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Prediction of Low-Maturity Gas and Heavy Oil: Biogenic Gas and Biodegraded Oil Modeling

M. Dubille* (Beicip-Franlab), F. Schneider (Beicip-Franlab), L. Montadert (Beicip-Franlab) & P.Y. Chenet (Beicip-Franlab)

SUMMARY

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F. Schneider, M. Dubille, L. Montadert, and P.Y. Chenet

Biogenic gas is becoming increasingly important as an exploration target in the petroleum industry because it occurs in geologically predictable circumstances and in large quantities at shallow depths as free gas or gas hydrates. As accumulations of biogenic gas result in a subtle synchronization between early generation and early trapping, we integrated a macroscopic model of microbial gas generation within a 3D basin and petroleum system forward simulator.

A macroscopical model of low maturity / biogenic gas generation in which hydrocarbons are generated through first order kinetic reactions at low maturity has been developed.

The transformation of substrate into biomass is described through a set of logistic equations coupled with the transport equations (advection and diffusion).

The first results of the model (see 1) are consistent with the observations in terms of nutrients and microbes concentrations.

Figure 1: Species and microbes concentrations calculated by the 1D model.

In addition secondary biodegradation model has been developed, making use of the same methanogenesis reaction, which transforms the saturated and aromatic light HC fractions into methane and increases the oil density.

This model can be coupled to a basin model predicting the HC composition.

Applications

The previous model has been applied successfully on different basins such as the Carupano Basin from the offshore Venezuela (Schneider et al, 2011), Magdalena Delta (offshore Colombia) and the offshore Vietnam where direct observations of low-maturity gas were available. Furthermore, it has been applied in the offshore Lebanon in order to check the viability of a biogenic gas system (Dubille et al, 2013; Schneider et al., 2013).

New applications have been successfully attempted in Northern Siberia, where present day temperature conditions have brought some reservoirs into the active biodegradation window.

The mass balance calculations provided by the model show that the biogenic gas generation is limited to areas where the active source-rocks remained in the oil window. Besides, the kinetics of oil expulsion versus secondary cracking in the source-rocks drive the composition of the gas (biogenic vs. thermogenic) in the shallow (< 2000 m) reservoirs.

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