Large-Scale Stratigraphic Architecture of a Deep-Water Slope Conduit, Nanaimo Group, Hornby Island, Canada*

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Abstract

Large conduits on continental margins provide large-scale pathways for sediment transfer to the deep-sea. In the rock record, the conduits comprise a network of channel bodies with axes represented by deep scour surfaces and amalgamated coarse-grained deposits. The margins of the conduits are often characterized by preservation of a variety of deposits that help reconstruct the history of protracted erosion, sediment transfer, and ultimately, deposition. In this study, the presence of a large-scale composite sedimentary body, attributed to submarine canyon or slope valley processes, is established in the Nanaimo Group on Hornby Island, southwestern British Columbia (Figure 1A). Hornby Island is located in the Strait of Georgia between Vancouver Island and mainland British Columbia, between the towns of Comox and Nanaimo. The Late Cretaceous Nanaimo Group is a >4 km thick siliciclastic succession thought to have accumulated in a deep-water foreland basin setting (Mustard, 1994). The recognition of a large-scale slope conduit deposit provides new insight into paleogeographic interpretations.

Hypothesis and Methods

The central portion of Hornby Island constitutes a 300 m high mountain composed of resistant conglomerate, with generally less resistant, interbedded sandstone, siltstone and shale present along its margins. This is apparent on the geological map from Katnick (2000), who established: (1) the deep-water character of the units, and (2) the stratigraphic continuity of the units across the island (Figure 1C, D). From this map, a first order appreciation of the slope conduit is ascertained. Katnick (2000) showed paleoflow was generally towards the southwest, with the strata shallowly dipping to the northeast. Using 3D visualization software (i.e., Google Earth and ArcGIS), it is possible to consider a depositional strike-oriented cross section and deduce the architecture and scale of the composite, coarse-grained sedimentary stratal body that defines the physiography of the island (Figure 2A). From this overview perspective, augmented with the geological map of Katnick (2000), we hypothesized that the core of the island largely represents submarine canyon or slope valley axis deposits, and the intertidal zones on the northwest and southeast side of the island constitute conduit margin facies. To test this hypothesis, fieldwork was undertaken in the summer of 2013.

Field Observations

The base of the stratigraphy is situated in the southwestern portion of the island and includes mudstone and siltstone characterized by chaotic bedding and numerous clastic injection deposits. These deposits are considered to record mass transport processes (cf. Nardin et al., 1979). The top of these deposits is marked by a high relief, undulatory surface that is overlain by a thick succession of coarse-grained strata that was deposited at the base of the hypothesized large-scale conduit (Figure 2). This basal conglomerate-dominated strata defines a channel form body that is at least 2000 m wide and 125 m thick (Figure 2A-1). A second resistant conglomeratic, large-scale channel form body defines the upper portion of the interpreted, composite conduit fill. This sedimentary unit defines a secondary escarpment on the island that is approximately 5,000 m wide and 150 m high (Figure 2A-2, D, F). The conglomeratic fill is typical of conduit axes deposits (Figure 2D, F). At the edges of the large-scale channel forms, coincident with the intertidal zones on the southeast and northwest sides of the island, are deposits consistent with conduit margin processes (Figure 2C). Thinly interbedded sandstone and siltstone, comprising Bouma sequences, represent deposition in levee or inner levee areas (cf., Deptuck et al., 2003). Chaotically bedded sandstone and siltstone are also present, including blocks of displaced strata with bedding oriented oblique to the regional strike and dip of beds in the area (Figure 2E). These strata represent mass wasting along the steep walls of the paleo-conduit.

Summary and Potential Paleogeographic Implications

In many deep-water foreland basins, the largest, and longest-lived conduits form along basin axes (ie. the foredeep), fed from numerous tributaries along the orogenic front. Ancient examples of this deep-water drainage configuration have been documented in the Cretaceous Magallanes foreland basin of southern Chile (Hubbard et al., 2008; Jobe et al. 2010) and the Oligo-Miocene Molasse foreland basin of Upper Austria (Hubbard et al., 2009; Bernhardt et al., 2012) (Figure 1E). Previous paleogeographic reconstructions drawn from the turbiditic Nanaimo Group of the northern Gulf Islands suggest paleoflow perpendicular to the ancient orogenic front. However, the scale and presumed longevity of the submarine conduit mapped on Hornby Island may suggest that paleoflow was oriented normal to that previously proposed, parallel to the interpreted fold and thrust belt. Future work will focus on further documentation of the sedimentology and stratigraphy of the Nanaimo Group in the northern Gulf Islands, which will be used to refine paleogeographic interpretations.

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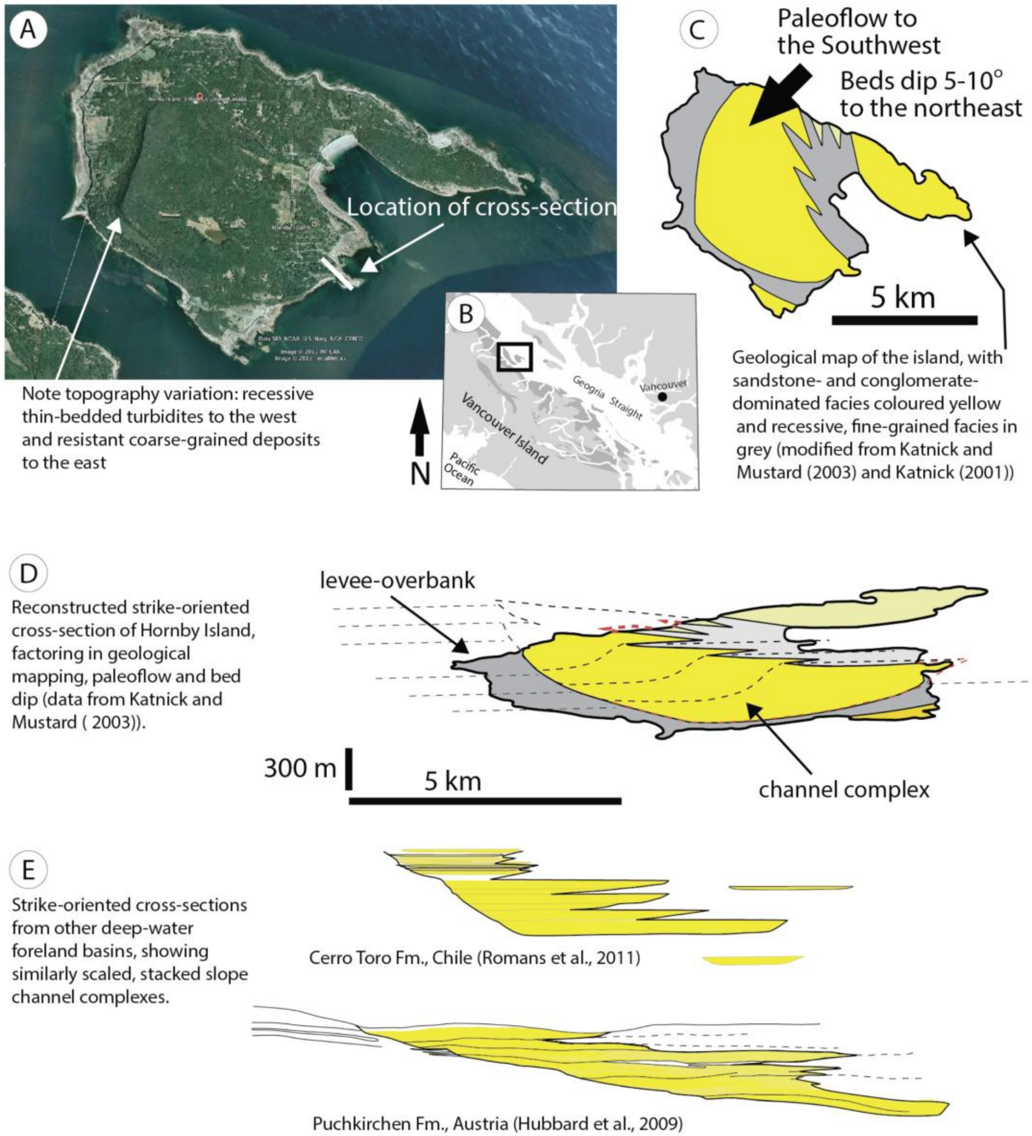

Figure 1. Study area and hypothesis. (A) Satellite image of Hornby Island from Google Earth. (B) Study area map with black rectangle highlighting the location of Hornby Island. (e) Geological map of Hornby Island, showing the distribution of coarse-grained versus fine-grained facies. (D) Interpreted strike-oriented cross-section of the turbidite system on Hornby Island based on data presented by Katnick and Mustard (2003) and Katnick (2001). (E) Strike-oriented cross-sections of deep-water foreland basin strata from other parts of the world for reference, highlighting the similarity in scale and stratal architecture with deposits in the Nanaimo Group.

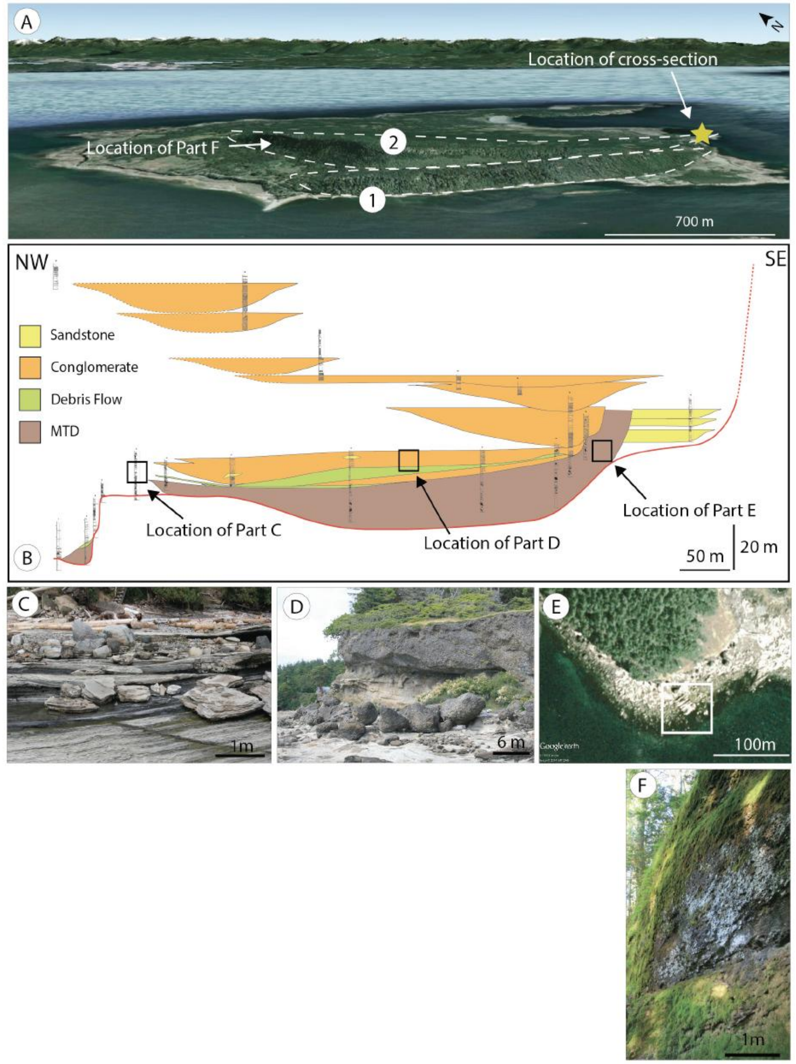

Figure 2. Sedimentological and architectural characteristics of the Nanaimo Group. (A) Satellite image highlighting two distinct generations of conglomerate deposition within the conduit. Paleoflow is directed out of the page towards the southwest. (B) Stratigraphic cross-section of the southeastern tip of Hornby Island denoted by the white line in part 1A, and the yellow star in part 2A. The red line represents the base of the composite channel succession. Fine-grained out-of-channel, recessive mudstones are dominant below and towards the SE (right side of cross section) of the basal erosional surface. (C) Photo of thin- to thick-bedded siltstone and mudstone at the margin of the submarine conduit deposit. (D) Photo of thick-bedded conglomerate, representing the edge of the axis. (E) Satellite image of a large slump block. This block, which is outlined by the white rectangle, is approximately 600 m^2. (F) Photo of a conglomerate bench indicated by the white arrow in part 2A.