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Early Mesoproterozoic arc magmatism followed by early Neoproterozoic granulite facies metamorphism with a near-isobaric cooling path at Mount Brown, Princess Elizabeth Land, East Antarctica

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ABSTRACT

Mount Brown is a unique inland outcrop between Prydz Bay and Denman Glacier that provides useful insights into the tectonic evolution of the Indian Ocean sector of Antarctica. The bedrock in this area is dominated by felsic orthogneisses with subordinate amounts of mafic granulites, anatectic paragneisses and pegmatite veins. Sensitive high-resolution ion microprobe (SHRIMP) U–Pb zircon dating reveals the emplacement of mafic granulite and felsic orthogneiss protoliths at ca. 1490–1400 Ma, sedimentation of paragneiss precursors after ca. 1250 Ma, and subsequent high-grade metamorphism accompanied by partial melting at ca. 920–900 Ma. The trace element geochemistry of these early Mesoproterozoic mafic–felsic igneous rocks indicates that they formed in a continental arc setting. Nd isotopic compositions for these rocks yield initial ε_{Nd} values ranging from +2.8 to −6.6 and Nd depleted mantle model ages clustering between 2.4 and 1.7 Ga, implying a significant crustal formation in the Paleoproterozoic. Petrographic textures, mineral compositions, and pressure–temperature (*P–T*) pseudosection calculations for mafic granulite and paragneiss in the system NC(K)FMASHTO [Na_2O–CaO(–K_2O)–FeO–MgO–Al_2O_3–SiO_2–H_2O–TiO_2–Fe_2O_3] system suggest that early Neoproterozoic metamorphism reached peak *P–T* conditions of 830–870 °C and 7–8 kbar, followed by near-isobaric cooling to 760–830 °C and 7–8.5 kbar. The age spectra and characteristics of geological events at Mount Brown are similar to those in the Rayner Complex, thereby supporting an eastward continuation of the Rayner orogen to Wilhelm II Land. Combined with existing data, we infer that a protracted tectonic evolution between the Indian craton and East Antarctica (possibly the Ruker craton) might have occurred for a period of ca. 600 Myr from long-lived oceanic subduction–accretion at ca. 1500–1000 Ma to final collision at ca. 1000–900 Ma.

1. Introduction

The East Antarctic Shield is commonly divided into three broad tectonic domains that have African, Indian and Australian affinities, respectively (e.g., Dalziel, 1991; Fitzsimons, 2003; Harley, 2003; Boger, 2011). The tectonic domain with an Indian affinity is located in the Indian Ocean sector of Antarctica and is thought to extend from Alasheyev Bight in Enderby Land east to the Denman Glacier in Queen Mary Land. However, bedrock exposures are concentrated in the western part of this domain, that is, the Napier–Tula–Scott Mountains, the Prince Charles Mountains (PCM) and Prydz Bay. To the east, the domain is almost completely covered by ice except for a few outcrops in the inland Mount Brown and along the coast of Wilhelm II Land (Mikhalsky et al., 2015). Taking into account the Napier–PCM–Prydz region includes diverse tectonic units that generally record late Mesoproterozoic/early Neoproterozoic (i.e., the Rayner orogeny) and/or late Neoproterozoic/Cambrian orogenesis (i.e., the Prydz orogeny) (Harley et al., 2013; Liu et al., 2013), any exposed units in the Prydz–Denman region could provide important insight into the tectonic evolution between India and East Antarctica.

Mount Brown, situated between Prydz Bay and Denman Glacier, is an elongate nunatak that protrudes slightly above the continental ice sheet. The lithology and petrography of rocks from Mount Brown were described briefly by Ravich et al. (1965). More recently, Mikhalsky et al. (2015) reported ages for one sample and geochemical data for two samples collected by the Soviet Antarctic Expedition of 1956–1957. However, the detail geology

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of this isolated nunatak and its tectonic implications remain poorly constrained. In view of this, we carried out a geological reconnaissance of Mount Brown during the 2014–2015 austral field season. In this contribution we present new petrological, geochemical and U–Pb zircon age data for various rock types from Mount Brown. We demonstrate that Mount Brown may represent the earliest portion of the long-lived Mesoproterozoic Rayner continental arc that underwent granulite facies metamorphism followed by near-isobaric cooling during the early Neoproterozoic. The new data provide a better understanding of the geological framework of the Rayner orogen and the Meso-Neoproterozoic accretionary and collisional processes that occurred between India and East Antarctica.

2. Geological background and field relationships

The Napier–PCM–Prydz region in Enderby, Kemp, MacRobertson and Princess Elizabeth lands comprises five Archean/Paleoproterozoic cratonic blocks, the Mesoproterozoic Fisher Terrane and the Meso-Neoproterozoic Rayner Complex (Fig. 1). Five Archean/Paleoproterozoic blocks include the Napier Complex in the Napier–Tula–Scott Mountains, the Ruker Terrane in the southern PCM, the Lambert Terrane in the northern Mawson Escarpment, and the Rauer Group and the Vestfold Block in Prydz Bay. Each of them has a distinct crustal history and therefore is unlikely to represent remnants of a single unified craton (Harley, 2003; Boger, 2011). The Fisher Terrane crops out in the southern sector of the northern PCM and records mafic–felsic volcanism and intrusion at 1300–1020 Ma, followed by amphibolite facies metamorphism at 1020–940 Ma (Beliatsky et al., 1994; Kinny et al., 1997; Mikhalsky et al., 1999, 2001). In comparison, the Rayner Complex extends from Enderby Land in the west to Princess Elizabeth Land in the east and contains 1380–1020 Ma mafic–felsic igneous rocks and coeval or younger sedimentary rocks that record regional granulite facies metamorphism accompanied by widespread charnockitic and granitic magmatism at ca. 1000–900 Ma (Kinny et al., 1997; Boger et al., 2000; Carson et al., 2000; Wang et al., 2008; Liu et al., 2009, 2014; Morrissey et al., 2015). To the east of the Lambert Glacier and the Amery Ice Shelf, the Rayner Complex was strongly reworked by a late Neoproterozoic/Cambrian high-grade tectonothermal event (Zhao et al., 1992; Hensen and Zhou, 1995; Fitzsimons et al., 1997; Liu et al., 2007). This event also affected the Lambert and Ruker terranes, but the metamorphic grade in these areas only reached the greenschist to amphibolite facies (Boger and Wilson, 2005; Phillips et al., 2007).

Mount Brown, located 260 km east of the Vestfold Hills, is a narrow NE–SW-trending ridge exposed above the continental ice sheet, with a length of 1.5 km and a width of 50–200 m (Fig. 2). A moraine belt of ca. 500 m long occurs on the northern end of the ridge. The outcropping bedrock in this area is dominated by banded felsic orthogneisses with subordinate layered or lenticular mafic granulites and interlayered anatectic paragneisses (Fig. 3a–d). Minor lenses or irregular blocks of ultramafic phlogopite–diopside rocks were also reported (Ravich et al., 1965; Mikhalsky et al., 2015). These metamorphic rocks have a regional NE–SW to NNE–SSW-trending gneissic fabric that dips towards the northwest at angles of mostly 10°–25° (locally up to 50°). Small tight folds are present within bands of mafic granulite (see Fig. 3c), suggesting an episode of earlier compressional deformation. Pegmatites derived from partial melting of metamorphic rocks are widespread in the area and garnet grains up to 3–6 cm in diameter were observed in a pegmatite vein. The orientations of pegmatite bands and veins are generally parallel to the regional gneissosity in the

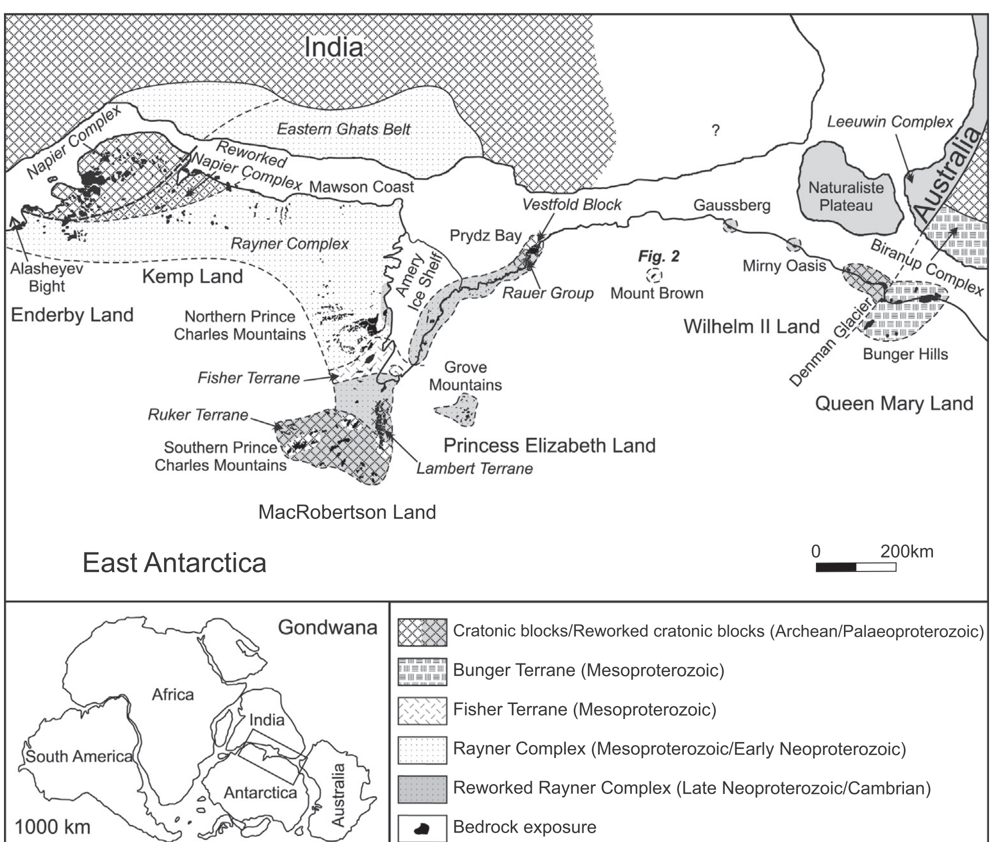

Fig. 1. Geological sketch map of the Indian Ocean sector of Antarctica and adjacent India and Australia prior to the Gondwana break-up (modified after Liu et al., 2013). Inset showing its location in the reconstruction of Gondwana at ca. 500 Ma.