Characterization of carbonate elastic and flow properties: from imaging to simulations and lab measurements

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ABSTRACT

This project aims at developing Digital Rock Physics (DRP) as the novel and future reservoir engineering simulation tool, especially as applied to the super giant carbonate reservoirs of Abu Dhabi. The approach consists in establishing a protocol to image carbonates from the nano-scale to micro-scale (Devarapelli et al., this conference), keeping track of the georeference of the samples. Experimental and numerical tools are used to measure and simulate porosity, elastic properties and flow properties at the different scales.
The protocol was tested on standard carbonate samples prior to be applied on heterogeneous core samples from Abu Dhabi reservoirs to calibrate and to validate the overall strategy. Micro-CT images were produced on plugs of 40mm, 12mm and 4mm in diameter with a respective resolution of 40mm, 12mm and 4mm; images were then captured at high resolution (20 nm) using Dual beam system consisting of SEM combined with Focus Ion Beam (Quanta 3D, FEI®) showing the existence of sub micrometric pores.

Porosity and pore size distribution were determined using mercury intrusion approach. A tri-axial stress core flooding system was used to investigate the macroscopic average mechanical properties (through acoustic wave measurements) and flow properties (gas and water permeabilities) of plugs (40mm and 12mm diameter ones). Segmentation and solid matrix extraction were realized with Avizo (©FEI) using the watershed procedure and with Sakhr (Jouini et al., 2015) using a bi-level algorithm to distinguish between the pores and the solid matrix. Both sets of results were compared and used to reconstruct the media and build numerical models.

Two numerical models were used to determine the elastic properties: Sakr (Jouini et al., 2015) and Abaqus (©Dassault system). The numerical simulations for flow were run using Palabos (©Flowkit) which is based on the Lattice Boltzmann method. The problem is set up to simulate steady-state, isothermal, single phase flow of liquid water. The simulations were run on parallel mode on Masdar Institute's High Performance cluster system. Devarapalli, R.S., Chevalier, S., Sassi, M. and M. Jouiad 2016 Advanced imaging method for tight carbonate GEO2016 the 12th Middle East Geosciences Conference and Exhibition.

Jouini, M.S., Vega, S. & Al-Ratrout, A., 2015. Numerical estimation of carbonate rock properties using multiscale images. Geophysical Prospecting, 63(2), pp.405–421. Available at: http://doi.wiley.com/10.1111/1365-2478.12156.