Constraining Hydrocarbon Migration as Predicted by Basin Simulators Using Natural Tracers: Application on Middle Eastern fields

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Abstract

The oil and associated components migrate from source to traps where they accumulate. The accumulated oil properties and volumes are controlled in part by the nature of the path and the distance oil travelled. Basin model simulations are currently the most important tools used to track migration and timing of hydrocarbon trap filling. However, constraining the numeric simulations to solve migration is not straightforward, since little information can be obtained from the field regarding the flow channels followed by oil at the time of migration. We developed a migration model based on the compositional evolution of a set of natural tracers. The natural tracers can be measured in oil samples obtained from test wells and compared with the values obtained from basin and tracer model simulations to further constrain these models. The natural oil tracers modeled are a set of nitrogen-based aromatic compounds, such as carbazole and its derivatives. Due to their syn-generation with oil and interactivity with the environment, the composition recorded in the accumulation bears the signature of the migration history. Source rocks and several fields presumably charged from the same fetch area were used to develop and test the numeric model in tracking migration and filling sequences. Questions as to the distance the oil travelled can also be addressed with our model, which is critical in areas where the source maturity is not adequately mapped. Based on model simulations and field data we determined a set of correlation coefficients between simulation results and values from fields that we used to estimate the most probable filling sequence and migration path. The correlation indexes can be practically used to determine not only migration parameters, but also used to estimate the charge risk of new prospects. Tracer compositional variations in the accumulated oil were also proven useful in determining the size of accumulation before the field is put on production. Our model simulations, confirmed by field observations, demonstrate the ability of the method to address various play risk elements during exploration and field development.