EVALUATION OF CEMENTATION EXPONENT FOR COMPLEX CARBONATE PORE SYSTEMS WITH APPLICATION OF DIGITAL ROCK ANALYSIS

Silva, F.B.M.[1], Branco, F.[1], Horta Jr., L.F.[1],Siqueira, M.F.[1],Sisk, C.[3]
(1) Ingrain Brasil, Rio de Janeiro, Brazil; (3) Ingrain Inc., TX, USA

ABSTRACT: Carbonates are still one of the most challenging reservoirs for characterization, even though they have produced large volumes of hydrocarbons globally for a long period of time. Significant variability in terms of rock properties and a high degree of heterogeneity, even within a small section of the reservoir, can lead to various uncertainties with respect to formation evaluation. By using the advancement of Digital Rock Analysis (DRA), three coquina carbonate rock types were analyzed using X-ray microtomography digitalization. This paper addresses the investigation of the Archie's cementation exponent ("m") for complex pore systems present in this type of carbonate. By expanding the classical work performed by Lucia et al. (1993), for the first time, it is possible to apply digitally the observations performed by the authors in a 3D perspective, thus creating an analogy with Pouillet's resistivity law.The formation factor is digitally computed by simulating an electrical flow in the digital rock saturated with a conductive brine. The conductivity of the rock is digitally calculated by taking into account the mineralogy distribution as well as the fluid saturation, and is combined with the porosity to obtain the Archie's cementation exponent. This DRA process is similar to the process in the laboratory, in which the resistivity of the fluid and the rocks fully saturated are measured. Therefore, both techniques were used in order to validate and expand the results. The work performed granted the integration of DRA results of resistivity with physical measurements, supported by thin section interpretation, allowing the characterization of the Archie's cementation exponent in the 3D digital rock volume. This approach allowed a deeper understanding of the rock itself, which was improved through digital trends of formation factor versus porosity at a smaller scale of the original rock volume while increasing the statistical significance of the analysis. As a conclusion of the successful application of the technique to these highly complex carbonates, the relationship between types of pore system and cementation exponent values obtained in this study shows an increased potential value to geological interpretations that can be performed from resistivity log analysis. This understanding of the pore systems from the cementation exponent perspective can be incorporated in the characterization of reservoir rock types which impacts the petrophysical modeling for fluid flow.

KEYWORDS: FORMATION EVALUATION, COMPLEX CARBONATES, DIGITAL ROCK ANALYSIS.