

SYNOPSIS OF THE POLARIS ZN-PB DISTRICT, CANADIAN ARCTIC ISLANDS, NUNAVUT

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Abstract

The Polaris Mine was a Mississippi Valley-type (MVT) deposit hosted in dolomitized Middle Ordovician limestone. Total production was 20.1 Mt at 13.4% Zn and 3.6% Pb. There are about 80 showings in the district, which stretches from Somerset Island to the Grinnell Peninsula. There are two deposit types in the Polaris District: 1) structurally controlled, carbonate-hosted Zn-Pb-Fe deposits typical of MVT deposits, and 2) structurally and stratigraphically controlled, carbonate-hosted Cu deposits enriched by later supergene removal of Fe and S.

Mineralization is paragenetically simple, with sphalerite and galena as the ore minerals, and with dolomite and marcasite as the main gangue minerals. The deposits formed from brines at about 90 to 100°C. The age of the mineralization is constrained to post-Late Devonian folding and may be associated with the last stages of the Ellesmerian Orogeny or the opening of the Sverdrup Basin. Copper-rich mineralization is known from four showings, is associated with zinc-lead mineralization and is confined to a single interval in the Silurian.

The metallogenic model for Polaris invokes a source of metal ions within the stratigraphic column since strontium shows no indication of basement involvement. Metals are then carried in sulphate-rich brines through deep aquifers. Driven by an orogenic process, circulating fluids rose along faults until they encountered organic-rich, permeable limestone overlain by impermeable shale. Bacterial sulphate reduction reduces sulphate to H₂S using organic matter as a reductant. The resulting H₂S has a shift in $\delta^{34}\text{S}$ values of -15‰. The H₂S reacts inorganically with zinc, lead, and iron ions to produce sulphides with a $\delta^{34}\text{S}$ value of about 10‰. Released hydrogen ions dissolve carbonate resulting in dissolution breccias and other dissolution fabrics. Excess sulphate was expelled from the system and produced a halo of barite up to 10 km from the deposit with $\delta^{34}\text{S}$ of 40 to 60‰.

Résumé

La mine Polaris consistait en un gisement de type Mississippi-Valley encaissé dans un calcaire dolomitisé de l'Ordovicien moyen. Au total, elle a produit 20,1 Mt de minerai titrant 13,4 % de Zn et 3,6 % de Pb. Le district de Polaris compte quelque 80 indices minéralisés et s'étend de l'île Somerset jusqu'à la péninsule Grinnell. On y trouve deux types de gîtes, à savoir des gîtes de Zn-Pb-Fe encaissés dans des roches carbonatées, qui affichent un contrôle structural et sont représentatifs des gîtes de type Mississippi-Valley, et des gîtes de Cu logés dans des roches carbonatées, qui montrent des contrôles structuraux et stratigraphiques et un enrichissement supergène ultérieur par l'élimination du Fe et du S.

Du point de vue paragenétique, les minéralisations sont simples. Elles présentent la sphalérite et la galène comme minéraux métallifères, ainsi que la dolomite et la marcasite comme principaux minéraux de gangue. Les gîtes du district se sont formés à partir de saumures affichant des températures de 90 à 100°C environ. L'âge maximal des minéralisations est défini par un plissement du Dévonien tardif, qui pourrait être rattaché aux dernières phases de l'orogène Ellesmérienne ou à l'ouverture du bassin de Sverdrup. Quatre indices minéralisées ont révélé des minéralisations riches en cuivre, qui sont associées aux minéralisations de zinc-plomb et confinées à un seul intervalle du Silurien.

Le modèle métallogénique proposé pour le district de Polaris établit une source d'ions métalliques dans la colonne sédimentaire, car la composition isotopique du strontium ne témoigne d'aucune contribution du socle. Les métaux ont donc été transportés dans des saumures riches en sulfates circulant dans de profonds aquifères. Un phénomène orogénique a fait en sorte que les fluides en circulation se sont élevés le long de failles jusqu'à ce qu'ils atteignent des horizons perméables de calcaire riche en matière organique, qui sont recouverts de shale imperméable. Des bactéries ont réduit les sulfates en H₂S en se servant de la matière organique comme agent réducteur. Le H₂S résultant présente un décalage des valeurs de $\delta^{34}\text{S}$ de -15 ‰. Le H₂S réagit de manière inorganique avec les ions de zinc, de plomb et de fer pour produire des sulfures dont la valeur de $\delta^{34}\text{S}$ est d'environ 10 ‰. Les ions d'hydrogène émis dissolvent les carbonates pour produire des brèches de dissolution et d'autres fabriques de dissolution. Les sulfates excédentaires ont été expulsés du système et ont produit une auréole de barytine qui s'étend jusqu'à 10 km du gisement et les valeurs de $\delta^{34}\text{S}$ de ce minéral varient de 40 à 60 ‰.

Introduction and History

The Polaris Zn-Pb District lies in the central Arctic Islands, Nunavut, and spans an area that is roughly 450 km north-south by 130 km east-west (Fig. 1). The southern limit is the southern edge of Somerset Island; the northern edge is the northern shore of the Grinnell Peninsula. The eastern limit runs along the longitude of Wellington Channel between Cornwallis and Devon islands and the western limit is on eastern Bathurst Island.

There are about 80 individual Zn-Pb showings occur within the study area (Fig. 1, Table 1). The largest of these is the Polaris deposit, a carbonate-hosted Zn-Pb deposit of about 20 million tonnes grading about 17% Zn+Pb. The deposit was mined from 1982 to 2002, when it shut down due to depletion of reserves. During its latter days, Polaris employed a workforce of 235 employees on an 8 week onsite and 4 week offsite rotation. Sphalerite and galena were separated from the gangue in a complex known as "the barge"

which in addition to the concentrator, housed offices, warehouse, powerhouse, and heavy equipment and other repair shops. The concentrator complex was built on a barge in Trois Rivières, Québec, and towed to Little Cornwallis Island where it was floated into an excavated lagoon and surrounded by rockfill. The annual mining rate of 1,040,000 tonnes per year produced 200,000 tonnes of zinc and 30,000 tonnes of lead concentrates that were stored in a large concentrate shed. Ocean-going ships docked near the concentrate shed and were loaded directly with a conveyor system. Freighters arrived in early July and departed up until late October.

Exploration in the Polaris District took place in five phases (Fig. 2): 1) a reconnaissance exploration period (1960-1970) during which most surface showings on Cornwallis and Little Cornwallis islands were found; 2) a discovery period (1971-1979) during which the Polaris orebody was drilled based on a gravity anomaly and feasibility studies were completed. Also, new showings were discovered, and many showings received limited drill testing; 3) a production period (1980-1988), dominated by drilling and mining at the Polaris Mine; 4) an ore-replacement exploration period (1989-2001) during which showings close to Polaris were extensively drilled, showings on Cornwallis Island drill tested, and new showings found and drilled on Somerset and Bathurst islands and on the Grinnell Peninsula; and 5) a reclamation period (2002-2004) during which the mine site was restored and the infrastructure removed.

Early studies on the Polaris deposit included a brief description of the geology and mineralization by Muraro (1974), fluid inclusion work by Jowett (1975), and lead isotope work on the Truro Island showing by Heal (1976). Kerr (1977) proposed a metallogenic model that required formation of karst during the Early Devonian Boothia Uplift, then migration of metal-bearing and sulphur-bearing fluids to the site of deposition during the Late Devonian. The karst model guided exploration during much of the 1970s and 1980s. Randell introduced a hydrothermal karst model (Randell, 1994; Randell and Anderson, 1997; Randell et al.,

1997), and controversial ideas related to the timing of folding. Sharp et al. (1995a,b) produced a field-trip guide for the Polaris Mine. Savard et al. (2000) reported on fluid inclusion and isotopic data from the deposit and Dewing and Turner (2003) looked at the relative ages of faults near Polaris. Mineralization at Polaris was dated by paleomagnetism (Symons and Sangster, 1992), and Rb-Sr dating of sphalerite (Christensen et al., 1995). Randell (1994), Disnar and

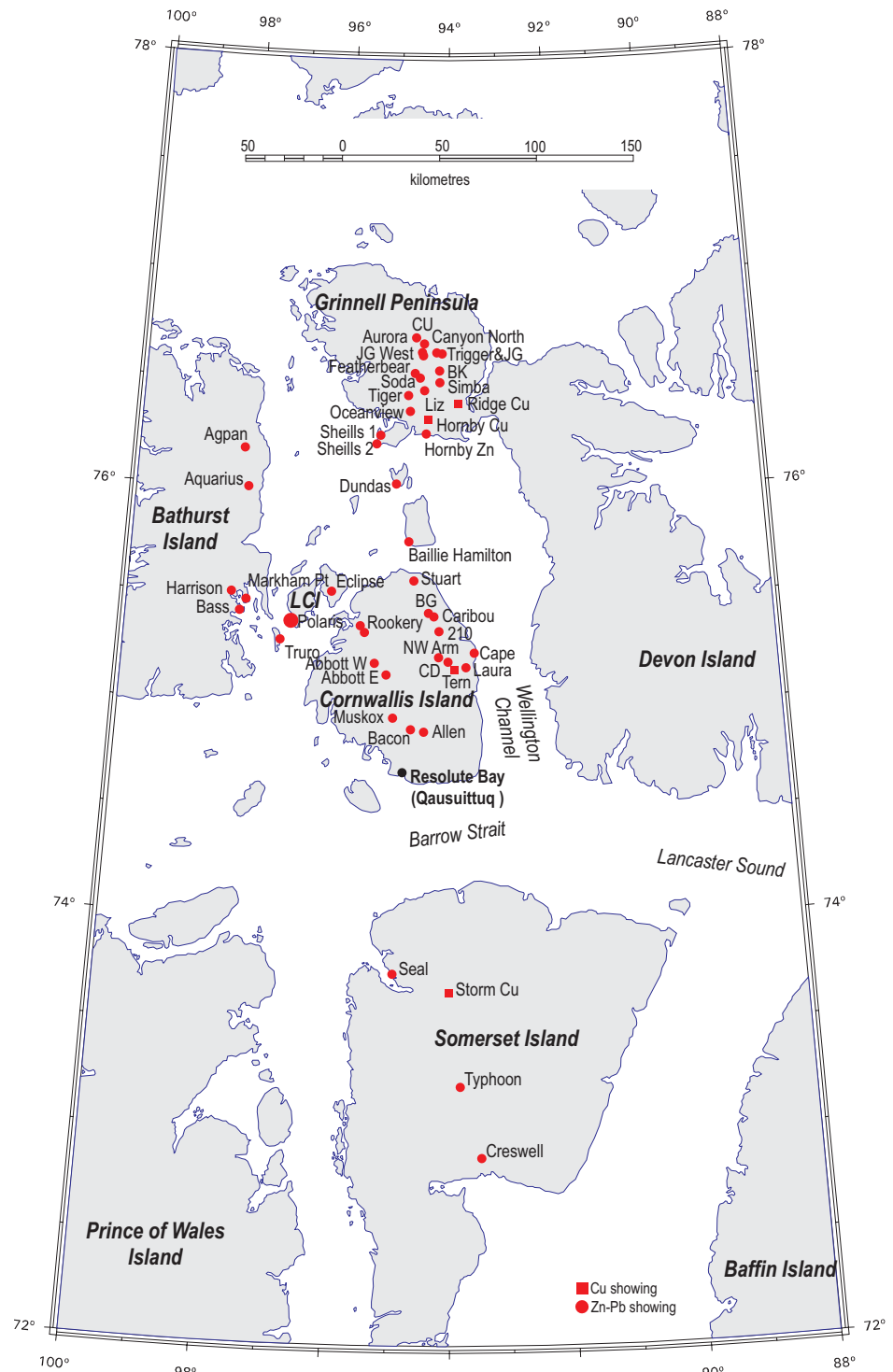


FIGURE 1. Lead-zinc-copper showings in the Polaris District, central Arctic Islands, Nunavut. LCI is Little Cornwallis Island. Some dots represent clusters of showings. Locations and sources are listed in Appendix 1.

TABLE 1. Distribution of showings by formation.

Formation	# showings	% of showings	Com.
Bird Fiord (Dbi)	3	3.75	Zn
Blue Fiord (Dbl)	15	18.75	Zn, Pb
Disappointment Bay (Ddb)	6	7.5	Zn, Pb
Prince Alfred (Dpa)	2	2.5	Zn, Pb, Cu
Barlow Inlet (Sbi)	2	2.5	Zn, Pb
Cape Storm (Scs)	5	6.25	Cu
Allen Bay (Osa)	8	10	Zn, Pb
Thumb Mountain (Oct)	34	42.5	Zn, Pb
Bay Fiord (Ocb)	2	2.5	Zn, Pb
Eleanor River (Oe)	2	2.5	Zn
Ship Point (Osp)	1	1.25	Zn
Total	80	100%	

Héroux (1995), and Héroux et al. (1996, 1999) examined organic matter alteration from Polaris.

Studies of individual showings apart from Polaris are restricted to showings in Devonian strata on Baillie Hamilton Island (Thorsteinsson, 1984), showings in Devonian strata on Bathurst Island (Harrison and de Freitas, 1996; Rose, 1999), the Rookery Creek showing on Cornwallis Island (Dewing and Turner, 2003), and the 'Bermuda' showing on Grinnell Peninsula (Mitchell, 2000).

Geological and Tectonic Setting

Cambrian to Devonian strata of the Arctic Islands are a mixed sedimentary-igneous succession, collectively referred to as the *Franklinian succession*, which were deposited on a passive-to-convergent cratonic margin (Fig. 3; Trettin, 1991). The upper boundary of this succession is constrained as latest Devonian or earliest Carboniferous, but the oldest strata are not exposed. Trettin (1991) suggested that the margin initiated following a widespread Proterozoic igneous event at 723 Ma (see Heaman et al., 1992). The oldest exposed strata are late Neoproterozoic in age (Dewing et al., 2004).

Following Precambrian continental breakup, thick Lower Cambrian clastics and carbonate rocks accumulated along the rifted margin. The shelf-to-basin transition was established by Early Cambrian time (Trettin, 1994; Harrison, 1995). During the Cambrian and Ordovician, the Franklinian shelf accumulated carbonates, evaporites, and continent-derived siliciclastic rocks. During this time, marked differences in subsidence rates between shelf and basin produced an escarpment at the shelf margin (Trettin, 1994). The Cambrian-Ordovician carbonate platform was bordered to the north by the shale-dominated Hazen Basin.

Cambro-Ordovician platformal strata pass southeast and south into the thin, undisturbed cratonic sedimentary cover. The boundary between these depositional realms occurs approximately at the southern and eastern boundaries of the Parry Island – Central Ellesmere fold belts. A hinge line exists between Somerset and Cornwallis islands; the Cambro-Ordovician sedimentary succession thickens rapidly northward across this feature (de Freitas and Mayr, 1993; de Freitas et al., 1999).

During latest Ordovician, the shelf margin retreated substantially towards the south and southeast, forming the Cape

Phillips Embayment. The embayment received mostly graptolitic shale and carbonates, but isolated microbial and coral-microbial banks within the embayment kept up with sea level rise at least until Early Silurian time (Wenlock). The shelf-to-basin transition was a ramp immediately following shelf retreat, but developed a steeper rimmed profile by late Llandovery time (Early Silurian). The facies front is well exposed halfway up the eastern coast of Cornwallis Island.

Vertical movement along a narrow, north-south intracratonic uplift running from Boothia Peninsula to Grinnell Peninsula during Late Silurian to Middle Devonian (Givetian) time produced unconformities and syntectonic clastic sediments (the Boothia Uplift). This deformation probably was caused by stress transmitted cratonward from the Caledonian Mobile Belt on East Greenland (Miall, 1986; Okulitch et al., 1986). Structures within the Boothia Uplift are characterized by broad synclines and narrow, evaporite-cored anticlines (Thorsteinsson, 1986; Mayr et al., 1998). The margins of the anticlines contain abundant thrust faults (Fig. 4; Henrichsen, 2003; Jobert, 2005). Dense, anastomosing arrays of subvertical normal faults with significant vertical offset characterize the western margin of the uplift on eastern Bathurst Island.

By early Middle Devonian time, the effects of plate convergence were widespread over most of the Arctic Islands. Shallow-marine and nonmarine syntectonic clastic rocks were deposited in a foreland basin adjacent to a southeastward- and southward-advancing deformation front. The maximum preserved thickness of this clastic wedge is about 4000 m. Thermal maturity indicators in the area of the Boothia Uplift are generally low (conodont alteration index of <2 and graptolite-based vitrinite equivalent reflectances of about 1% (Gentzis et al., 1996; Héroux et al., 1999)) indicating that the clastic wedge could not have attained a great thickness over the Boothia Uplift.

In the Arctic Islands, the youngest preserved strata are of Famennian age. The Middle Devonian to earliest Carboniferous phase of deformation is known as the Ellesmerian Orogeny (Thorsteinsson and Tozer, 1970). East-west-trending folds that resulted from the Ellesmerian Orogeny characterize Melville, Bathurst, and southern Ellesmere Islands. In the area of the pre-existing Boothia

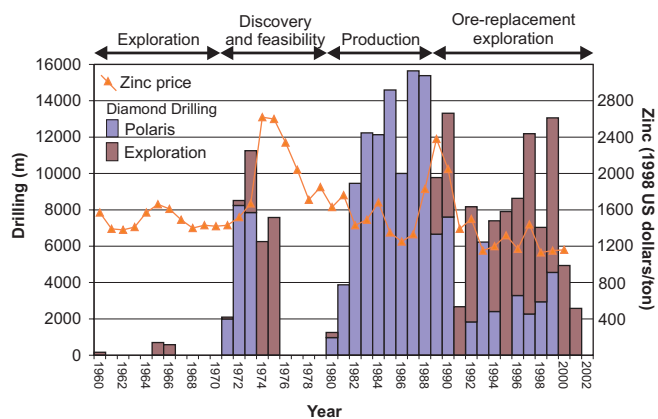


FIGURE 2. Exploration and ore-definition drilling in the Polaris District between 1960 and 2002. High zinc prices in 1974 and 1990 coincide with new rounds of regional exploration. Historical zinc prices from Planchy (1998).

Synopsis of the Polaris Zn-Pb District, Canadian Arctic Islands, Nunavut

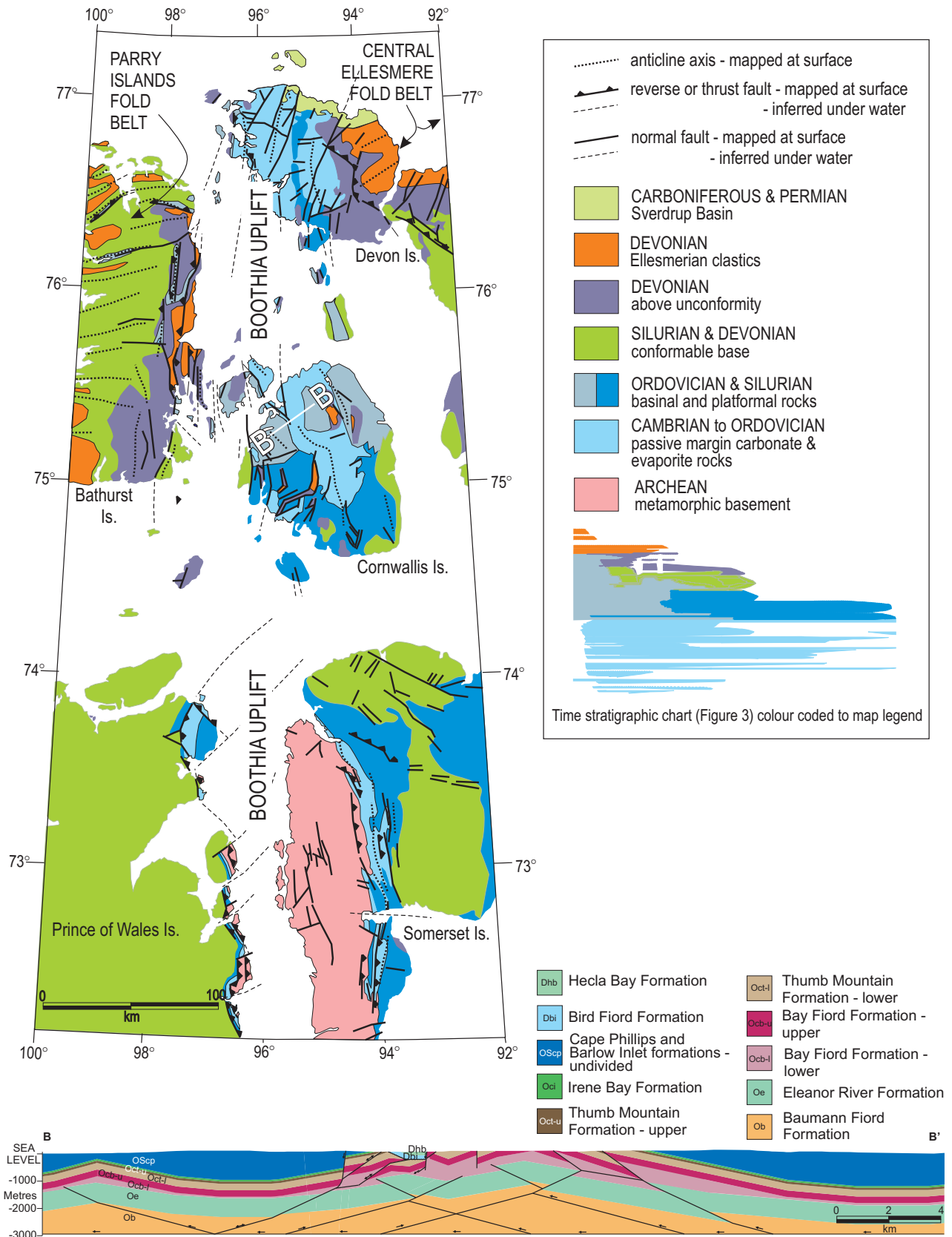


FIGURE 4. Generalized geological map of the central Arctic Islands, Nunavut, (after Okulitch, 1991). The base of the legend shows the time-stratigraphic diagram in Figure 3 colour coded to match this map legend. At the base of the diagram is a hypothetical cross-section B-B' (shown by white line in the centre of the map). This presents a conceptual model (Henrichsen, 2003) that shows a Boothia structure with a thick, evaporite-filled core and thrust carbonates on the flanks. No attempt was made to balance sub-Baumann Fiord units. Later extension reactivated some of the thrusts as normal faults and created small half grabens.

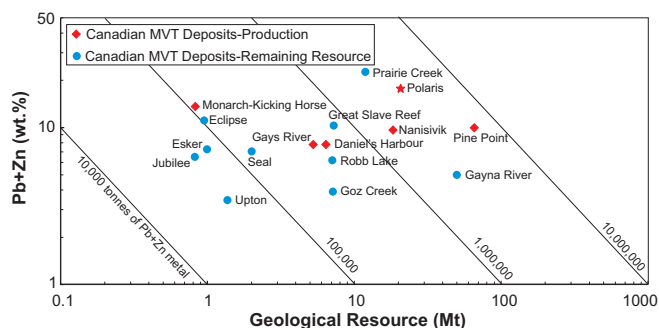


FIGURE 5. Resources versus grade diagram for Canadian Mississippi Valley-type deposits and resources. Production at the Polaris Mine is marked by red star. From Paradis et al. (this volume).

Uplift, the Ellesmerian compression produced low-amplitude east-west folds locally forming an interference fold pattern with the pre-existing north-south Boothia folds.

Rifting during the Early Carboniferous (Viséan) produced the Sverdrup Basin to the north of the lower Paleozoic shelf margin. Regional extension related to the formation of the Sverdrup Basin may have reactivated older thrust faults within the Boothia Uplift as extensional faults creating half grabens locally on the leading edge of the older thrusts.

Mineral Deposits and Occurrences

Deposit Types and Classification

There are two deposit types in the Polaris District: 1) structurally controlled, carbonate-hosted Zn-Pb-Fe deposits typical of the Mississippi Valley-type (MVT) deposit, and 2) structurally and stratigraphically controlled, carbonate-hosted Cu deposits enriched by later supergene removal of Fe and S. This deposit type is not discussed in detail herein.

Deposit Distribution

The Ordovician Thumb Mountain Formation hosts most of the Zn-Pb mineralization and includes the largest deposits at Polaris, Eclipse, and Truro. Consequently, the Thumb Mountain Formation has been extensively prospected. Significant mineralization was found in the Devonian Blue Fiord Formation only in 1995 (Harrison and de Freitas, 1996) and 14 of the 15 showings in that unit were found between 1996 and 2001. Copper mineralization is restricted to the Cape Storm, Prince Alfred, and Douro formations.

Grade and Tonnage

Before mining, the Polaris orebody contained a diluted in situ ore reserve of 26 million tonnes grading 3.7% Pb and 13.9% Zn based on an 8% combined Pb+Zn (cutoff over five metres). Total production at the end of mine life was 20.1 Mt of ore at 13.4% Zn and 3.6% Pb. This places Polaris in the upper echelon of individual carbonate-hosted Zn-Pb mines in the world (Fig. 5).

No other showing in the district was found to be economic so their grade and tonnage are speculative. Teck Cominco estimated the Eclipse showing to contain 765,000 (undiluted) tonnes grading 0.89% Pb and 11.84% Zn, with a possible additional 165,000 tonnes grading 0.07% Pb and 8.83% Zn. Eclipse contains both sulphide and oxide ore making the recovery more difficult. Estimates of the size of the Seal

showings indicate up to 2 Mt (diluted) at 7% Zn. No other showings had ore-grade intersections that could be correlated to nearby drillholes

Age

The age of sphalerite crystallization at Polaris has been established as 366 ± 15 Ma, (Late Devonian to Early Carboniferous) based upon Rb/Sr isotopic ratios in sphalerite (Christensen et al., 1995). This age is supported by a Late Devonian magnetic paleopole for the ore (Symons and Sangster, 1992). Recent, as yet unpublished, work by Christensen indicates some showings (e.g. Dundas Island) have a Viséan (Early Carboniferous, 337 Ma) age, synchronous with the opening of the Sverdrup Basin.

Deposit Morphology

Host Rocks

Four stratigraphic units are exposed around Polaris (Figs. 6, 7, 8). The oldest is the Middle Ordovician Bay Fiord Formation, a 440 m thick succession of anhydrite and dolostone. This is overlain by the Middle to Upper Ordovician Thumb Mountain Formation, which, where unaltered, consists of 340 m of carbonate. These shallow-water carbonates and evaporites are overlain by deeper water shale of the Irene Bay (60 m) and Cape Phillips (600 m) formations. The Thumb Mountain Formation hosts the mineralization at the Polaris Mine.

The lower member of the Thumb Mountain Formation is approximately 250 m thick and consists of dolomitic limestone or dolostone. The basal 35 to 45 metres are composed of thick-bedded, burrow-mottled, lime- or dolomudstone and wackestone. Overlying strata of the lower member (approximately 180 m) consist of medium- to thick-bedded, pale grey to brown, lime- or dolomudstone, peloidal grainstone, with lesser wackestone. Metre-scale cycles of mottled dolomudstone or wackestone overlain by plane-laminated or fenestral lime- or dolomudstone occur. The uppermost 10 to 30 m of the lower member of the Thumb Mountain Formation, known as the *Tetradium* Interval, contain rare to abundant *Tetradium* (characterized by calcite-filled tubes with a 0.5 to 2.0 mm square cross-section).

The upper Thumb Mountain Formation is approximately 80 m thick. A basal chert marker (4-10 m thick) consists of thickly bedded, medium to dark brown, burrow-mottled skeletal wackestone with white-weathering silicified burrows several centimetres in diameter. Above the Chert Marker, the upper Thumb Mountain Formation consists of 30 to 40 m of burrow-mottled, medium-bedded skeletal wackestone with lesser interbeds of nodular, argillaceous lime mudstone and wackestone. This is followed by 15 to 20 m of massive to thick-bedded, fossiliferous wackestone containing abundant macrofossils. The uppermost part of the Thumb Mountain Formation consists of 20 to 25 m of argillaceous, nodular, skeletal wackestone with interbedded green terrigenous mud.

Within the upper Thumb Mountain at Polaris, and on western Cornwallis Island, is the organic-rich "Vr" Marker, a 1 m thick wackestone bed with total organic carbon of between 0.5 and 1.5%, and containing abundant, dark orange to dark brown algal colonies up to 1.5 cm long and 0.5 cm

high that are internally massive or faintly laminated.

The Irene Bay Formation is a 55 m thick Upper Ordovician sequence gradationally overlying the Thumb Mountain Formation. It consists of interbedded green mudstone, argillaceous grey-green limestone, and massive to nodular grey limestone.

The Upper Ordovician to Silurian Cape Phillips Formation has a lower Ridge Member (a thickly bedded dolomitic or calcareous wackestone that is 7-10 m), overlain by 600 to 2200 m of shale, argillaceous limestone, and chert. A facies front on central Cornwallis Island marks the transition from basinal Cape Phillips Formation to the north to platformal strata of the Allen Bay, Cape Storm, Douro, and Barlow Inlet formations to the south.

Unconformably overlying Ordovician or older Silurian strata are several Upper Silurian - Lower Devonian alluvial conglomerate units that record the Boothia Uplift (Fig. 3; Miall and Gibling, 1978; Thorsteinsson and Uyeno, 1980; Muir and Rust 1982; de Freitas and Mayr, 1993; Mayr et al. 1998). Conglomerate units are restricted to regions in front of each Boothia-aged thrust fault. The Early Devonian Disappointment Bay Formation overlies the conglomerate, or forms the lowest Devonian unit where the conglomerate is absent. This is, in turn, overlain by the dolomitic Blue Fiord and Bird Fiord formations. Devonian units sit with an angular unconformity on underlying Ordovician and Silurian units on Cornwall Island (Thorsteinsson, 1986), Little Cornwallis Island (Turner and Dewing, 2004), and Grinnell Peninsula (Mayr et al., 1998).

Dimensions

Dimensions of the Polaris deposit are 800 m strike length, 300 m at its widest point, and a thickness ranging from 20 m in the west to 100 m in the central portion. The deposit is blind, with the topmost ore lying 50 m below surface on the west and up to 160 m

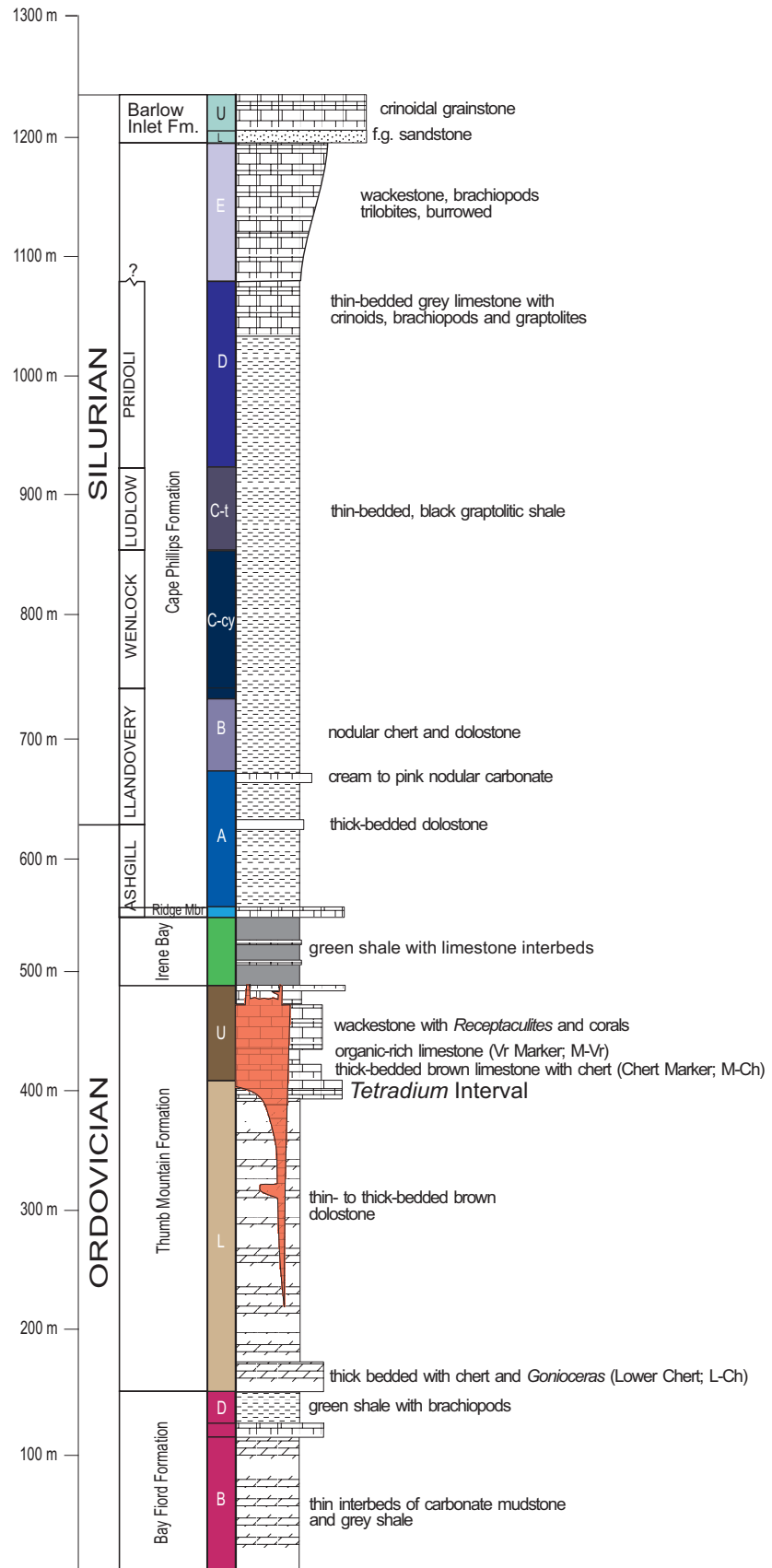


FIGURE 6. Stratigraphic column for Little Cornwallis Island. Ore at the Polaris Mine is hosted in the Thumb Mountain Formation (red overlay). Cape Phillips Formation member C is divided on the basis of graptolites into a cyrtograptid-bearing “C-cy” unit and a *Bohemograptus tenuis* bearing C-t unit.

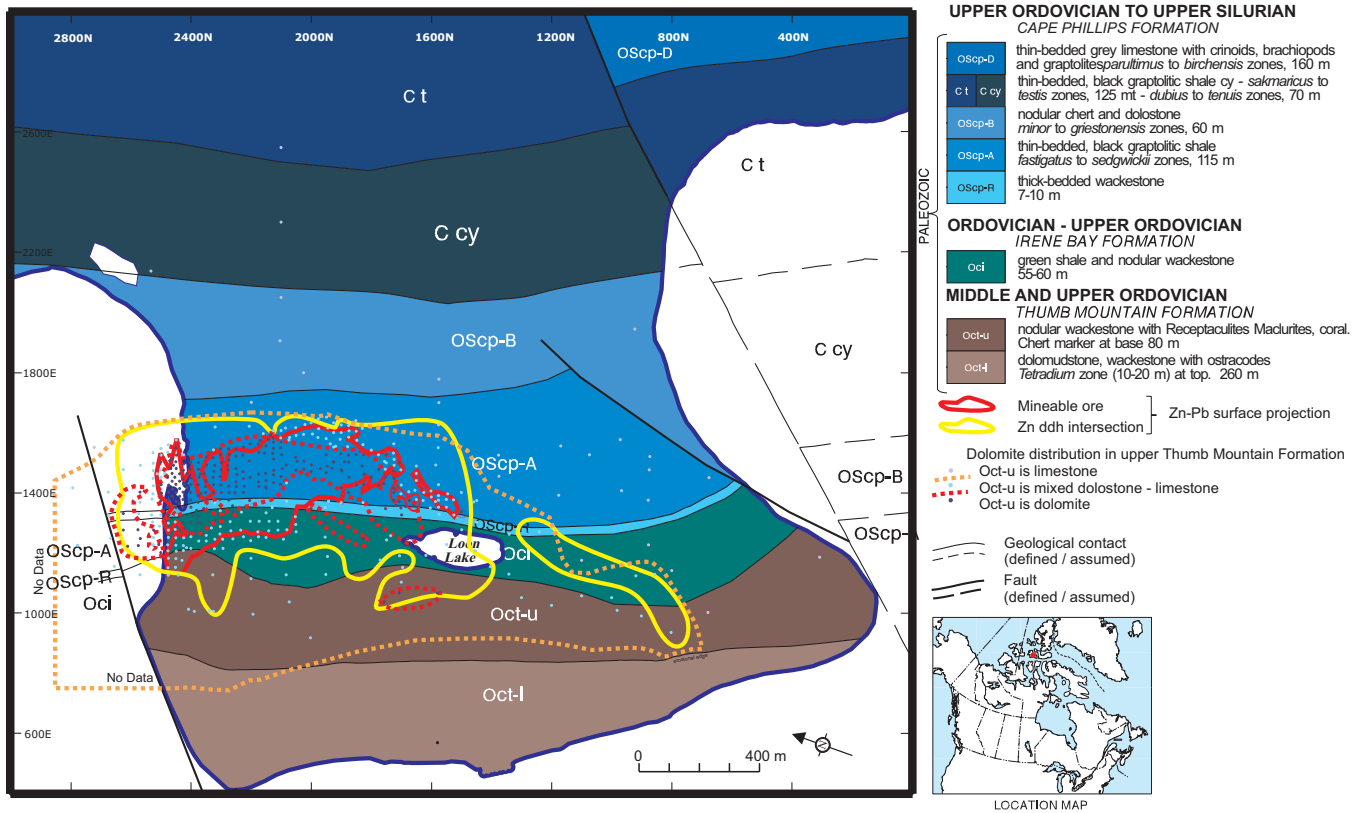


FIGURE 7. Geological map of Polaris Peninsula, Little Cornwallis Island. Plan of the mined ore shown in solid red. The limit of the drillholes containing an interval of >1% Zn are shown by a yellow line. The limits of completely and incompletely dolomitized upper Thumb Mountain Formation are shown by dashed lines and coloured dots. The mine grid is 23° east of true north. After Turner and Dewing (2004).

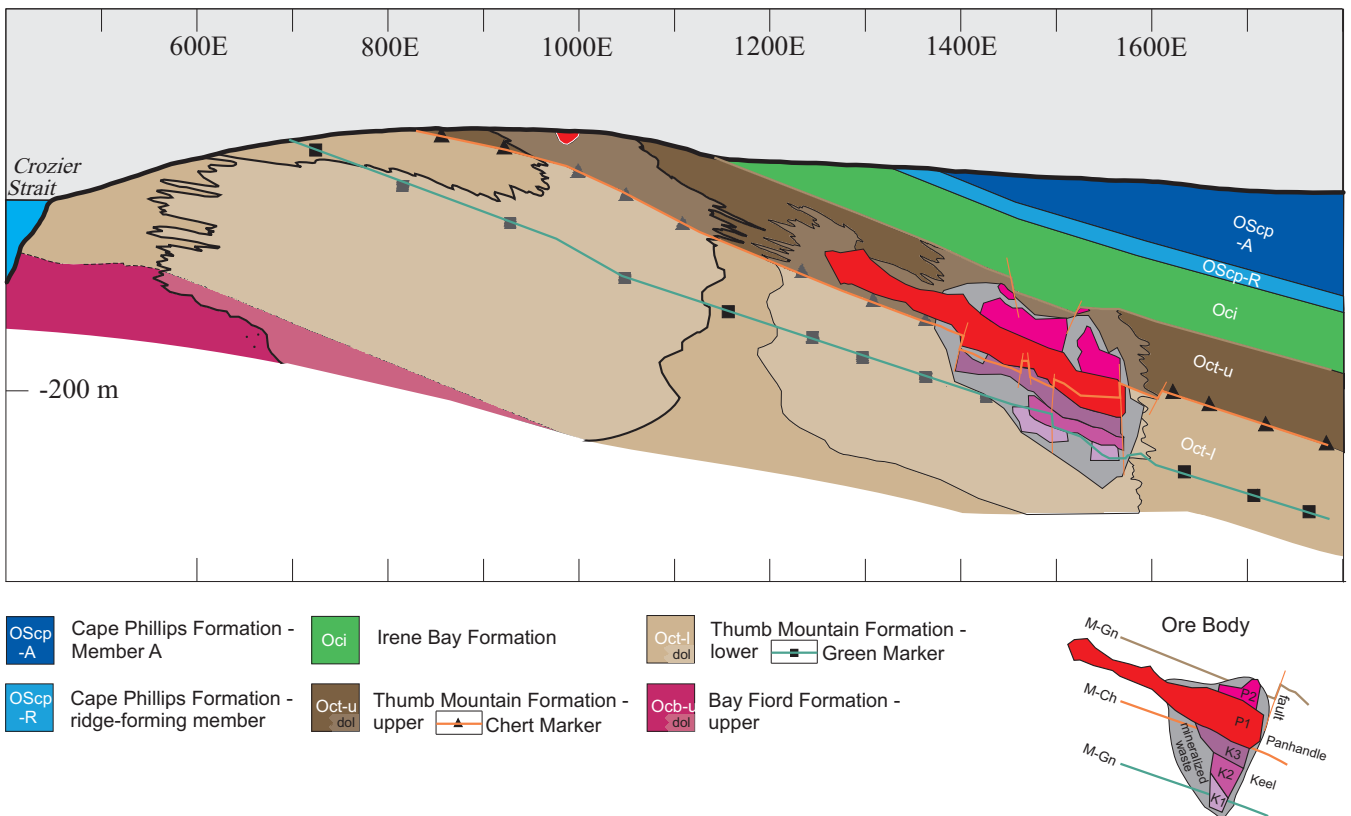


FIGURE 8. Section through the Polaris Mine on mine grid 2100 N showing the outline of the mined ore, mineralized waste and the collapse of the marker beds in the orebody. The dolomitization outlines are after Randell (1994). No vertical exaggeration. Dominant lithotypes for each unit are on the legend for Figure 7.

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TABLE 2. Ore grade by division within Polaris Mine.

Zone	Pb+Zn	Fe	Zn/Pb
P2	16.5	4.6	3.1
P1	22.4	4.5	3.5
K3	19.1	3.1	5.6
K2	17.3	1.7	4.3
K1	15.5	0.8	8.1

below surface on the east side. It forms a continuous sulphide body.

The Eclipse showing is 700 m long, with a 300 metre long western portion that is about 70 to 100 m wide and an eastern portion about 250 m long and 25 to 50 m wide, separated by a 150 m long central portion that appears to be poorly mineralized. The Seal Showing has a strike length of about 400 m, daylight to the southwest, and is 50 to 100 m wide and 12 to 20 m thick. Other showings range in size from 100 by 80 m (Dundas Island) to many that are <10 m across. Showings often occur in clusters of 5 to 10 spread parallel to strike over roughly 10 km.

Nature of Sulphide Orebodies

The Polaris orebody consists of two parts (Fig. 8). The Panhandle Zone forms the upper part of the deposit and is an elongate tabular Zn>Fe>Pb body, roughly concordant with the upper Thumb Mountain Formation, in which carbonate is almost completely replaced by sulphide. The Keel Zone occupies the lower and eastern part of the orebody and consists of a Zn>Pb>Fe vein stockwork. Five ore types were recognized: two ore types occur in the upper Thumb Mountain and three in the lower Thumb Mountain (Sharp et al., 1995b).

P1 ore was the economically most important and formed a 10 to 30 m thick, high-grade Zn-Fe-Pb, tabular unit hosted in the basal part of the upper Thumb Mountain Formation. P1 ore consisted of massive, carbonate replacement, breccia-fill and vein sulphide averaging 4 to 5% Fe with up to 30% Fe (see Table 2). Overlying the P1 ore, above the major north-south structures defining the boundaries of the Keel graben, lie blocks designated as P2 ore. This ore is composed of numerous thin to 1m thick veins of sphalerite, marcasite, and galena oriented vertically, sub-perpendicular to bedding. Marcasite halos surround most P2 veins. Directly underlying the P1 tabular body is the high-grade K3 ore composed of complex, cross-cutting veins along with massive to disseminated sulphide replacing Tetradium beds with 3 to 5% Fe. Differentiation between K3 and P1 ore was based mainly on lower iron contents of K3 versus the P1 ore. K2 ore underlies the K3 unit and is composed of fracture-filling and vein sulphides with lesser replacement of carbonate, and local pods of mineralized brecciation carrying grades of 8 to 20% Pb+Zn and 1 to 2% Fe. The lowermost ore unit is K1 ore composed of fracture-filling and vein sulphides, is discontinuous and of lower grade (10 to 15% Pb+Zn, 1 % Fe). This ore unit follows either the north-south (mine grid) axis of mineralization or a northeast-southwest trend and is centred on lower stratigraphic horizons around a green marker bed in the lower Thumb Mountain Formation. To the east and west of the orebody, sulfide mineralization dies out rapidly within 15 m of the ore boundaries. Sulfide feathers out into small,

scattered lenses and sulfide vein systems to the north and south of the orebody.

Only the Eclipse and Seal showings have the pervasive replacement of carbonate by sulphides, which is typical of the high-grade ore at Polaris, but the solution breccias that are so prominent at Polaris are poorly developed at Eclipse, Seal, and at other showings. Similarly, the abundant marcasite that characterized Panhandle mineralization at Polaris is not present at Eclipse, Seal, Truro, or most other showings. Only the JG showing on Grinnell Peninsula contained a long drill intersection of marcasite with minor sphalerite, but adjacent drillholes contained little or no sulphides.

Mineralogy, Textures, and Ore Chemistry

The Polaris orebody exhibits multiple generations of dolomite and sulphide precipitation and of carbonate and sulphide dissolution. Details of the alteration are after

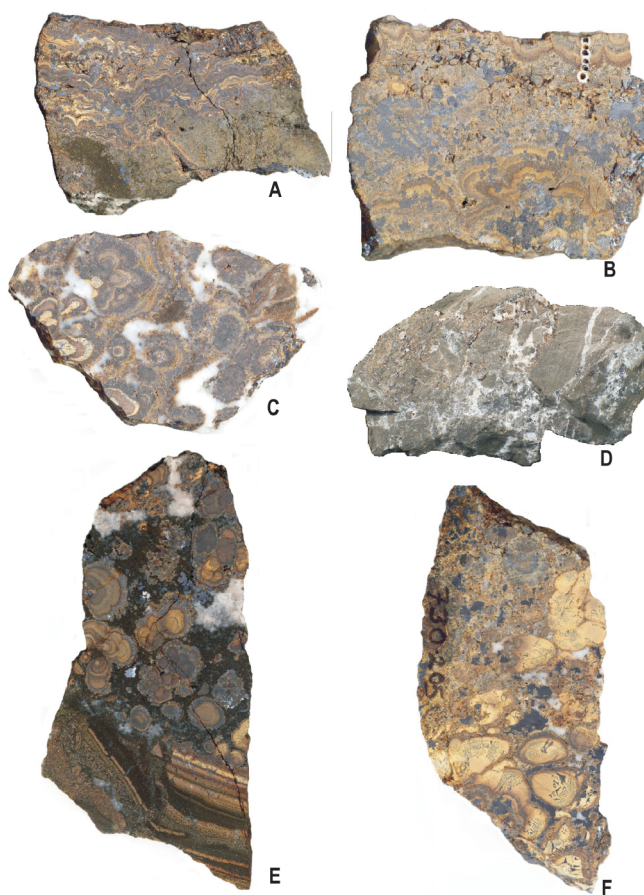


FIGURE 9. High-grade ore samples from the Polaris Mine. Designators for mine location in the keel mining areas are based on elevation and mine grid coordinates. They are level, in metres, with 1000 being sealevel and decreasing with depth, followed by, in metres, the latitude coordinate divided by 10. Hence 850-176 refers to 850 level at 1760 north latitude. Keel stopes, all oriented east-west, mined the keel ore zone from 1720N or 172 stope in the south to 237 stope in the north at 2370 north latitude. (A) Marcasite replaced carbonate and banded sphalerite, 880 level by waterline cutout, 7 cm wide. (B) Sphalerite-galena vein showing banded ore on either side and crystalline galena and sphalerite in the centre, 820 Bypass, 8 cm wide. (C) Colloform and banded ore, 820-229, 8 cm wide. (D) Mineralized collapse breccia, 820-218, 8 cm wide. (E) Marcasite-rich ore showing collapsed fragments of banded sphalerite 880-185, 11 cm high. (F) Colloform sphalerite with dendritic galena and minor dolospar, 730-205, 9 cm high.

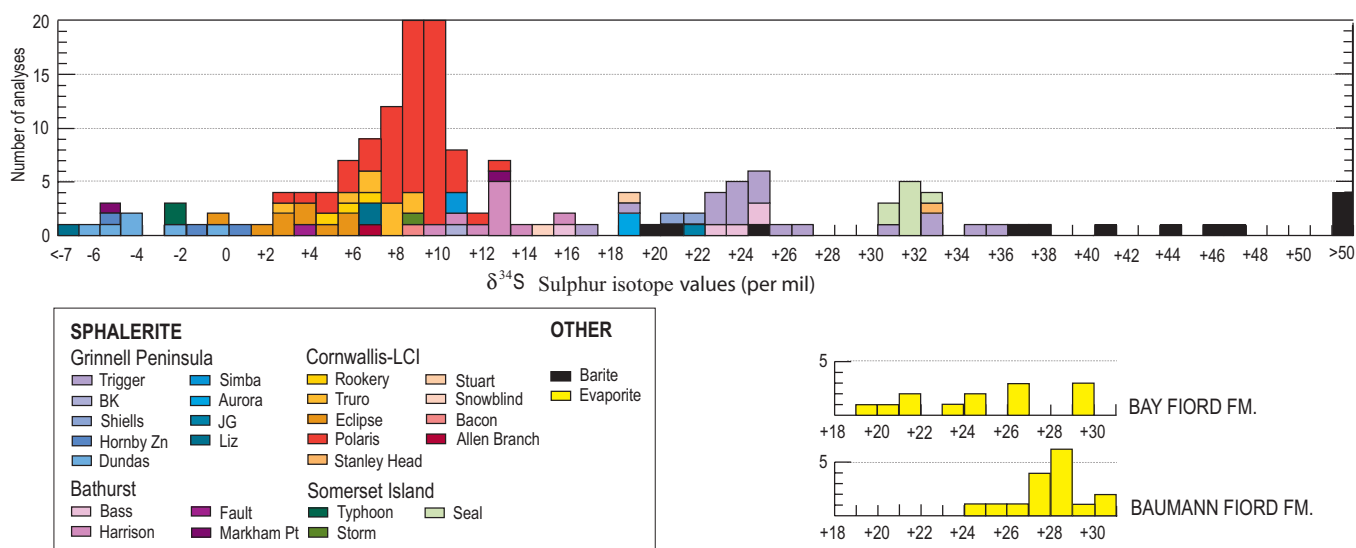


FIGURE 10. Sulphur isotopes from sphalerite in the Polaris District colour coded by location. Data from Davies and Krouse (1975), Randell (1994), and Mitchell (2000), and as well as unpublished GSC data.

Savard et al. (2000). The alteration that extends farthest from the orebody is brown, Fe-poor dolomite that replaces the original limestone of the host Thumb Mountain Formation. Crystal size of the replacement dolomite increases towards the core of the deposit. The replacement dolomite always contains some sphalerite or galena, thus is considered part of the mineralizing event. Two types of sparry dolomite are recognized: 1) white, saddle dolomite, which fills vugs and fractures or that can grow replacively from finer grained replacement dolomite. It is Fe poor and inclusion rich and the bulk of the fluid inclusion homogenization temperatures range from 85 to 105°C; 2) white to pink, Fe-rich, inclusion-poor saddle dolomite that fills vugs and appears to post-date the white saddle dolomite. Most homogenization temperatures fall in the range of 80 to 105°C. The $\delta^{18}\text{O}$ (SMOW) and $\delta^{13}\text{C}$ (PDB) values for the replacement dolomite and the two types of saddle dolomite cluster tightly with $\delta^{18}\text{O} = -10.0$ to -8.5‰ and $\delta^{13}\text{C} = -1.5$ to $+1.0\text{‰}$. $^{87}\text{Sr}/^{86}\text{Sr}$ ratios for replacement dolomite and the two sparry dolomite phases range from 0.70822 to 0.70948. This is above the range for Middle Ordovician seawater (0.7078 to 0.7083; Savard et al., 2000).

Sphalerite occurs as small subhedral crystals disseminated in the host dolostone; within brecciated dolostone as fine aggregates, yellow, grey, brown, and black crystals, and light to dark brown colloform masses and banded encrustations (Fig. 9). Sphalerite $\delta^{34}\text{S}$ values range from +2 to +13‰ with a median of +9‰ (Fig.10; Randell, 1994). Laser ablation studies on $\delta^{34}\text{S}$ in colloform sphalerite from Polaris (Jaroslaw Nowak, unpublished data, see Fig. 9B) indicate that each band shows a systematic variation from 8‰ in the colloform centre of the mass to 12‰ at the outer crystalline rim. Homogenization temperatures for sphalerite range from 65 to 145°C with most of the data falling between 90 and 105°C. Ice melting temperatures indicate salinity in the range of 24.6 to 31.3 wt.% (NaCl + CaCl₂). Hydrocarbon inclusions are rare (<0.07 mol %; Savard et al., 2000).

Galena occurs as small dendritic and skeletal intergrowths within colloform sphalerite, and as cubes and truncated

(octahedral) cubes, or as thin, polycrystalline veins. Galena $\delta^{34}\text{S}$ ranges from 1.0 to 9.4‰ with a median of 4.5‰. Low α lead occurs in galena within the Panhandle ore. This material was separated and sold at a premium to silicon chip manufacturers who used it to make solder in which the electrons in the outer orbitals would not jump to the next-closest solder. Marcasite typically replaces carbonate, is massive, and green-brass, but also occurs as small needles on dolomite, or as submillimetre blades and aggregates. Limited sampling of marcasite for $\delta^{34}\text{S}$ gives a range of 4.9 to 8.9‰.

Pyrobitumen is a common, though volumetrically small, component of the deposit occurring in vugs as crusts or blobs up to 1 cm in diameter. It occurs on top of sulphides and the two sparry dolomite phases, but predates calcite phases. Native sulphur ranges up to 4 wt.% (S. Grasby, GSC-Calgary, unpublished data). Dating of pyrobitumen by Re-Os gives 368 ± 15 Ma, indicating that it is part of the mineralizing event (Selby et al., 2005). Other evidence for hydrocarbon generation at Polaris is found in abundant bitumen (68% of 125 organic matter separates contain bitumen), hydrocarbon fluid inclusions, thermal maturity values indicating passage into the oil window, and petrographic evidence for localized, direct transformation of alginite into bitumen (L.V. Stasiuk, pers. comm., 1992; Randell, 1994).

Barite is rare within the Polaris Mine, occasionally occurring as 1 to 3 mm crystals sparsely coating sphalerite in vugs, but commonly occurs in veins, along faults, or as pore-fill in crinoidal grainstone for up to 10 km from the deposit. Barite $\delta^{34}\text{S}$ values range from +36 to +58‰. It commonly occurs with quartz.

There are at three phases of calcite that post-date the main mineralizing event. The first is a fine-grained, grey calcite that appears to have grown at a fluid interface and is associated with small needles of pyrite. The second phase of calcite consists of small, clear crystals less than 5 mm in length. The third phase consists of 2 to 5 cm, often doubly terminated, brown crystals. Small crystals of brown sphalerite rarely occur between the second and third phases of calcite. Homogenization temperatures for calcite range from 75 to

175°C with most of the data above 120°C. Ice melting temperatures indicate salinity in the range of 0.0 to 0.9 wt.% NaCl equiv. Calcite has $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values (PDB) of 5.0 to 25.4‰ and -25.1 to -5.1‰, respectively. $^{87}\text{Sr}/^{86}\text{Sr}$ ratios for replacement calcite range from 0.70796 to 0.70883 (Savard et al., 2000).

Other Zn-Pb showings have simple paragenetic sequences and a subset of the ore textures seen at Polaris (Fig. 11). The smallest showings only contain fracture-filling crystalline sphalerite (\pm galena, marcasite); larger showings exhibit some replacement of carbonate by sphalerite in addition to the fracture-filling phases; the largest showings (Eclipse, Truro) exhibit barite, marcasite replacement of carbonate, minor collapse breccias, banded aggregate and colloform sphalerite in addition to fracture filling and replacement crystalline sphalerite.

Alteration Mineralogy/Chemistry

Geology of Dolomitized Body

The dolomite halo shows sharp margins on its downdip (east) and southern limits, but extends 550 m up dip where it is exposed on surface on the Polaris Peninsula (Figs. 7, 12; Sharp and Dewing, 2004). Carbonate beds in the overlying Irene Bay Formation are dolomitized directly over the orebody, but the upper surface of the dolomite halo drops to lower stratigraphic levels with increasing distance from the orebody. Thinning of the upper Thumb Mountain Formation and collapse of the overlying Irene Bay Formation starts at the edge of the dolomitized halo indicating the removal of some calcite material during the dolomitization. Collapse continues towards the centre of the deposit indicating that upper Thumb Mountain Formation continued to be thinned even after it was dolomitized. The Thumb Mountain Formation is thinned by 50% in the orebody (Figs. 8, 12). Few beds within the dolomite halo escape dolomitization; even apparently impermeable lime mudstone beds are dolomitized. All beds outside of the dolomitized halo are limestone in the vicinity of Polaris.

Breccias occur only within the dolomitized halo around the orebody and always contain at least some mineralization. Brecciation is thus considered to be part of the mineralizing

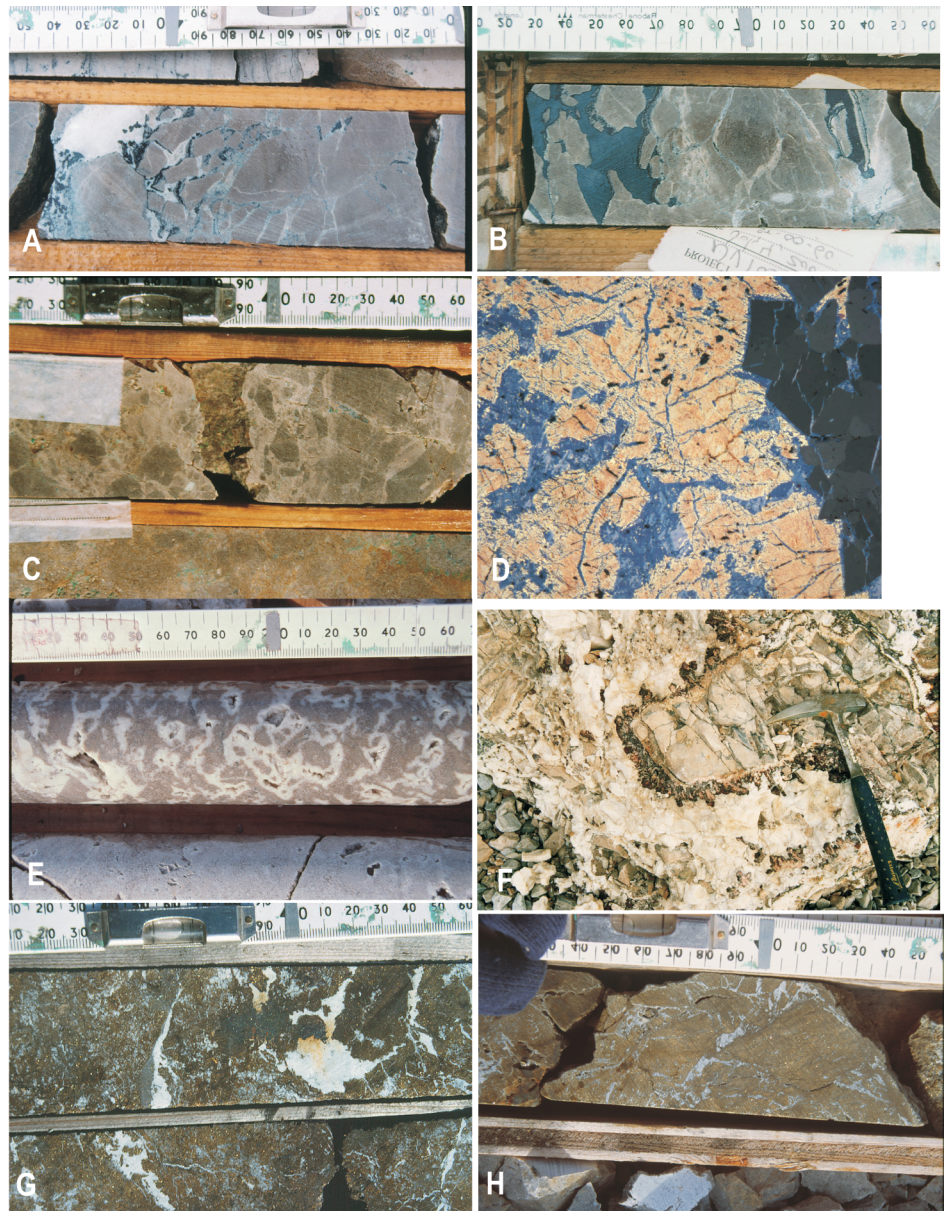


FIGURE 11. Alteration and sulphide textures from the Polaris District. *Somerset Island*: (A) Crackle and mosaic breccia with chalcocite and calcite. Storm showing ddh ST60 76.4 m. (B) Massive chalcocite cementing brecciated Allen Bay Formation. Storm showing ddh ST60, 75.65 m (C) Solution breccia, Storm showing ddh ST60, 138.4 m (D) Storm Showing. Chalcopyrite and bornite in dolomite-lined vug being replaced by digenite. Storm showing ddh ST60, 45 m x10. Photo by N.S.F. Wilson, GSC Calgary. View is 5 mm wide. (E) Pseudobrecciated Turner Cliffs Formation. Seal showing ddh AB95-2, 161 to 215 m. *Dundas Island*: (F) Sphalerite and marcasite on collapse breccia clast. *Grinnell Peninsula*: (G) Marcasite and trace sphalerite replacing carbonate. JG showing ddh 99-10, 34.0 m (H) Marcasite replacing brecciated carbonate and cemented by dolospar. Liz showing ddh LZ01, 18.4 m

event. Breccias are concentrated in certain stratigraphic intervals away from the orebody, but become thicker and coalesce towards the orebody. There is a general (though not infallible) progression from pseudobreccia and crackle breccia to collapse or solution breccia towards the core of the orebody (Fig. 12). Collapse breccias are common within the orebody but pervasive overprinting and replacement by zinc-lead-iron sulphide mineralization makes it difficult to recognize carbonate textures.

The gradation from pseudobreccia to crackle breccia to collapse or solution breccia towards the orebody is presu-

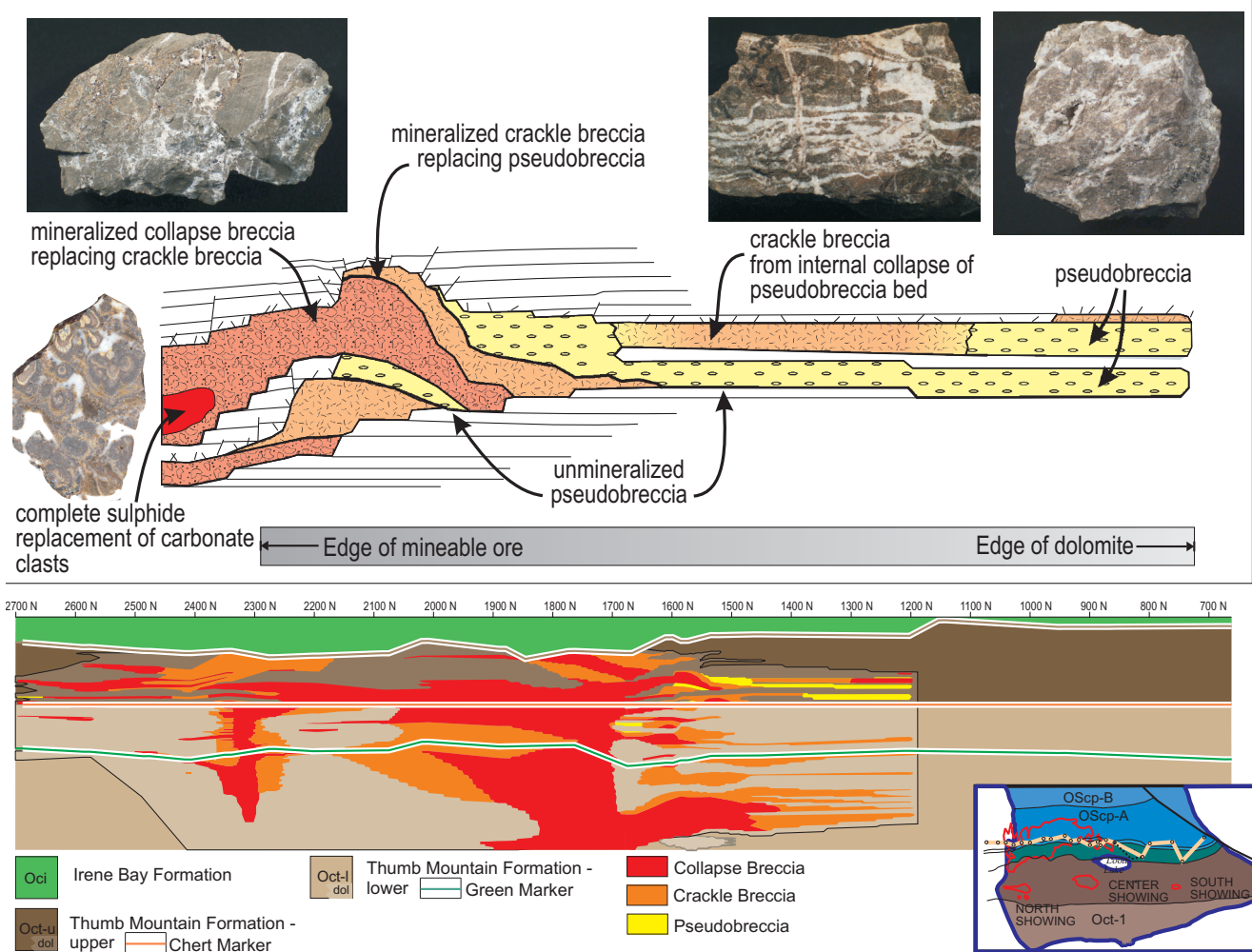


FIGURE 12. Lower part: Long section through Polaris Mine hung on the base of the Chert Marker (M-Ch) showing distribution of dolomitization and breccia types. Note the thinning of the upper Thumb Mountain Formation starting at the edge of the dolomitization and continuing towards the centre of the orebody. Section length 2000 m, location shown on inset map. No vertical exaggeration. Upper part: Schematic figure showing the distribution of breccia fabrics within the upper Thumb Mountain Formation at Polaris Mine (roughly between 1400 and 1650 N). Pseudobreccia forms in porous beds far from the orebody and grades into crackle and collapse breccia closer to the ore. x2 vertical exaggeration.

ably a result of increasing dissolution. Pseudobreccia is formed in porous and permeable beds where acidic fluid migrating away from the site of ore deposition began to remove carbonate. Removal of carbonate reduced the strength of the pseudobrecciated beds and these began to collapse. Crackle breccia formed as blocks of pseudobreccia crumbled and settled into the newly created void space and as undissolved beds adjusted due to the overall thinning of the Thumb Mountain Formation. The increasingly porous and permeable crackle breccia zones were then further dissolved creating solution and collapse breccias (Fig. 12). Pseudobreccia is only recognized on the fringes of the dolomitized halo as it has been overprinted by more intense brecciation and mineralization closer to the orebody.

Clay Mineral Assemblages

There is a zonation of clay mineral assemblages within the host rocks away from the ore (Fig. 13; Héroux et al., 1996, 1999). Six clay mineral assemblages are present: 1) the background sedimentary clay assemblage in the Cape Phillips Formation consists of illite>interstratified

illite/smectite>chlorite; 2) the background clay mineral assemblage for the Thumb Mountain Formation is illite>chlorite>interstratified illite/chlorite; 3) the Irene Bay Formation and less commonly the uppermost part of the Thumb Mountain Formation contains a background chlorite-corrensites assemblage (chlorite+corrensites+chlorite/smectite mixed layer)>illite, interstratified with illite/smectite; 4) directly over the main orebody in the upper part of the Thumb Mountain and in the Irene Bay formations is a pure illite facies (with traces of chlorite) containing well crystallized illite with few swelling layers; 5) within 250 m of the ore in the Thumb Mountain Formation is a coarse kaolinite assemblage. It contains kaolinite and illite, with some traces of chlorite. The kaolinite to illite ratio is always much higher in the 2 to 16 micron fraction than in the <2 micron fraction. Scanning electronic microscopy shows that this kaolinite is present as large vermicules filling the porosity in dolostone; 6) within 1000 m of the orebody in the Thumb Mountain Formation is a fine kaolinite assemblage containing illite and kaolinite with trace chlorite. The illite to kaolinite ratio is

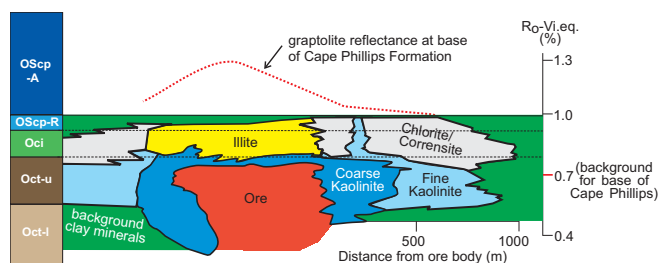


FIGURE 13. Schematic long section through the Polaris Mine showing the distribution of clay mineral assemblages and graptolite reflectance in the overlying Cape Phillips Formation. Stratigraphic column shown on the left (north) side. Details in Randell (1994) and Héroux et al. (1996).

about the same in the less than 2 micron fraction as in the 2 to 16 micron fraction.

Organic Matter Alteration

Reflectance of organic matter (R_0) in the impermeable Cape Phillips and Irene Bay formations near the ore shows higher values than away from the ore (Fig. 13; Randell, 1994; Héroux et al., 1996, 1999). Above the orebody, graptolites in the Cape Phillips Formation exhibit a R_0 of 1.35%, twice the expected background value ($R_0=0.7\%$) for this lithostratigraphic unit as determined from remote diamond drillholes and outcrops. R_0 values from the Irene Bay Formation are also 50% higher than background above the ore zone. These values decrease away from the ore, attaining background values at 1.2 km radius from the mine. In contrast, R_0 values from the upper Thumb Mountain Formation within the ore deposit are 20% lower than the expected R_0 background ($R_0=0.5\%$ rather than 0.75%). This “suppressive” effect is also shown by decreasing R_0 values with depth. The difference between the lowest and the highest R_0 values, occurring respectively near the bottom and the top of at the same diamond drill, is twice the lower value.

Cu-Rich Mineralization and Associated Alteration

Alteration at the copper-rich showings at Storm and Hornby Zn includes fracturing to crackle breccia; small zones of mosaic packbreccias with calcite, pyrite, and subordinate chalcocite cement; pervasive hematite staining; and rare malachite/chalcocite on fractures. Mineralization is usually accompanied by medium to coarsely crystalline dolomitization and local dedolomitization of the host lithology; minor sparry dolomite; pockets of silicification; limonite staining and hematization; crackle and mosaic breccias with solution-rounding clasts. Chalcocite and bornite are the most common copper sulphides, with lesser chalcopyrite (Fig. 11). Accessory copper minerals include cuprite, covellite, and native copper. Malachite and azurite occur as surface stain and are associated with iron oxides in drill core. Pyrite is the main non-copper sulphide but small veins of sphalerite and galena occur. Fluid inclusion homogenization temperatures on sparry dolomite yield 100 to 120°C and ice melting temperatures indicate salinities >35 wt.% NaCl eq. Sphalerite has a $\delta^{34}\text{S}$ value of 8.5 ‰, whereas two samples of chalcocite yielded $\delta^{34}\text{S}$ values of -9.5 and +10.7 ‰.

Two diagenetic events are documented at the Storm showing. The first was dolomitization accompanied by precipitation of pyrite, chalcopyrite, and lesser bornite. Silica, in the

form of cryptocrystalline quartz, minor sphalerite, and galena, were deposited at the margins of the alteration system. The second event was minor dissolution and dedolomitization of dolomite, dissolution of galena, and precipitation of zinc oxides, covellite, chalcocite, bornite, native copper, iron oxide, and malachite. Bornite, covellite and chalcocite replace pyrite and chalcopyrite and fill fissures within the rock. These copper minerals were subsequently altered to malachite and azurite. Calcite precipitation accompanied the second event.

The copper mineralization in the Polaris district is thought to be directly associated with the main zinc mineralizing event because 1) Zn-Pb mineralization occurs with or overlaps copper mineralization and 2) both were formed by saline brines of similar composition and temperature. Copper mineralization occurs at the contact between the Allen Bay and Cape Storm formations, possibly reflecting a local source of metals.

Structure and Deformation

The primary control on the location of showings within the Polaris District is structural. Mineralization occurs in four distinct structural settings: 1) along strike-slip and tear faults that separate the east margin (Harrison, Agpan, Aquarius showings) and west margin (Liz-Tiger-Simba, BK, Trigger) of the Boothia Uplift from the adjacent Parry Island and Central Ellesmere fold belts; 2) in grabens and half grabens along extensionally reactivated, Boothia-aged thrust faults (Eclipse, Rookery, Hornby, Dundas, Abbott, Bacon); 3) in the axial region of east-west trending anticlines (Stuart River, Caribou, Baillie Hamilton, high-grade zones within Polaris Mine); and 4) on an east-west-trending fault on Somerset Island marked by a line of small grabens and facies change (Seal, Storm). This structure directly lines up with the southern bounding fault of the Proterozoic Borden Basin on Baffin Island and thus is presumably the reactivation of basement faults reflected in the overlying Paleozoic strata.

There is a second-order, stratigraphic control on the location of mineralization within the sedimentary pile and on the mineralogy of the showing. Limestone units that are overlain by less permeable shale, evaporite, or argillaceous dolostone units are preferentially mineralized. These include the Thumb Mountain, Blue Fiord, and Allen Bay formations. Cu-Fe±Zn-Pb mineralization (Storm Cu, Hornby Cu, Eclipse, Tern Lake) occurs only within Silurian strata, either at the contact between the Allen Bay and overlying Cape Storm formations (Storm, Tern Lake), or where Early Devonian synorogenic clastic strata overlie Silurian strata (Hornby Cu, Eclipse).

Two showings on eastern Cornwallis Island located along the shelf margin contact between the basal Cape Phillips Formation and the platform Barlow Inlet Formation (Laura Lakes and Cape) have no obvious associated structures and appear to be stratigraphically controlled showings.

Genetic Models

The model for the Polaris deposit (Fig. 14) invokes a source of metal ions within the stratigraphic column, since strontium or lead isotopes show no indication of basement or basal clastics being involved. Metals are then carried in sul-

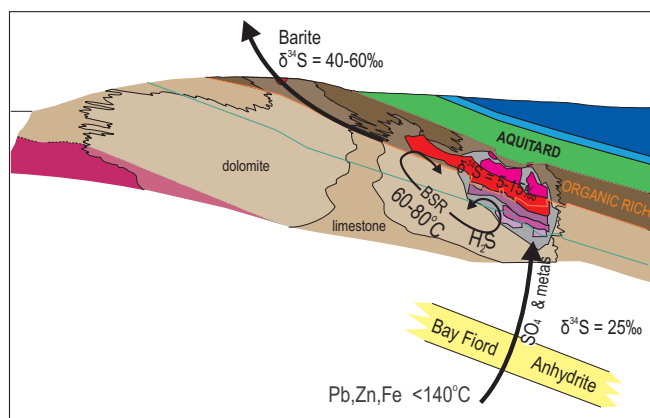


FIGURE 14. Genetic model for the Polaris Mine showing the origin of metal and sulphate-rich fluids in the sedimentary pile, transport as a single fluid to site of ore precipitation, reduction and fractionation by bacterial sulphate reduction (BSR), combination of isotopically light H_2S and metal ions to form ore and create acidic fluids, and expulsion of isotopically heavy sulphate to produce a barite halo. Legend as for Figure 8.

phate-rich brines through aquifers deep in the stratigraphic column. Driven by an orogenic process, either the Late Devonian Ellesmerian Orogeny or the mid-Carboniferous opening of the Sverdrup Basin, circulating fluids rose along faults until they encountered the organic-rich, permeable Thumb Mountain Formation limestone overlain by the impermeable Irene Bay Formation shale.

Bacterial sulphate reduction reduces sulphate to H_2S using the abundant algal organic matter in the upper Thumb Mountain Formation as a reductant. The resulting H_2S has a shift in $\delta^{34}S$ values of -15‰ (Fig. 10). The H_2S reacts inorganically with zinc, lead, and iron ions to produce sulphides with a $\delta^{34}S$ value of about 10‰ . Released hydrogen ions dissolve carbonate resulting in dissolution breccias and other dissolution fabrics. It is proposed that excess sulphate was expelled from the system and produced a halo of barite up to 10 km from the deposit with $\delta^{34}S$ values of 40 to 60‰ . Evidence of a temporal link between barite and ore is based on one sample from the 930-124 stope at Polaris that has sphalerite that pre- and post-dates barite, proximity to Polaris (barite is common only on southern Little Cornwallis Island), heavy sulphur isotope values, and occurrence with marcasite.

Temperatures measured from fluid inclusions and inferred from the thermal maturity data indicate a range of 80 to 105°C . This is the appropriate range for bacterial sulphate reduction (Machel et al., 1995). Thermochemical sulphate reduction is unlikely to have been active since 1) the temperatures are too low ($\geq 140^\circ\text{C}$ is needed); 2) there is no blocky calcite with strongly negative $\delta^{13}C$ values, which is typically produced during thermochemical sulphate reduction; 3) there is fractionation of the sulphur isotopes, a process that does not occur during thermochemical sulphate reduction (Machel et al., 1995); and 4) the $\delta^{34}S$ in individual sphalerite masses is inhomogeneous, typically showing a variation from 8‰ in the colloform centre of the mass to 12‰ at the outer crystalline rim. Presumably this reflects pulses of fluid activity, with bacterial sulphate reduction producing a gas cap with strongly fractionated H_2S , followed by the introduction of metal-rich brine, rapid precipitation of

amorphous colloform sphalerite, followed by slower precipitation of crystalline sphalerite as the gas cap is depleted and gas slowly produced by ongoing bacterial sulphate reduction.

This model fails to explain many of the showings on Grinnell Peninsula, at the Seal deposit on Somerset Island, or at Bass Point on Bathurst Island, where the $\delta^{34}S$ of sphalerite is about the same as marine sulphate (25 to 30‰). These showings also lack barite and some have sphalerite in calcite veins. Grinnell and Somerset are beyond the northern or southern limits of the Baumann Fiord and Bay Fiord evaporites and may reflect the long distance transport of thermochemical sulphate reduction generated gas. If so, the $\delta^{34}S$ of individual crystals should be homogeneous.

Exploration Methods

Historical

Exploration cycles in the district typically started with prospecting, stream sediment heavy mineral sampling, and more recently, airborne hyperspectral surveys. These activities have been followed by property-scale mapping, soil sampling, clay and thermal maturity analysis, gravity, IP, and magnetic surveys. Targets identified were then drilled.

Geological techniques have focused on property-scale mapping of alteration indicators, such as the distribution of dolomite, carbonate dissolution fabrics, barite, and sulphide occurrences and textures. Stream sediment heavy mineral sampling has proven effective in locating showings, but soil sampling often gives results that are hard to interpret, presumably due to the lack of soil development and chemical weathering in the permafrost zone. Clay mineral and organic matter alteration techniques (described above; Héroux et al., 1999) are effective in locating showings and providing vectors to the area of maximum alteration. Airborne hyperspectral surveys employed by Noranda on Grinnell Peninsula located numerous new showings, but other airborne techniques (e.g. EM) failed to locate any new showings. The Polaris Mine responded well to IP and gravity surveys, with a whopping 2.2 milligal residual gravity anomaly over the deposit, although the gravity anomaly is influenced more by the large body of dolomite within limestone rather than sulphide within dolomite. IP located the Polaris deposit, but

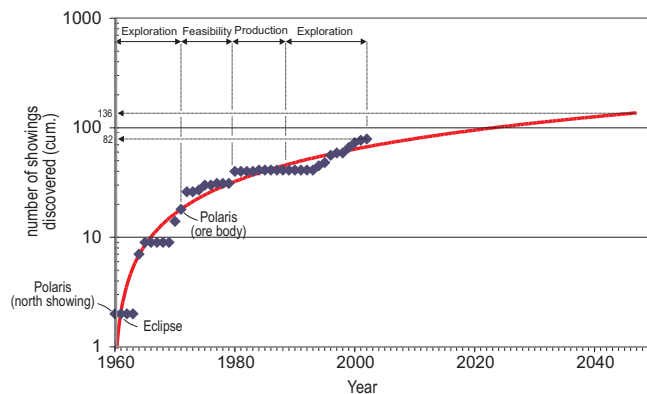


FIGURE 15. Graph of number of known showings versus year of discovery. Eighty-two showings are known and the best-fit curve indicates that as many as fifty showings remain to be found.

elsewhere in the district has provided numerous false positives due to salt-water lenses (taliks) within the permafrost and remains of uncertain value.

Potential for New Targets

Exploration potential exists for additional deposits within the Polaris District. The curve showing number of known showings versus year indicates that many showings remain to be found (Fig. 15). The difficult logistics and short summer season often governed exploration instead of geology, so undiscovered showings could be significant.

The district may respond well to a second exploration cycle built on more sophisticated exploration techniques. Exploration starting with hyperspectral surveys to identify areas of iron oxides, barite, and clay mineral alteration could be followed by thermal maturity sampling spatially associated with potential structurally controlled fluid conduits, pathfinder geochemical surveys (Zn, Pb, Cd, Cu, Ba, Fe), and then the more traditional methods described above.

Highest priorities for additional exploration (Fig. 16) should be 1) poorly explored, Devonian-filled half grabens at Rookery Creek, Taylor River, and Eleanor River on Cornwallis Island; on Baillie Hamilton Island; and along the Icefield fault on Grinnell Peninsula; 2) Liz-Tiger-Simba trend on Grinnell Peninsula; 3) carbonate-hosted, copper-rich showings associated with the Allen Bay-Cape Storm formational contact in the vicinity of faults northeast of Resolute Bay, and on structures parallel to the Aston-Batty Line on Somerset Island and on southern Devon Island; and 4) unexplained thermal anomalies at Victor Creek northeastern Cornwallis Island described by Héroux et al. (1999), and 5) buried Thumb Mountain Formation on eastern Bathurst Island

There is another, as yet untested, deposit model for a separate type of lead-zinc mineralization in the district. Absolute dating of the Nanisivik deposit on northern Baffin Island (Sherlock et al., 2003) has yielded a Middle Ordovician age (461 Ma or Chayzan) for the mineralization and associated alteration of volcanic dykes. This result, while controversial, indicates that some potential exists for iron-rich, carbonate-hosted deposits in areas that overlie the ancestral Borden Basin (Fig. 17). The age of mineralization as determined by Sherlock et al. (2003) is synchronous with the deposition of the Bay Fiord Formation. The intraplatfor-

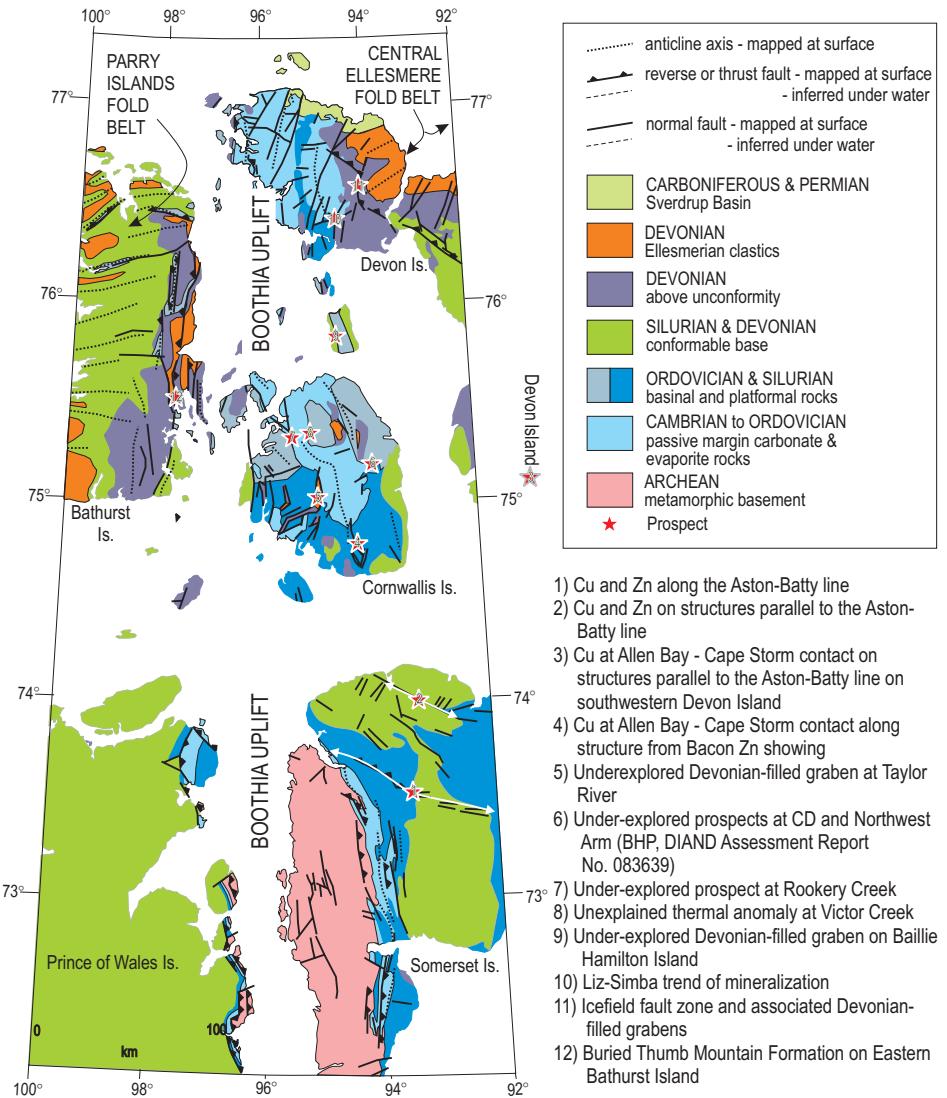


FIGURE 16. Prospects for Zn-Pb or Cu potential within the Polaris District that these authors consider to have high potential.

mal basin that developed and accommodated evaporites of the Bay Fiord Formation may have resulted from the onset of subduction under the North American continent and the associated drag from the down-going slab. The “Melville Arch” (Figs. 3, 17) might have been the resulting peripheral bulge.

Knowledge Gaps

The following knowledge gaps need to be addressed for effective future exploration:

Mapping

- 1:50 000 mapping is required on Cornwallis Island to locate small, Ellesmerian-aged structures that are beyond the resolution of the current 1:250 000 map. These structures controlled fluid flow at Polaris and on northeast Cornwallis Island (Jobert, 2005). Locating these potential fluid conduits would help target exploration.
- 1:50 000 mapping is required on Somerset Island in the

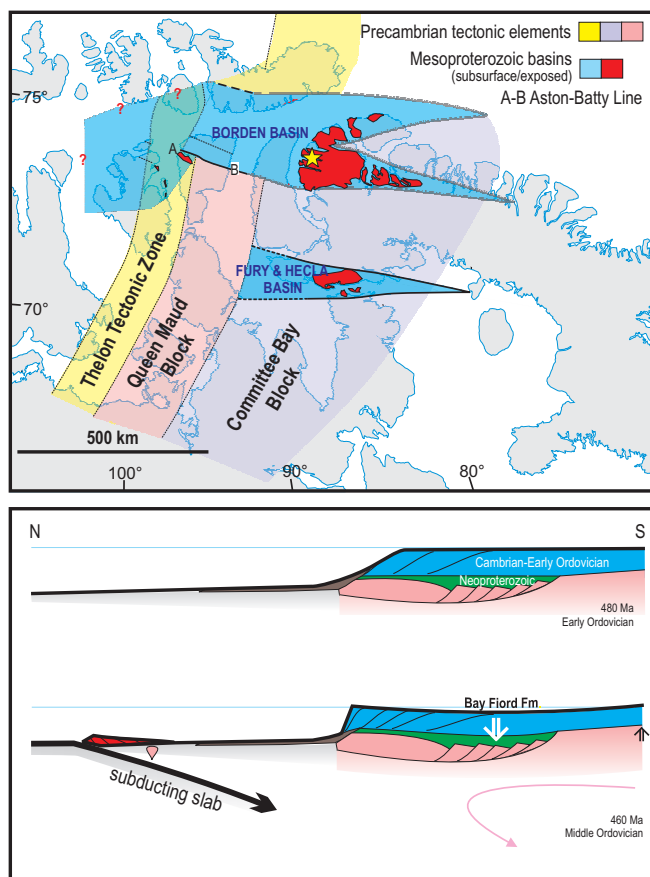


FIGURE 17. Top. Distribution of Precambrian tectono-stratigraphic elements and their inferred distribution below the Paleozoic cover (modified from Jackson, 2000). Outcrops of Proterozoic sedimentary basins in red. Location of Proterozoic sedimentary basins in blue. Nanisivik Mine shown by yellow star. Line A-B shows location of Aston Batty Line on northern Somerset Island. *Bottom.* Possible configuration of the northern margin of Laurentia in the Early and Middle Ordovician showing the postulated onset of subduction below Laurentia and the formation of an intraplatformal basin (Bay Fiord Formation) and a peripheral bulge.

area of the Aston-Batty Line to better define its location and look for additional alteration indicators.

- Mapping and prospecting in stratigraphy younger than the Middle Ordovician Thumb Mountain Formation. The Allen Bay-Cape Storm contact in the vicinity of faults on Somerset, Cornwallis, Grinnell, and Devon islands may be analogous with the Storm copper showing and should be revisited.
- The Devonian stratigraphy is complex and poorly understood. New data on the age of the base of each subbasin are desirable. Many of the Devonian-filled half grabens on Cornwallis, Grinnell, and Bathurst islands have never been mapped in detail or prospected.

Geochemistry

- Geochemical characterization of the alteration halo should be improved as a guide to exploration: 1) chemistry of dolomite associated with alteration versus regional burial dolomite; 2) barite distribution; 3) hyperspectral, PIMA and ASTER response of alteration products (barite, dolomite, clay); and 4) thermal alteration of organic matter across the district

- Organic matter studies to 1) characterize hydrocarbon generation around the Polaris deposit and perform mass balance calculations; and 2) continue mapping thermal maturity indicators to look for buried orebodies in areas of exploration interest.

Geophysics

- Higher resolution regional gravity and aeromagnetic surveys would better locate basement structures that partially control structures in overlying Paleozoic strata.
- Shallow seismic surveys of Pb-Zn prospects using a low-energy source may offer an alternate way to pinpoint drill targets.

Acknowledgements

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