Unlocking the Potential of Carbonate Source Rocks in Saudi Arabia: NMR Applications to Understanding Storage Capacity and Maturity

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ABSTRACT

The success of unconventional resource plays depends on their initial rock properties and the advances horizontal drilling and completion technologies. In contrast to conventional reservoirs, where the porosity and pore size distribution are controlled by deposition and burial "compaction", these parameters in unconventional source rocks are related to maturity and variation in organic matter content and type. Pore distribution between organic and inorganic grains impacts the wettability of such formations where mix wettability is most likely to occur. In addition, pore size and shape have a significant effect, not only on permeability and flow behavior, but also on drilling and completion as pores with nano-scale diameters could have a significant amount of adsorbed gas. Formation evaluation of complex unconventional reservoirs with standard logging tools does not provide a full understanding of the reservoir properties and their relation to productivity. Nuclear magnetic resonance (NMR) tools are lithology independent and respond solely to porosity and fluids; different studies demonstrated that this technology can be used for fluid typing and the investigation of the pore system distribution. Mercury Injection Capillary Pressure "MICP" and NMR data provide indirect measurement of pore size distribution. Focus ion beam (FIB) and scanning electron microscope (SEM) images at 1 μm of size are used to understand the microstructure and to estimate the pore size when resolution allows the captureof features of interest. This study consists of two main parts; initially NMR data was applied for formation water saturation estimation and the quantification of organic and inorganic pores. GRI analyses were used to calibrate NMR results. Posteriorly MICP, NMR and SEM/FIB images were used for pore size and permeability estimation. Results from two wells from a carbonate source rock in Saudi Arabia are presented. The targeted formation is a late Jurassic interval and consists of one of the most promising shale gas reservoirs in the Kingdom as they feed the giant Ghawar oil field. The source rock is predominantly calcareous and is interpreted to have been deposited in a restricted marine environment within an intra-shelf basin. Results showed that porosity is predominantly organic with large variability in the pore structure, at nano-micro scales with a link to productivity and play delivery. Understanding these variations help optimize well locations and landing intervals.