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Research paper

Mesozoic rift to post-rift tectonostratigraphy of the Sverdrup Basin, Canadian Arctic

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ABSTRACT

Jurassic-Cretaceous rift successions and basin geometries of the Sverdrup Basin are reconstructed from a review and integration of stratigraphy, igneous records, outcrop maps, and subsurface data. The rift onset unconformity is in the Lower Jurassic portion of the Heiberg Group (approximately 200–190 Ma). Facies transgress from early syn-rift sandstones of the King Christian Formation to marine mudstones of the Jameson Bay Formation. The syn-rift succession of marine mudstones in the basin centre, Jameson Bay to Deer Bay formations, ranges from Early Jurassic (Pleinsbachian) to Early Cretaceous (Valanginian). Early post-rift deposits of the lower Isachsen Formation are truncated by the sub-Hauterivian unconformity, which is interpreted as a break up unconformity at approximately 135–130 Ma. Cessation of rift subsidence allowed for late post-rift sandstone deposits of the Isachsen Formation to be distributed across the entire basin. Marine deposition to form mudstone of the Christopher Formation throughout the Canadian Arctic Islands and outside of the rift basin records establishment of a broad marine shelf during post-rift thermal subsidence at the start of a passive margin stage. The onset of the High Arctic Large Igneous Province at approximately 130 Ma appears to coincide with the breakup unconformity, and it is quite typical that magma-poor rifted margins have mainly post-rift igneous rocks. We extend the magma-poor characterization where rifting is driven by lithospheric extension, to speculatively consider that the records from Sverdrup Basin are consistent with tectonic models of retro-arc extension and intra-continental rifting that have previously been proposed for the Amerasia Basin under the Arctic Ocean.

1. Introduction

The Sverdrup Basin of the Canadian Arctic Islands (Fig. 1) originated during Carboniferous rifting and is host to strata as young as Paleogene (Balkwill, 1978). Even though it is well established that the Sverdrup Basin contains a record of Mesozoic rifting that led to formation of Amerasia Basin and the Arctic Ocean (e.g., Embry, 1991), the overall tectonic geometry of the basin could be further developed, and there is uncertainty in the literature regarding key basin tectonic events. For example, an in-depth analysis of stratigraphy and tectonics places the breakup unconformity at the Albian-Cenomanian boundary (Embry and Dixon, 1990; Embry, 1991), whereas more recent speculation is that it lies near the Valanginian-Hauterivian boundary (Embry and Beauchamp, 2008; Embry, 2011). The intent here is to show stratigraphic cross-sections and review published data from the Sverdrup Basin that allow for interpretation of basin geometries within a tectonostratigraphic framework.

1.1. Rift basin tectonostratigraphy

Stratigraphic successions typical of rift basins are well understood, a summary based largely on Prosser (1993) and Williams (1993) is as follows. Pre-rift deposits are typically separated from early syn-rift deposits by a rift-onset unconformity (Falvey, 1974). Early syn-rift deposits are coarse-grained and typically alluvial. Accommodation space is generated by extensional faulting and as accommodation increases the early syn-rift stratigraphic succession is transgressive, or retrogradational. Maximum

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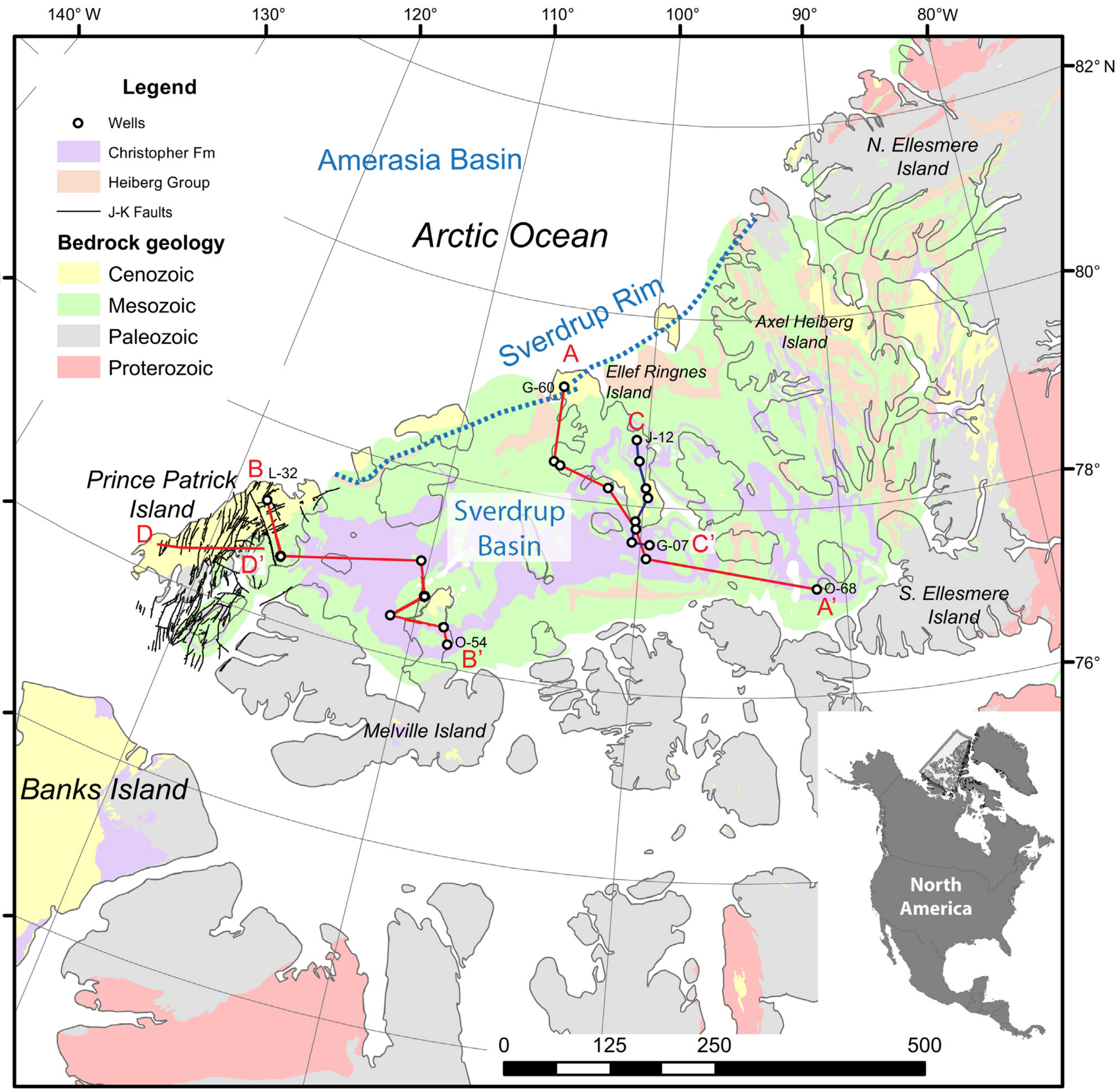

Fig. 1. Geology of the study area showing location of sample sites, cross-sections (Figs. 4–6), and seismic section (Fig. 8). Surface and sea bottom bedrock geology is from Okulitch (1991). The Sverdrup Rim was first described by Meneley et al. (1975). Jurassic-Cretaceous faults on Prince Patrick Island are from Harrison and Brent (2005).

accommodation at the rift climax is demarcated by the furthest extent of backstepping facies, either maximum trangression or retrogradation (e.g., Hadlari and Rainbird, 2006), and may be protracted. Extension rates decrease after the rift climax, and as accommodation decreases it is exceeded by sediment flux thereby allowing facies to prograde into and fill the basin during the early post-rift phase. Early post-rift deposits are truncated by the breakup unconformity (Falvey, 1974). During the late post-rift phase extensional faulting is localized elsewhere, probably at the developing continental margin, the rift basin starts to subside slowly along with the surrounding crust due to thermal subsidence, and so deposition onlaps basin margins and encroaches upon regions outside of the rift basin. Where rifting proceeds to development of a passive margin, the late post-rift deposits are transgressive and facies typically indicate establishment of a broad marine shelf. Proximity to the continent-ocean transition will determine whether the shelf setting is maintained or rift basins are ultimately overlain by continental slope deposits (e.g., Franke, 2013).

2. Geological framework of Sverdrup Basin

The Sverdrup Basin underlies most of the northern Canadian Arctic Islands and extends from Ellesmere Island in the northeast, to Prince Patrick Island in the southwest (Fig. 1). The first rifting event in the Sverdrup Basin was Carboniferous to Early Permian, and ended by the mid-Permian (Embry and Beauchamp, 2008). It is considered to have been an extensional basin from the mid-Jurassic to mid-Cretaceous (Embry and Beauchamp, 2008) that was separated from the developing Amerasia Basin, presently offshore, by a