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Intersecting fold belts in the Bathurst Island region, Nunavut

Christopher Harrison

Geological Survey of Canada, 601 Booth St., Ottawa, ON, K1A 0E8, Canada

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ABSTRACT

The Bathurst Island archipelago in the central part of the Canadian Arctic Islands, includes Bathurst Island proper and six other significant islands to north and west. This is the site of two intersecting fold belts: the northerly-trending Cornwallis Fold Belt and the westerly-trending Parry Islands Fold Belt

Significant components of the report area include Precambrian seismic basement, the Franklinian shelf (Cambrian to Devonian), a Middle and Upper Devonian clastic wedge, and outliers of the Sverdrup Basin (Carboniferous-Cretaceous). Total thickness of the Cambrian to Devonian succession is 7.6–8.8 km in the island group. Oldest identified strata are evaporites of the Middle Ordovician Bay Fiord Formation. These form a ductile decollement zone that at a depth of 4100–5500 m everywhere underlies thrust-folds. Above this are shelf carbonates, deep water mudrocks, and shallow to deep water strata associated with tectonic activity through the upper Silurian to Lower Devonian Cornwallis Fold Belt. The end of uplift-related deposition is marked by a transition to basin fill mudrocks, succeeded in the later Devonian by shelf-deltaic and fluvial sandstones and other clastic rocks.

Structures of Cornwallis Fold Belt feature north and in part west-striking thrust panels and evidence of unroofing in early Ludlow to mid-Emsian time. Also included are westerly-transported thrusts kinematically linked to easterly- striking wrench faults that are presumably reactivated as thrusts and forming large interference structures during development of Parry Islands Fold Belt deformation in the Late Devonian to early Carboniferous. Parry Islands Fold Belt features upright surface folds, subsurface thrusts, ductile deformation and detachment in Ordovician salt and Devonian shale. Structures include northerly- and southerly-transported thrusts, zig-zag structures, pop-up and pop-down structures.

1. Introduction

Bathurst and adjacent smaller islands are part of the Parry Islands. These are situated in the west central part of the Canadian Arctic Islands bound to the east by Grinnell Peninsula of Devon Island and Cornwallis Island, and by Melville Island to the west (Fig. 1). This island group includes Bathurst Island proper (16,042 sq. km), Helena Island in the north, Alexander, Massey, Vanier and Cameron Islands to the northwest and Byam Martin Island farther west.

Dominant geological features, evident on satellite imagery (Fig. 2), include the easterly trending Parry Islands Fold Belt and its intersection with the northerly trending Cornwallis Fold Belt. Based on reports and interpreted seismic profiles of adjacent Melville Island, the Parry Islands Fold Belt is expressed in Ordovician evaporites, Ordovician shelf carbonates, Ordovician to Devonian deep water mudrocks and Middle to Upper Devonian sandstones, siltstones and shales (Tozer and Thorsteinsson, 1964; Kerr, 1974; de Freitas et al., 1993). Westward facies changes in the Middle Devonian from sandstone to shale has had some influence on structural character of the Parry Islands folds (Stage 2 deformation) and these features are documented in the present paper. The end of Parry Islands Fold Belt deformation is marked by an angular unconformity below Carboniferous strata (Tozer and Thorsteinsson, 1964). Outliers of Carboniferous strata feature ENE-striking normal faults that have extensionally reactivated Parry Islands reverse faults (Stage 3 deformation) (Harrison et al., 1993). Other faults have offset Cretaceous strata (Harrison and de Freitas, 1998) and indicate a phase of faulting potentially related to the Paleogene Eurekan Orogeny (Stage 4 deformation). Of more direct interest are patterns of structural style and sedimentation that are observed within and approaching the basement-involved Boothia Uplift and its detached and mobile cover, the Cornwallis Fold Belt (Stage 1 deformation). The depositional record of uplift produced by emplacement of northerly-striking thrust anticlines is recorded in shallow water to nonmarine facies belts of eastern Bathurst Island and a belt of deep water strata preserved through central Bathurst Island (Harrison and de Freitas, 1998; de Freitas et al., 1993). The eastern belt includes primarily shallow marine carbonates (Lochkovian), nonmarine strata (Pragian) and overlying shallow water carbonates (Emsian). These grade westward to submarine fan deposits,

E-mail address: christopher.harrison@canada.ca.

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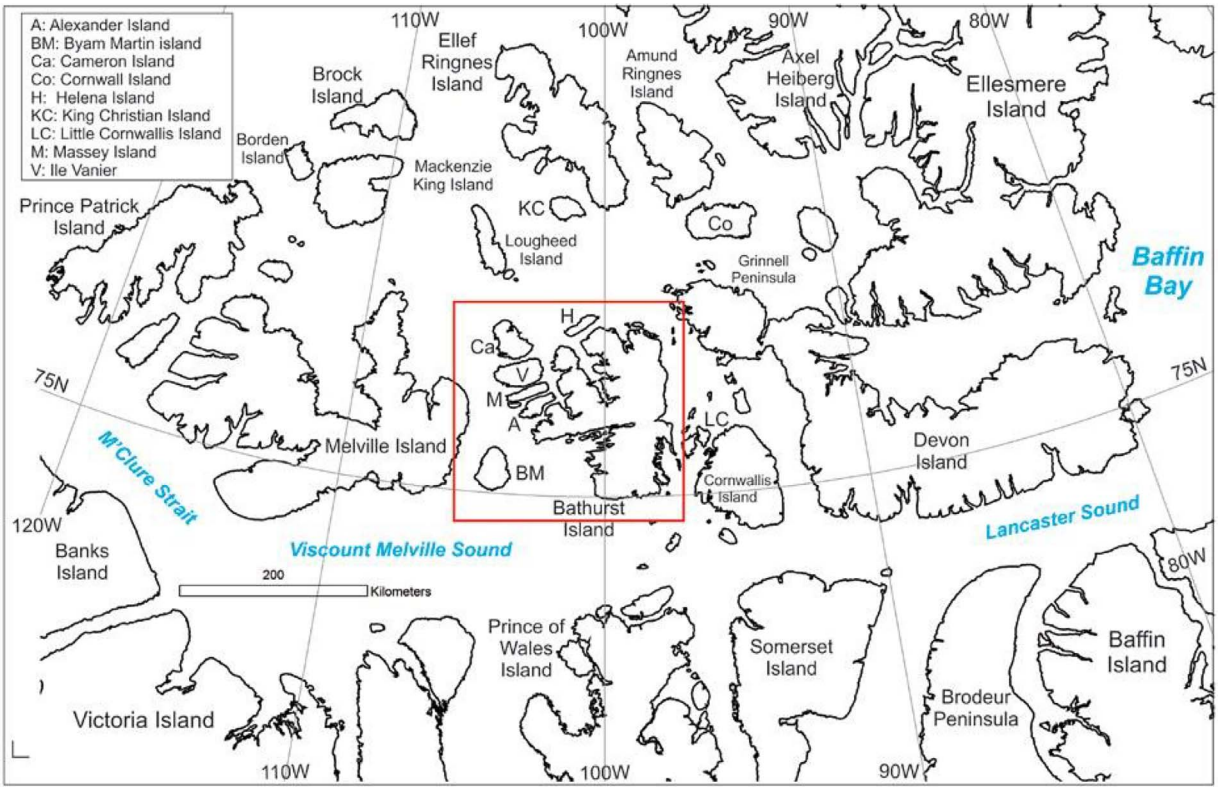

Fig. 1. Location map and place names of the central Arctic Islands.

including olistostromes (Ludlow to Emsian) .The end of uplift is marked by the progradation of upper Emsian to lower Eifelian limestone beds westward over clinoformed mudrocks. Collectively these strata document the history of uplift on Boothia Uplift including angular unconformities at four stratigraphic levels that mark the diachronous end of thrust-folding in Cornwallis Fold Belt (Harrison and de Freitas, 1998). These features are exposed on the limbs and in the hinge of twelve dissected Parry Islands anticlines over a north-south distance of 175 km.

Especially useful for documenting the structural style of the Cornwallis and Parry Islands fold belts on Bathurst Island are structural cross-sections and interpreted seismic profiles. The seismic profiles derive from acquisition in the 1970s by Panarctic Oils Limited. These provide insight into the top six seconds (two way travel time) of regional stratigraphy and structure, and reveal structural styles associated with salt-based folding, and the linkage of folding to syntectonic sedimentation. These profiles are now owned by Suncor Energy Inc. which is thanked for allowing publication of these data.

In the Parry Islands Fold Belt there is a complete absence of diapirs in the west and only four small ones on Bathurst Island. However, evidence for salt is confirmed in the Sabine Bay A-07 well of Melville Island which penetrates the decollement lower Bay Fiord Formation and features three lithologies in roughly equal proportions: salt, dolostone and anhydrite (Harrison, 1995). The implication is that the mix of competent and ductile elements in the lower Bay Fiord Formation has limited the ability to produce classic salt diapirs.

2. History of geological study

The existence of the Parry Islands Fold Belt was first outlined by Fortier and Thorsteinsson (1953). Interference structures with Cornwallis Fold Belt on eastern Bathurst Island were described by McNair (1961). Permian and younger strata of southern Sverdrup Basin were located on Cameron Island by Tozer (1963) and Greiner (1963), and the first exploratory drill hole was completed in 1964 (Dominion Explorers Group, 1964). In total there have been 176 wells drilled in the Canadian Arctic Islands through to 1987 including four on Bathurst Island, three on Ile Vanier and 14 on Cameron Island.

The first systematic description of the geology of Bathurst Island and the first comprehensive geology map were provided by Kerr (1974). Contributing to our understanding of the region are studies that include Embry and Klovan (1976) for the regional analysis of the Middle and Upper Devonian clastic wedge, Mayr (1980) for the analysis of selected exploratory wells of Bathurst, Cameron and Vanier islands, Thorsteinsson and Mayr (1987) for the geology of eastern Devon Island, Mayr et al. (1998a) for Grinnell Peninsula of northwestern Devon Island, and Harrison (1995) for the structure of Melville Island. Preliminary contributions to the present study of Bathurst Island are given in de Freitas et al. (1993), Harrison et al. (1993), and Harrison and de Freitas (1996). Harrison and de Freitas (1998) provide new preliminary geology maps. Resource potential is described by Anglin and Harrison (1999). In addition to capitalizing on the latest bedrock geology maps, the present study also features interpreted seismic profiles Conversion to depth has been facilitated by sonic logs of selected wells of the Bathurst Island region.

3. Regional geology

3.1. Summary of geological features

3.1.1. Precambrian basement rocks

The oldest rocks of the Canadian Arctic Islands are those of the Archean Rae craton exposed on Baffin Island and potentially extending onto eastern Devon Island (Fig. 3). Archean rocks are also reported on eastern Victoria Island which are likely continuous with the Archean Slave craton of the northwestern mainland (Campbell, 1981; Rainbird and LeCheminant, 2002). These are all considered part of the Canadian shield as are high grade Paleoproterozoic plutonic and supracrustal rocks of eastern Devon island and southeastern Ellesmere Island (Frisch, 1988). Younger Proterozoic strata are generally unmetamorphosed