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Enhanced Characterization of Heavy Oil Bearing Unconsolidated Clastic Reservoir of Kuwait by Integrating Dielectric Dispersion and Diffusion-Based NMR

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ABSTRACT

Characterization of heavy oil reservoirs and their fluid viscosity is critical to assess the reservoir potential, identify the sweet spots, define the reservoir producibility, design the recovery strategies and help on the production prediction. A robust workflow, integrating the latest advances of dielectric dispersion and diffusion based-NMR measurements, was developed for characterizing the heavy oil reservoirs and understanding its fluid complexity. This paper, describes the workflow applied to the heavy oil bearing unconsolidated shaly-sand reservoirs of Kuwait, which show vertical and lateral variation in viscosity, in addition, to the variation in permeability and irreducible water volumes required for enhanced production prediction and simulations. The diffusion NMR measurements were introduced to define the oil signature and fluid volumes. Although, this advanced NMR technique is sensitive to fluid types and oil viscosity, it lacks in distinguishing bound water and heavy oil signals. To overcome this challenge, the dielectric dispersion measurement was introduced to aid the NMR interpretation. The dielectric logging was used to identify the hydrocarbon bearing zones and quantify the total water volume regardless of the formation water salinity and the rock electrical properties, taking advantage of its resistivity-independent saturation approach. The quantitative water volume from dielectric was used to constrain the bound water volume and fine-tune the water and oil NMR cutoffs of the Diffusion-T1-T2 NMR approach. This has, consequently, enhanced the quantification of the oil volume from the diffusion NMR approach and reliably estimate its viscosity. Over the zones with shallow invasion, as is the case in most viscous oil reservoirs, the multiple-spacing dielectric measurement allows determination of accurate flushed zone water saturation, enabling direct detection of moveable hydrocarbon. This, in addition, to the use of the multi-frequency dielectric measurement to provide an in-situ estimate of the Archie's parameters where the core plugs and laboratory rock analysis are very difficult to obtain because of the unconsolidated nature of the rock. The workflow, applied on a number of wells, has provided enhanced characterization of the unconsolidated clastic reservoir and its heavy oil property. The results have been benchmarked with the laboratory fluid analysis data (PVT) over the same interval and a very good agreement has been demonstrated.