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Modelling hydrocarbon generation and migration within a passive continental margin setting, Orange Basin (South Africa)

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Natural gas leakage is observed along most continental margins of the world. In the form of methane and carbon dioxide these gases are highly relevant as greenhouse gases. Their origin and amount contributing to climate change is still under discussion. These gases are either sourced through biogenic gas generation, gas hydrate dissociation or derived by thermogenic hydrocarbon generation from buried source rocks. Recently, surface features like mud volcanoes, pock marks and possibly cold-water corals have been recognised and gas seepage events have been mapped from seismic sections in the Orange Basin (Ben Avraham et al., 2002; Paton et al., in prep). The Orange Basin at the western African passive continental margin is one of the main depocentres in the South Atlantic covering the Early Cretaceous rifting stage with the opening of the Atlantic Ocean and the succeeding Late Cretaceous to Tertiary drifting stage. It represents an ideal region to study the controls on the location, initiation and evolution of these surface and buried features.

Here we investigate a transect across the basin margin from the shelf region to the deep marine domain including the time-frame from syn-rift through post-rift to the present day. The model building (Petromod, IES GmbH, Germany) is based on interpreted seismic sections and input variables calibrated to available well data and geochemical data. The input variables for each time interval are the age of deposition, sediment thickness, bathymetry, sediment-air or sediment-water interface temperatures, the heat flow into the sedimentary column over time as well as source rock parameters (TOC, hydrogen index). Within the basin three different source rocks are available for po-

tential hydrocarbon generation. These are an Upper Jurassic-Neocomian lacustrine source rock (Type I) within local syn-rift graben structures, a Barremian-Lower Aptian marine-transitional source rock (Type II to III) which is sourcing two commercial gas fields (Kudu and Ibubhesi) in the basin and an uncertain Cenomanian-Turonian marine source rock (assumed Type II).

Through initial modelling using the phase kinetic approach by Di Primio and Horsfield (2006) the petroleum system evolution and source rock maturity has been reconstructed for each time step. The Barremian-Aptian source rock is the most relevant source for the studied interval and maturity is most sensitive to the heat flow and sedimentary load. For gas migration through the sediment column variations in lithology as well as physical properties (e.g. porosity, density, compressibility, permeability, thermal conductivity and heat capacity) are highly relevant and have been tested in the model runs. The fluid flow predictions were calibrated against observed gas chimneys in the seismics. The timing of possible leakage events, fluid flow direction as well as the volume of hydrocarbon generation was calculated for each time-step in the model.

Such a modelling approach is aimed to help estimating the volume of leakage through the sediments into the ocean and will furthermore lead to a better understanding on associated processes at passive margin like the presence and stability of gas hydrates and slope stability.

References: Ben Avraham, Z., Smith, G., Reshef, M., and Jungslager, E. (2002). Gas hydrate and mud volcanoes on the southwest African continental margin off Sough Africa. Geology, 30 (10), 927-930. Di Primio, R.; Horsfield, B. (2006): From petroleum-type organofacies to hydrocarbon phase prediction, AAPG Bulletin, 90, 7, 1031-1058.