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An Integrated Geomechanical, Petrophysical and Petrographical Study to Evaluate the Efficacy of a Plug Cleaning Technique for Ultra-Low Permeability Rocks

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Abstract

Core analysis practices recommend removal of residual fluids before laboratory measurements of porosity, permeability, and fluid saturations. The most common methods used for core cleaning are Dean-Stark and Soxhlet extraction. While these techniques are adequate for conventional rocks, they are -a) time consuming and b) may induce micro-fractures in unconventional with ultra-low permeability, thus affecting permeability and porosity measurement. In order to reduce the cost and time of fluid extraction and measuring permeability for such rocks, the GRI crushed-rock technique was proposed. However, the crushing process may destroy connected micro-pores which would not be accounted for in subsequent measurements.

A cleaning method for ultra-low permeability rocks involving multiple cycles of pressurized CO₂ driven extraction has been previously proposed. The method employs automated gradual pressure release to avoid parting or fracturing the weak planes or the rock matrix during the CO₂ phase change. However, it is critical to ascertain that the permeability increase is resulting from removal of fluids alone and not due to induced fractures.

The paper seeks to investigate the effect of the supercritical CO₂ based cleaning process on the samples. The method undertaken is a multidisciplinary look utilizing a strength index, mineralogical composition, and studying the pore attributes and oil content before and after cleaning. Brazilian tensile strength is utilized as an index and is measured on multiple plugs at the same depth to assess whether samples develop fractures during cleaning. X-Ray Diffraction (XRD) is performed to characterize mineralogical composition while LECO TOC method and rock-eval pyrolysis are utilized to determine oil content. Pore attribute characterization is done by Scanning Electron Microscopy (SEM) and thin section study.

Source rock analysis confirmed the extraction of pore fluids. Preliminary results showed that tensile strength did not decrease significantly following fluid extraction. Comparison of the strength index before and after cleaning showed that a lower decrease in tensile strength is associated solely with the cleaning

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process while a bigger difference indicates presence of fractures. Additional pore attribute and mineralogical studies supported the results observed in the strength index characterization.

The suggested additions to the previously proposed cleaning method address uncertainties in core cleaning and help to enable representative measurement of petrophysical properties of ultra-tight rocks. The integrated study combining strength index characterization, petrographical and source rock analysis provides a comprehensive validation method for the effectiveness of the Huff & Puff cleaning technique.