An integrated approach to 3D geological modelling of the Western Bredasdorp Basin (South Africa)

W.A. Sonibare\textsuperscript{1,2}, M. Scheck-Wenderoth\textsuperscript{2}, J. Sippel\textsuperscript{2}, R. di Primio\textsuperscript{2}, Z. Anka\textsuperscript{2}, D. Mikeš\textsuperscript{1}

1. Earth Sciences, Stellenbosch University, South Africa (shoniwas@yahoo.com)
2. Department 4 “Chemistry of the Earth” Deutsches GeoForschungsZentrum - GFZ, Potsdam, Germany

\textbf{ABSTRACT}

Defining a realistic geological model to reconstruct present-day basin configuration and its temporal evolution relies principally on the accurate prediction of geologic assumptions (boundary conditions). Though several geo-modelling efforts, in recent years, have focused on delimiting the associated uncertainties relating to these assumptions, a rigorous modelling workflow that attempts to quantify the effect of these uncertainties at all scales, and particularly in three-dimensions is still lacking. Here, we present the application of a 3D geological modelling procedure, involving both conceptual and numerical approaches and based on a multi-disciplinary and multi-scale dataset, to assess the geodynamic implications of crust-mantle dynamics on the observed basin-fill geometry as well as its hydrocarbon potential. The focus of this study i.e. the Western Bredasdorp Basin constitutes the extreme western section of the larger Bredasdorp sub-basin, which is the westernmost of the five southern South Africa offshore sub-basins (others being Infanta, Pletmos, Gamtoos and Algoa). Interpretation of 1200 km 2D seismic-reflection profiles together with the analysis of well logs and cores are integrated into a consistent 3D structural model which consists of 10 stratigraphic layers- representing the syn-rift to post-rift successions with basin-fill geometric information and lithology-depth-dependent properties (porosities and densities). Isostatic compensation combined with 3D gravity modelling was subsequently performed to predict the depth to the crust-mantle boundary (Moho) as well as the crustal density. A heterogeneous upper crustal layer, consisting of pre-rift meta-sediments with a series of structural domains, gives the best consistency with the measured gravity field. A rather fast and short-lived subsidence is interpreted for the syn-rift phase based on the analysis of thickness distribution pattern and sedimentation rate, leading to the inference of a pull-apart basin structural style for the study area.

Three syn-rift (pre-Valanginian and Hauterivian) and three post-rift (Aptian, Barremian and Turonian) source rock intervals are modelled for hydrocarbon generation. Basal heat-flow incorporating radiogenic heat production from our crustal model gives a straightforward calibration of the present-day maturity. In order to further constrain thermal maturity within the basin, we employ vitrinite reflectance data from which an observation of a varied paleo-thermal history is obvious. Therefore, a variety of erosive, paleo-thermal and mantle-related hotspot events are currently being explored for a full calibration of the timing of hydrocarbon generation.

\textbf{KEYWORDS:} 3D geological modelling, Crustal-scale basin model, Thermal maturity calibration, 3D petroleum system modelling, Western Bredasdorp Basin