Geophysical Research Abstracts, Vol. 9, 08038, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-08038

3D Gravity Modelling and Subsidence Analysis in the Orange Basin, Southwest African Continental Margin

K.K. Hirsch (1), M. Scheck-Wenderoth (1), D.A. Paton (2), R. di Primio (1), B. Horsfield (1), S.A.P.L. Cloetingh (3), F. Beekman (3)

(1) GeoForschungsZentrum Potsdam, Germany, (2) Colorado School of Mines, USA (3) Vrije Universiteit Amsterdam, Netherlands (Hirsch@gfz-potsdam.de / Fax: +49-331-288 1349 / Phone +49-331 288 1792)

Although the development of passive margins has been extensively studied over a number of decades, significant questions still remain on how mantle and crustal dynamics interact to generate the observed margin geometries. Here we investigate the Orange Basin, located on the south-west African continental margin, using 3D crustal models. The basin fill has been considered to comprise a classic rift-drift passive margin sequence recording the break-up of Gondwana and subsequent drifting of the South Atlantic.

A combined approach of subsidence analysis and crustal modelling was chosen to gain better insight into the interplay of rift tectonics and subsidence controlling mechanisms. The marine gravity field is characterised by a free-air gravity high with an adjacent low landwards, commonly referred to as the “edge-effect” anomaly. Static gravity modelling was undertaken to investigate the density structure of the lithosphere that best explains this anomaly.

Based on interpreted seismic reflection data, a 3D geological volume was generated. An isostatic calculation (Airy´s model) using a homogenous middle and lower crust was applied to this geomodel to derive the position of the Moho for an isostatically balanced system.

The best-fit model required dense, presumably mafic, material in the middle and lower crust. In addition, an abrupt change to less dense material is needed to reproduce the adjacent gravity low landwards. However, this type of model neither considers the dynamic nature of the margin nor accounts for other processes (e.g. sedimentation and magmatic underplating) that may play an important role in the evolution of the margin.

To address the dynamic margin evolution, backstripping/subsidence analysis was undertaken to identify the tectonic driving forces and quantify their magnitude and timing. From this it is possible to determine the influence of loading-induced subsidence on the margin, and thus incorporate it into future gravity modelling.

All of the wells, when backstripped, generated a similar subsidence pattern comprising three main phases in which the rate of subsidence changes remarkably. The first phase (130 Ma to 95 Ma), broadly agreeing with theoretical cooling curves, coincides with the end of rifting and onset of drifting in the South Atlantic. In addition this phase could be related to the coeval influence of the Tristan da Cunha Plume and related magmatism. This first phase and a later phase (95 Ma to 80 Ma) correlate with a maximum in denudation of onshore South Africa (Gallagher and Brown 1999, Tinker 2005). Furthermore, the phase of most rapid subsidence not only correlates with the denudation maximum onshore but also with maxima in kimberlite emplacement and related intrusions (Tinker, 2005). The final stage (post 80 Ma) shows a distinct deceleration in all backstripped wells on the continental shelf and deposition moves westward to the continental slope. Our results indicate that basin evolution is intimately related to onshore denudation processes and sediment supply, such that only a holistic approach allows the correct assessment of the driving forces.

Gallagher, K. and Brown, R., 1999. Denudation and uplift at passive margins: the record on the Atlantic Margin of southern Africa. Phil. Trans. R. Soc. Lond. A, 357(1753): 835-859.

Tinker, J., 2005. Using apatite fission track thermochronology and offshore sediment volumes to test the balance between denudation (onshore) and deposition (offshore) since Gondwana break-up., PhD Thesis, Department of Geological Sciences, University of Cape Town.