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The seismotectonics of Southeastern Tanzania: Implications for the propagation of the eastern branch of the East African Rift

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ABSTRACT

Seismicity patterns and focal mechanisms in southeastern Tanzania, determined from data recorded on temporary and permanent AfricaArray seismic stations, have been used to investigate the propagation direction of the Eastern branch of the East African Rift System southward from the Northern Tanzania Divergence Zone (NTDZ). Within the NTDZ, the rift zone is defined by three segments, the Eyasi segment to the west, the Manyara segment in the middle, and the Pangani segment to the east. Results show that most of the seismicity (~75%) extends to the south of the Manyara segment along the eastern margin of the Tanzania Craton, and at ~6–7° S latitude trends to the SE along the northern boundary of the Ruvuma microplate, connecting with a N–S zone of seismicity offshore southern Tanzania and Mozambique. A lesser amount of seismicity (~25%) is found extending from the SE corner of the Tanzania Craton at ~6–7° S latitude southwards towards Lake Nyasa. This finding supports a model of rift propagation via the Manyara segment to the southeast of the Tanzania Craton along the northern boundary of the Ruvuma microplate. However, given the limited duration of the seismic recordings used in this study, the possibility of another zone of extension developing to the south towards Lake Nyasa (Malawi) cannot be ruled out. Focal mechanisms along the boundary between the Victoria and the Ruvuma microplates and offshore southeastern Tanzania show a combination of normal and strike slip faulting indicating mainly extension with some sinistral motion, consistent with the mapped geologic faults and a clockwise rotation of the Ruvuma microplate.

1. Introduction

The southward propagation of the Eastern branch of the East African Rift System (EARS) through Kenya and into northern Tanzania, where the rift zone splits into three segments, the Eyasi segment to the west, the Manyara segment in the middle, and the Pangani segment to the east, has been well studied (e.g., Dawson, 1992; Ebinger et al., 1997; Foster et al., 1997) (Fig. 1). Southeastern Tanzania is situated at the southern end of this so-called Northern Tanzania Divergence Zone (NTDZ) (Fig. 1), where the nature of the seismicity, the stress regime and the locus of rifting are, by contrast, less well understood. Southeastern Tanzania encompasses the boundaries between the proposed Victoria and Ruvuma microplates, which are rotating in counterclockwise and clockwise directions, respectively, with respect to the Nubian Plate (Calais et al., 2006; Stamps et al., 2008; Saria et al., 2013, 2014; Fernandes et al., 2013; De'prez et al., 2013). It has been suggested that the Eastern branch may connect with the Davies Ridge offshore via the northern edge of the Ruvuma microplate (O'Donnell et al., 2013) (Fig. 1). It also has been suggested that the Eastern branch may connect to the Western branch of the EARS via a transverse fault zone along the margin of the Tanzania Craton (Le Gall et al., 2004) (Fig. 1). Alternatively, Mougenot et al. (1986) suggested that the Eastern branch might not extend through southeastern Tanzania but instead may be propagating along the Pangani rift across northeastern Tanzania (Fig. 1).

The seismicity and stress regime in northern Tanzania have been studied in great detail to understand extension within the NTDZ (Wohlenberg, 1969; Fairhead and Girdler, 1971; Sykes and Landisman, 1974; Bâth, 1975; Fairhead and Girdler, 1969; Nyblade et al., 1996; Langston et al., 1998; Macheyeki et al., 2008; Mulibo and Nyblade, 2009; Albaric et al., 2009), but seismicity in southeastern Tanzania has not been similarly investigated and remains poorly understood. This is mainly because until recently there have been few seismic networks within the area to record local seismicity. In this paper, data from temporary and permanent seismic stations in and surrounding southeastern Tanzania operated between 2009 and 2011 are used to investigate seismicity and the regional stress regime, and to elucidate from them the propagation direction of the Eastern branch of the rift system south of the NTDZ.

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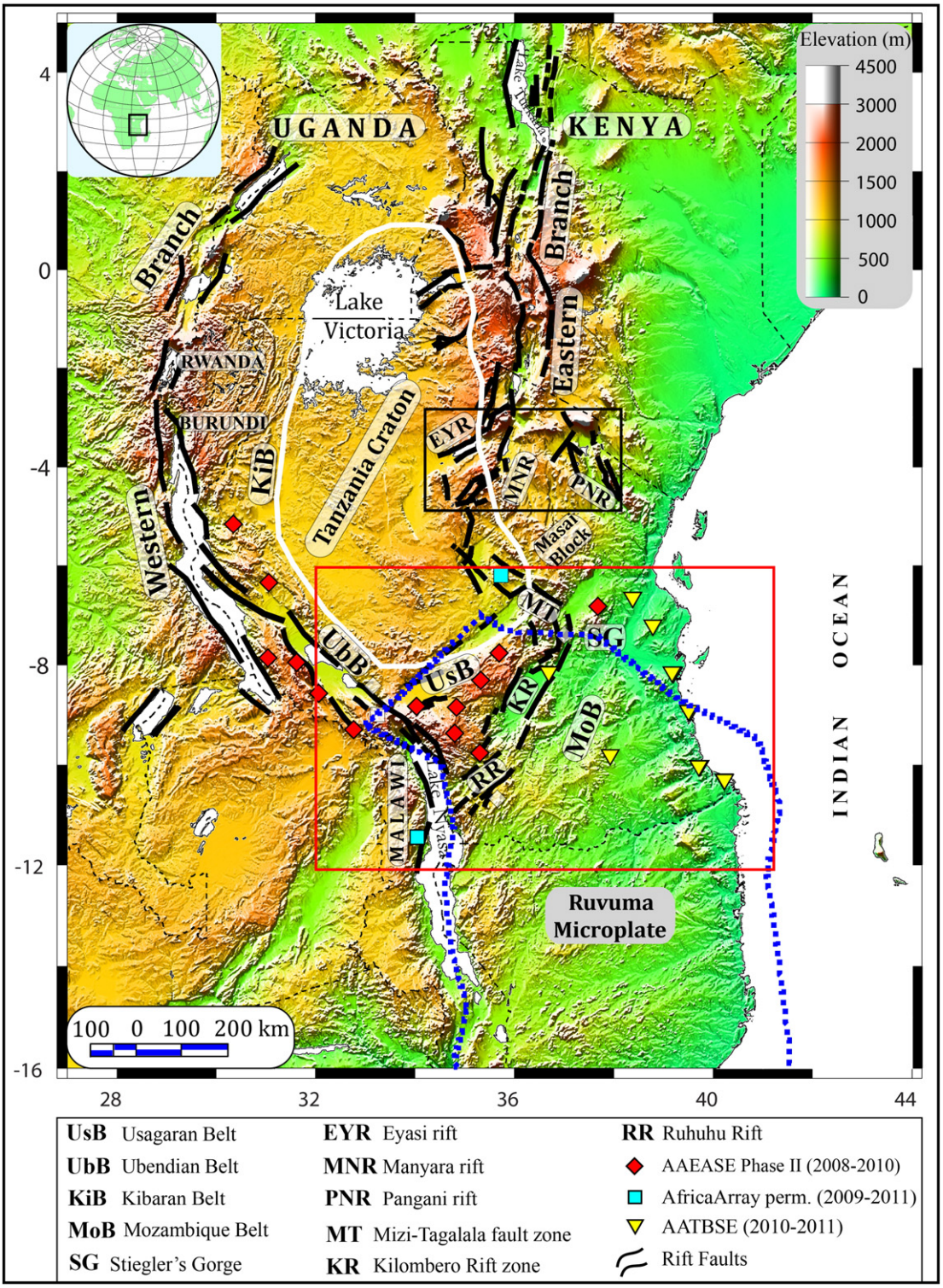

Fig. 1. Topographic map of East Africa showing the regional geology, including the Tanzania Craton (bold outline), the Proterozoic mobile belts surrounding the craton, the major Cenozoic rift faults and the three rift segments of the Northern Tanzania Divergence Zone (NDTZ). Seismic stations used are also shown. The black box shows the NDTZ, the red box shows the region that is enlarged in Figs. 2 and 5, and the blue dashed line shows the boundary of the Ruvuma microplate.

2. Background

2.1. Geology and tectonic setting

The topography and the major tectonic provinces of the study area are shown in Figs. 1 and 2, which include the area to the south and southeast of the Tanzania Craton along the southeastern side of the East African Plateau. The Tanzania Craton forms the core of the Precambrian tectonic framework of eastern Africa and is flanked by several Proterozoic mobile belts (Figs. 1 and 2). To the south and southeast of the craton lie the Ubendian and Usagaran Belts, respectively (Lenoir et al., 1994; Theunissen et al., 1996). The eastern part of the Usagaran Belt and the Tanzania Craton is bordered by the Mozambique Belt, which covers much of the study area and is characterized by north-south