In-situ Characterization of Carbonate/Oil/SmartWater Interfacial Layers Using Advanced EM Techniques

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Abstract. The visualization and characterization of interactions between SmartWater, oil and carbonate rock play a major role to understand the causative mechanisms behind wettability alteration and enhanced oil recovery. However, conventional imaging methods fail to provide such important analysis due to limited resolution and visualization capabilities.

To address this gap, cryogenic electron microscope (EM) and liquid cell holder have been utilized in this study. The results from each of these techniques are discussed and compared. The liquid cell transmission electron microscope (TEM) holder with an encapsulation function feature successfully enabled the direct observation and analysis of liquid sample close to its native conditions. Energy dispersive spectroscopy (EDS) analyses have been simultaneously utilized to provide the chemical mapping of rock-fluid interfaces. These results provide, for the first time, nano-scale images of oil droplets, calcite nanoparticles and dissolved salt ions in their native environment. The compositional distribution of multiple elements and elemental mapping of the structures in solution are also presented.

The presented novel nanoscale characterization brings a new insight about the rock-oil-brine interactions and this understanding can become critical to optimize the salinity and SmartWater compositions used for enhanced oil recovery in carbonate reservoirs.