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A Novel Non-Destructive and Rapid Cleaning Method for Intact Ultra-Low Permeability Rocks

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Abstract

Laboratory measurements of porosity and matrix permeability are essential for accurate petrophysical characterization to aid in optimized planning for field development. The core must be cleaned before any petrophysical properties, such as porosity and permeability, are measured. The goal of the cleaning process is to remove all hydrocarbons, water and any possible invasion of drilling fluid during the coring process. Multiple cleaning methods, including flow-through cleaning, centrifuge flushing and distillation/extraction using Dean-Stark or Soxhlet methods are used and have been proven to be effective methods in conventional core. However, for unconventional rocks with ultra-low permeability like shales, the above methods are ineffective and time consuming. The distillation/extraction cleaning process has potential to induce micro fractures and/or parting of the rock that affect the measurements. Moreover, some cleaning methods for tight rocks involve crushing the sample to make the process time efficient. The disadvantages with this method include destroying the pore structure and rock fabric, overestimation of permeability and the amount of removable fluids and the inability to measure permeability under stress.

In this paper, an alternative technique for removal of mobile fluids from intact plug samples for subsequent permeability measurement is explored. The method involves multiple cycles of pressurized CO₂ driven extraction. Samples from low permeability formations were cleaned using the proposed method. CT scans, microscopic images and steady state permeability measurements were employed to ensure the samples selected for this study were free of any pre-existing fractures. The weights of the samples were monitored at the end of each cleaning cycle. The cleaning process was considered complete when the weights stabilized. Comparison of pre and post cleaning oil and water saturation measurements using Karl-Fischer, Pyrolysis, and NMR indicate a significant decrease in fluid saturations. Lastly, porosity of the samples also increased as a result of the cleaning process.

The technique introduced in this paper provides a means to more accurately measure the absolute matrix permeability of ultra-tight rock, improving the understanding of fundamental petrophysical properties.