AAPG Datapages/Search and Discovery Article #90318 ©2018 AAPG/Middle East GTW, Carbonate Reservoirs of the Middle East & Their Future Challenges, Abu Dhabi, UAE, January 30 – February 1, 2018

Evaluation of Complex Carbonates from Pore-Scale to Core-Scale

Osama AlJallad[1], Moustafa Dernaika[1], Safouh Koronfol[1], Yasir Naseer Uddin[1], and Prasanta Kumar Mishra[2]

[1]Ingrain Inc.
[2]Kuwait Oil Company.

ABSTRACT

Carbonate rock properties may be defined differently at different scales and this introduces a challenge in capturing the heterogeneity in a single rock volume. This research work studied whole core samples using multi-resolution imaging and advanced computations. The samples could not be directly measured by conventional techniques due to their fractured state and complex nature. The cores are Mid-Cretaceous in age, derived from a giant oil field in the Middle East and are predominately composed of limestone with complex paragentic history.

The core samples were first imaged by X-ray Dual Energy CT scanner in 3D at a resolution of 500 µm/voxel. The whole core CT images revealed extreme heterogeneity along the sample lengths and showed varying distribution patterns of high and low density textures. Selected plugs from those densities textures were acquired to accurately represent the different flow phases in the whole core samples. The 23 plugs were fully characterized by high resolution X-ray CT images at 40 µm/voxel, thin-section photomicrographs, poroperm measurements and Mercury Injection Capillary Pressure (MICP). These analyses provided detailed understanding of the geological and petrophysical variations within the different density textures in the whole core samples. Simultaneously, smaller-scale subsamples were obtained from the different porosity regions in the plugs and scanned at higher resolutions down to Nano scale at 0.064 µm/voxel.

The dual energy CT scans along with core visual inspection, thin-section photo-micrographs and mercury injection pore throat size distributions (PTSD), demonstrated that each density region had similar geological and fluid flow characteristics throughout the core intervals. The upscaled poroperm data for all the core intervals gave a linear trend with clear increment of porosity and permeability as a function of low density phase in the core. The permeability KV/KH anisotropy ratios were digitally computed for all the core intervals, and were found to vary from 0.44 up to 0.94, which reflect the relative presence and distribution of the high and low density regions in the reservoir core samples.

The digital analyses of the data together with the effects of heterogeneity distributions in the core provided improved understanding of the geological and petrophysical properties in these complex reservoir rocks that would not be possible by conventional methodologies.