PRACTICAL BASIN MODELING: CASE STUDIES FROM THE GREATER CAMPOS BASIN, BRAZIL FOCUSED ON EXPLORATION RISKING AND DECISION SUPPORT

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Over the past two decades, traditional basin models have become increasingly sophisticated. However, in many instances these advances have outpaced the geologic data available for validation, and as a result modern basin models are frequently under-constrained. That is, while the sophistication of algorithms that simulate the various basin processes has evolved, key model parameters such as subsurface temperature, heat flow, and even chronostratigraphy are poorly understood or unknown. This is especially true in frontier areas where charge is a key issue and well control is limited or lacking.

This presentation highlights a simpler and more practical modeling approach that quickly quantifies key charge aspects in order to predict parameters such as volumes, GOR, fluid phases and post-generative alteration. The approach is based on an interactive, map-based petroleum system analysis and prospect risking toolkit designed for the exploration geologist. It utilizes seismic interpretations and other geological data to integrate the geological history with hydrocarbon generation and migration, in order to assess critical charge parameters and risks.

Study Area

Modeling results are presented from the offshore Campos, Santos and Espirito Santo Basins of Brazil (collectively, the Great Campos Basin). The stratigraphic input for these models are interpreted depth grids derived from the WesternGeco/TGS Nopec 1999-2000 2D seismic survey, which consisted of strike- and dip-oriented lines spaced between 4km and 10km

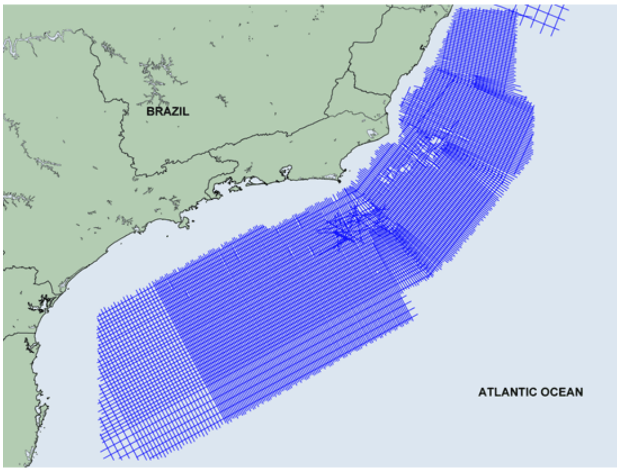
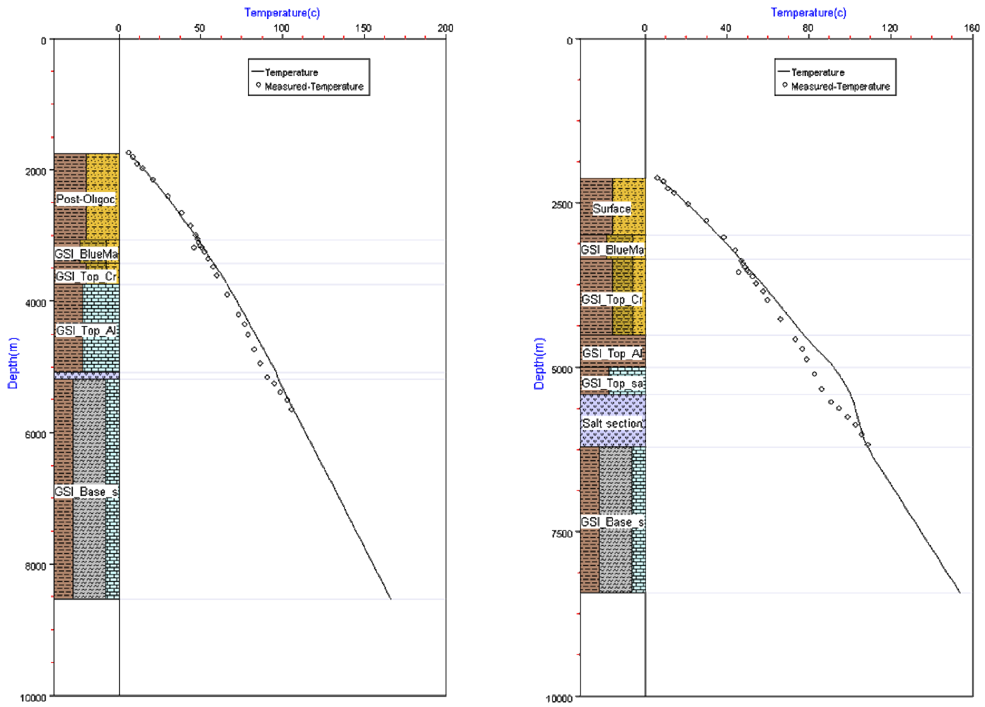


Figure 1. 2D Seismic grid used as model input.

(Figure 1). The stratigraphic data are integrated with well logs and geochemical data from oils and source rock intervals in order to calibrate and constrain the thermal and geologic model. The modeling was conducted using the software *Trinity* developed by Zetaware.

Effects of Salt Movement on Source Rock Evolution

The most important source rocks in the Great Campos Basin are represented by the rift-phase Coquinas Sequence of the Lagoa Feia Formation (Syn-Rift II stage of Gibbs et al., 2003; Late Barremian – Early Aptian). These are overlain by a variably thick evaporitic sequence marking the transitional phase of sedimentation in the basin. Major salt structures in the form of salt walls and diapirs developed in the deepwater, the evolution and thickness of which can have a fundamental effect on the timing of source rock evolution due to the high thermal conductivity of the salt (Figure 2).



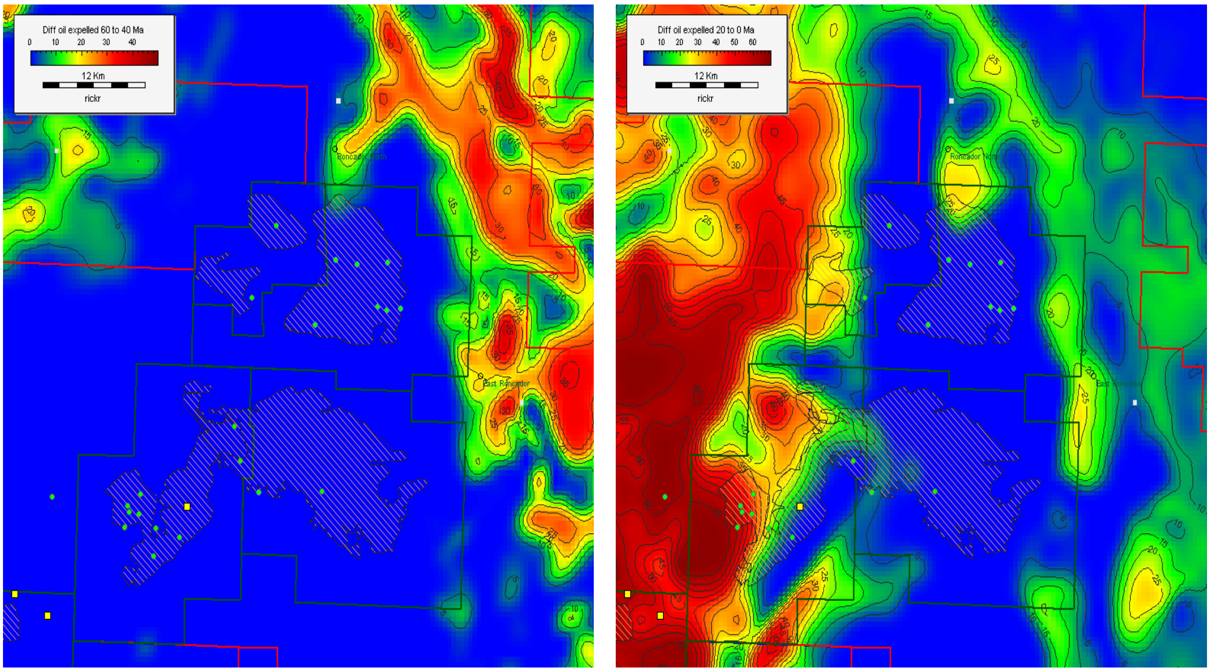
Pseudo-well N **Pseudo-well E**

Figure 2. Depth profiles showing the effect of variable salt thickness on temperature profile.

A salt movement algorithm was developed to model the change in salt thickness at any given location over time, which when combined with the difference in subsurface thermal conductivity of the salt and sediments respectively, can be used to create *temperature scaler maps* that simulate the salt effects on source rock evolution.

Variations in Charge Timing

Variations in charge timing in the Great Campos Basin arise not only from difference in salt thickness, but also due to variable sedimentation. This is a fundamental charge issue with respect to the giant deepwater Roncador and Albacora fields. Distal of the NW-SE basement high above which these giant fields are located, the principal stage of hydrocarbon generation from rift source rocks occurred during Paleocene to Oligocene time (60 – 40 Ma), whereas to the west generation occurred primarily during the past 20 Ma (Figure 3). These differences together with the temperature history of reservoir horizons can be used to understand regional variations in oil quality.



Oil Expelled, 60 - 40 Ma
(MM bbl/km^2)

Oil Expelled, 20 - 0 Ma
(MM bbl/km^2)

Figure 3. Oil expulsion from rift source rocks around Roncador and Albacora deepwater fields, Campos Basin, Brazil.

Modeling Oil Quality Variations

Oil quality in the deepwater Campos Basin is a complex function of biodegradation, charge volumetrics and charge timing. It has long been acknowledged that biodegraded oils are more common in reservoirs where temperatures are less than 60-80^{o}C, due to the temperature tolerance of hydrocarbon-degrading microbes. However, only recently has it been recognized that biodegradation is related not only to (present day) reservoir temperature, but more importantly to the *reservoir temperature history in relation to the timing of charge* (Yu et al., 2001; 2002).

This approach suggests that an early hydrocarbon charge at reservoir temperatures less than approximately 60°C, will be at high risk for biodegradation and adverse oil quality. However, that risk is mitigated if the majority of the hydrocarbon charge occurs late, say over the last 20 Ma or more recent. This is due to the "induction time" required for bacteria to significantly alter the properties of an oil column (Larter et al., 2003). Hence, a late charge is

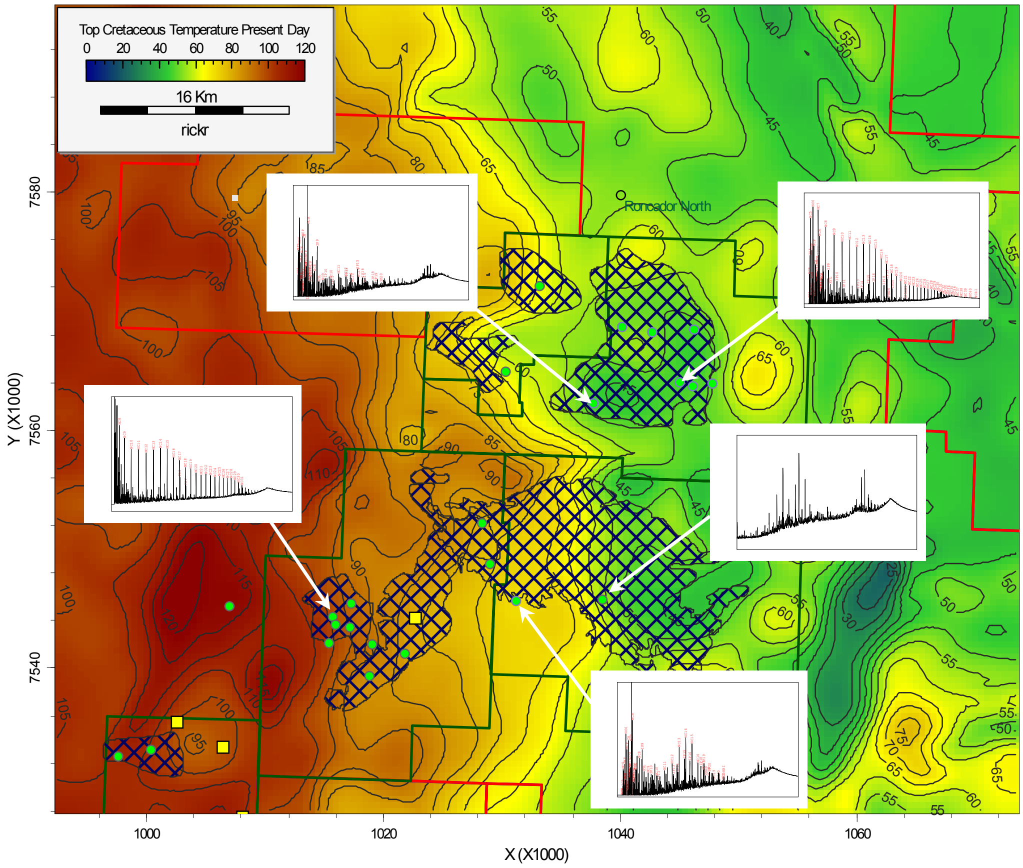


Figure 4. Present-day temperature at Cretaceous reservoir level, Roncador and Albacora deepwater fields. Gas chromatograms of oils illustrating the degree of biodegradation are inset.

favorable for oil quality despite an unfavorable charge temperature history.These oil quality concepts are illustrated in the temperature and charge models for the deepwater Roncador and Albacora fields (Figure 4). Better-quality oils found in Albian turbidites of the Albacora Main field (21° – 27° API) are the result of charge from "late kitchens" below and to the south of the reservoirs during the last 15 Ma. Heavier oil in Tertiary turbidites of the Albacora L'este field was emplaced earlier, is variably biodegraded, and did not benefit from a similar late charge. The charge history is also not favorable for Maastrichtian turbidites of the Roncador field, which generally did not exceed 60°. However, the eastern portion of the field where better quality oils are observed (27° – 32° API) benefits from a late charge originating from a large drainage area immediately to the north and east.

References

Gibbs, P.B., Brush, E.R. and Fiduk, J.C. 2003, The distribution of syn-rift and transition stage source rocks in time and space on the conjugate central/southern Brazilian and West African margins. PESGB/HGS Int. Conf on Africa E&P, September 3-4.

Larter, S., A. Wilhelms, I. Head, M. Koopmans, A. Aplin, R. Di Primio, C.Zwach, M. Erdmann, and N. Telnaes, 2003, The controls on the composition of biodegraded oils in the deep subsurface-part 1: biodegradation rates in petroleum reservoirs: Org. Geochem. 34, 601-613.

Yu, A.Z., G. Cole, G. Grubitz, and F. Peel 2001, Biodegradation Index (BDI): A new approach to predict biodegradation risk and reservoir fluid quality based on the basin's thermal and hydrocarbon charge histories. Abstract, AAPG 2001 Annual Meeting.

Yu, A.Z., G. Cole, G. Grubitz, and F. Peel 2002, How to predict biodegradation risk and reservoir fluid quality. World Oil, 223, No. 4.