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Geochemical processes and pore accessibility implicated in energy geosciences

QINHONG HU[1], FANG HAO[1], QIMING WANG[1] AND TAO ZHANG[2]

[1]China University of Petroleum (East China)
[2]University of Texas at Arlington

Energy geosciences fields in the context of carbon neutrality include geological storage of carbon dioxide and green hydrogen, enhanced geothermal energy utilization, efficient shale oil and gas extraction, as well as high-level nuclear waste geological repository. It involves sandstone, carbonate rock, mudstone, salt rock, granite, basalt and other rocks. Such a geological system involves a wide nm-μm scale pore size, various pore connectivity and wettability[1]. This presentation focuses on the geochemical aspects of coupled thermal-hydraulic-mechanical-chemical-biological (THMCB) processes, such as diffusion and chemical transport, compounded by pore structure characteristics (especially low pore connectivity, a topological attribute of pore structure) of various rocks. A series of complementary methods for quantifying pore connectivity and its effects on geochemical processes is developed, including mercury intrusion porosimetry, nuclear magnetic resonance, X-ray CT, focused ion beam-scanning electron microscopy, (ultra) small-angle neutron and X-ray scattering, hydrophilic and hydrophobic liquids and tracers followed by laser ablation-inductively coupled plasma-mass spectrometry tracer mapping [2]. Some rocks may exhibit poor microscopic scale connectivity and corresponding abnormal diffusion characteristics, which will strongly affect macroscopic chemical transport and the application of various rocks to help achieve carbon neutrality. Through multi-approach experimental and theoretical research, applying a variety of micron-decimeter scale sample sizes and nano-micron scale characterization capabilities, this presentation demonstrates that the diffusion coefficient, adsorption coefficient, and chemical transport mechanism and parameters of geomedia with low pore connectivity can depend on the sample size of various rocks due to pore accessibility, reflecting the macroscopic fluid-rock interaction behavior emerging from the micropore structure mechanism.

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