Numerical Modeling of the Thermal Maturation, Petroleum Generation and Migration in the Central Tucano Basin, Brazil

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Basin modeling results of the central Tucano basin, including 1D and 2D models, are discussed in this paper.

The Tucano basin, located onshore northeast Brazil, is part of an aborted rift system, originated in the Neocomian, and consists of east and west dipping half-grabens. The sedimentary fill in the prerift stage is mainly of Jurassic age and includes the potential reservoir of the Sergi Fm. The synrift development (Berriasian-Aptian) began with the main potential source rock of Candeias Fm, and was followed by a thick sandstone succession of the Ilhas and Massacara Groups.

Two regional seismic lines and four wells were modeled. Calibration was achieved considering eroded thickness from the upper to middle synrift succession that increases towards the western border.

The models indicate that generation and expulsion could have occurred in the depocenters. Petroleum saturation and migration was mainly restricted to the depocenter. Uncertainties are related to the presence of effective source rocks. The principal pulse of petroleum generation-expulsion for the Candeias Fm could occur during Barremian-Aptian times, coeval with sedimentation of the Massacara Group.

Model results indicate that the migration of fluids was influenced by faulting. Compartmentalization is present, especially with an impervious fault model. Vertical leakage is highly effective with pervious faults. Sergi Fm could represent an effective carrier bed in some regions. Petroleum accumulations appear mainly restricted to traps associated to, or near the depocenter.

Future Exploration Strategy of a Frontier Offshore Campeche Area Provided by Basin Modelling

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Previous regional one-dimensional basin modelling studies suggest a possible deficiency in hydrocarbon charge originated by low source rocks maturity in a frontier region of the northeastern offshore Campeche production area. Updated geological, geophysical and geochemical interpretation of the area and a combination of multi-one- dimensional with two- and three dimensional basin models, were developed. An evaluation of the hydrocarbon charge, pathways and types of migration, as well as volumes of trapped hydrocarbons were determined at each prospect. Two-dimensional models contributed to the detection of possible seal failures and to the assessment of the amount of hydrocarbon losses during migration. By integrating these results to multi-one-dimensional basin models it was possible to visualize that the biggest traps do not necessarily contain the highest hydrocarbon volumes.The real three-dimensional model allowed us to observe changes of petroleum saturations in three-dimensions through time and corroborate the predominant migration style. It also helped to identify structures that might have the most attractive hydrocarbon saturations. The application of these tools allows us to do a more precise geologic risk analysis and improve the ranking of exploration opportunities by better understanding of both the regional source rock maturity and the volume of trapped hydrocarbons in each prospect. This study has provided a new exploration strategy on this frontier area.

Sensitivity and uncertainty analysis in basin modeling to quantify the value of data

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In basin modeling, uncertainties exist concerning the geologic concept of a model, its assumptions and its input parameters. Therefore, outcomes of geologic models should be expressed in a probabilistic rather than a single-valued form. Monte Carlo methods are not appropriate because they need many realisations which is not feasible for multidimensional non-linear basin models due to their oftentimes extensive computing times. Methods of experimental design and response surface modeling are more appropriate because they sample the parameter space in an optimal manner thereby reducing the number of necessary model runs significantly. Higher-order designs can be used to describe the actual behavior of the response function and their uncertainty. Well data, seismic data or laboratory data are used to constrain the model outcome. Their potential in reducing uncertainty can be determined and therefore the actual value of available data and data to be acquired can be quantified.

It is the particular geological history and the particular exploration and modeling question that determines which parameters are most important and which type of data has the greatest influence on the model response and therefore the greatest value in reducing the uncertainty of the model outcome. Applications to 1D thermal modeling show that maturity of source rocks and timing of HC generation and expulsion can be a complex function of individual parameters such as heat flow history and source rock type but also of the interaction of parameters which is frequently neglected. 2D fluid flow modeling is particularly sensitive to permeability structure and to sedimentation history while 3D migration is sensitive to spatial distributions of thermal, geochemical and structural geological parameters. Examples of all three applications will be shown

Wadi Aabeid Field in Northwest Euphrates Graben in Central Syria

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Heavy oil was discovered in Cretaceous Rmah and Judea formations in the Wadi Aabeid structure in 1990 in the northwest Euphrates graben at approximately 2000m. The structure is an elongated domal anticline located on the up thrown side of a deep-seated east west fault bounding the Euphrates-Palmyride transition zone. Since then a 3D survey has been shot and several wells were drilled to develop the field. The Rmah formation is composed of organic rich dark brown chert and brown argillaceous limestone and Judea formation is mostly sucrosic dolomite with lesser amounts of limestone and mudstone. The production comes from fracture and primary porosities in these formations. The discovery well tested 6800 BOPD. Although, the field is structurally controlled, the fracture porosity is unevenly distributed. The knowledge of fracture porosity is an important issue in field development since the flow capacity of wells is greatly improved by proper acidification.

Rmah chert with Type II Kerogen is immature in all wells studied within and surrounding the field. Basin modeling suggests that hydrocarbons found in the Wadi Aabeid field have been migrated from depth from other source rocks in adjacent basins via deep seated faults.

Various attribute maps and neural net generated seismic and attribute facies maps for the producing interval suggest a NW-SE and NE-SW conjugate fault system which possibly controls the fracture system. These maps have provided useful guidance in the development of Wadi Aabeid field.

Exploration of a Frontier Area Using Numerical Stratigraphical Modeling, Application to the Offshore Colorado Basin of Argentina

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In the Argentine Continental Margin, the Colorado Basin (160,000 km²) records 12,000 m. of continental and marine sediments. With the 3000 km of 2D seismic shot in 1999, began the commercial exploration of the deep water areas (1000-3500 m). Currently, a few wells located on the basin borders investigated only the upper-third (Upper Cretaceous to Quaternary) of the sedimentary column. In order to optimize and validate the geological model, a numerical stratigraphical approach (Dionisos) was used to simulate a 3D model of the stratigraphic architecture detailing sequences and facies distribution of the eastern part of the basin. The software simulates erosion, transport and deposition of the sediments using macro-scale physical laws and geological input (accommodation maps).

The Colorado Basin initiated by a Lower Mesozoic rifting-period was followed by a Cretaceous to Miocene sag period that ultimately reached the present day passive margin configuration. The simulation has quantified the geological parameters and evaluated the facies distribution, including the non-drilled areas (Lower Cretaceous, Jurassic, the eastern part of the basin). Matching with the seismic information, the simulation indicates a drastic change from continental to restricted and the open marine environments around the Atlantic spreading period corresponding to the beginning of the sag phase.

Focusing on the methodology, this study shows the different stages of the stratigraphic modeling from the interpretation of the dataset (seismic lines, cuttings, wireline logs and paleontological data) to the model validation. This study clearly illustrates the interest in stratigraphic modeling techniques for basin exploration with relatively few data.