Paper Number: 4934

Integrated 3D Geophysical Model of the Main Karoo Basin

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The Main Karoo basin covers a large portion of South Africa, with the inland portion forming part of a high plateau (>1000 m, Figure 1). The basin passes over changing crustal and mantle terranes, thickening from ~1 km over the Archean Kaapvaal craton in the northeast to up to 5 km over the surrounding Proterozoic Namaqua-Natal belt (NNB, Figure 1). This is change is determined from wells [11, 12] and seismic data [4, 8, 9, 12] that were combined into a 3D model of the basin.

This deepening does not fit the regional ground gravity data, therefore the deep crust and mantle density structure below the basin were incorporated into the model. This change from on- to off-craton is correlated with a more mafic lower crust below the NNB as seen on seismic data [1, 2, 6, 9], and deepening of the Moho over the NNB as seen from teleseismic data (from 35-40 km to >45 km, [10]). The upper mantle velocities also change across the basin [5]. Fast velocities below the NNB are linked to refertilisation of the mantle resulting in an increase in mantle density as seen from xenolith data and gravity modelling [7; 14]. The long wavelength field associated with these changes in mantle density is quantitatively investigated in this study by inverting GOCE satellite gravity and gravity gradient data (Gzz, [3]). The inversion results show an approximate 35 to 50 kg/m^3 density decrease from off- to on-craton, which is in line with previous estimates [7]. An unrealistically deep Moho is, however, needed below Lesotho to model the strong gravity low in this region. This region is not covered by teleseismic data.

Loading at the base of this model (300 km) was calculated to determine if the model is isostatically compensated. As South Africa is not experiencing significant uplift or subsidence it is expected to be in equilibrium, thus providing a measure of the accuracy of the model. The high topography is shown to be largely compensated by the variations in Moho depths and mantle densities. Loading is, however, evident below Lesotho and the edge of the plateau (escarpment). This loading was compensated and the gravity low below the craton still fit with a similar residual by modelling a lower density in the asthenosphere below the escarpment (20 to 60 kg/m^3 decrease). The lower density body approximately follows the 1200 m topographic contour. This deeper density anomaly allows for more reasonable crustal thicknesses to be modelled below Lesotho, similar to surrounding depths. The anomaly compensating this high topography may, however, be deeper than modelled here, i.e., linked to the deeper Large Low Shear Velocity Province [13].

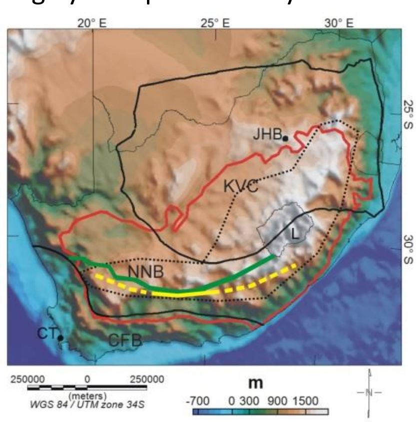

Figure 1. Topographic map of South Africa with the main tectonic

terranes marked: KVC – Kaapvaal Craton; NNB – Namaqua and Natal Proterozoic Belt and CFB – Cape Fold Belt. The Karoo basin (red line) and asthenospheric anomaly (black dots) are marked. The cities of Johannesburg (JHB) and Cape Town (CT) are shown, and the country of Lesotho (L).

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