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Advanced imaging method for tight carbonate

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ABSTRACT

In order to meet the world growing energy demand, oil industries are aiming in increasing the oil recovery factors from mature fields under primary and secondary production. Currently EOR presents 3 to 5% of the total oil production and it is expected to be responsible for 20% of oil produced in 2030. One of the major challenges to achieve this goal is to be able to sweep oil from sub-micrometric pores especially in tight carbonate. Hence, a better description of the pore networks, pore connectivity and pore throats and its interaction with oil during the reservoir exploitation will contribute to a more reliable interpretation of the fluid substitution monitoring.

This approach, known as digital rock physics (DRP), consists of simulating rock properties using three-dimensional (3D) microtomography images. In the last decade, DRP has been widely implemented to estimate several rock properties, such as porosity, permeability and elastic moduli, in different rocks [1-6]. However, mismatches were observed when processing microtomography images of heterogeneous samples and more specifically in carbonates with unresolved pore structures [7-10]. Hence, a crucial condition for obtaining reliable simulated rock properties is to correctly characterize the pore network.

In this study, reliable imaging protocol including macro and micro XCT tomography in one hand and FIB-SEM nanotomography in the other hand was developed to capture different heterogeneities existing in carbonate (texture, mineralogy, phases, pore size). This approach, consisting of comprehensive extraction of the carbonate heterogeneities at different scale while keeping track of geo-reference is build on these 2 major components: Comprehensive image segmentation based on image thresholding or texture applied to well-defined region of interest (ROI). This method allows reliable data extraction at different resolutions.

Keep track of the real position of the ROI in the core-plug leading to register all acquired data. Our protocol consisting of correlative imaging down to nanometric scale aims to draw the full core-plug texture and pore networks at different resolutions from 40 μm resolution using CT-scan to 25 nm resolution using FIB/SEM.

Key words: XCT – FIB/SEM – Imaging protocol – Carbonate

EOR: Enhanced Oil Recovery

DRP: Digital Rock Physics

XCT: X- Ray Computing tomography

FIB/SEM: Focused Ion Beam combined with Scanning Electron Microscopy. ROI: Region Of Interest