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Sedimentology of an early Cambrian tide-dominated embayment: Quyuk formation, Victoria Island, Arctic Canada

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ABSTRACT

The early Cambrian (series 2, stage 4) Quyuk formation is exposed in the Minto Inlier of western Victoria Island, Canadian Arctic Islands, and forms the base of the Phanerozoic succession. Coeval with other sandstones of this age in Laurentia, it was deposited in a shallow-marine embayment on a passive margin during the initial phase of the early Paleozoic transgression. Four facies associations are recognized: (1) offshore muds consisting dominantly of dark gray laminated mudstone with discontinuous laminae of medium- to coarse sand; (2) offshore sand dune fields characterized by laterally continuous, planar cross-stratified beds up to 1.4 m thick of medium- to coarse-grained sandstone; (3) distal nearshore consisting dominantly of fine- to medium-grained bioturbated sandstone and fine- to medium-grained sandstone interbedded with laminated mudstone; and (4) proximal nearshore characterized by laterally continuous fine- to medium-grained bioturbated sandstone and medium-grained oolitic ironstone. Large scale dunes of facies association 2 record areas where tidal currents were amplified and had available sediment supply in contrast to facies association 1, which was sediment starved. Dunes are, for the most part, non-bioturbated or contain just a few individual burrows belonging to *Skolithos*. In nearshore settings, bioturbation in the form of a typical early Cambrian suite of shallow-subtidal ichnofossils predominated, representing a low-diversity *Cruziana* ichnofacies. Oolitic ironstone horizons in the proximal nearshore mark periods of low sedimentation rates when iron became concentrated and calcite was the primary cementing agent. The coastline is envisaged as a complex of bays and lagoons.

1. Introduction

Early Cambrian shallow-marine settings on the continental shelves of a number of cratons are unique transgressive environments that led to the deposition of vast amounts of compositionally mature sand, in comparison to younger rocks of a similar setting (Dalrymple et al., 1985; Cant and Hein, 1986; Simpson and Eriksson, 1990; MacNaughton et al., 1997; Desjardins et al., 2010a, 2012a,b). Thermal subsidence of the passive margin along these continental margins associated with the protracted breakup of the supercontinent Rodinia during the late Neoproterozoic led to a global rise in sea level and created the necessary accommodation space (e.g., Bond et al., 1984; Levy and Christie-Blick, 1991). The absence of land plants before the Silurian promoted the development of extensive subaerial dune fields and braided fluvial systems on land (Cotter, 1978; MacNaughton et al., 1997; Rainbird et al., 1997; Long and Yip, 2009). Large amounts of siliciclastic sediment stored on the land surface of the continental interiors were carried to the continental shelf by fluvial systems and by the flooding and ravinement of pre-existing sandy coastal deposits during the transgression, establishing these shallow seas as the sandiest of the Phanerozoic. Prolonged eolian action on the barren craton limited the amount of fine-grained sediment supplied to the shelf system (Dalrymple et al., 1985). The facies present evidence for a combination of variably strong tidal action and subordinate storm processes (Desjardins et al., 2012a,b).

Continental shelves with significant tidal currents usually occur on wide passive continental margins because tidal action typically increases as shelf width becomes greater. These shelves are commonly straight and the shoreline is essentially parallel to the shelf break for several hundred kilometers. Structural complexities in continental margins create large-scale embayments, where the distance from the shoreline to the shelf margin may increase significantly and the flow is partially confined (Reynaud and Dalrymple, 2012). In rare instances, tidal signal can be preserved in coastal embayments (e.g., Dixon et al., 1995; Yoshida et al., 2004) where the bay's depth and length increase tidal resonance and amplify the tidal wave (Pugh, 1987; Darlymple et al., 1990; Sztanó and de Boer, 1995). In general, open-mouthed embayments accentuate the tide because the cross-sectional area through which the tidal wave passes becomes smaller in a landward direction (see Reynaud and Dalrymple, 2012). As a result, tidal range and current

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speeds are commonly higher in embayments than on straight shelves (e.g., Reynaud et al., 2003).

Here, we present a detailed study of the sedimentology of the Quyuk formation exposed around the head of Minto Inlet in the western part of Victoria Island in the western Canadian Arctic (Fig. 1). The nature of the Cambrian transgression in Arctic Laurentia is not well known, in part because of the lack of exposure and also because the most outboard deposits are more or less absent (Dewing and Nowlan, 2012). Documenting the previously undescribed Quyuk formation adds to our understanding of the Cambrian style of tidal-shelf to shoreline sedimentation and helps write a missing chapter in the Cambrian stratigraphy of the Canadian Arctic Islands.

2. Regional geologic setting

The Rodinia supercontinent broke up during the late Neoproterozoic and the core of present-day Laurentia includes Greenland but excludes terranes that may have existed offshore along eastern and western North America. By Cambrian time northern Laurentia was bordered by passive margins on its present-day north, east, and west (e.g., Hadlari et al., 2012).

A suite of mafic intrusions were emplaced along the length of the North American Cordillera at ca. 780 Ma (Harlan et al., 2003). Rifting probably began when ca. 720 Ma intrusion of Franklin dikes and flood basalts of the Natkusiak Formation along the Franklinian margin of the Canadian Arctic Islands (Heaman et al., 1992; Rainbird et al., 1998), broadly coeval with extrusion of volcanics in the Mackenzie Mountains (Macdonald et al., 2011). However, sedimentary rocks recording the early phase of passive margin development, correlative with the Windermere Supergroup of the western margin of Laurentia (Ross, 1991), are exposed only sporadically in the Franklinian basin (Trettin, 1991; Harrison, 1995; Dewing et al., 2004).

Lower Cambrian strata are common around the margin of Laurentia. In the Arctic Islands, the Ellesmere Group was deposited in an open-marine shelf with progradation of the prodeltaic front towards the shelf-edge and deepwater basin (Dewing et al., 2008). Similarly, the Lower Cambrian Gog Group in the southern Rocky Mountains represents deposits of a passive margin in shallow subtidal, inner-shelf, and

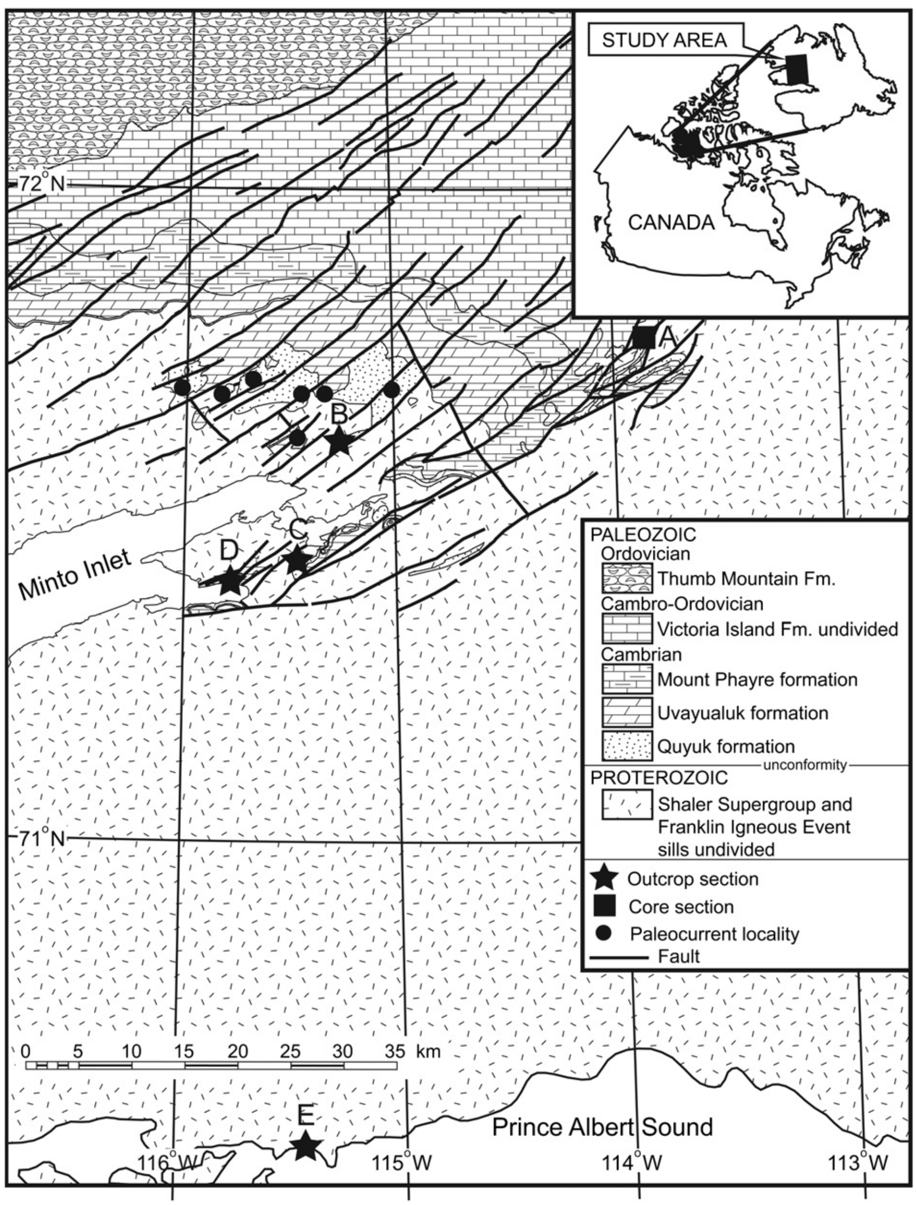

Fig. 1. Geology of the Minto Inlier.
Modified from Dewing et al. (2013).