

The Impact of the Agulhas Current System on Sedimentary Systems at the Southeast African Margin - Shallow, Mid- and Deep-Water Contourite Formation

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Abstract: *Sedimentary systems from Madagascar through Davie Ridge, Zambezi and Limpopo Margin, Natal Valley to the Cape of Good Hope were investigated with multichannel seismic and echosounder surveys to prepare the SAFARI drilling proposal 702 to IODP (Hall, Zahn et al.), which is going to be scheduled within the coming years. On the search of suitable drilling locations to study the Agulhas Current paleoceanography in the Neogene, intense interaction with the sedimentary systems was observed in water depths ranging from the shelf edge in front of the Limpopo and Zambezi River, in mid-water off Madagascar and on Davie Ridge, to deeper water in the Natal Valley and at the Cape of Good Hope.*

Key words: *Contourite, Southeast Africa, Agulhas Current, Seismic Survey*

The thermohaline circulation in the Eastern Indian Ocean is dominated by the Mozambique and Madagascar Currents, which join as the Agulhas Current south of Madagascar to carry enormous amounts of heat from the Indian to the Atlantic Ocean. The most sensitive part of the interocean exchange is located at the southern tip of Africa and on the Southeastern African continental margin. As the current patterns are assumed to be heavily influenced by changes in the global climate, variations in current intensity and enhancement of the retroflexion back into the Indian Ocean are closely related to glacial and interglacial conditions, which drive N-S shifts of the frontal system with the Circumantarctic circulation. Drilling results may therefore reveal critical information about the evolution of both the paleoclimate and the paleocirculation back to Miocene times.

A multichannel seismic survey off Mozambique, Madagascar and South Africa was carried out to identify potential drilling locations to study the Neogene evolution of the Agulhas current system during the last 10 million years. As an outcome of several regional surveys between 35°S and 15°S, we found the margin to be dominated by current-controlled sediment buildups, rather than being influenced by terrigenous sediment input only (Fig. 1). Wide parts of the continental margins were shaped by contour currents ranging in water depth from ~100 m down to more than 3000 m water depth. Also shelf regions reveal pronounced coast-parallel sediment transport, serving as redistribution mechanism and as significant margin sediment source.

Drilling along the pathway of the Agulhas Current from Madagascar to South Africa is challenging due to the erosive capacity of this major ocean current and associated countercurrents, and depositional processes need to be understood to ensure the completeness of sedimentary archives and sufficiently stationary depocenters through the time interval of investigation.

A combination of plate tectonic constraints, determining average slope angles and the breakup geometry of the margins, and the orientation of the currents with respect to the average contour direction in turn control a locally variable setting with huge contouritic depocenters forming at indentations of the margins, e.g. in front of the River Zambezi and River Limpopo, while areas in close proximity are characterized by strong erosion. Off Madagascar, mid-water deposition is fed by local channels and overflows, being redistributed by alongshore currents in >1000 m water depth. The same water depth is affected on Davie Ridge near DSDP Site 242. Shallow water contourites form from 100 through 1500 m off Zambezi and Limpopo (Fig. 2), with maximum deposition in a few hundred meters water depth.

Further south, near the Natal Valley and off the Cape of Good Hope, the margin slope is particularly steep and orientation of contours and currents match quite well, leading to non-deposition or erosion at the upper and middle slope. The Agulhas Current, having picked up material on its path, loses particles at its base forming thicker fallout units beneath.

At the southern tip of Africa, winnowing and erosion dominate on the whole margin, with local variations due to complex topography. At the proposed sites, winnowing or reduced sedimentation can be clearly identified.

A suite of drill sites has been proposed to trace the Agulhas Current and its related deposits. While off Madagascar and at Limpopo and Zambezi, terrigenous input feeds the current, and material is partially just redistributed by shelf recirculation cells from lee eddies, southern sites lack sediment supply, sedimentation at the southern sites may be controlled by variations in transport capacity.

Overall, although main objectives of the drilling proposal focus on paleoclimate and paleoceanography back to the mid Miocene, significant evidence can be expected from the SAFARI drilling about contourite systems at the East African margin and its spatial and temporal variability

REFERENCES

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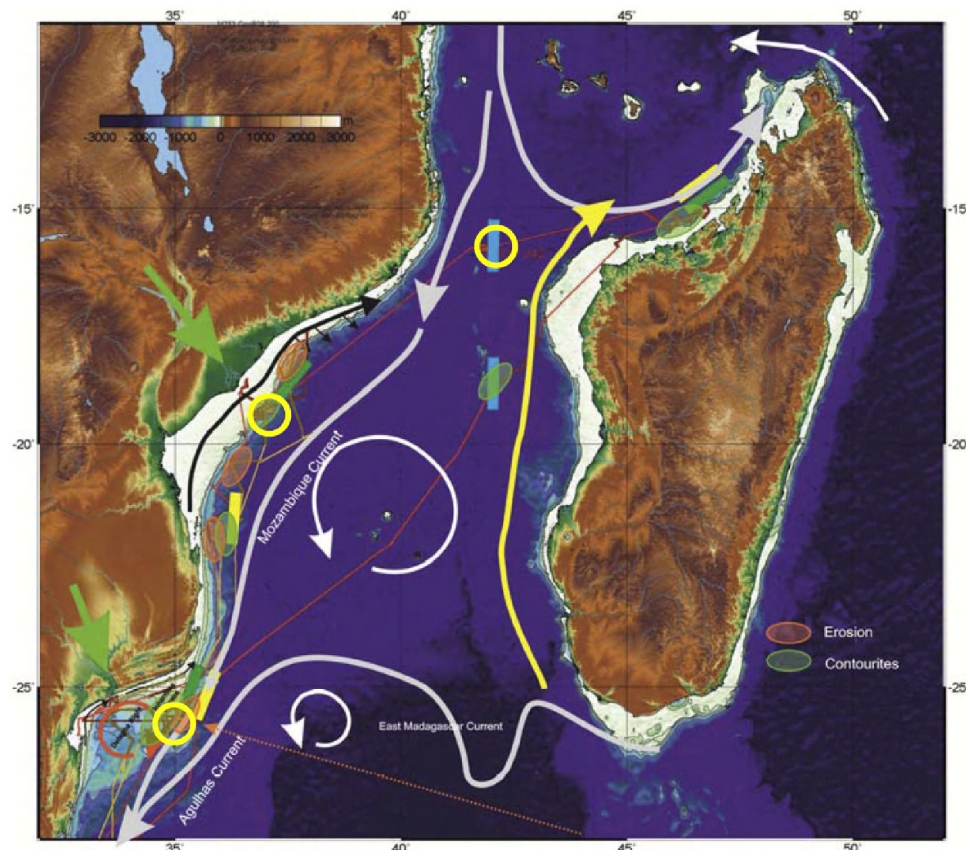


FIGURE 1. Current-controlled sedimentation on the SE African continental margin between 10°S and 30°S. A distinct pattern of erosional (red ellipse) and contouritic (green ellipse) domains is observed. Formation of deep water (blue bars), mid water (yellow bars) and shallow water (green bars) contourites is documented in seismic pre-site survey data for the IODP drilling proposal SAFARI. Green arrow denote significant terrigenous sediment flux from Limpopo and Zambezi River, which contribute to the contourite formation. Drilling is proposed at the yellow circles, which represent sediments being distinctly influenced by the ambient current regime through most of the Neogene.

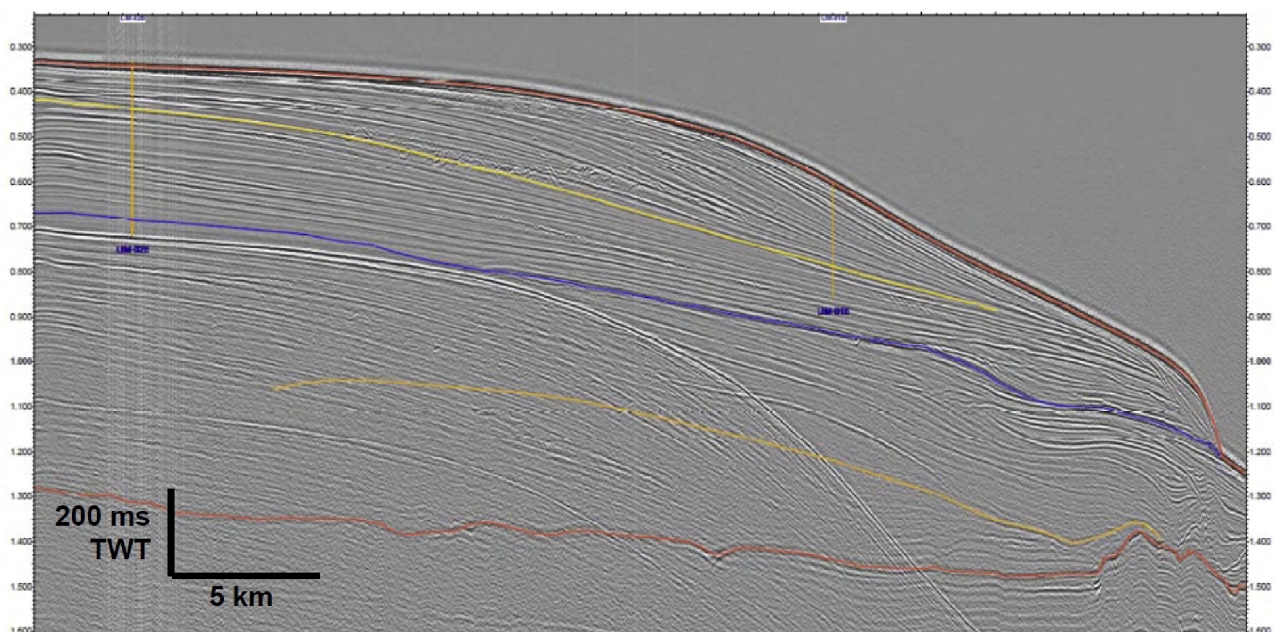


FIGURE 2. Seismic line across proposed Sites LIM-01B and LIM-02B (orange lines) on the Inharrime Terrace off Limpopo River. Interpretation according to Preu et al. (2011) identifies plastered drift units back to the middle Miocene (blue horizon).