian beds, which are overlain by easternmost outcrops of the Disappointment Bay Formation. This situation prompts the following conclusions:

1. It confirms that the regional dip of the Cape Phillips Formation is to the east.
2. It indicates that the normal faults transecting the formation are characterized by modest displacements.

3. It indicates that only the lower Llandoverian and Ashgillian (Upper Ordovician) parts of the Cape Phillips Formation are not exposed on Baillie Hamilton Island. The thickness of this interval of beds in nearby Dundas Island and Cornwallis Island is in the order of 200 m. On the basis of the foregoing circumstances, and the assumption that the easterly dip of Cape Phillips beds continues westward beneath the unconformable cover of the Disappointment Bay, westernmost strata of the latter formation in the environs of the sulphide deposit may well lie directly on the Thumb Mountain Formation. Such a stratigraphic-structural situation would exhibit all four of Kerr's (1977) controls for lead-zinc mineralization in this region.

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