Advanced Characterization of Cretaceous Carbonate Reservoirs in South Iraq Using Nuclear Magnetic Resonance Logs and Electrical Borehole Images

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Abstract

Cretaceous carbonate reservoirs in South Iraq are long known for exhibiting highly varying properties within small sections of the reservoir, making it difficult to simulate and history-match. The inflow profile is still challenging to predict. The heterogeneity of these reservoirs still has a high uncertainty in the area of southern Iraq where oil production and water-cut continue to prove to be challenging to model, requiring continuing refinement of static models. A focused approach involving a detailed understanding of the fluids saturation, pore-size distribution, permeability, rock texture, reservoir rock type, and natural fracture systems at different scales is needed. The rock texture is comparatively unstable and is continuously subjected to multiple stages of dissolution, precipitation, and recrystallization, which obscures any relationships that might have existed between depositional attributes, porosity, and permeability. With the absence of core data, different log measurements are needed to build a realistic model of the petrophysical properties, the conventional resistivity and porosity measurements are often not sufficient to resolve changes in pore size and texture, so additional measurements are required; particularly borehole images and nuclear magnetic resonance that can extract information on different textural elements and porosity types. The workflow integrates image logs and NMR logs with a new approach. Electrical borehole images and NMR logs were acquired in multiple wells in the Cretaceous carbonate reservoirs in South Iraq. Borehole images were integrated with other petrophysical data in sequential steps to classify the different types of pore space: connected to vugs, isolated vugs, connected to fractures, aligned at bed boundaries, or within the rock matrix. The contribution of these different pore types to the total porosity of the formation was quantified in addition to the geometric information of different types of heterogeneities. NMR log data was analyzed using gaussian decomposition technique to locate and extract the volumes of three separate pore body modes. The resultant outputs of macro, meso, and microporosity best reconstruct the input NMR spectrum and provide the permeability heterogeneity corresponding to the different pore sizes. This info, further integrated with borehole image analysis results can characterize the carbonate in such details that are needed to quantify high-resolution textural details, capillary pressure, and pore-network geometry to realistically model such reservoirs that honor and predict the production within optimal tolerance. This study presents the impact of facies heterogeneity on the evaluation of the Cretaceous carbonate reservoirs in the South of Iraq and also presents a comprehensive workflow to evaluate and characterize porosity and permeability systems accurately in non-cored wells.