DESCRIPTIVE NOTES

THE CORNWALLIS DISTRICT

Lower Paleozoic strata (Cambrian to Upper Ordovician) were deposited on a quiescent passive continental margin spanning the entire present-day Arctic archipelago (Trettin, 1991). Flat-lying carbonate-dominated strata south of Parry Channel overlie cratonic basement. Deformed strata north of Parry Channel, nearer the paleo-continental margin transition to deeper water, consist of lagoonal carbonate and evaporite units. In the Silurian, development of a rimmed, starved basin over part of the formerly platformal region resulted in deposition of the shale-dominated, predominantly deep-water Cape Phillips Formation.

Development of the basement-rooted Boothia Uplift began in the Late Silurian as a consequence of intraplate compressive stress originating within the Caledonian Orogen (northeast Greenland; Late Silurian to Early Devonian). The southern part of the uplift developed where flat-lying lower Paleozoic strata veneer cratonic rocks, and lacks the subaqueous evaporite rocks characteristic of the Ordovician farther north; it consists of a basement-rooted, west-vergent thrust system exposed on Prince of Wales and adjacent islands.

Little Cornwallis and Cornwallis islands are located on the northern part of the uplift, where Ordovician strata contain evaporite units. Here, the uplift is characterized by roughly north-trending broad synclines and narrower anticlinoria, which carry on their flanks multiple, blind or exposed, subtle, east- and west-vergent thrust faults of small displacement, and associated, roughly perpendicular tear faults. In this area, the Silurian Barlow Inlet Formation, which conformably to unconformably overlies the Cape Phillips Formation, records early development of Boothia Uplift folds: it was deposited both around the margins of the Boothia Uplift and in the broad synclinal valleys then developing over the top of the Boothia high. It predates peak shortening and the development of topographic differential in the Early Devonian.

Early and Middle Devonian erosion cut across the anticlines, forming an unconformity. Together with Devonian sedimentation, this gradually obliterated the regional topographic variation that resulted from Caledonian-aged folding and thrusting.

In the late Middle and Late Devonian, southward compression to the north of the former Boothia Uplift first shed fine terrigenous material southward onto the northern part of the uplift, then caused development of an evaporite-based fold-thrust belt (Harrison, 1995; Harrison and de Freitas, 1998) in areas east and west of the northernmost part of the uplift (Ellesmerian Orogeny; Late Devonian to Early Carboniferous; Bathurst, Melville, Devon, and Ellesmere islands). The Boothia Uplift formed a buttress, slightly oblique to the compressive stress, around which pronounced deformation progressed. Structures of the Boothia Uplift associated with this orogeny include: 1) complex north-trending strike-slip and thrust faults along the margins of the northern part of the Uplift, which might be reactivated Caledonian-aged structures; 2) subtle east-trending folds in Paleozoic strata over the northern Boothia Uplift; and 3) abundant brittle faults (normal and strike-slip) that formed as local adjustments under the transpressive regime.

After the end of the Ellesmerian orogeny, Carboniferous rifting north of the Boothia area heralded the development of the Sverdrup Basin. Extensional deformation might have affected the northern part of the Boothia Uplift as well, reactivating pre-existing structures as normal faults.

The north-trending area underlain by the Boothia Uplift (that part north of Boothia Peninsula) is characterized by numerous Zn-PbCu showings, and constitutes the Cornwallis Zinc District (Dewing and Turner, 2003); this extends from northern Somerset Island in the south to Grinnell Peninsula (Devon Island) in the north (~ 400 km), and spans eastern Bathurst and Cornwallis islands west-to-east (~ 125 km).

STRATIGRAPHY

Rock exposure in the Cornwallis Zinc-Lead District is generally poor, and the detailed lithostratigraphy and sedimentology of map units must be painstakingly assembled from disparate localities (e.g., Turner and Dewing, 2002); actual thicknesses are commonly difficult or impossible to ascertain, particularly for Devonian units. Most Ordovician and Silurian lithostratigraphic units do not exhibit significant lateral facies or thickness changes. Latest Silurian and Devonian units, however, are characterized by patchy original distribution, significant lateral facies variability, and, commonly, striking differences in thickness from one locality to another. In the case of lower and lower Middle Devonian formations, unit thickness is meaningless except at the local scale, because of marked lateral variability that resulted from Late Silurian to Early Devonian tectonism associated with development of the Boothia Uplift, and consequent division of the region into smaller depocentres with local facies variation. Thickness of upper Middle Devonian terrigenous units was in part a function of distance from the developing Ellesmerian Orogen. On Little Cornwallis Island, a Middle Devonian unit commonly recognised elsewhere in the area (Blue Fiord Formation) is absent, of negligible thickness, or indistinguishable from the other Devonian units (all are poorly exposed). Similarly, at Rookery Creek, both the Disappointment Bay and Blue Fiord formations are either absent or indistinguishable.

It is only by mapping sub-formation-scale stratigraphic units that the detailed disposition and deformation of rock units, and the geologic history of important areas in the Cornwallis District, can be deciphered. The subdivisions of the Bay Fiord, Thumb Mountain, and Cape Phillips formations used in this work are not part of the formal nomenclature for these units, but are critical to assembling an accurate understanding of structures in the area. On Little Cornwallis Island, recognition of important faults is critically dependent on the ability to identify graptolite biozones within the 655 m thick Cape Phillips Formation, a shale that underlies much of the island. Without the map patterns and stratigraphic relations at the sub-Devonian unconformity that are revealed by biostratigraphic subdivision of the shale, much of the structural complexity of the island would remain invisible.

LITTLE CORNWALLIS ISLAND GEOLOGY

Little Cornwallis Island is on the western flank of the northern part of the Boothia Uplift, with the central part of the uplift to its east (on Cornwallis Island) and the Ellesmerian Parry Islands Fold Belt to the west (on Bathurst Island). The island's geology is dominated by poorly exposed rocks of the Ordovician Bay Fiord, Thumb Mountain, and Cape Phillips formations, Silurian rocks of the Barlow Inlet Formation, and Devonian Disappointment Bay, Bird Fiord, and Hecla Bay formations. The island's eastern lobe lies on the western flank of a north-northwest-trending anticline, the eastern part of the western lobe is in a broad syncline, and the western part of the western lobe is on the eastern flank of an anticline. The most recent, publicly available map of Little Cornwallis and Cornwallis islands is an A-series map (Thorsteinsson,1986), which was based on much earlier field work. Little Cornwallis Island was remapped in 2002, in order to elucidate the area's relationship with the Boothia Uplift (to the east) and the Ellesmerian fold/thrust belt (to the west), within the context of defining regional structural controls on Cornwallis District Zn-Pb ± Cu mineralisation.

The eastern two-thirds of the island are characterized by three east-vergent thrusts, marked by the juxtaposition of disparate sub-formation-scale stratigraphic units and contrasting bedding dips (steep dips only near the leading edges of thrusts; generally shallow otherwise). The central of these three thrusts forms a band of higher topography, where resistant lime mudstone of the lower Thumb Mountain Formation was placed over recessive Irene Bay, Cape Phillips, and Disappointment Bay strata; the other two thrusts are not marked by significant topographic differential. The areas between thrusts contain numerous normal faults, generally parallel to the thrusts, some of which define narrow grabens.

The western one-third of the island contains flat-lying (eastern part) to steeply east-dipping (westernmost part) Ordovician strata and an extensive area of Devonian rocks that delineate a north-trending syncline. Steep dips at the western margin of the island are interpreted to result from proximity to a west-vergent thrust just offshore; this is supported by the presence of wrench faults extending to the east.

Thrusts are interpreted to be of Caledonian age (late Silurian – early Devonian). The Silurian Barlow Inlet Formation is conformably present atop the E member of the Cape Phillips Formation only on the western lobe of the island. It was likely absent from the eastern lobe of the island, which was structurally higher on the anticline flank. This formation was deposited during the early stage of Caledonian deformation, and records deposition in synclinal lows between incipient folds of the Boothia Uplift. On the eastern half of the island the stratigraphic position of the sub-Devonian unconformity cuts systematically down to the east, corresponding with positions higher on the anticline's flank. Near the anticline axis, the unconformity is low in the Thumb Mountain Formation, indicating the removal of approximately 1 km of strata. At a more local scale, the unconformity's position also varies systematically with distance from each of the thrusts on the anticline's flank, cutting lower towards the leading edge of each thrust. A Devonian alluvial conglomerate is present atop the sub-Devonian unconformity surface only east of the westernmost Caledonian-aged thrust. It lies on top of Barlow Inlet strata immediately east of the westernmost fault, but on progressively lower units moving east up the lower slope of the next thrust, which was a high area being eroded. The conglomerate unit is exposed on the easternmost part of the island, where it rests on lower Thumb Mountain rocks. Its presence there suggests that the distribution of surface-breaching faults and the local conglomerate-filled mini-basins they delimit extended well onto the Boothia Uplift high. The Early Devonian Disappointment Bay Formation overlies the conglomerate, or forms the lowest Devonian unit where the conglomerate is absent. In the syncline on the western lobe of the island, it overlies Cape Phillips E member or Barlow Inlet Formation, supporting the idea that the alluvial conglomerate unit was areally restricted to regions in front of each formerly topographically imposing thrust fault. Although the syncline would have formed a low area in the early Devonian, alluvial material was not abundantly supplied to this area, because the thrusts surrounding it have vergences away from the syncline. In areas near thrusts, the Disappointment Bay Formation lies directly on the unconformity, which cuts across the tilted strata on the thrust sheet. Deposition of Disappointment Bay and subsequent Early and Middle Devonian formations gradually erased the Caledonian paleotopography of the Boothia Uplift. Influx of Middle Devonian Hecla Bay Formation sandstone heralded the onset of the Ellesmerian Orogeny, to the north.

Normal faults may be the product of either local trans-tensional areas that developed during the Ellesmerian orogeny (late Devonian-early Carboniferous), or extension during the opening of the Sverdrup basin (early Carboniferous). The cause of north-trending folding in Devonian strata is uncertain.

ROOKERY CREEK AREA GEOLOGY

The Rookery Creek area (northwestern Cornwallis Island) contains gently west-dipping strata that lie on the western flank of a north-northwest-trending, Caledonian-aged, Boothia Uplift anticline ('Central Anticline'; Thorsteinsson, 1986), and contains an east-vergent Caledonian-aged thrust that carried upper Bay Fiord strata over lower Thumb Mountain rocks.

Barlow Inlet rocks are present in the western part of the map area ('Abbot River Syncline' of Thorsteinsson, 1986), where they unconformably overlie the D member of the Cape Phillips Formation. Although the Barlow Inlet has a conformable contact with Cape Phillips E member elsewhere (lower on the flank of the Boothia Uplift, on western Little Cornwallis Island), the higher structural position in the Rookery Creek area resulted in erosion or non-deposition of the E member. Unconformably overlying the Barlow Inlet Formation in the Abbot River Syncline and perhaps present as far east as the western border of the Rookery Creek half-graben is a lowermost Devonian conglomerate, interpreted to be alluvial material shed into synclinal lows from uplifted areas (anticlines and/or related thrust/reverse faults) during and after the main phase of uplift development. From west to east, the sub-Devonian unconformity cuts across a stratigraphic thickness of at least 1 km of west-dipping Ordovician-Silurian strata, and may sit as low as the lower Thumb Mountain Formation just west of the east-vergent thrust fault. Devonian strata of the Bird Fiord Formation are the oldest Devonian rocks overlying the unconformity in the central part of the map area

Early Ellesmerian tectonism supplied terrigenous material of the Hecla Bay Formation (unknown thickness) to the area. These rocks are preserved only in the Rookery Creek half-graben. The half-graben contains east-dipping strata in an area defined by a western fault that acted as a fulcrum, and has only minimal (several tens of metres) of west-down displacement, and an eastern, west-down normal fault that places Middle Devonian Hecla Bay rocks beside Middle Ordovician Bay Fiord Formation rocks. Although this fault appears to have a vertical displacement of over 1 km, the low position of the unconformity in that area indicates a less striking throw on the order of 150 m (depending on the thickness of the Hecla Bay Formation). Formation of the half-graben post-dated deposition of the Hecla Bay Formation, and most likely represents a local area of extension in the complicated transpressive regime of the Ellesmerian orogeny.

Zn-Pb MINERALISATION ON LITTLE CORNWALLIS ISLAND

WESTERN LITTLE CORNWALLIS ISLAND

The Polaris Mine was located on westernmost Little Cornwallis Island, near the leading edge of a Caledonian-aged thrust, and between two of the thrust sheet's tear faults. Mineralisation has been dated at 366 ± 15 Ma (Rb-Sr; Christensen et al., 1995), coincident with Ellesmerian compression. Low-angle, oblique orogenic compression into the staggered segments of the thrust fault might have dilationally opened the offsetting tear faults and related smaller structures, providing conduits for orogenically-driven metalliferous fluids.

EASTERN LITTLE CORNWALLIS ISLAND

On eastern Little Cornwallis Island, MVT mineralisation is concentrated near the intersection of a north-trending graben-bounding normal fault and a northeast-trending cross fault (possibly a tear fault on the thrust sheet near the leading edge of which the normal fault is located). The graben-bounding fault misleadingly appears to exhibit many hundreds of metres of vertical displacement, because basal Devonian conglomerate is at surface next to lower Thumb Mountain strata; at this location, however, the sub-Devonian unconformity is low in the upper Thumb Mountain Formation. Throw on the normal fault was, therefore, most likely on the order of <200 m, and possibly as little as several tens of metres.

Sulphides are scattered at locations along the length of the graben-margin fault, but are particularly concentrated near its intersection with the north-northeast-trending cross fault. Here, Zn-Pb mineralisation is present in upper Thumb Mountain rocks very close to the sub-Devonian unconformity, in the area south of the cross fault. The uncertain age of the graben-forming fault that controls sulphide distribution means that the mineralizing event might have been significantly younger than that on western Little Cornwallis Island.

Zn-Pb MINERALISATION AT ROOKERY CREEK

Most of the known zinc mineralisation at Rookery Creek is located where one of the graben-margin faults is intersected by east-northeast-trending cross faults that moderated downdropping and offset stratigraphic units within the half-graben (Turner and Dewing, 2002). Mineralisation is therefore constrained to be younger than Hecla Bay age (i.e., Late Devonian or younger). Host rocks are the upper Thumb Mountain Formation, lower Thumb Mountain Formation, Bay Fiord Formation, and Devonian conglomerate. Mineralised areas are generally (but not always) marked by rusty weathering and dolomitization of the host rock. Sphalerite and minor galena fill voids caused by brecciation of the host rock and by the dissolution of macrofossils. There is little or no replacement of carbonate host rocks by sulphides. Barite is locally present at the central showings. Preliminary geochemical results indicate that the sphalerite precipitated from a saline fluid between 80–90 °C, with a $\delta^{34}S$ composition of + 5 ‰.

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