Reconstruction of petroleum charge and alteration: A case study from the Norwegian North Sea.

Rolando di Primio
Lundin Norway

Summary

Three exploration wells were drilled by Lundin Norway from 2013 to 2015 targeting Triassic to Permian inlier basins, representing structural compartments of a single field on the granitic core of a structural high, Norwegian North Sea. All wells encountered oil and gas accumulations with column heights ranging from 45 to 22 m.

The reservoir temperatures in all wells are close to 80ºC, formation pressure was hydrostatic to slightly depleted. The pressure differences observed between the individual compartments indicate that the reservoirs are not in full communication.

Organic geochemical analysis of produced oil and gas samples as well as cuttings and core chips revealed a complex petroleum composition, characterized by the occurrence of gas, light and heavy oil in the reservoir. The gas caps in the wells are small (4-5 m) and are in thermodynamic equilibrium with the underlying oil leg. Methane carbon isotopes lie between -46 and -48 ‰, and the gases are severely depleted in CO_2, indicating potential contribution of secondary biogenic methane to the gas cap by biodegradation of the underlying oil leg. The oil legs of both wells show a lighter, undegraded oil composition at the top, grading into a heavy, asphaltene-rich oil at the base of the column. Samples taken below the oil water contact show residual oil saturation with clear signs of biodegradation.

Core extract analysis indicate high to very high asphaltene contents in the oil columns with variable distributions, indicating ongoing or complete asphaltene aggregation, segregation and phase separation resulting in the formation of tar mats. Depending on reservoir properties the tar accumulations can lead to complete occlusion of porosity, resulting in the formation of completely impermeable zones which can act as baffles to fluid flow.

Integration of organic geochemical observations with basin and fluid flow modelling as well as PVT simulations allowed the reconstruction of the processes leading to the present day fluid composition and distribution. Understanding the processes leading to asphaltene destabilization and phase separation significantly aids in addressing production strategies, and has also implications for neighboring prospectivity.

The results presented demonstrate the very dynamic nature of in-reservoir processes, the numerical modelling of which is currently largely neglected as it falls between conventional basin and reservoir modelling.