Available online at www.sciencedirect.com
SCIENCE DIRECT®

Precambrian Research 145 (2006) 81–92

Precambrian Research

www.elsevier.com/locate/precamres

Neoproterozoic arc–back–arc system analog to modern arc–back–arc systems: evidence from tholeiite–boninite association, serpentinite mudflows and across-arc geochemical trends in Eritrea, southern Arabian-Nubian shield

M. Teklay *

Department of Earth Sciences, University of Asmara, Eritrea

Received 3 May 2005; received in revised form 25 August 2005; accepted 28 November 2005

Abstract

Neoproterozoic volcano–sedimentary–plutonic associations in Eritrea are part of the Arabian-Nubian Shield. In central Eritrea, the dominant low-grade supracrustal rocks are of volcanic origin, associated with subordinate sedimentary rocks and lenses of serpentinites. Pre- to syn-kinematic diorites and tonalites of ca. 810 Ma age and late- to post-kinematic granites of 585 Ma age intrude these supracrustal rocks. Low-K tholeiite–boninite metavolcanic rocks have trace element characteristics that are similar to modern oceanic primitive arc volcanic rocks. Boninites are found together with serpentinite bodies that are very similar to serpentinite mudflows occurring on modern forearcs, indicating a palaeo-forearc setting for central Eritrea.

In contrast, the predominant rocks in western Eritrea are supracrustal sequences of sedimentary origin, with subordinate volcanic rocks. Tholeiitic metavolcanic rocks from western Eritrea have trace element characteristics that are similar to modern back–arc basin basalts. The timing of magmatism in both areas (ca. 850 and 800–850 Ma, western and central Eritrea plus northern Ethiopia, respectively) is broadly coincident. In the absence of major crustal discontinuities that might separate major terranes along the central-western Eritrean transect, this large Neoproterozoic tract may represent an 800–850 Ma NW-palaeo oceanic arc–back–arc system. Systematic spatial variations in Ti, Nb, Y and Zr concentrations from forearc, through arc, to back–arc provide further evidence for the north-west direction of subduction.

Keywords: Neoproterozoic; Tholeiite–boninite; Serpentinite mudflows; Arc–back–arc; Eritrea; Arabian-Nubian Shield

1. Introduction

The Neoproterozoic Arabian-Nubian Shield and the Mozambique belt together constitute the East African Orogen (EAO) that formed when the Mozambique Ocean closed as a result of the consolidation of East and West Gondwana (Stern, 1994; Johnson and Woldehaimanot, 2003). The Arabian-Nubian Shield, exposed in the Arabian Peninsula, Sinai, southern Israel, Jordan, Eastern Desert of Egypt, the Red Sea Hills of Sudan, Eritrea, and Ethiopia, is an excellent example of continental crust formation in association with plate tectonics during Neoproterozoic time. Isotopic evidence indicates that the core region of the ANS

* Fax: +291 1 162236.
E-mail addresses: mengist@asmara.uoa.edu.er, mengistt@gmail.com.

0301-9268/$ – see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.precamres.2005.11.015

comprises juvenile crust produced from 870 Ma to at least 690 Ma (Stern, 1994). The formation of so much juvenile continental crust in the ANS has implications for the global continental growth rates in the Neoproterozoic (Reymer and Schubert, 1984,1986). Lateral crustal growth through arc accretion has been proposed as the main mechanism for the evolution of the ANS (Stoeser and Camp, 1985; Kröner et al., 1987,1991; Abdul-Rahman, 1995). However, two additional models have recently been proposed: accretion of both arcs and oceanic plateaux (Stein and Goldstein, 1996; Teklay, 1997) and the Turkic-type orogenic model of Sengör and Natal'in (1996), whereby much of the ANS crust formed in broad forearc complexes. Testing of these models requires further chemical, chronological and isotopic studies of the ANS.

Boninites are high-Mg, silica-oversaturated lavas that are important but rare component of subduction zone magmatism. Boninites are most commonly found in forearc regions of intra-oceanic convergent margins. Boninites are rare because their petrogenesis requires a unique combination of depleted mantle peridotite, abundant water, and an abnormally high geothermal gradient at relatively shallow levels in the mantle wedge (Crawford et al., 1989). Magmas with boninitic affinities are reported from the Neoproterozoic ANS (Reischmann, 1986; Woldehaimanot, 1995; Wolde et al., 1993; Yibas et al., 2003; Katz et al., 2004), although, no boninites have been reported for the Arabian part of the ANS. The recent discovery of boninite in part of the ANS in central Eritrea is important because it provides a petrogenetic test of the tectonic models of the region.

The aim of this paper is to document for the first time the occurrence in Eritrea of Neoproterozoic boninites, serpentinite mudflows, and a Neoproterozoic arc–back–arc system similar to modern arc–back–arc

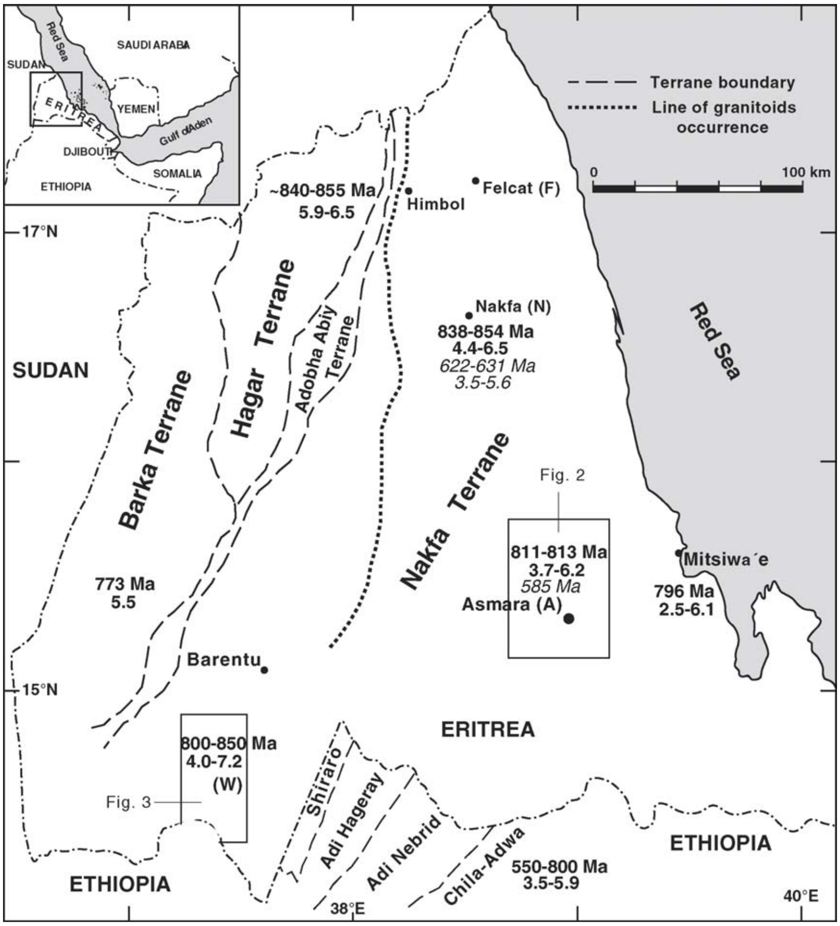

Fig. 1. Simplified terrane map of Eritrea showing ages and initial epsilon Nd values for Neoproterozoic magmatic rocks (ages and initial epsilon values in italic are for late- to post-kinematic granitoids). Source of data: Beyth et al. (1997), Teklay (1997) and Teklay et al. (2001, 2002a,b, 2003). Terrane division in Eritrea after Drury and de Souza Filho (1998). The volcano–sedimentary blocks, ages and initial epsilon Nd values for northern Ethiopia are from Tadesse (1996) and Tadesse et al. (2000).