Investigation Into Modes Of Fluid Flow In Oil Spontaneous Imbibition Into Unconventional Source Rocks Using NMR

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Abstract

Objectives/Scope: This study aims to obtain insights into the transport of hydrocarbon, brine, or fracturing fluid in a source rock pore system where three types of pores, organic pores, mineral pores, and microfractures, constitute the fluid flow pore network.

Methods, Procedures, Process: NMR spectroscopy and imaging were simultaneously used to measure the in situ oil distribution in the source rock plugs at different imbibition times when oil was spontaneously imbibed from the bottom of the plugs. The NMR spectroscopy determines the contribution from different type of pore to the flow process. The NMR imaging measures the oil front in the sample from imbibition. Together, the method allows the examination of the flow mechanism in source rocks and identification of modes of fluid flow associated with the petrophysical properties of the source rock.

Results, Observations, Conclusions: From the NMR spectroscopy and imaging measurement of spontaneous imbibition, it is clear that all the measured samples have fractures that allow oil flow from one end to the other in less than 24 hours. However, further oil flow into the rock matrix by spontaneous imbibition differs. The three flow modes were identified in samples from different zones in a Middle East source rock reservoir: matrix dominant flow, fracture dominant flow, and dual continuum flow. In samples from the organic-rich zones, the oil imbibition from the fracture into the matrix is much slower than from the base of the sample into the matrix, i.e., in this sample oil flows into the rock matrix along the bedding much faster than in the direction perpendicular to the bedding. In contrast, in the organic-lean samples, the flow from the fractures to the matrix is as efficient or even more efficient than from the end of the sample. In some samples, from the NMR data, the oil simultaneously imbibed into the matrix pores from the bottom of the plugs and from the fractures with approximately the same efficiency, clearly indicating a dual continuum flow mode.

Novel/Additive Information: This study shows that NMR spectroscopy and imaging methods are valuable tools in investigating in situ fluid flow in unconventional source rocks. Using the NMR method, three flow modes were identified using plugs from a source rocks reservoir.