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Structural features of the Southwest African continental margin according to results of lithosphere-scale 3D gravity and thermal modelling

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ABSTRACT

To understand the structure of the Southwest African continental margin, a lithosphere-scale 3D structural model has been developed, covering the marginal Cretaceous-Cenozoic Orange, Luderitz, Walvis and Namibe basins, the easternmost Walvis Ridge offshore. Onshore, the model includes two late-Proterozoic Owambo (Etosha) and Nama basins. This 3D model integrates published thickness maps (sediment isopach maps), shallow seismic and well data as well as published deep seismic information and has been additionally constrained by 3D gravity and thermal modelling.

Using 3D gravity modelling, the first order configuration of the crystalline crust has been resolved with respect to the location of the continent–ocean boundary. The distribution of a high-density lower crustal layer indicates a continuous body extending below the Cretaceous-Cenozoic depocentres and aligned parallel to the coast line. In addition, high-density zones within the continental crystalline crust had to be included in the model to fit observed and calculated gravity. The obtained Moho topography correlates with the major tectonic units of this continental margin.

The results of the 3D thermal modelling indicate that there is a clear relationship between the location of thickened sediments and areas with increased temperatures within the upper 10 km of the 3D model. This indicates that the low thermal conductivity of the sediments increases heat storage within the areas covered by thick sediments. Within the deeper crust, the main feature of the temperature distribution is the transition across the continental margin from the relatively cold oceanic part to the warm continental one. This regional pattern is controlled by the thickness of the crystalline continental crust, which is characterized by an increased radiogenic heat production. At a depth of 80–90 km, the temperature becomes higher beneath the oceanic domain than beneath the continent, reflecting the configuration of the lower thermal boundary which is represented by an isothermal lithosphere–asthenosphere boundary.

1. Introduction

The Southwest African continental margin offshore the western coast of South Africa and Namibia (Fig. 1) is a passive volcanic margin (Blaich et al., 2009; Brown et al., 1995; Gladczenko et al., 1997, 1998; Macdonald et al., 2003; O'Connor and Duncan, 1990; Talwani and Abreu, 2000). There, Early Cretaceous continental break-up resulted in the formation of oceanic lithosphere within the Atlantic Ocean between Africa and South America as well as in the formation of several sedimentary basins along the western African coast (e.g. Macdonald et al., 2003; Seranne and Anka, 2005; Stewart et al., 2000). Tectonically, the Southwest African continental margin encompasses the Orange, the Luderitz, the Walvis, and partially the Namibe basins (Fig. 2). All these basins have axes parallel to the present-day coastline of southwest Africa and contain thick sequences of Cenozoic to upper Lower Cretaceous post-breakup sediments, Upper Jurassic-lower Lower Cretaceous syn-breakup sediments and, possibly, Upper Carboniferous to Triassic-Lower Jurassic Karoo sediments (Clemson et al., 1999; Erlank et al., 1984) and sediments of older ages (Gladczenko et al., 1998). Consequently, the sedimentary archives in the area under consideration have recorded the main tectonic stages that occurred within the Southwest African continental margin. In addition, this segment of the West African continental margin is complicated by the presence of the NE–SW striking magmatic Walvis Ridge.

To analyse the present-day structure of the passive margin of South Africa and Namibia, a lithospheric-scale 3D model has been

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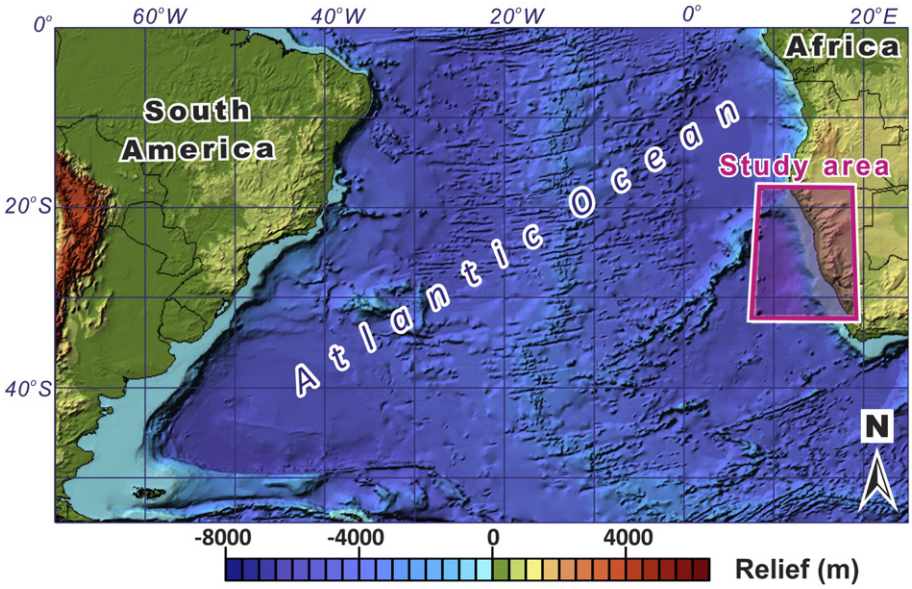

Fig. 1. Location of the study area within the Southern Atlantic (the bathymetry after IOC, IHO and BODC, 2003).

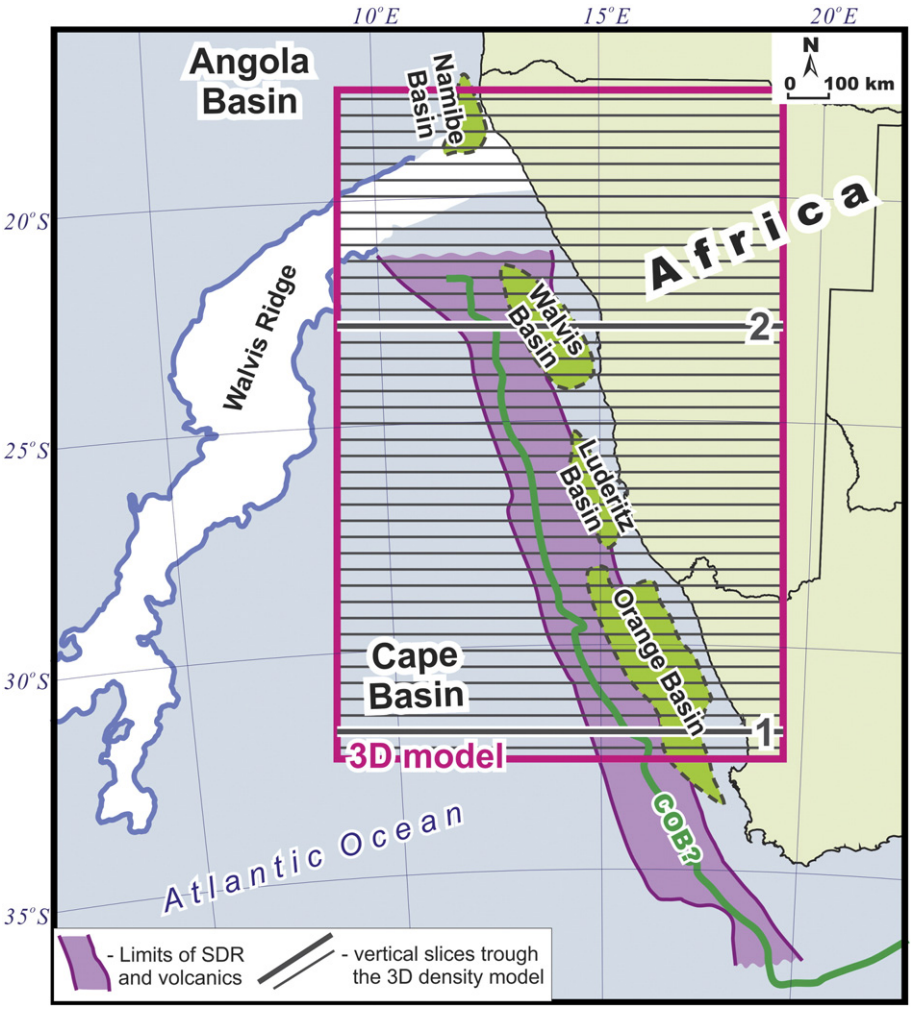

Fig. 2. Overview map of the Southwest African continental margin with location of the lithosphere-scale 3D structural/density model (after Light et al., 1993; Stewart et al., 2000). Black lines are the vertical slices through 3D model (two selected slices from Fig. 12 are highlighted by bold lines and numbering). SDR: seaward-dipping reflectors (after Bauer et al., 2000; Elliott et al., 2009) and COB: continent–ocean boundary (after Pawlowski, 2008).