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Sequence and tectonostratigraphy of the Neoproterozoic (Tonian-Cryogenian) Amundsen Basin prior to supercontinent (Rodinia) breakup

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ABSTRACT

Intracontinental basins that lack obvious compartmentalization and extensional faults may lie inboard of, and have the same timing as, rifted continental margins. Neoproterozoic successions of northwest Laurentia are an example where rift and intracontinental basins are spatially and temporally related. This study describes Tonian-Cryogenian pre-rift strata of the upper Shaler Supergroup, deposited in the Amundsen Basin (Victoria Island, Canada), in which five transgressive-regressive (T-R) cycles are identified. The pre-breakup succession in the Amundsen Basin has stratigraphic architecture that differs from adjacent, fault-bound rift basins. There is little evidence for extensive progradation, which resulted in broad, layer-cake stratigraphy where shallow-water facies predominate, deposited on a storm-dominated ramp. Correlation between the Amundsen and Fifteenmile (Yukon) basins is complicated by differing rates and regimes of subsidence, with the exception of a basin-deepening event that occurred in both basins and correlates with the global Bitter Springs isotope stage, initiating sometime after ~811 Ma. Contrary to previous correlations, we propose that the upper Shaler Supergroup and Little Dal Group of the Mackenzie Mountains Supergroup (Mackenzie Basin) are equivalent to the entire Fifteenmile Group. The identification of cycles and subsidence patterns in the Amundsen Basin prior to Rodinia break-up has implications for understanding the stratigraphic architecture of other intracontinental sag basins. We recognize three tectonostratigraphic units for the upper Shaler Supergroup that record an initial sag basin, followed by early extension and thermal doming, and finally rifting of the Amundsen Basin. Subsidence possibly was related to multiple cycles of intra-plate extension that complemented coeval fault-controlled subsidence. Analysis of pre-rift strata in the Amundsen Basin supports multi-phase, non-correlative break-up of Rodinia along the northwest margin of Laurentia.

1. Introduction

The Neoproterozoic was a dynamic era in Earth history, during which major changes in the isotopic composition of seawater (e.g. Halverson et al., 2007), the evolution of early animals (e.g. Morris, 1993), low latitude glaciations (e.g. Kirschivink, 1992), and the formation and breakup of the supercontinent Rodinia occurred (e.g. Hoffman, 1991). Recognition of a late Mesoproterozoic supercontinent evolved from the correlation of sedimentary successions between northwestern Canada and Australia (Eisbacher, 1985; Bell and Jefferson, 1987); and reconfiguration of remnant Grenville terranes (1200–960 Ma) preserved on several continents (Moores, 1991; Gower and Krogh, 2002; Davidson, 2008). In most reconstructions of Rodinia, Laurentia is interpreted to have formed the core of the supercontinent (e.g. Hoffman, 1991; Li et al., 2008). The Amundsen and Mackenzie basins are considered to have been embayments of an epeiric sea that covered northwestern Laurentia during the time between amalgamation and break-up of Rodinia (Fig. 1; Young, 1981; Rainbird et al., 1996). There remains debate about the paleogeographic fit of the continental blocks that surrounded Laurentia, with numerous different models proposed (e.g., Hoffman, 1991; Brookfield, 1993; Borg and DePaulo, 1994; Dalziel, 1997; Burrett and Berry, 2000; Wingate and Giddings, 2000; Li et al., 2008; Evans, 2009; Li and Evans, 2011). Questions also remain about the nature and timing of the break-up of Rodinia,

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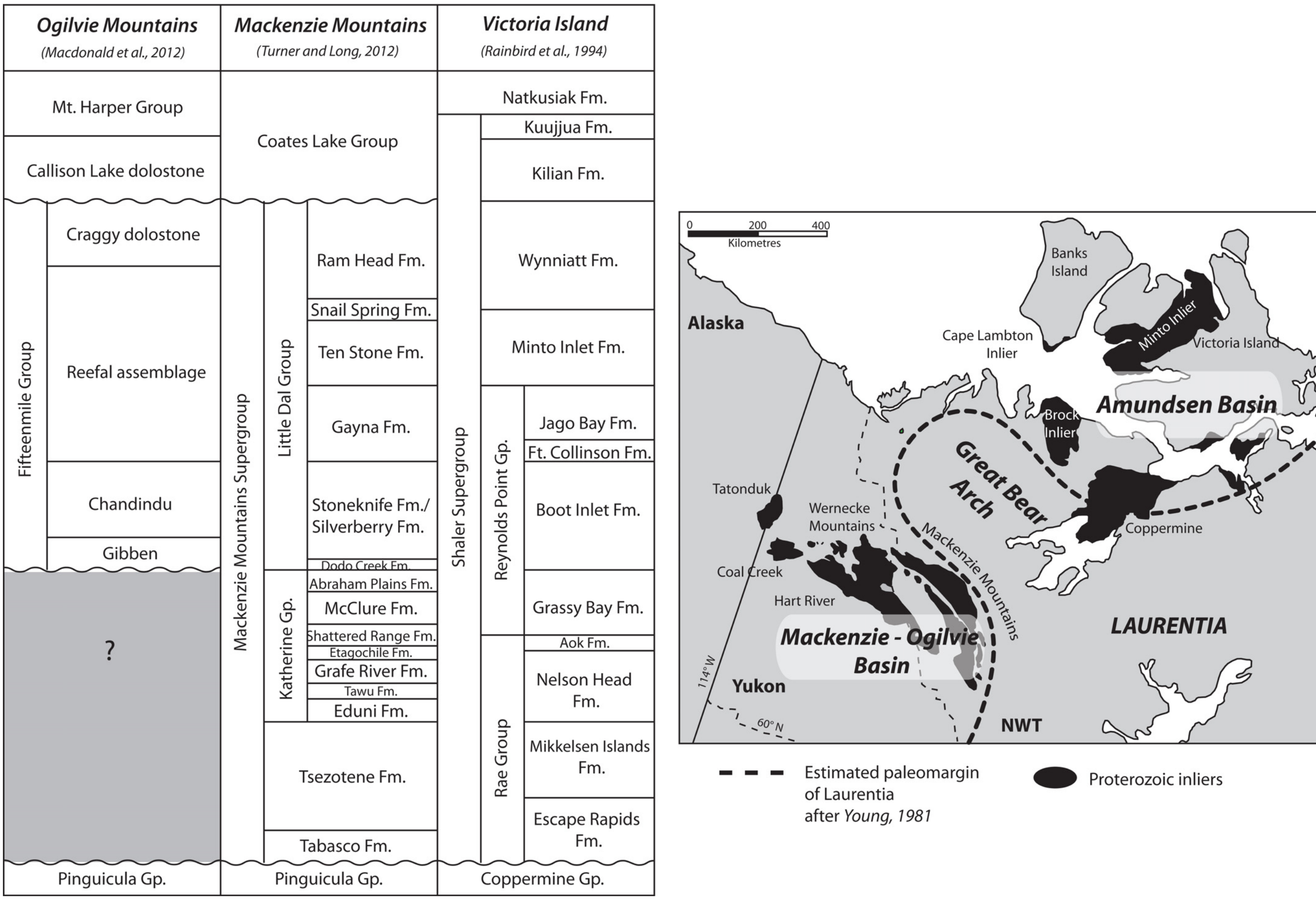

Fig. 1. Correlation chart of the Shaler Supergroup (after Rainbird et al., 1994 and references therein), Mackenzie Mountains Supergroup (after Turner and Long, 2012 and references therein), and Fifteenmile Group (after Macdonald et al., 2012 and references therein), and map showing the localities of Proterozoic outcrops (shown in black) in northern Canada and the estimated paleomargin of Laurentia.
Modified from Young (1981).

in particular along the northwest margin of Laurentia. Studies of sedimentary rocks in the Ogilvie Mountains, Yukon (Macdonald et al., 2010, 2012; Halverson et al., 2012), Mackenzie Mountains, Northwest Territories (Turner and Long, 2008), and the Amundsen Basin, Northwest Territories (Rainbird et al., 1996) invoked different models for pre-720 Ma extension in a northwest–southeast orientation. Turner and Long (2008) attributed extension to simple shear, lower-plate upper-plate detachment along transfer faults for the Mackenzie Mountains Supergroup, whereas Macdonald et al. (2012) interpreted normal faults related to extension and to thermal decay of a mantle plume for the Fifteenmile Group. The interpretation of Macdonald et al. (2012) corroborates the interpretation of an intracontinental sag basin for the Shaler Supergroup (Rainbird et al., 1996).

In this paper, we identify several transgressive-regressive (T-R) cycles, which help to provide a tectonostratigraphic framework for a succession in the Amundsen Basin, Northwest Territories (Canada) that corresponds to deposition ca. 900–780 Ma, prior to the breakup of Rodinia. Stratigraphic cycles record global to intrabasinal controls, and can be used to correlate and discriminate among coeval stratigraphic sections in now geographically disparate basins. It is well established that the Shaler Supergroup of the Amundsen Basin records deposition in terrestrial and rhythmically alternating restricted to open-marine conditions (Young, 1981; Rainbird et al., 1996), but stratigraphic division that would better document the causes and responses of cyclic paleoenvironmental changes has previously been attempted only for the Kilian and Kuujjua formations (Rainbird, 1993) and Boot Inlet Formation (Narbonne et al., 2000; Fig. 2).

Pre-breakup successions of intracontinental sag basins have stratigraphic architectures that differ from those of fault-bound rift basins and of passive margins where the geometry and architecture of thick prograding sequences can more easily be recognized (Lindsay et al., 1993; Vecsei and Duringer, 2003). Sedimentation rates in the Amundsen Basin generally kept pace with, or were briefly outmatched by subsidence, and there is little evidence for large-scale progradation, thereby resulting in a broad layer-cake stratigraphy. Correspondingly, shallow-water facies predominate and were deposited on gently sloping ramps with little, if any, fault-bound compartmentalization. Assignment of subsidence mechanism, or the recognition that such cycles relate to pre-rift extension, is difficult. Despite the Amundsen Basin being a broad (~300 km), shallow-water basin in which most of the sediments were deposited above storm wave-base (SWB), it is possible to identify cycles and interpret subsidence patterns prior to break-up of Rodinia, which has implications for understanding stratigraphic architecture of other intracontinental sag basins.

2. Regional geology

The Neoproterozoic (Tonian-Cryogenian) Shaler Supergroup is over 4 km thick in the Amundsen Basin (Fig. 2), comprising in