CSPG ROCK ANALYSIS WORKSHOP
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Understanding pore structure, pore orientation and fluid saturation in mudrocks using small angle scattering

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Summary

Mudrocks are fine-grained sediments with pore structure that have significantly been altered on different scales due to compaction and diagenesis. The complexity of pore systems is vast, because a broad range of irregular pore shapes along with a wide distribution of the sizes are entangled with both connected and disconnected pores. Permeability and wettability are affected by the pore structure and type, size, and arrangement of pores, controlling fluid transport, storage as well as sealing capacity. For these reasons, a quantitative analysis of the pore system is often required as the pore structure and pore connectivity are of major importance in practical applications of mudrocks. Pore sizes in mudrocks generally range over several orders of magnitude, i.e., sub-nanometer to several micrometers. Thus, there is no single method that adequately scans this wide range in scale and different methods are often utilised in combination to determine porosity values and to investigate pore structure. Small angle neutron scattering (SANS) combined with very small angle neutron scattering (VSANS) probes this broad pore size range, providing porosity, pore size distribution and specific surface area as well as fractal dimensions. The latter can be used to approximate diffusion coefficients, needed to assess reactive transport properties or hydrocarbon gas migration from sorption pores to transport pores.

Furthermore, upon injection of supercritical fluids (e.g. CO_2, CD_4, C_2D_6) into the pore space at high pressures, pore accessibility as well as phase behavior (sorbed phase, free phase depending on pore size) can be studied This mostly involves the application of a simplified two-phase scattering model that distinguishes solid matrix and pore space (i.e. fluid) but does not account for density profiles in the fluid phase (i.e. free phase and adsorbed phase). However, those three parameters (i) adsorbed phase density and (ii) matrix – matrix scattering and (iii) scale-dependent scattering length density variation become increasingly important for closed porosity determination since they bias its calculation due to their effect on the coherent differential scattering cross section (i.e. similar to intensity). Like in most studies they do attempt to quantify the adsorbed phase and its effect on the differential scattering cross section despite its implications on gas storage capacity and closed porosity.

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We here present SANS/USANS results obtained on up to 100 different mudrock samples originating from radioactive waste storage sites, hydrocarbon seals and shale gas reservoirs across the globe. We will demonstrate differences in pore size distribution as a function of mineralogy or maturity which are essential for pore network modelling. We further discuss diffusion coefficients calculated from fractal dimensions and the phase behavior of reservoir gases in the pore space.