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# Late Cretaceous onset of current controlled sedimentation in the African–Southern Ocean gateway

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ABSTRACT

During the breakup of Gondwana the Mozambique Ridge, a Large Igneous Province emplaced between 140 and 125 Ma, was located in the evolving African–Southern Ocean gateway. Therefore, it represents an archive of the evolving exchange of water masses between the South Atlantic and Indian Ocean via the development of surface, intermediate, and bottom circulation. Two Cretaceous seismic units (S1 and S2a) were deposited on top of magmatic basement separated by a hiatus. Unit S1 mostly shows seismic reflections parallel to the top of the basement and no indications of current activity. The occurrence of several sediment drifts within seismic unit S2a indicates the onset of current controlled sedimentation. Based on our observations we propose deposition under partly euxinic conditions in the area of the Mozambique Ridge until ~100 Ma. The onset of a strong shallow circulation affecting deposition at the Mozambique Ridge is inferred by the Late Cretaceous ~25 Myr hiatus reported by drilling results and documented in the seismic records, whereas black shales deposited in the nearby deep Transkei Basin indicate a restricted deep circulation at least until ~85–80 Ma. We propose that the observed hiatus might be a consequence of a late Early Cretaceous uplift of the Mozambique Ridge and the progressive opening of the Agulhas Passage allowing inflow of surface (Upper Pacific Water, Upper North Atlantic Water) and intermediate water (Intermediate Southern Ocean Water) into the study area. The intense circulation that caused the hiatus seems to have weakened in Campanian times, which is documented by the occurrence of sediment drifts in seismic unit S2a. We suggest that the onset of current controlled sedimentation was caused by palaeogeographic modifications in the Atlantic Ocean along with relocation of circulation pathways. Our results illustrate the crucial role of the African–Southern Ocean gateway in the commencing water mass exchange between the Atlantic and Indian Ocean and highlight the complex interactions that eventually lead to the initiation of a proto–Antarctic Circumpolar Current in Turonian times.

## 1. Introduction

For several decades Large Igneous Provinces (LIP) like the Mozambique Ridge (MozR) have been of great interest because of their potential far-reaching impact on biosphere and atmosphere leading to climate shifts and mass extinctions (Coffin and Eldholm, 1994; Saunders, 2005; Wignall, 2001). Despite the probable influence of palaeo-climate by emission of greenhouse gases during emplacement of the MozR, its elevation and location in the African–Southern Ocean (A–SO) gateway (Fig. 1a) presents another criterion that might have influenced palaeo-climate: the obstruction of ocean currents circulating in the evolving Southern Ocean (Durgadoo et al., 2008). A prominent example of such an impact on palaeocean circulation is the Rio Grande Rise/Walvis Ridge System, which likely acted as a barrier for deep-water circulation between the North and South Atlantic Ocean until its Late Cretaceous subsidence (Murphy and Thomas, 2013; Voigt et al., 2013; Wagner and Pletsch, 1999).

Various authors focused on the evolution of water masses in the Southern Ocean and inferred a late Early Cretaceous onset of deep-water formation and thus of palaeocean circulation in the Indian sector (Murphy and Thomas, 2012, 2013; Poulsen et al., 2001; Robinson et al., 2010). It is a matter of ongoing debate whether Northern Component Water or Southern Component Water acted as driving mechanism of Late Cretaceous ocean circulation, but circulation evolved from a sluggish and partly regional to an ocean wide and open deep-water circulation until the end of the Mesozoic era (Donnadieu et al., 2016; Huber et al., 1995; MacLeod et al., 2011; Murphy and Thomas, 2013; Robinson and Vance, 2012).

The study of sediment drifts offers an approach to reconstruct palaeoceanography because the observed morphologic, stratigraphic and seismic characteristics allow for the interpretation of the pathway and approximate flow intensity of the water mass that was responsible for their development (Faugères et al., 1999; Hernández-Molina et al., 2006; Müller-Michaelis

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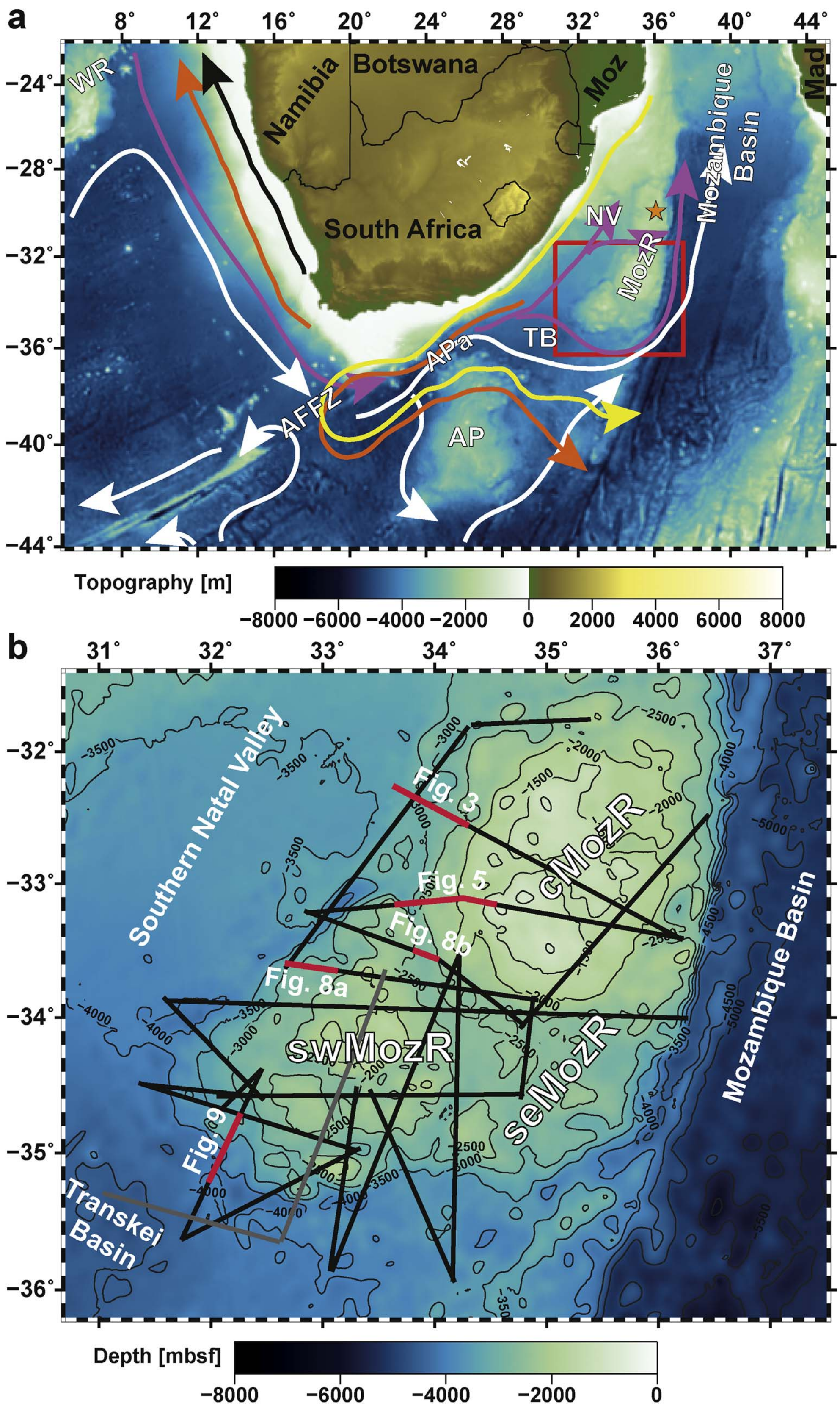


**Fig. 1.** **(a)** Bathymetric map (Weatherall et al., 2015) of S Africa with parts of the South Atlantic and SW Indian Ocean. The arrows show the schematic flow paths of surface currents and deeper water masses (Gruetzner and Uenzelmann-Neben, 2016; Lutjeharms, 2006; Uenzelmann-Neben and Huhn, 2009; Uenzelmann-Neben et al., 2007; Uenzelmann-Neben et al., 2011): Agulhas Current (yellow), Benguela Current (black), Antarctic Intermediate Water (orange), North Atlantic Deep Water (purple) and Antarctic Bottom Water (white). Orange star marks the location of DSDP Leg 25 Site 249 on the northern Mozambique Ridge. Red box indicates study area shown in Fig. 1b. AFFZ = Agulhas Falkland Fracture Zone; AP = Agulhas Plateau; APa = Agulhas Passage; Mad = Madagascar; Moz = Mozambique; MozR = Mozambique Ridge; NV = Natal Valley; TB = Transkei Basin; WR = Walvis Ridge. **(b)** Bathymetric map (Weatherall et al., 2015) of the study area in the southwestern Indian Ocean (500 m contour lines in black). MCS profiles of SO 183 are shown in grey and SO 232 are shown in black. Thick red lines mark intervals of MCS profiles shown in figures. cMozR = central Mozambique Ridge, swMozR = southwestern Mozambique Ridge, seMozR = southeastern Mozambique Ridge.

et al., 2013). The analysis of sediment drifts led to a proposed late Eocene to early Oligocene onset of current controlled sedimentation in the Transkei Basin SW of the MozR (Fig. 1a) (Schlüter and Uenzelmann-Neben, 2007), whereas onset of current controlled sedimentation at the MozR was suggested for ~15 Ma (Uenzelmann-Neben et al., 2011).

This study represents the second contribution to a series of three publications about the southern MozR that are based on a new high-resolution multichannel seismic (MCS) reflection survey. While the first study investigated the basement structure, origin and emplacement history of the southern MozR (Fischer et al., 2017), this manuscript