Characterization of Hydrocarbon Generation and Migration Dynamics Based on Seismic Interpretation and Basin Modeling: An Integrated Study of the Orange Basin, South Africa

Alexander Hartwig [1], Donna Boyd [2], Gesa Kuhlmann [3], Selwyn G. Adams [4], Curnell Campher [5], Zahie Anka [1], Rolando Di Primio [1], Tony Albrecht [6], and Varsha Singh [7]
[1]Deutsches GeoForschungsZentrum GFZ, Potsdam, Germany.
[2]AEON, University of Cape Town, Cape Town, South Africa.
[3]Bundesanstalt für Geowissenschaften und Rohstoffe, Berlin, Germany.
[4]University of Western Cape, Cape Town, South Africa.
[5]Petroleum Agency South Africa, Cape Town, South Africa.
[6]Forest Oil Corporation, Denver, CO.
[7]PetroSA, Cape Town, South Africa.

Gas chimneys, pockmarks, seafloor mounds, and seismic anomalies associated with gas migration have been identified throughout the Orange Basin, South Africa. Using a 2-D seismic dataset covering exploration blocks 1 through 4, located on the western passive margin of South Africa gas escape features have been identified on a basin-scale. Seismic interpretation as well as identification and characterization of gas leakage are the first steps for the construction of a basin-wide petroleum system model. Previous research has been carried out in blocks 2, 3 and 4 to understand the petroleum system evolution of the southern Orange Basin. Integration of these results with ongoing investigation on northernmost block 1 provides new insights and a basin-wide view into the gas migration and seepage dynamics of the South African Orange Basin.

Based on their association with the basin elements, gas leakage in the Orange Basin has been classified into two main categories: stratigraphic and structurally controlled. Stratigraphically-controlled gas chimneys occur above onlaps and pinch-outs of Aptian aged sequences. These chimneys either reach the surface, are sealed within the Miocene, or terminate at the Cretaceous-Paleogene unconformity (22At1). Their occurrence throughout the study area is constrained to the shelf up to water depths less than 400 m. Active structurally-controlled gas chimneys are only found in the northern part of the basin. They occur dominantly in the extensional domain west of the present-day shelf break and above Cretaceous normal faults.

A fundamental understanding of the controls on present-day and paleo gas seepage is essential when calibrating the reconstructed thermal and burial history of the Orange Basin, especially with respect to the simulation of hydrocarbon generation, migration, sequestration, and leakage. Our efforts are leading to an integrated 3-D petroleum system model of the entire Orange Basin, in which new compositional kinetics for Aptian/Albian and Cenomanian/Turonian source rock samples from ODP wells will be used to constrain thermogenic methane contribution to the hydro- and atmosphere as a function of geologic time.