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ScienceDirect
Global and Planetary Change 60 (2008) 416–428
GLOBAL AND PLANETARY CHANGE
www.elsevier.com/locate/gloplacha

Indications for bottom current activity since Eocene times: The climate and ocean gateway archive of the Transkei Basin, South Africa

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Received 19 February 2007; accepted 17 July 2007
Available online 7 August 2007

Abstract

The Transkei Basin deposits document the sediment transport around South Africa and, hence, reveal details of palaeocurrent activity of this region for the past 36 my. Thermohaline driven water masses like the North Atlantic Deep Water (NADW) and the Antarctic Bottom Water (AABW), which are part of the global conveyor belt and the main motor for the heat transfer worldwide, have to pass the southern tip of Africa. A large amount of their sedimentary freight is deposited in the submarine Transkei Basin. By the investigation of high resolution seismic reflection data from central Transkei Basin sediments, we reconstructed depocentres and interface outlines for five different time slices since Cretaceous times. Since at least Late Eocene times, we observe an increasing activity of proto-AABW and later proto-NADW in the Transkei Basin. The current's settings were recurrently modified by various large scale global events, like the opening of the Drake Passage Gateway and the Tasman Gateway (~34 Ma), respectively, or the closure of the Panama Isthmus (~3 Ma). The investigations reveal a strong influence of global tectonic and climatic events on NADW and (proto-) AABW and their influence on Transkei Basin deposition.

Keywords: depocentres; depositional model; thermohaline circulation; current reconstruction; Transkei Basin; NADW; AABW; Agulhas Drift

1. Introduction

One of the world's most important motors for water exchange and global heat transfer is represented by the global conveyor belt, which is driven by various thermohaline currents spread all over the world's oceans. The flow paths of these thermohaline currents are determined by factors like Earth's rotation, the ocean floor topography, ocean gateways and prevailing wind directions. Sedimentary sequences that have been deposited and shaped by these long-term currents reveal information about flow paths, strengths and directions, and thus shed light on former current attributes and behaviour. A detailed reconstruction of palaeocurrent flow paths improves the knowledge of oceanic gateways and palaeoclimatic conditions and leads to a better understanding of their development. Off South Africa some of these large scale thermohaline currents, namely the cold North Atlantic Deep Water (NADW) and Antarctic Bottom Water (AABW) and the warm Agulhas Current (AC) meet within a small area. AABW is defined as all bottom waters of non-circumpolar water of Antarctic origin (Orsi et al., 1999). It is triggered by the Antarctic Circumpolar Current (ACC), which can be

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doi:10.1016/j.gloplacha.2007.07.002

observed since the opening of the Drake Passage and the Tasman Gateway for deep water at ~36 Ma, respectively (Stickley et al., 2004; Livermore et al., 2005). One branch of AABW originates in the Weddell Sea and flows northwards into the South Atlantic, where it splits off into an eastward and a westward flowing branch. NADW originates in Arctic regions and flows through the Atlantic southward into the Cape Basin, Southwest of South Africa. At the southwestern tip of Africa it turns to the East and flows, like parts of the AABW, through the Agulhas Passage into the Transkei Basin and the Natal Valley and further into the Mozambique and Somali Basin (Van Aken et al., 2004). Parts of NADW transform to Lower Circumpolar Deep Water by upwelling and mixing and flow back into the South Atlantic (Gordon, 1986; Park et al., 1993).

Today, NADW and AABW enter the Transkei Basin from the West through the Agulhas Passage (Mantyla and Reid, 1995; Arhan et al., 2003), while the AC flows from the Natal Valley (Fig. 1) westward into the Transkei Basin and through the Agulhas Passage further into the South Atlantic.

The region South of South Africa is characterised by two features, namely the submarine Agulhas Plateau and the Transkei Basin (Fig. 1). The Agulhas Plateau is a deep-sea plateau that rises up to 2000 m above the surrounding seafloor and lies in water depths around 4500 m. Between the Agulhas Plateau and the South African continental shelf we find the only 50 km wide Agulhas Passage, which represents the only deepwater gateway between the Indian and Atlantic Oceans in this region (Fig. 1).

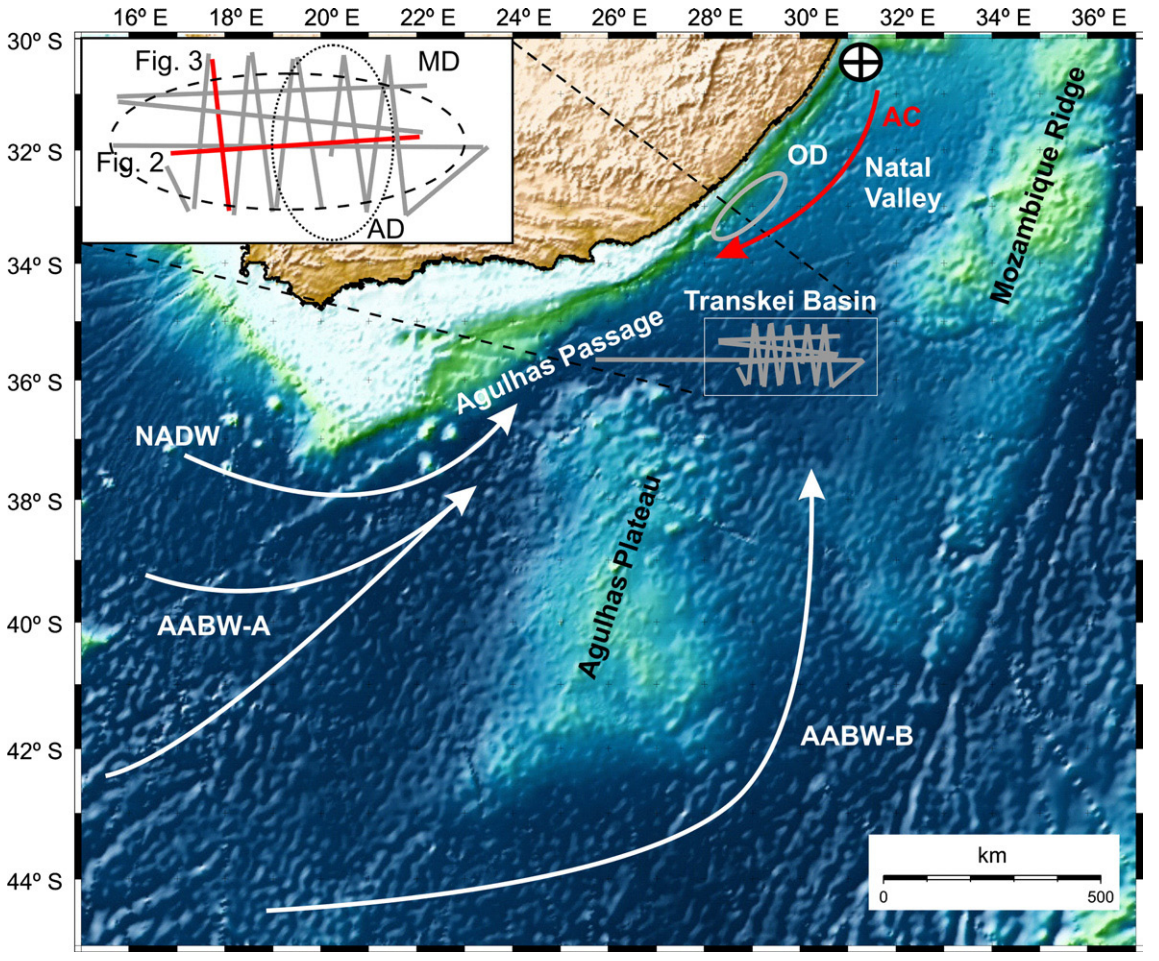

Fig. 1. Bathymetric map of the research area off South Africa (Smith and Sandwell, 1997) showing the location of seismic lines and ocean current flow paths (schematically). AABW-A: Antarctic Bottom Water flowing in WE direction; AABW-B: Antarctic Bottom Water flowing in SN direction; AC: Agulhas Current; AD: Agulhas Drift; MD: M-Drift; NADW: North Atlantic Deep Water; OD: Oribi Drift. Circle with cross: Bore hole near Stanger. Grey lines indicate location of seismic reflection profiles. Red indicated lines in blow-up show reflection seismic profiles shown in Figs. 2 and 3.