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Letter Section

# Discovery of a giant deep-sea valley in the Indian Ocean, off eastern Africa: The Tanzania channel

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ABSTRACT

During the Fanindien 2006 cruise of *R/V 'Beautemps-Beaupré'*, high resolution multibeam bathymetry, sub-bottom profiling and sediment coring was carried out along the East African margin, offshore Tanzania and Mozambique (Indian Ocean). The newly acquired data reveal the presence of a giant deep-sea valley (the Tanzania channel) that is more than 10 km wide at 4000 m water depth, along the continental rise. The valley remains ~70 m deep and 7 km wide at 800 km from the Tanzania coast. Morphological comparison with worldwide submarine channels show that the Tanzania channel is one of the largest known submarine valleys. This discovery brings new light on development of submarine valleys that drain sediments originated from the East African Rift System (EARS) highlands (i.e. the Tanzania channel and its neighbor Zambezi channel located ~1000 km southward). Both of the systems have a morphology markedly different to the classical sinuous, V-shaped channels located at similar latitudes (e.g. the Zaire or Amazon channels). Their submarine drainage system consists of a downslope converging tributary canyons joining a central trunk channel in the continental rise. The presence of such giant deep-sea drainage systems is probably linked to a strong structural control on the sediment pathway, associated to a massive sediment transfer towards the Indian Ocean in relation with the tectonic activity of the East African Rift System (i.e. the uplift periods trough mid-Miocene and Plio-Pleistocene times) and its interplay with the East African equatorial climate changes.



## 1. Introduction

The importance of submarine channels as preferred pathways for sediment transfer from the continents to deep-water environments has been recognized since the 1950's and the first discoveries of large deep-sea turbidite systems, e.g. the Amazon, Zaire, NAMOC systems and many more (Hesse et al., 1987; Flood et al., 1991; Piper and Normark, 2001; Babonneau et al., 2002). Although their morphology and internal architecture has been intensively studied since they are considered as important targets for oil exploration (Wynn et al., 2007), many recent works have also proved that the record of sediment flux to deep water turbidite systems can provide high resolution records of the land climate, sea-level changes and tectonics that affect the source area (Flood and Piper, 1997; Hesse and Khodabakhsh, 1998; Baztan et al., 2005; Maslin et al., 2005; Zühlsdorff et al., 2007; Piper et al., 2007; Toucanne et al., 2008). During the last few decades, many deep-sea research projects have focused on the west and northwest African margins, of major interest for both the petroleum industry and academia (Wynn et al., 2000; Babonneau et al., 2002; Saugy and Eyer, 2003; Antobreh and Krastel, 2006) The eastern African margin, however, remains very poorly studied. The recent FanIndien explorative cruise (*R/V Beautemps-Baupré*, SHOM, 2006) crossed the western Indian Ocean from the Ormuz Strait (Gulf of Oman) to the Mozambique Strait. During this survey, a giant submarine valley (more than 10 km wide) was discovered offshore Tanzania (Fig. 1). Using EM120 multibeam bathymetry and imagery, high resolution 2D seismic and piston coring, the Tanzania channel could be described in detail along the 260 km of survey. Here we present the first results concerning its morphology between 4000 and 4500 m water depth.

## 2. Regional setting

The eastern African margin formed during the break-up of Gondwana and relative drifting of the Africa and Madagascar continental blocks during Mesozoic and Cenozoic times (Salman and Abdula, 1995). The formation of the Indian Ocean at the end of the Mesozoic induced the creation of several marginal sedimentary basins,

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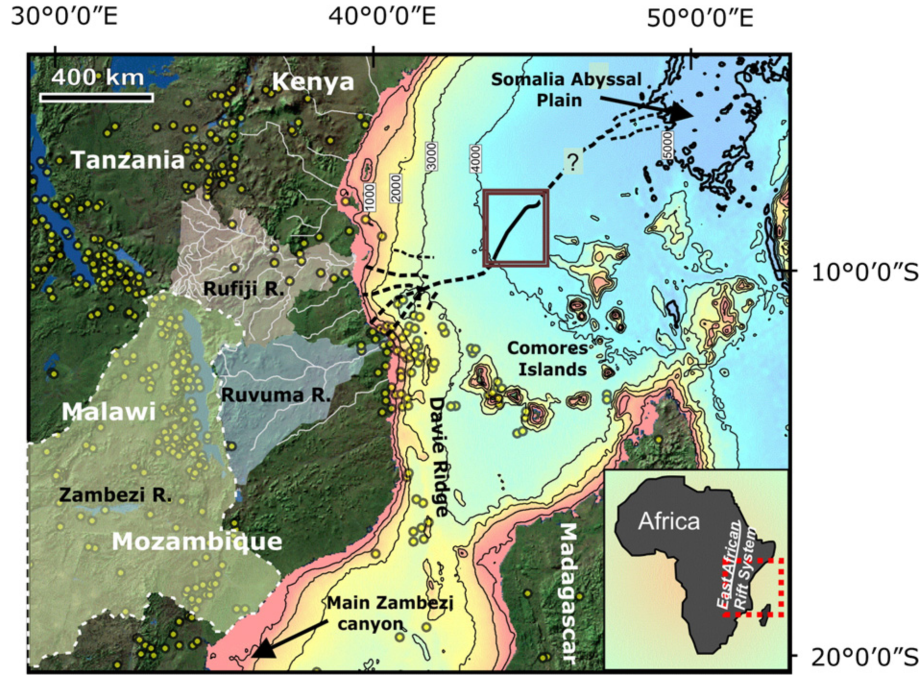


**Fig. 1.** Location map of the study area**.** Bathymetry data is from the ETOPO2 bathy charts. Bathymetric contours are in meters. The Somalia Abyssal plain is defined by the −5000 m contour. Onshore topography is derived from the NASA Shuttle Radar Topography Mission elevation model (http://www2.jpl.nasa.gov/srtm/index.html). Location of the main rivers (solid white lines) along the East African margin and localization of the Rufiji (shaded grey), Ruvuma (shaded blue), and Zambezi (shaded light green) rivers watersheds. Dashed line indicates the proximal and distal supposed trajectory of the Tanzania channel. Solid line indicates the position of the Tanzania channel along the 260 km of survey. Yellow circles indicate recent earthquake distribution in the area (Chorowicz, 2005). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

which finally formed the single system of the East African marginal sedimentary basin after the Late Cretaceous. The coastal plain of Tanzania and the Davie submarine ridge (Fig. 1) are also part of the south–eastern branch of the East African rift system (Chorowicz, 2005). At present day, the East African rift system is still propagating southward (Fig. 1), inducing consequent seismic activity (Fairhead and Stuart, 1982; Chorowicz, 2005).

The Tanzania continental shelf is very narrow (from 3 to 10 km), except off the Rufiji delta where it extends on more than 40 km. The upper continental slope develops from −100 m to −2500 m, with average slope values of 1,5 to 2°, that locally steepen to more than 4,5°. From −2500 to −4000 m the lower slope develops with gentler gradients (~0, 25°). Then the slope passes to the continental rise (with an average slope of ~0.08°) and finally reaches the Somalia abyssal plain down to 5000 m water depth.

The Tanzania channel is located basinward of a large drainage system, mainly composed by the Rufiji river (180,000 $km^2$ drainage basin), the Ruvuma river (163,500 $km^2$), and smaller rivers (Fig. 1). Both the Rufiji and Ruvuma rivers mouth are constituted by large deltas extending over more than 1400 $km^2$. The regional climate is controlled by the seasonal variability of the intertropical convergence zone (ITCZ), which brings rains during one single season corresponding to the austral summer (months of November–April) with prevailing NE monsoon associated with a southern position of the ITCZ (Gasse, 2000). The dry and windy season occurs in winter months (from May to October), when the region experiences a complete reversal in wind direction and stronger SE monsoon winds prevail. Cyclones are also a common regional feature, occurring generally during the months of January to March.

## 3. Results and discussion

Bathymetry and acoustic imagery were collected using the multi-beam echosounder SIMRAD EM120 (12 kHz). Sub-bottom seismic lines were collected using the SBP 120 profiler, which offers deeper penetration and higher resolution (~1 m) than conventional sub-bottom systems, with sweep frequencies between 2, 5 and 7 kHz.

The data acquired between 4000 and 4500 m water depth show that the Tanzania channel is characterized by a rectilinear course (Fig. 2). A higher sinuosity is only observed where a rocky sea mount deflects the channel course (Fig. 2). At 4000 m water depth, the Tanzania channel is a relatively flat bottomed valley up to 12 km wide and ~100 m deep, with steep walls (max. 15°), that develops along a very gentle slope (0.09°, Fig. 2). Down-flank mass transport deposits (Fig. 3a) are observed, as well as small scour-like features (or internal channels), suggesting that erosion and by-pass dominate. The 100 m high levees are symmetrical, showing parallel, low amplitude to transparent acoustic facies (Fig. 3a), and large scale sediment waves that suggest overflow of the finest part of the channelled flows. However, it is also possible for sediment waves to be formed by bottom currents and sedimentological data would be needed to confirm the dominance of turbidity current processes on the channel flanks. Between 4100 to 4300 m water depth, the Tanzania channel floor is marked by an abrupt break of slope (reaching a maximum of 0.23°), associated with a deflection in the channel course (Fig. 2). Detailed bathymetry data show large and elongated incisions in the channel floor (scours): the largest one borders the right flank of the channel (Fig. 2). Downstream, this scour enlarges and forms a central thalweg, associated with the onset of an asymmetrical morphology and the development of internal terraces. In the third channel section, the slope values decrease to 0.03° and the internal thalweg deepens and migrates laterally. The Tanzania channel course is then deflected by a 500 m high and 30 km long rocky mound (Fig. 2). Downstream, the internal channel becomes large enough to join both levees and to form a unique U-shaped, 5–7 km wide and 60–70 m deep valley (Figs. 2 and 3b). The flanks are steep, bordered by levees associated with low amplitude to transparent drape-like facies and sediment waves (Fig. 3b).

Our data do not cover the proximal and distal part of the Tanzania channel. However, the more recent bathymetric charts from ETOPO2