Available online at www.sciencedirect.com
ScienceDirect
Marine and Petroleum Geology 25 (2008) 989–999
Marine and Petroleum Geology
www.elsevier.com/locate/marpetgeo

Conspicuous seismic reflections in Upper Cretaceous sediments as evidence for black shales off South Africa

Philip Schlüter*, Gabriele Uenzelmann-Neben

Alfred Wegener Institute for Polar- and Marine Research, Bremerhaven, Germany

Received 3 July 2007; received in revised form 2 October 2007; accepted 5 October 2007

Abstract

The Upper Cretaceous is commonly associated with greenhouse climate, Oceanic Anoxic Events (OAE), and the ongoing break up of Gondwana, which resulted in strong variations of the ocean's currents flow paths and climate change. Little is known about these changing conditions, in particular south of South Africa. A high-resolution seismic reflection data set from the submarine Transkei Basin off South Africa revealed various depositional stages for this region for the past ~90 Ma. In these seismic sections, a recurrently appearing high-amplitude horizon within weak to homogeneous Upper Cretaceous reflections was observed. Due to the inaccessibility of any drill hole data from the Transkei Basin and adjacent regions, the origin of this reflector is difficult to specify. It is roughly dated at ~80–~85 Ma, which falls within the last big OAE in Upper Cretaceous (OAE 3). A seismostratigraphic analysis led to an exclusion of several features as the origin for this reflector, such as gas hydrates, opal bearing horizons or biogenic oil. Other possible features, such as lithologic variations, intrusions or black shales, are discussed in more detail. According to its appearance and reflection characteristics it could possibly be the first report of black shales in this region.

Keywords: Seismic stratigraphy; Deep-sea basin; Black shales; Oceanic Anoxic Event; Upper Cretaceous

1. Introduction

The oceanic and climatic conditions off South Africa since the Eocene have been the subject of research in several studies (e.g. Tucholke and Embley, 1984; Ben-Avraham et al., 1993; Niemi et al., 2000; Boebel et al., 2003; Schlüter and Uenzelmann-Neben, 2007a, b; Uenzelmann-Neben et al., 2007), but little is known from earlier stages. The Upper Cretaceous and early Palaeogene are characterised by the ongoing break-up of Gondwana and, hence, creation of new oceanic basins. Along with this tectonism, the oceanic circulation patterns as well as the global heat exchange altered significantly (Poole et al., 2005). Additionally, the beginning isolation of Antarctica is a key factor for the evolution of the palaeo-climatic conditions at that time (Kennett, 1977). The period between ~100 and ~50 Ma is characterised by a significant cooling of the Earth's climate, especially on the Southern Hemisphere (greenhouse to icehouse, Sellwood and Valdes, 2006).

The region south of South Africa is characterised by deep-sea basins and deep-sea plateaus that originated in Upper Cretaceous times, caused by the ongoing break-up of Gondwana since the Jurassic (König and Jokat, 2006). Due to the unique location of the submarine Transkei Basin within the varying current system off South Africa, its sedimentary content has been influenced by water masses since then and provides information about possible palaeo-current pathways and also palaeo-climate conditions. These data are important for climate reconstructions because they can shed light on the interdependence between different large-scale factors like changing current systems or ocean gateways and global climate change. Unfortunately, continuous sediment deposits from deep-sea basins since the Upper Cretaceous that are located at crucial gateways are rare and, consequentially, have not yet been studied extensively.

*Corresponding author. Tel.: +49 471 4831 1041; fax: +49 471 4831 1149.
E-mail address: Philip.schlueter@awi.de (P. Schlüter).

0264-8172/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.marpetgeo.2007.10.003

In 2005 a set of high-resolution seismic reflection profiles across the Transkei Basin was collected, which shows sedimentary infill at least representing the past 90 myr. Analysis of these sediments helps us to improve the knowledge about global water exchange, heat transfer and climate change, especially between ~90 and ~36 Ma.

2. Geological background

Today, the region south and southeast of South Africa is mainly characterised by the submarine Agulhas Plateau and the submarine Transkei Basin (Fig. 1). The Agulhas Plateau is a deep-sea plateau rising up to 2700 m above the surrounding seafloor and reaches a water depth of up to 1800 m. It is separated from the African continental shelf by the up to 4500 m-deep, East–West oriented Agulhas Passage. The deep-sea Transkei Basin is located east of the Agulhas Plateau and south of the adjacent submarine Natal Valley and reaches a water depth of 4500 m (Fig. 1). Within the central Transkei Basin, we observe up to 1800 m-thick sedimentary sequences (Schlüter and Uenzelmann-Neben, 2007a).

Determining the age of the Transkei Basin and its sedimentary infill is difficult due to the absence of any drill-core information within this region. Initial seafloor spreading off Southeast Africa between the Mozambique Ridge and East Antarctica commenced at 155 Ma (Jokat et al., 2003). The development of an extensional basin south of South Africa before 130 Ma is unlikely, due to the Maurice Ewing Bank (MEB), attached to the Falkland Bank (FB), which only later moved in a westerly direction (König and Jokat, 2006). Fig. 2 shows the situation at 80 Ma, where the MEB and the FB moved along the Agulhas Falkland Fracture Zone (AFFZ) further to the southwest. Studies of Goodlad et al. (1982) and Tikku et al. (2002), who used plate movement velocities and directions, revealed an initial rifting and with it the opening of the Transkei Basin at ~124 Ma. Although the rifting happened during the Cretaceous magnetic quiet zone (Fullerton et al., 1989), the development of the Transkei Basin, as well as the Agulhas Plateau, must have been finished at around 90 Ma (Dingle and Camden-Smith, 1979; Labrecque and Hayes, 1979; Martin and Hartnady, 1986; Ben-Avraham et al., 1993). The maximum age of the basin's sedimentary content must be around 90 Ma, therefore, this sedimentary infill was subdivided into two parts. The lowermost $\sim\frac{1}{2}$ of the Transkei Basin's sediment contains information about the Upper Cretaceous and the Early Paleogene, on which we focus in this study. The topmost $\sim\frac{1}{2}$ of the basin's sediments (Figs. 3 and 4, units 2–5) shows the influence of deep-bottom current activity in this region since late Eocene times (Schlüter and Uenzelmann-Neben, 2007b). Since ~36 Ma, Antarctic Bottom Water (AABW) or the North Atlantic Deep Water (NADW) flowed in eastward direction through the Agulhas Passage and the Transkei Basin around the South African coast and influenced sedimentation in the basins. The warm surface Agulhas Current (AC) flowed westward from the Indic into the South Atlantic Ocean.

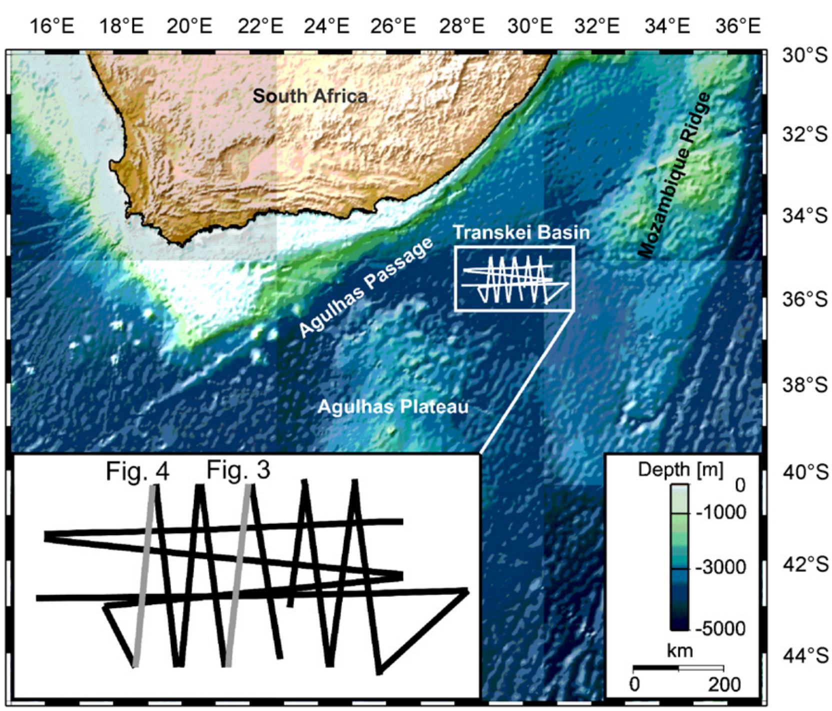

Fig. 1. Bathymetric map of the research area off South Africa (after Smith and Sandwell, 1997), showing the location of the seismic reflection lines in the central Transkei Basin. Grey indicated lines in the blow-up represent seismic profiles shown in Figs. 2 and 3.