Precambrian Research 237 (2013) 101–115

Contents lists available at ScienceDirect

Precambrian Research

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

Eastward transport of the Monapo Klippe, Mozambique determined from field kinematics and computed tomography and implications for late tectonics in central Gondwana

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ARTICLE INFO

Article history:
Received 19 April 2013
Received in revised form 29 August 2013
Accepted 6 September 2013
Available online 17 September 2013

Keywords:
Monapo Klippe
Kinematic indicators
Computed tomography
East African Orogen
Gondwana assembly

ABSTRACT

We present a detailed kinematic study of the boundary between the Monapo Klippe and the underlying Nampula Block in northern Mozambique. The Monapo Klippe is an allochthonous klippe of granulite-facies metamorphic rocks with subsidiary granitic and mafic intrusive rocks. The klippe overlies the Nampula Block which is made up of ortho- and paragneisses that are lower metamorphic grade and considerably older than the rocks of the Monapo Klippe. The boundary between the klippe and the underlying Nampula Block is a distinct mylonitic shear zone of variable width. The mylonite composition varies with the local footwall lithology but the dominant composition is quartz-rich with minor feldspar augen and biotite. The mylonite is interpreted to have formed as an early broad ductile shear zone that evolved during multiple phases of shearing to a narrow high-strain, lower temperature mylonite horizon. Kinematic indicators observed in outcrop, thin section, and image slices from X-ray computed tomography of three-dimensional mylonitic fabrics record top-to-east motion. The granulite-facies Cabo Delgado Nappe Complex, which lies to the north of the Monapo Klippe, has been hypothesized as the root terrane for the klippe. The Cabo Delgado Nappe Complex records top to the north-west motion at around 630–610 Ma. However, granitic and pegmatitic rocks that intrude the Monapo Klippe, and which also cross-cut the mylonite fabric as well as being deformed by it, are considered to be part of the Cambrian Murrupula Suite dated at between 530 and 470 Ma. This suggests that the emplacement of the Monapo Klippe over the Nampula Block is part of a later extensional phase post 530 Ma associated with east-directed post-orogenic collapse following Gondwana assembly.

1. Introduction

During the amalgamation of Gondwana, between ~630 and 480 Ma, numerous crustal blocks collided to form a number of major orogenic belts along the eastern edge of Africa (Meert, 2003; Stern, 2004; Collins and Pisarevsky, 2005). The timing and orientation of collision of these different crustal blocks have been the subject of ongoing debate within this part of Gondwana (Pinna, 1995; Sacchi et al., 2000; Viola et al., 2008; Jacobs et al., 2008; Grantham et al., 2008, 2013; Ueda et al., 2012a; Macey et al., 2013) and elsewhere within the supercontinent (Kriegsman, 1995; Shackelton, 1996; Jacobs et al., 1998; Fitzsimons, 2000; Collins et al., 2007; Kelsey et al., 2008; Grantham et al., 2008; Baba et al., 2010; Tucker et al., 2011; Collins et al., 2013). The ongoing debate is driven by three main problems: (1) the paucity of outcrop in key areas where orogens are thought to cross or intersect, (2) resolution the timing of orogeny and its duration in different parts of the Gondwana supercontinent; and (3) determination of the transport direction of what are in most cases reworked high-grade metamorphic rocks. Work to address problems (1) and (2) is ongoing and continuous. For example, recently there has been a major research focus on resolving the geological history of the Sør Rondane Mountains in Antarctica, considered to be one of several keystones for understanding assembly of central Gondwana. Outcrop is very scarce and hard to access but the recent work has made significant inroads into understanding the timing relationships of major geological events in this region (Satish-Kumar et al., 2013 and references therein). Nevertheless, attempts to address problem (3) remain problematic principally because of the lack of reliable and widespread kinematic indicators that can be linked to

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http://dx.doi.org/10.1016/j.precamres.2013.09.007