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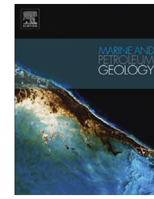

Research paper

# Mesozoic and Early Cenozoic sediment influx and morphology of the Mozambique Basin

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A B S T R A C T

The Mozambique Basin is one of the oldest extensional sedimentary basins developed along the eastern African margin. The basin hosts a continuous record of sediments since the Jurassic separation of Antarctica from Africa. The objectives of this study were to extend the regional stratigraphic framework north of the Zambezi Delta into the deep abyssal plains and review the early evolution of the Mozambique Basin using nine multi-channel seismic reflection profiles.

We identify six major stratigraphic units that were deposited in Jurassic, Early Cretaceous, Late Cretaceous, Paleogene, Neogene and Quaternary times. Mesozoic sedimentation rates of 5–10 cm/kyr and 1–3 cm/kyr during the Paleogene are calculated in the deeper basin. The presence of shales in neighbouring wells on the shelf implies an euxinic environment in the rapidly subsiding basin until Early Cretaceous times. The Mesozoic sediments have a high seismic velocity that exceeds 4.5 km/s, except in a distinct Early Cretaceous low-velocity (3.7 km/s) zone that may indicate the presence of under-compacted, overpressured shales. In spite of the fact that the Zambezi catchment was much smaller in pre-Miocene times, the high Late Cretaceous sedimentation rates can be attributed to rapid denudation of the African continent after a major tectonic uplift episode at approximately 90 Ma. Increased sediment influx into the basin from the Zambezi in Late Cretaceous times resulted in the formation of an elongated submarine fan lobe into the Mozambique Channel north of Beira High. Strong north-south bottom currents commenced within the channel in Late Cretaceous times, forcing the aggradation of sediments on the southern flank of the lobe. In addition, we observe several current-controlled sediment deposits in the deeper basin that are influenced by north-south bottom currents. Low Paleogene sedimentation rates are attributed to a sediment-starved basin during a relative quiet tectonic phase onshore.



## 1. Introduction

The separation of East and West Gondwana resulted in the formation of extensional sedimentary basins along the African margin (Jokat et al., 2003; Koenig and Jokat, 2010; Mahanjane, 2012; Nairn et al., 1991; Reeves, 2000; Salman and Abdula, 1995). The Mozambique and Somali basins were the first basins to form along the east African margin (Coffin, 1992; Coffin et al., 1986; Leinweber and Jokat, 2012; Leinweber et al., 2013). Basin formation was complemented by eastward flowing rivers systems that transported large quantities of sediments into the newly formed depressions.

Most of the east African basins show a continuous post-Jurassic record of sediment deposition (e.g. Somali, Rovuma and Mozambique) (Coffin et al., 1986; Salman and Abdula, 1995). Sedimentary deposits contain a precious archive of past processes that shaped the landscape. Palaeo-reconstructions of Africa and the West Indian Ocean rely on the quantification of these events. Important information can be found in the Mozambique Basin, its northern neighbour the Somali Basin, and its Antarctic conjugate basin, the Riiser-Larsen Sea. Despite its importance, literature about the geological evolution of the Mozambique Basin is scarce.

Few seismic data are available in the abyssal plains of the

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Mozambique Channel (Droz and Mougenot, 1987). Commercial seismic data were mainly acquired on the shelf. This gap was closed in 2007 when different seismic/geophysical data were collected with R/V Marion Dufresne II as part of the MD163-MoBaMaSiS expedition (Reichert, 2007) (Fig. 1). These data included reflection and wide-angle seismic data, as well as gravity, magnetic and bathymetric data. The expedition aimed to collect data that could be used to understand the continental break up and geological history of the basin. Here, we introduce a stratigraphic interpretation of the multi-channel reflection seismic (MCS) data acquired during the expedition. We discuss the influence of former geological events on the changing environmental settings during the break-up in the Mesozoic and try to quantify the amount of the material eroded from the Eastern Africa.

### 1.1. Tectonic and geological setting

The break up of Gondwana has been described as a two phase process by several authors (Cox, 1992; Eagles and König, 2008; Leinweber and Jokat, 2011; Mahanjane, 2012; Reeves, 2000). The seafloor spreading record in the Mozambique Basin can be quite simply interpreted in terms of the divergence of Africa and Antarctica. As seen from a fixed Africa, initial rifting in Early Jurassic times occurred in response to southwest-directed motion of Antarctica. This displacement was followed by southward relative movement during the second phase. The palaeo-position of Madagascar is important for the geological history of the region. Although long a subject of debate (Flores, 1984; Foerster, 1975; Kamen-Kaye, 1982), it is now widely accepted that Madagascar drifted southwards from Tanzania along the Davie shear zone (Rabinowitz et al., 1983; Coffin and Rabinowitz, 1987) or Davie Ridge Transform fault system *(referred to with different names by various authors)*. During its drift phase, Madagascar moved southwards with seafloor spreading in the Somali Basin until some time during the Early Cretaceous (M10n or M0, 129.5 or 118Ma). The island has occupied its present position as part of the African plate since the termination of seafloor spreading in the west Somali Basin (Cochran, 1988; Eagles and König, 2008; Rabinowitz et al., 1983; Salman and Abdula, 1995).

Onshore, the African topography is interpreted as a product of complex cycles of erosion (Burke, 1996; Patridge and Maud, 1987 and references therein). Patridge & Maud (1987) suggest a single Jurassic-to-Miocene cycle of erosion briefly interrupted by tectonic interludes. Most of the erosion occurred in the earlier part of the above time interval resulting in the deposition of thick Jurassic and Cretaceous strata offshore. Regional uplift may have accompanied intense magmatism between 90 and 70 Ma in southern Africa (Burke, 1996). This is evident from the rapid denudation and thick Upper Cretaceous deposits along the Limpopo Valley (De Buyl and Flores, 1986), at the mouth of the Orange River (Miller, 1995; as cited in Burke, 1996), and in the increased sediment discharge of the Zambezi (Walford et al., 2005). Among the major rivers that drain into the Mozambique Basin are the Zambezi and its tributaries that are responsible for the wide continental shelf along the Mozambique coast. The present Zambezi has a catchment area of 1,400,000 $km^2$. The sediment load of the Zambezi River is estimated to have increased by an order of magnitude in the last 120 Ma (Walford et al., 2005). They assume that sediment yield rates depend on basin area and maximum elevation. The modern Zambezi system is thought to have developed from two drainage systems separated by the Victoria Falls – Upper Zambezi and Middle Zambezi. They merged no earlier than Pliocene times (Nugent, 1990; Thomas and Shaw, 1988) and thereby increased the sediment discharge of the Zambezi. Prior to that, the Upper Zambezi is proposed to have continued its southerly course into Botswana and into Orange or Limpopo river drainage systems. Increases in sediment flux from the Zambezi River are observed over 3 periods:

1. Since Late Cretaceous (90-65 Ma): simultaneous with rapid denudation of southern Africa after a tectonic uplift and increase of the catchment area.

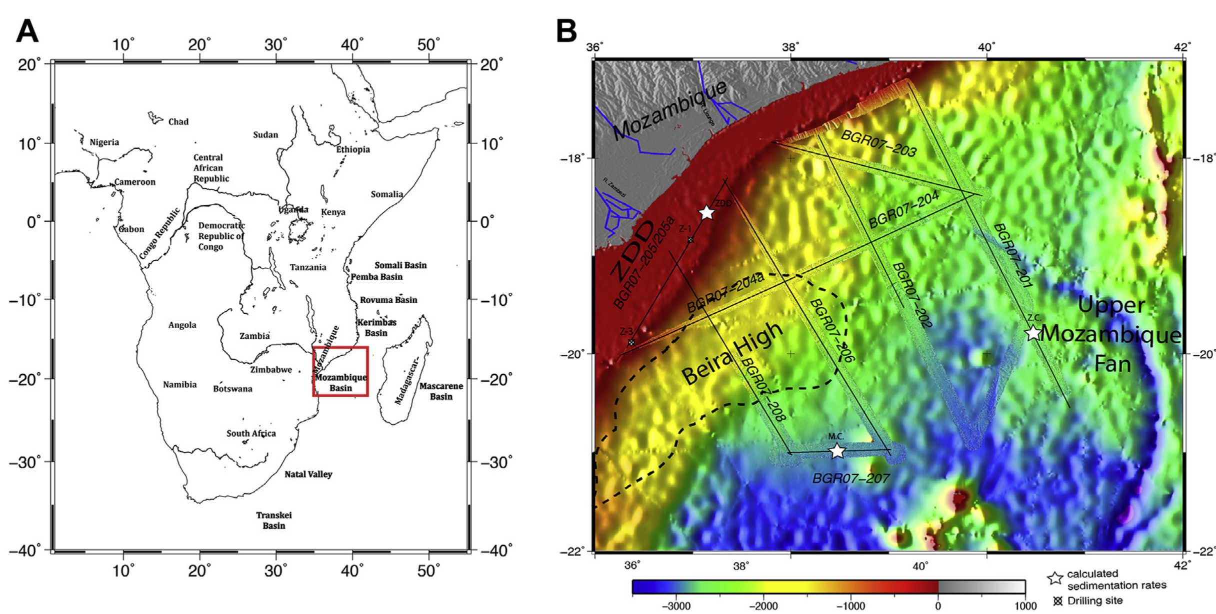


**Fig. 1.** (A) Major rift basins along the east African margin. The oldest magnetic anomalies have been identified in the Somali and Mozambique Basins. The extent of the surveyed area is indicated by a red box. (B) Bathymetric map of Mozambique Basin showing seismic reflection profiles (black) and drilling sites Zambezi-1 (Z-1) and Zambezi-3 (Z-3) in the Zambezi Depression Delta (ZDD) used in the study. Multi-Beam Echo Sounder (MBES) data from expeditions MD-163 (Reichert, 2007) are overlain on the GEBCO_08 grid. The locations of our calculated sedimentation rates are indicated by white stars. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)