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Regional structure of the Southwest African continental margin based on results of lithosphere-scale 3D gravity and thermal modelling

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A lithosphere-scale 3D structural model has been constructed in order to understand the structure of the Southwest African continental margin of South Africa and Namibia. This 3D model covers the marginal Cretaceous-Cenozoic Orange, Luderitz, Walvis and Namibe basins, the Walvis Ridge as well as two late-Proterozoic Owambo and Nama basins within the continent. The well-constrained 3D model has been used as a structural base for 3D gravity and thermal modelling.

The first order configuration of the crystalline crust has been derived by 3D gravity modelling additionally constrained by available deep seismic information. According to the results of the gravity modelling, the Walvis Ridge is underlain by relatively thin continental crust. An important result of this study is related to the 3D distribution of a high-density layer within the lower crust of the study area. The thickness of this high-density lower crustal layer is largest beneath the Walvis Ridge, reaching more than 30 km. In addition to the high-density lower crust, high-density zones within the continental crystalline crust had to be included into the model to fit observed and calculated gravity. The thickness of this layer is locally up to 40 km. The obtained configuration of the Moho clearly correlates with the major tectonic units of the Southwest African continental margin where a deep Moho corresponds to Precambrian continental crust and a shallow one is located beneath the younger oceanic crustal domain.

3D thermal modelling has been carried out, assuming that the Southwest African continental margin has already reached steady-state conditions and that heat conduction is the dominant mechanism of heat transfer. The obtained results of the 3D thermal modelling demonstrate that there is a clear correlation between the location of thick sediments and areas with increased temperatures within the upper part of the 3D model. This implies that the low thermal conductivity of the sediments causes heat storage within the areas where sediments are thick. On the other hand, the main feature of the temperature distribution in the deeper part of the lithosphere is a gradual transition across the continental margin from a relatively cold oceanic part to a warmer continental part. This regional pattern is controlled by the large thickness of the continental crystalline crust, which is characterized by an increased radiogenic heat production in comparison to the upper mantle. Nonetheless, at a depth of 80-90 km, the temperature beneath the oceanic crustal domain is higher than beneath the continental domain, reflecting the configuration of the lower thermal boundary, which is represented by an isothermal lithosphere-asthenosphere boundary.