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# Fresh geoscientific data from the Natal Valley and Mozambique Ridge

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## ABSTRACT

Although the broad break-up sequence of Gondwana around southern Africa during the Jurassic and Cretaceous is understood, the refit of Africa and Antarctica remains unclear. This is due to uncertainty regarding the areas both onshore and offshore of SE Africa that are underlain by oceanic crust as well as the ages of that oceanic crust. An example is the enigmatic Mozambique Ridge that has been variously proposed to be either continental or oceanic in origin (or both). In order to help resolve these issues, during 2009 a marine geophysical survey was undertaken over the Natal Valley and the Mozambique Ridge. This cruise collected magnetic and gravity data, together with swath bathymetry and echo-sounder data. The results revealed that the magnetic anomalies of the southern Natal Valley are consistent with earlier work whereas the Northern Natal Valley is more complex than previously suspected. The Mozambique Ridge contains striped magnetic anomalies indicative of the ridge having been formed at a mid-ocean ridge.

**Key words:** Gondwana break-up, marine magnetics, Natal Valley, Mozambique Ridge.

## INTRODUCTION

The break-up of Gondwana around southern Africa commenced with the development of ca. 180 Ma Karoo Igneous Province. Whilst the broad aspects of break-up are established (*viz.* Watkeys, 2006), there are certain details that are still obscure, most notable being the exact refit of SE Africa and Antarctica. This is due to uncertainty regarding whether oceanic crust developed in association with the Karoo Igneous Province (Jourdan *et al.*, 2007) as well as whether the Mozambique Ridge is oceanic or continental in origin.

Consequently the AISTEK III expedition was undertaken offshore of SE Africa in the Natal Basin and the Mozambique Ridge from 9th April to 1st June, 2009 using the RV *Pelagia* operated by the Nederlands Institute voor Onderzoek der Zee (NIOZ). Its aim was to build on the data gathered during the AISTEK II cruise (Jokat, 2006) by acquiring new geoscientific data in order to shed new light on the early seafloor spreading history during the Mesozoic Gondwana break-up. Further information about the cruise tracks, participants *etc*., may be found on the NIOZ website: http://www.nioz.nl/nioz_nl/311f5c0580f51abbe64e179d90a5aac5.php

## METHOD AND RESULTS

The main experiment was to systematically gather marine magnetic data to identify magnetic spreading anomalies. In the general, the line spacing varied between 18 and 36 km, and had a N-S orientation. In the northern Natal Basin additional E-W lines were acquired. The measurements were accomplished with a towed magnetic gradiometer system, consisting of two Overhauser sensors, and a ship mounted fluxgate magnetometer.

In addition, gravity data were acquired with a LaCoste & Romberg S 56 gravimeter. Harbour measurements were taken four times in Durban. Furthermore, swath bathymetric data with a Simrad EM301 system, and 3.5 kHz sediment echo-sounder data were acquired along all tracks. Both systems are ship-mounted and were provided/prepared by NIOZ.

Magnetic stripes in the oceanic crust of the southern Natal Valley Basin are very subdued but nevertheless visible. They confirm more or less the previous geodynamic models for this area. The northern Natal Valley however shows are more complex magnetic pattern than previously reported (Tikku *et al*., 2002). Since the N-S line layout provided no unique pattern of

spreading anomalies, a number of E-W lines were undertaken. The aim was to establish the presence or absence of magnetic anomalies that might correlate with the onshore N-S trending ca. 174 Ma MORB-like Rooi Rand dyke sheeted dyke swarm that lies parallel to the Lebombo "monocline" (Watkeys, 2002). As no N-S trending magnetic anomalies of were found, there is still no known oceanic crust that formed in association with the Karoo Igneous Province. A surprising result is that no pronounced magnetic anomaly marks the termination of continental/transitional crust in the area.

The most striking result of the cruise is that the denser magnetic survey lines over the Mozambique Ridge revealed the presence of magnetic striping. This suggests that the Mozambique Ridge formed at a mid-ocean ridge. This is corroborated by the samples of basalts with MORB compositions collected from a DSDP core in the central Mozambique Ridge (Thompson *et al*., 1982) and dredged from the southern Mozambique Ridge (Watkeys *et al.*, 2006; Kretzinger, in prep.).

This oceanic origin for the Mozambique Ridge has two implications. Firstly, the previously interpreted continental origin for this feature formed an impediment to a tight refit between the continental crust of SE Africa and Western Drönning Maud Land, Antarctica. This has long been suggested from the onshore geology *(viz.* Groenewald et al., 1991). The recognition of the Mozambique Ridge as a feature that developed after continental break-up now allows such a tight refit. Secondly, on the basis of preliminary data from the AISTEKII cruise (Jokat, 2006), the Mozambique Ridge was modelled as an aseismic ridge that had subsided with the surrounding oceanic crust since the Early Cretaceous (Watkeys *et al*., 2006). However there were some uncertainities in this model. The magnetic anomalies recorded during the AISTEKIII cruise allow refinement of the modelling that revealed the Mozambique Ridge to have formed as a volcanic archipelago that extended southwards from central Mozambique in the widening SW Indian Ocean.

## CONCLUSIONS

AISTEK III is most detailed marine geophysical survey to date of the Natal Valley and Mozambique Ridge. The magnetic anomalies identified have confirmed the conclusions of previous work in the oceanic crust of the southern Natal Valley but has shown that the oceanic crust of the northern Natal Valley is more complex than previously suspected. The enigmatic Mozambique Ridge has both striped magnetic anomalies and basalts of a composition that indicate that it developed at a mid-ocean ridge. Such an oceanic origin allows the Mozambique Ridge to be removed when refitting Gondwana so that a tight refit is possible between the continental crust of SE Africa and Antarctica In the Early Cretaceous it originally formed a volcanic archipelago as SE Africa and Antarctica were separating but has subsided with time.

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