

EGU21-511

<https://doi.org/10.5194/egusphere-egu21-511>

EGU General Assembly 2021

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## Carbonate pore type quantification through digital image analysis – dual-porosity reservoir example of the Arabian Gulf.

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The Barremian Upper Kharaib Formation reservoir unit was deposited in a carbonate ramp setting and shows moderate vertical facies variability, transitioning from a wackestone-dominated transgressive phase into a grainstone-dominated regressive phase. A dual-porosity system containing micro and macro-pores characterizes this reservoir, with microporosity as the dominant fraction of total porosity and holding large amounts of hydrocarbons in place. Porosity variations in the reservoir section shows no clear vertical trends, while permeability shows significantly higher values in the regressive phase sediments.

Digital image analysis (DIA) was done on this study using the different methods of visual estimation, colour selection based on histogram analysis and trained machine learning, with the measured area seen as a proxy for the total pore volume. A total of 285 images captured from 142 thin sections from 4 different wells were analysed. Colour selection through automated batch processing was done to quantify total macroporosity in all thin sections, using the petrographic images captured under XPL. Different RGB color codes and tolerance parameters were used in different runs on the same image, in an attempt to address the uncertainty in macroporosity measurements. Machine learning was applied using selected training images and manually classified pixel sets defining 2 classes (porous and non-porous space).

Total macroporosity is separated into interparticle and intraparticle/mouldic porosity (intrafossil porosity and probable dissolution of bioclasts/peloids/intraclasts) based on visual estimations, given that an unambiguous automated classification of these pore types is practically impossible to obtain. Microporosity is estimated to represent more than 60% of the total porosity. Considerable differences exist between the pore networks of the transgressive and regressive phase deposits, with the latter showing stronger heterogeneity and higher average interparticle macroporosity values in grainstone intervals containing coarser carbonate particles and small or no amount of interparticle micrite. These carbonate particles are, however, micritized and contain considerable volumes of microporosity within.

Pore type quantification through DIA can provide an objective, relatively quick and inexpensive

methodology to provide useful insights into petrophysical relationships and to complement petrographic observations and core analysis results. Detailed depositional and stratigraphic models coupled with this quantitative data would help to better understand the depositional and diagenetic controls on rock properties variability.