[PS]Structural Architecture of the Southern Orange Basin, Block 5/6, Offshore South Africa*

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Abstract

The Orange Basin is a passive margin recording the continental break-up of Gondwana by tectonic processes involving rifting and drifting of the South Atlantic Ocean. The northern part of the Orange basin preserves the main depocentre where the remarkable Ibhubesi Gas Field is located. Based on exploratory results the tectonostratigraphy, the Orange Basin is characterised by syn-rift grabens and half-grabens, as well as thick Barremian-Lower Aptian post-rift sequences ranging in thickness from 7 km in the north to 3 km in the south. The post-rift sedimentary succession in the south is thinner, resulting in potential for oil-prone source rocks compared to the northern side of the Orange Basin which is gas prone.

In this study the subsurface stratigraphy and structural architecture of the southern part of the basin is delineated through the interpretation of 2D reflection seismic data from Block 5/6. The structural deformation revealed by the southern Orange Basin records the compressional domain - transitional domain – extensional domain; marked by the presence of grabens, toe thrust structures and listric faults, respectively. Transform faults act as conduits for gas seepage which is a positive indication for an existence of an active petroleum system. The transitional crust is characterised by seaward dipping reflectors, volcanics interbedded with siliclastic sediments and volcanic intrusions. Investigation of the southern segment of the Orange Basin presents an opportunity to examine the under-explored ultra-deep waters where there is potential for deep-seated slope fans (canyon fill and slumped blocks) and basin floor fans (turbidites and channelized facies).

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Introduction

The 191 600 km^2 Orange Basin (OB) is a passive margin basin recording the continental break-up of Gondwana by tectonic processes involving rifting and drifting of the South Atlantic Ocean (Figure 1A). The OB extends from Namibia to South Africa and two remarkable gas fields have been discovered to date; the Kudu gas field located offshore southern Namibia and the Ibhubesi gas field in western South Africa (Figure 1B). In South Africa, the Orange Basin is 145 000 km^2 in extent (Broad et al., 2006), making it volumetrically the largest offshore basin. The northern sector of the basin preserves the main depocentre where confidence in the existence of an active petroleum system is verified by the notable gas discoveries and one oil discovery in sparsely distributed wells (Van der Spuy et al., 2003) see Figure 1C. Structurally, syn-rift grabens and half-grabens; growth faults and fault traps have been identified. The post-rift (transitional) Barremian-Lower Aptian sequences range in thickness from 7 km in the north to 3 km in the south (Figure 1B) and evidence exists that the underlying basement topography (Figure 1D) contributed significantly to the sediment deposition (Petroleum Agency SA internal report, 2013). The drift and late-drift tectono-stratigraphic sequences are Cretaceous and Cenozoic in age (Brown et al., 1995).

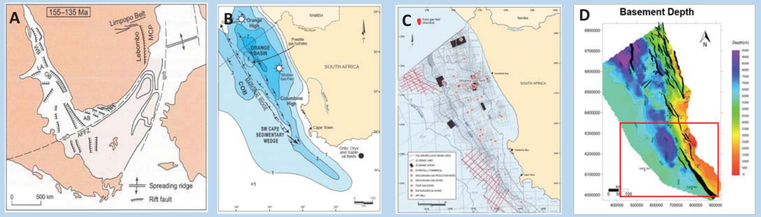

Figure 1: **A)** Figure showing Pangaea during stage 3 indicating fracture systems associated with the split of Gondwana into two plates (Watkeys, 2006). WB – Walvis Basin, LA – Luderitz Arch, OB – Orange Basin, AFFZ – Agulhas-Falkland Fracture Zone, AB – Agulhas Bank, GM – Gulf of Mexico, WS – Walvis, MCP – Mozambique Coastal Plain. **B)** Isopach map outlining the Orange Basin in km. The Ikudu and Ibhubesi gas fields along the Southwest African Coastal Basin are shown (Petroleum Agency SA, 2015). **C)** Figure showing the extensive seismic data coverage in South Africa with sparsely distributed wells as one well is found per 4000 km^2 (Petroleum Agency SA, 2015). **D)** The depth map of basement Orange Basin (Petroleum Agency SA internal report, 2013).

Study Area

The study area is located in the southern part of the Orange Basin within exploration licence block 5/6 (Figure 2), which is operated by Anadarko (80%) and PetroSA (20%). High-resolution 2D reflection seismic data acquired for the southern part of the Orange Basin consists of vintage surveys ranging from 1976 up to 2002. In this study, the seismic subsurface stratigraphy and structural architecture of the southern part of the basin is delineated through the interpretation of 2D reflection seismic data from Block 5/6 using the Kingdom Suite Interpretation software package. The post-rift sedimentary succession in the south is thinner resulting in potential for oil-prone source rocks whilst the northern side of the Orange basin which is gas prone. In the southern portion the A-C and A-N wells drilled up to a depth of 4176 m and 3753 m respectively, reveal Barremian gas shows and oil staining (Petroleum Agency SA report, 2013).

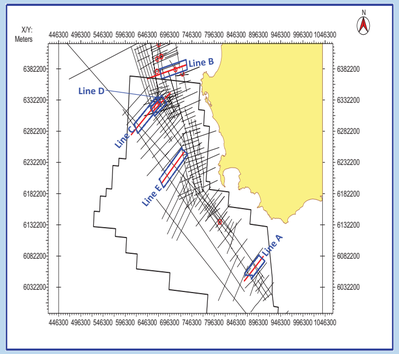

Figure 2: Figure showing the coastline of South African and the extent of 2D seismic data covering the southern part of the Orange Basin. The lines used in subsequent figures to illustrate structural features such as grabens, sag phase, transitional crust, intrusions. Bock 5/6 outline is shown for ease of reference.

Structural setting of the Southern Orange Basin

The structural deformation revealed by the southern Orange Basin records the compressional domain - transitional domain – extensional domain. The initial rifting phase is marked by the presence of syn-rift grabens and half grabens which trend parallel to the present day shoreline (Figure 3 and Figure 4), These grabens are infilled by volcanoclastic material. The transitional crust is characterised by seaward dipping reflectors (SDRs), volcanics interbedded with siliclastic sediments and volcanic intrusions. The packages of SDR signify stages of rifting and lava outpourings during the opening of the southwestern Atlantic margin. These SDR packages mainly comprise of basaltic extrusives interbedded with fluvial deposits (Figure 5 and Figure 7). Pure zones of volcanic sequences and intrusions dominate westwards towards the mid-oceanic ridge (MOR). The paleo high areas where carbonate platforms were possibly built are postulated as potential carbonate plays (Figure 7). Transform faults act as conduits for gas seepage which is a positive indication for an existence of an active petroleum system. Noted listric faults are dominant in the drift section of the basin (Figure 5 and Figure 6). Paleo-canyons and modern day canyons are noted along the steep shelf in the southern sector of the Orange Basin (Figure 8).

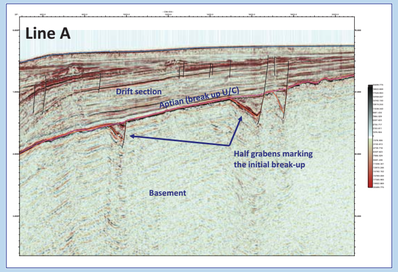

Figure 3: Interpreted seismic line (TWT) showing a series of half grabens.

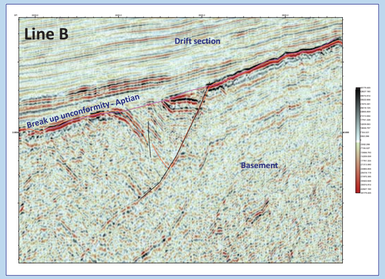

Figure 4: Interpreted seismic line (TWT) showing a close up view of the half graben.

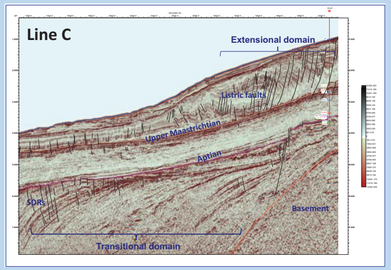

Figure 5: Interpreted seismic section (TWT) showing the transitional domain marked by SDRs and the extension domain marked by the presence of listric faults.

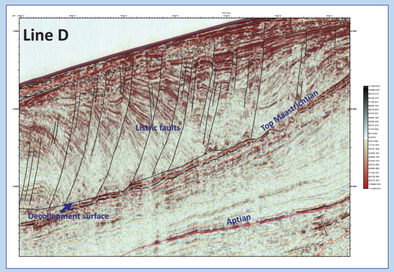

Figure 6: Interpreted seismic section (TWT) showing a close up view of listric faults. Note the increase in sediment thickness towards the fault.

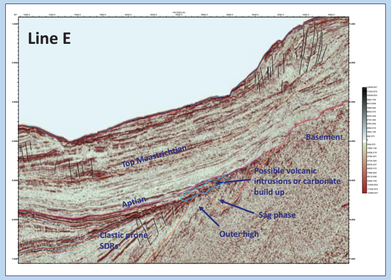

Figure 7: Interpreted seismic line (TWT) showing seaward dipping reflectors (SDRs) onlapping onto the outer high. Note the possible volcanic intrusions or carbonate build up on the outer high region.

Figure 8: Google Earth image showing a series of notable canyons along the steep shelf edge in the Southern Orange Basin.

Conclusion and Future work:

The structural setting revealed by the southern section of the Orange Basin shows potential for petroleum accumulation as noted by the presence of toe-thrust lead areas, gas chimneys, gas and oil shows indicating an active petroleum system. This research offers an opportunity for examining the under-explored ultra-deep water areas where potential for deep seated slope fans (canyon fill and slumped blocks) and basin floor fans (turbidites and channelized facies) is predicted. Understanding of the structural architecture of the southern Orange Basin will be beneficial for the re-evaluation of prospectivity in the southern section to better frame the exploration strategies. Further work focusing on detailed seismic interpretation, sequence stratigraphy, and basin modelling work will assist in further constraining the structural setting of the southern segment of the Orange Basin; which will significantly contribute to the greater understanding of the regional geology of the Orange Basin.

References:

Broad, D.S., Jungslager, E.H.A., Mclachlan, I.R. and Roux, J. (2006). Offshore Mesozoic Basins. In: Johnson, M.R., Anhaeusser, C.R. and Thomas, R.J. (Eds.), The Geology of South Africa. Geological Society of South Africa, Johannesburg/Council for Geoscience, Pretoria, 553-571.

Brown, L.F. Jr., Benson, J.M., Brink, G.J., Doherty, S., Jollands, A., Jungslager, E.H.A., Keenan, J.H.G., Muntingh, A. and Van Wyk, N.J.S. (1995). Sequence stratigraphy in offshore South African divergent basins. In: Am. Ass. Petrol. Geol., Studies in Geology, 41, An Atlas on Exploration for Cretaceous Lowstand traps, by Soekor (Pty) Ltd., 0-183.

Jungslager, E.H.A. (1991). Integration of borehole data with the regional seismic/sequence stratigraphic framework of the western offshore, South Africa. S. Afr. Geophys. Ass, 2nd Tech. Mtng., abstracts, 105.

Petroleum Agency SA internal report. (2013). Basin Analysis Study of the Orange Basin, authors: A. Fielies, A. Davids , J.Salomo, S.Davids, C. Van Bloemenstein and J. Roux: s.n.

Petroleum Agency SA. (2015). Petroleum Exploration in South Africa, Cape Town: s.n.

Van der Spuy, D., Jikelo, N. A., Ziegler, T., and Bowyer, M. (2003). Deepwater 2D data reveal Orange basin objectives off western South Africa. Oil and gas journal, 101(14), 44-49.

Watkeys, M. K. (2006). Gondwana break-up: a South African perspective. The geology of South Africa. Johannesburg & Pretoria: Geological Society of South Africa & The Council for Geoscience, 531-539.