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Investigation of the South African continental passive margin using 3D lithospheric models

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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 data from the Orange Basin of South Africa using 3D lithospheric models.

The southwest African continental margin was formed by continental rifting during the Late Jurassic in response to extensional stress generated by the impending break-up of the South American and African continental plates.

One of the main present day depocenters along the margin is the post-rift Orange Basin, which provides an ideal study area to understand the entire process of margin evolution. A combined approach of subsidence analysis and crustal modelling was chosen to gain better insight into the interplay of rift tectonics, rift-related volcanic sequences, and seaward dipping reflector emplacement.

The marine gravity field of offshore southwest Africa is characterised by a free-air gravity high with an adjacent low landwards, commonly referred to as the "edge-effect" anomaly. As a product of rifting this anomaly has the potential to tell us something about the geometry and dynamics of the continental break-up.

Static gravity modelling was undertaken to investigate the density structure of the lithosphere that best explains the anomaly.

Based on interpreted seismic reflection data, a 3D geological volume was generated. An isostatic calculation (Airy´s model) was carried out for this geomodel to derive the Moho´s position for an isostatically balanced system. The initial model correctly reproduced the position of the edge-effect anomaly; however, it did not reproduce the observed wavelength or amplitude. This initial model assumed that the anomaly originated within the lower crust.

Further models were run in which the density structure of the crust was altered until the wavelength and amplitude of the anomaly were reproduced. The best-fit model requires 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, and the depth to the Moho has to be increased.

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.

The dynamics of margin evolution is revealed through subsidence analysis. Using techniques such as backstripping it is possible 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.