Precambrian Research 281 (2016) 312–337

Contents lists available at ScienceDirect

Precambrian Research

journal homepage: www.elsevier.com/locate/precamres

Genesis of the Tonian Imorona–Itsindro magmatic Suite in central Madagascar: Insights from U–Pb, oxygen and hafnium isotopes in zircon

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ARTICLE INFO

Article history:
Received 22 September 2015
Revised 28 March 2016
Accepted 22 May 2016
Available online 31 May 2016

Keywords:
Madagascar
Zircon
Geochronology
Precambrian tectonics
Oxygen isotopes
Hafnium isotopes

ABSTRACT

Madagascar occupies an important location within the East African Orogen (EAO). The EAO comprises an assemblage of Neoproterozoic microcontinents and arc terranes lodged between older cratonic blocks during the final assembly of the supercontinent Gondwana. The Imorona–Itsindro Suite of central Madagascar represents voluminous Tonian-aged (850–750 Ma) magmatism with controversial petrogenesis. Early work proposed arc magma generation coinciding with oceanic plate subduction during closure of the Mozambique Ocean along the 'Betsimisaraka Suture' in eastern Madagascar. Recently, others have questioned the existence of such a suture in Madagascar and rather suggest extension related emplacement into the middle and upper crust through a system of pre-existing structures. New U–Pb (zircon) geochronological data coupled with in-situ oxygen and hafnium isotopic analyses demonstrate that the Imorona–Itsindro Suite had several source components. Most of the Tonian-aged magmatic rocks were derived by mixing between ancient crust and mantle derived melts. $\delta^{18}O$ values show variation that indicates significant involvement of crustal material and hydrothermal fluids. Predominantly low negative $\varepsilon_{Hf}(t)$ values are also variable and indicate significant crustal involvement in the genesis of the Tonian magmas. A compilation of all available geochronological data shows magmatism was essentially continuous for ~100 Myr but with periods of increased activity at ~800 Ma, ~791 Ma and ~784 Ma. Temporal analysis shows magmatic cycles of enrichment and depletion on the scale of 15–40 Ma. Spatial variations in isotope compositions reflect the heterogeneity of probable crustal source rocks present in the Ikalamavony, Itremo, Antananarivo and Masora Domains. A tectonic model is proposed for the Imorona–Itsindro Suite as a long-lived Andean-like arc on the margin of the Mozambique Ocean. The longevity and temporal isotopic trends are interpreted as reflecting cycles of arc advance and retreat.

1. Introduction

The East African Orogen (EAO) is one of the largest of orogens formed during the Ediacaran/Cambrian amalgamation of Gondwana (Stern, 1994, 2002; Meert, 2003; Collins and Pisarevsky, 2005; Johnson et al., 2011; Fritz et al., 2013). This relationship is expressed in the Mozambique Belt (see Fritz et al., 2013 for a recent summary), where the EAO separates Neoproterozoic India from the African Congo-Tanzania-Bangweulu Block (Fig. 1a). To the north, in the Arabian–Nubian Shield, the EAO consists of fragments of pre-Neoproterozoic continental crust in Saudi Arabia, Yemen and the Horn of Africa (e.g. the Afif Terrane), interleaved with Neoproterozoic oceanic-arc like terranes (Johnson et al., 2011; Robinson et al., 2014; Blades et al., 2015) with final amalgamation in the Ediacaran (Doebrich et al., 2007; Cox et al., 2012). The pre-Gondwana ocean that separated these landmasses is referred to the Mozambique Ocean. Although the Arabian–Nubian Shield preserves many oceanic suture zones recording accretion of the shield but as the orogen is traced south, the identification of potential sutures becomes less clear. This led Shackleton (1996)

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http://dx.doi.org/10.1016/j.precamres.2016.05.014
0301-9268/