Abstract

Long-lived (800 Ma) Paleo– to Mesoproterozoic accretionary orogens on the margins of Laurentia, Baltica, Amazonia, and Kalahari collided to form the core of the supercontinent, Rodinia. Accretionary orogens in Laurentia and Baltica record predominately radiogenic zircon $\varepsilon Hf_{(t)}$ and whole-rock Pb isotopic compositions, short crustal residence times (ca. 0.5 Ga), and the development of arc-backarc complexes. The accretionary orogenic record of Laurentia and Baltica is consistent with a retreating accretionary orogen and analogous to the Phanerozoic western Pacific orogenic system. In contrast, the Mesoproterozoic orogens of Amazon and Kalahari cratons record unradiogenic zircon $\varepsilon Hf_{(t)}$ values, ca. 0.8 Ga crustal residence times, and more ancient whole-rock Pb isotopic signatures. The accretionary orogenic record of Amazonia and Kalahari indicates the preferential incorporation of cratonic material in continental arcs of advancing accretionary orogens comparable to the Phanerozoic eastern Pacific orogenic system. Based on similarities in the geodynamic evolution of the Phanerozoic circum-Pacific orogens peripheral to Gondwana/Pangea, we suggest that the Mesoproterozoic accretionary orogens formed as peripheral subduction zones along the margin of the supercontinent Nuna (ca. 1.8–1.6 Ga). The eventual collapse of this peripheral subduction zone onto itself and closure of the external ocean around Nuna to form Rodinia is equivalent to the projected future collapse of the circum-Pacific subduction system and juxtaposition of Australia-Asia with South America. The juxtaposition of advancing and retreating accretionary orogens at the core of the supercontinent Rodinia demonstrates that supercontinent assembly can occur by the closure of external oceans and indicates that future closure of the Pacific Ocean is plausible.

1.0 Introduction

The supercontinent cycle is a fundamental process in the evolution of our planet that can be traced back at least to the late Archean, but mechanisms for the assembly of supercontinents are not well understood (Nance et al., 2014; Nance et al., 1988). The Wilson cycle (Dewey, 1969; Wilson, 1966) predicts that supercontinents assemble through protracted single-sided subduction systems leading to continental collisions and aggregation of cratons. Such tectonic scenarios resulted in the incorporation of continental blocks into Asia throughout the Paleozoic and Mesozoic (Collins et al., 2011 and references therein), and the assembly of Gondwana in the Neoproterozoic (e.g., Collins and Pisarevsky, 2005; De Waele et al., 2008; Meert and Van Der Voo, 1997; Merdith et al., 2017; Rapela et al., 2011; Spencer et al., 2013). Gondwana's amalgamation resulted from the juxtaposition of Archean/Paleoproterozoic cratons with Neoproterozoic mobile belts (Figure 1A) (Spencer et al., 2013 and references therein). However, it has been shown that the major suture of the supercontinent Rodina (the Grenville suture) juxtaposes isotopically juvenile crust, that youngs toward the adjacent suture from either side (Figure 1A) (Spencer et al., 2013). Thus, Rodinia appears to have formed by a different geodynamic process from, for example, Gondwana amalgamation – a series of asymmetrical subduction and collision processes resulting in ancient cratonic basement adjacent to sutures.

Rodinia-suturing orogens probably reflect the closure of ocean basins with dual subduction zones verging in opposite directions (Spencer et al., 2013). Subduction zones that were established along the periphery of the preceding supercontinent, Nuna (Pisarevsky et al., 2014; Zhang et al., 2012), continued until the amalgamation of Rodinia. The pre-amalgamation setting appears to be analogous to the modern Pacific Ocean, which has subduction zones on opposite margins of its basin. The accretionary orogens that record subduction along the margins of the Pacific Ocean have a protracted ca. 0.55 Ga history, which began during the amalgamation of Gondwana in the late Neoproterozoic. From the