Probing Heterogeneity in Carbonates via Multiple Resolution Imaging Tools

Varslot, Trond [1]; Knackstedt, Mark [1]; Sok, Robert [2]; Senden, Tim [1] (1) Australian National University, Canberra, ACT, Australia. (2) Digital Core Laboratories, Canberra, ACT, Australia.

The heterogeneity of carbonate reservoirs leads to complicated relations between porosity, geophysical response and permeability. In reality, the characterization of geophysical properties of carbonate core material requires an ability to account for pores at all relevant length scales in the samples. Extreme variability in carbonate depositional environments and susceptibility to a range of post-depositional processes results in complex pore and mineral phase structures comprising length scales from tens of nanometers to several centimeters. To increase understanding of the role of pore structure and mineralogy on connectivity, permeability and geophysical and petrophysical response requires one to probe the structure in carbonates in a continuous range across many decades of length scales (from 10 nm to 10 cm) and to integrate information at these different scales.

In this paper experimental techniques including micro-computed tomography, backscattered scanning electron microscopy (BSEM), SEM with energy dispersive x-ray spectroscopy (SEM-EDS) and Focussed ion beam SEM (FIBSEM) are used to probe the pore scale structure in carbonates across many decades of scale. The techniques give complimentary pieces of information; for example, micro-CT enables one to map the pore structure within the carbonate in 3D, while SEM with EDS allows quantitative analysis of the elemental composition of the core in 2D. We then utilize a recently developed method of 3D image registration techniques to integrate or couple information obtained at various length scales. This allows one to calibrate the data from varying tomographic and microscopic techniques and to characterize carbonate core material across many decades of length scale. Case studies on carbonate cores are used to illustrate how the multiscale information can be used to enhance our understanding of geophysical response and flow properties.