Dynamic X-ray Tomography Studies of Multiphase Flow, Reactive Transport and Evolution of Pore Structure

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X-ray microtomography has emerged as a powerful technique for understanding the physics of flow, transport and reactive processes in carbon storage, hydrocarbon recovery, and contaminant transport. Pore-scale imaging provides an enormous amount of information describing spatio-temporal evolution of pore structure and fluid distributions - images consisting of ~ billion voxels are routinely provided at the micron-scale spatial resolution, and ~ 10s (synchrotron) to ~ 10min (micro-CT) temporal resolution, at the ~ *mm* to ~ *cm* scales. To highlight these capabilities, three exemplar dynamic imaging studies are presented.

The first study [1] is dedicated to reservoir-conditions injection of CO2 in a brine-saturated limestone rock. Multi-phase flow events can be identified in pore space, such as non-local interface recession, local and distal snap-off. Capabilities of X-ray tomography include measurements of capillary trapping (residual saturation), wettability (contact angle) and capillary pressure (curvature). *The second study* [2] examines dynamics of fluid/solid reaction between brine-equilibrated CO2 and carbonates. The impact of initial pore structure, flow conditions, and mineral composition on reaction rates can be distinguished by an analysis of probability distribution functions of velocities characterising evolution of physico-chemical heterogeneity. In complex mineralogies, flow field heterogeneity can lead to time-dependent dissolution patterns, from uniform dissolution to dissolution characterised by widening of a dominant channel, as seen in Fig.1.

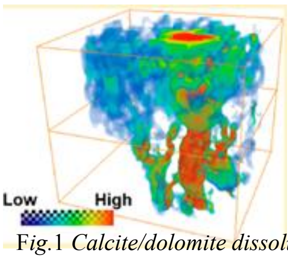

Fig.1 *Calcite/dolomite dissolution by CO2/brine*

In the third study [3], dynamic synchrotron tomography characterises evolution of pore structure in oil shale during pyrolisis. The structural transformation of organic layers within the shale can be quantified, which helps design of recovery schemes.

[1] Andrew M., Menke H., Blunt M.J., Bijeljic B. (2015) *Transport Porous Med.*, **110**, 1, 1-24. [2] Al-Khulaifi, Y., Lin, Q., Blunt M.J., Bijeljic B. (2017) *Environ. Sci. Technol.* **51**, doi: 10.1021/acs.est.6b06224. [3] Saif, T., Lin, Q, Singh, K., Bijeljic, B., Blunt, M.J. (2016) *Geophys. Res. Lett.* **43**, doi:10.1002/2016GL069279.