Modeling Conventional and Unconventional Petroleum Systems in Saudi Arabia

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Abstract

The 3-D regional Basin and Petroleum System models were built to understand the generation, expulsion, retention and migration of hydrocarbon in the Kingdom. Basin and petroleum system modeling brings together several dynamic processes, including sediment deposition, burial, kerogen maturation kinetics and multiphase fluid flow. These models reconstruct the paleo-geometry by assigning unconformities and estimation of eroded thicknesses. All facies are assigned with rock petrophysical properties. Source rock maps were constructed using measured values from lab and from petrophysical deltaLogR method. Calibration of the model, based on observed maturity (vitrinite reflectance) and present-day temperatures, took into account major erosion episodes. Although simplification is always needed due to the regional nature of models in terms of structural model, lithological assignments and rock properties, our models still accurately reproduced the conventional hydrocarbon accumulations as well as their characteristic shapes and predicted some additional minor accumulations untested by exploration so far. This reflects the quality of the maps used, which reproduce the main large structural trap. To understand the conventional systems, simple kinetic scheme based on oil-to-gas cracking reaction was used.

Fit-for-purpose and state of the art Petroleum System Models were built for unconventional plays. This new technology was implemented first time in Saudi Aramco and in the oil industry. The results from basin modeling produced the maps of maturity, oil and gas saturations, volume in place for oil and gas (i.e., adsorbed + free), API gravity prediction in the area of oil saturation in these unconventional shale plays. In addition, the maps of bulk modulus of elasticity, Poison's ratio, Principal stresses, Yield-line distance (pressure needed to frac the rock), and organic porosity creation due to maturity were created. An example of this advance petroleum system modeling is presented for the Cretaceous shale in Rub Al-Khali area of Saudi Arabia. This modeling project was part of the unconventional resource assessment study in this basin.