HYDROCARBON GENERATION, MIGRATION AND CHARGE RISK FOR DEEP WATER PLAYS ALONG THE BRAZILIAN PASSIVE MARGIN ASSESSED WITH 3D PETROLEUM SYSTEMS MODELLING

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The Brazilian passive margin has been one of the most prolific areas for deep water hydrocarbon exploration during the last decade. Recent giant discoveries such as the Mexilhao gas and condensate field (around 5 tcf) in the Santos basin or the Jubarte/Cachalote oil fields with more than 8 Bbbls of proven reserves in the Northern Campos basin demonstrate the potential of the passive margin of Brazil. Nevertheless, the inherent risk of dry holes or non-commercial discoveries is accompanied by the high costs of ultra-deep-water hydrocarbon exploration. The prediction and correct characterization of hydrocarbon composition, phase behavior and properties (e.g. API gravities and GOR's) is therefore of great importance. In order to understand and study the petroleum systems and the hydrocarbon occurrence **as well as the** compositions, a set of 3D-Exploration models for the Santos, Campos and Espirito Santo basin were created.

A 3D-Exploration model is based on all available geophysical, geological and geochemical data, and simulates the complete hydrocarbon charge process from generation, expulsion, migration and loss. Special emphasis is placed on the composition of the hydrocarbon fluids with a resultant assignment of multi-component kinetics for a correct hydrocarbon phase modeling, a "geologically" correct salt reconstruction through space and time and the risk of hydrocarbon alteration by biodegradation. The simulations were performed with a Hybrid 3D simulator combining Darcy, flowpath and invasive percolation modeling technology with fully coupled pvt-controlled (PVT-Flash) multi-component modeling throughout the entire migration process.

The regional scale 3D exploration models have a grid resolution of 250 x 250 m and are based on structural maps using 2D and/or 3D seismic data. The stratigraphic column incorporated into the models comprises sediments from Early Cretaceous up to present day. 2D structural balancing was used to analyze and quantify the salt timing. In order to apply

geologically meaningful paleo-geometries of the salt through space and time, the sedimentary thickness of the overburden was analyzed, assuming that the vertical stress is the most important controlling parameter.

Hydrocarbon mass balance analysis and source rock tracking using these models show a clear predominance of the rift stage Barremian lacustrine source rocks which correlates with the observed isotopic signal and biomarkers. The Albian and Cenomanian/Turonian drift marine source rocks are in many areas immature and have therefore only a localized influence on the hydrocarbon charge of the various reservoir systems (mainly turbiditic sandstone sequences in the Upper Cretaceous and Tertiary). The detailed charge history analysis for the Campos basin, for example, shows two significant charge pulses related to the salt timing and the subsidence / burial history. The first pulse is mainly related to the initial opening of the salt windows charging Cretaceous structures. The shallow burial of these structures lead, in our opinion, to a high degree of alteration of the entrapped hydrocarbons. Induced by further burial in the Tertiary, a second pulse of hydrocarbons was generated and charged the Cretaceous and Tertiary structures. This leads to a complex accumulation pattern: hydrocarbons with altered hydrocarbon of Cretaceous age mixed with fresh hydrocarbons of Tertiary age. We will show the complexity and the interaction of the different driving parameters for the charge and the risk of alteration. This explains the diversity and complexity of the occurring hydrocarbons along the passive margin of Brazil.

The application examples illustrate how a quantitative charge risk analysis can be performed, and how the controlling geologic risk factors can be assessed in a consistent and dynamic way. The modeling results provide a significant improvement of the understanding of the evolution of the petroleum systems and are used to support exploration decisions in the region.