New Insights into Tar Mat Formation in Oil Reservoirs

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Abstract

New insights to reservoir tar mats are made by integrating advances in asphaltene science and downhole fluid analysis (DFA). The Yen-Mullins model of asphaltenes has enabled development of the industry’s first predictive equation of state (EOS) for asphaltene concentration gradients, which has been referred to as the Flory-Huggins-Zuo (FHZ) EOS. The FHZ EOS model shows that asphaltene concentration gradients can be large owing to both the gravity term and gas/oil ratio (GOR) gradients. The FHZ EOS is reduced to a very simple form – the gravity term only for low GOR black oils and heavy oils, and heavy oils are shown to exhibit enormous asphaltene concentration gradients in contrast to predictions from conventional models. Coupled with DFA measurements, the FHZ EOS has successfully addressed a variety of reservoir concerns including reservoir connectivity, asphaltene concentration gradients, viscosity gradients, fluid disequilibrium, and asphaltene phase instability in oil reservoirs. Two types of tar mats are discussed, one with a discontinuous increase in asphaltene concentration versus depth typically at the base of an oil column (corresponding to asphaltene phase transition); the second with a continuous increase in asphaltene content at the base of a heavy oil column due to an exponential increase in viscosity with asphaltene content. The predictions are in good agreement with the laboratory and field observations and the mechanisms of forming these two kinds of tar mats are also discussed. This methodology establishes a powerful new approach for conducting the analyses of asphaltene concentration grading and tar mat formation in oil reservoirs by integrating the Yen-Mullins model, and the FHZ EOS with DFA technology.