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Geology of the Monapo Klippe, NE Mozambique and its significance for assembly of central Gondwana

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ABSTRACT

The Monapo Klippe in north-east Mozambique is an ovoid-shaped outcrop measuring approximately 35 × 40 km and is clearly visible on satellite and geophysical images. Based on recent field mapping, geochemical studies and new geochronological data, we present a revision of the lithostratigraphy of the klippe and offer a model for its origin and emplacement in the framework of regional tectonics. There are three main groups of rocks within the klippe: (1) the Metachéria Metamorphic Complex; (2) the Mazerapane Intrusive Suite; and (3) the Ramiane Intrusive Suite. The Metachéria Metamorphic Complex consists of a mélange of granulite gneiss, including mafic, felsic, pelitic and carbonate rocks, characterised by a strong penetrative shear fabric. The largely undeformed Mazerapane and Ramiane Suites have intruded into the Metachéria Metamorphic Complex. The Mazerapane Suite consists of foid-bearing ultramafic and mafic gneisses and intrudes into the western half of the complex, whereas the Ramiane Suite is dominated by alkaline granitic rocks, contains no foid-bearing units and intrudes into the eastern half of the complex. In addition to these three main units, there are a number of minor but structurally important units, the main ones of which include amphibolite-facies tonalitic gneisses and the Evate calcite carbonatite. Underlying all of these units is a narrow, high strain mylonite zone. Undeformed pegmatite bodies and dykes cross-cut all rock types of the Monapo Klippe including the marginal mylonite. Near identical dates for the intrusion of the Ramiane Suite at 637 ± 5 Ma and metamorphism of the Metachéria Complex at 634 ± 8 Ma indicates a major episode of granulite-facies metamorphism and crust generation at this time. The ~635 Ma age for the granulite-facies metamorphism is comparable to granulite-facies events identified in other parts of the East African Orogen in Tanzania, Madagascar and other parts of northern Mozambique to the north of the Lúrio Belt. The absence of granulite-facies rocks in the underlying Nampula Block is consistent with structural arguments that the Monapo Klippe is the remnant of an allochthonous thrust sheet. In this context, the Monapo Complex is very similar to other granulite-facies "klippe" in East Africa, Antarctica and Sri Lanka, lending support to the idea of a Pan-African mega-nappe formerly existing across greater East Gondwanaland.

1. Introduction

The diverse terranes amalgamated during the Meso to Neoproterozoic to form present day northern Mozambique preserve a record of the kinematics of Gondwana construction as well as an opportunity to observe deeper crustal levels of a large orogenic belt. The crust in northern Mozambique is cut into two similar but different tectonic blocks by the ENE-trending, NW-dipping Lúrio Belt. This belt is made up of highly strained Neoproterozoic mafic granulites of the Ocua Complex and is thought to mark a major crustal boundary (Fig. 1; Viola et al., 2008; Bingen et al., 2009; Macey et al., 2010). To the south of the Lúrio Belt, the Nampula Block (the Nampula Complex of Jacobs et al., 2008) forms a large contiguous crustal block which consists of 1150–1070 Ma orthogneisses and

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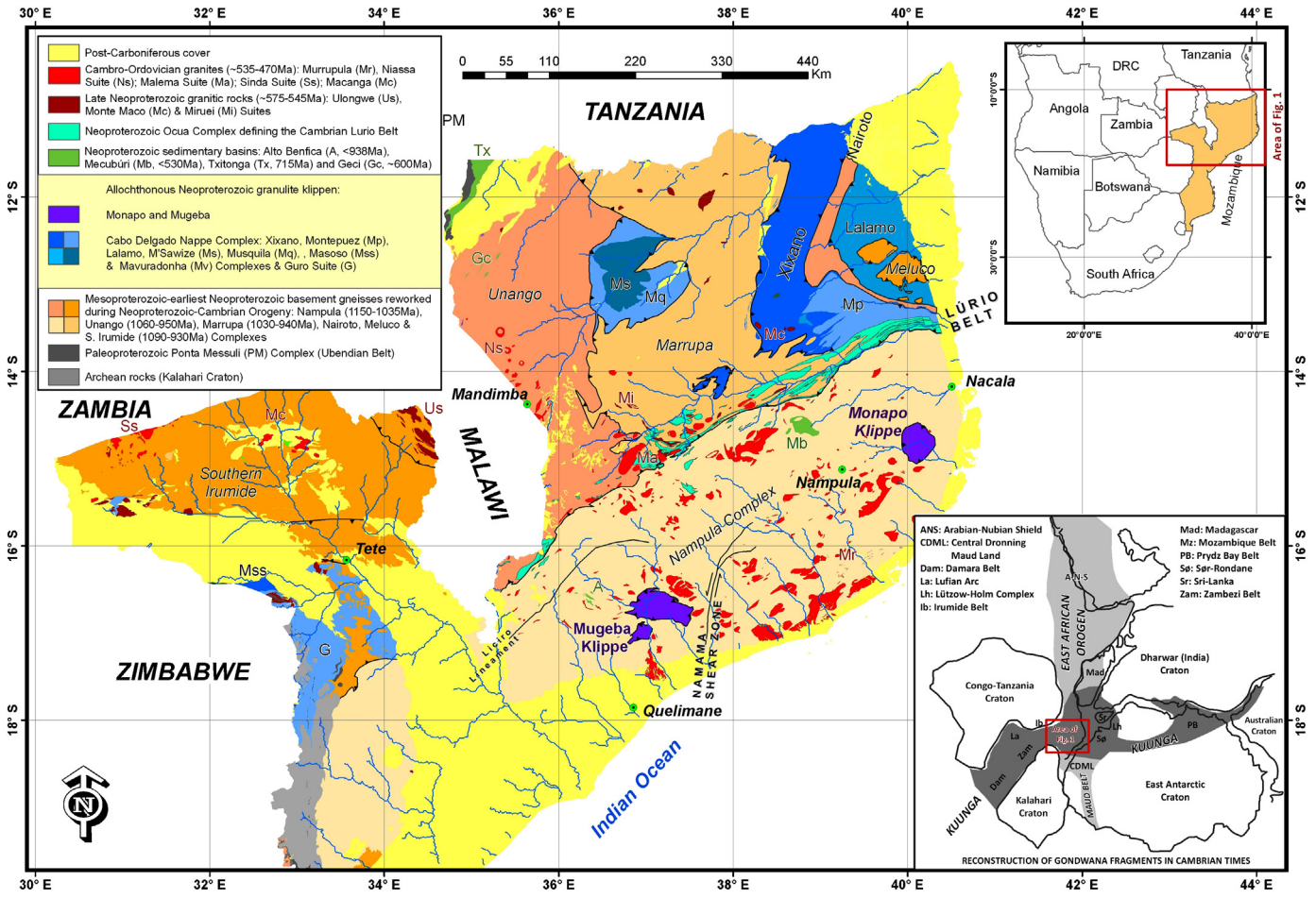

Fig. 1. Simplified geological map of NE Mozambique after Norconsult (2007a,b), Macey et al. (2007) and Grantham et al. (2007) showing the main lithostratigraphic units. Bottom inset shows reconstruction of Gondwana during the Cambrian after Meert (2003), with the locations of the East African Orogen and Kuunga Orogen shown.

metasedimentary rocks with high grade metamorphism around 1090–1070 Ma (Macey et al., 2010). The Mesoproterozoic rocks of the Nampula Block are overlain by isolated allochthonous Neoproterozoic granulite klippen (Monapo and Mugeba Klippen; Pinna et al., 1993; Grantham et al., 2008) and para-autochthonous metamorphosed molasse sediments (Mecubúri and Alto Benfica Groups; Thomas et al., 2010; Fig. 1). The Namuno Block (Grantham et al., 2008) north of the Lúrio Belt consists of similar Mesoproterozoic crustal gneisses (Unango and Marrupa Complexes), but with slightly younger protolith ages, 1060–940 Ma (Bingen et al., 2009), and metamorphic ages ~940 Ma that are interleaved with slices of high grade metamorphic rocks of more mafic character, the Neoproterozoic Cabo Delgado Nappe Complex (including the Xixano, M'Sawize, Muaquia and Lalamo complexes), forming a stack of west vergent, nappes (Viola et al., 2008; Bingen et al., 2009; Boyd et al., 2010). The various litho-tectonic entities were tectonically juxtaposed during the protracted, late Neoproterozoic to early Paleozoic (c. 630–495 Ma) amalgamation of Gondwana (e.g. Jacobs et al., 1998, 2008; Meert, 2003; Stern, 2004; Collins and Pisarevsky, 2005; Collins et al., 2007; Grantham et al., 2008; Bingen et al., 2009). Collisional orogenesis was followed by the intrusion of late- to post tectonic Cambrian-Ordovician K-granites, in particular the voluminous Murrupula Suite (~530–495 Ma) that intrudes the Nampula Block (Macey et al., 2007; Jacobs et al., 2008; Ueda et al., 2012).

Two principal models have been proposed to explain the current architecture and geological evolution of Northern Mozambique crust, and in particular, the nature of the Lúrio Belt. In the first model, assembly involves convergence of eastern and western Gondwana associated with closure of the Mozambique Ocean along the East African Orogen (Holmes, 1951; Stern, 2004) extending southward into Antarctica to form the East African Antarctic Orogen (EAAO) (Jacobs and Thomas, 2004; Jacobs et al., 2008). In this model the Lúrio Belt of Northern Mozambique represents an accommodation zone between two thermomechanically very different parts of the EAAO, separating a part where the orogen root delaminated from a part that did not delaminate (Jacobs et al., 2008) and as such it does not represent a Neoproterozoic suture zone (Jacobs and Thomas, 2004; Jacobs et al., 2008). The Mecubúri and Alto Benfica Groups were deposited in basins that developed as a result of extensional collapse of the thickened lithosphere of the EAAO, near-contemporaneous with the intrusion of post-collisional granites into the Nampula Block (Jacobs et al., 2008; Thomas et al., 2010; Ueda et al., 2012).

The second model proposes a two-stage amalgamation of Gondwana components (Grantham et al., 2008, in press). The first stage involves the collision between east and west Gondwana components (the microcontinent Azania colliding with the Congo-Tanzania-Bangweulu block; Collins and Pisarevsky, 2005) forming the N–S trending East African Orogen (750–620 Ma; Stern, 1994; Meert, 2003) and, in northern Mozambique, formation of the west-vergent Namuno accretionary terrane stack. The second stage involves the collision of the newly formed this northern Gondwana block (combined East African Orogen, Namuno Block) with a southern Gondwana block (Nampula-Kalahari-western Dronning Maud Land) along the E-W striking Damara-Lufilian-Zambezi-Lúrio-Prydz Bay belts alternatively referred to as the Malagasy