Multiscale porosity an mineral mapping of shales

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Shales are characterized by multi-scaled pore systems (from micro- to nano-meter scale) associated with variable spatial distributions of mineral grains/particles up to the core scale. Some grains are nearly non-porous (like tectosilicates, carbonates, etc.) whereas the clay matrix is bearing most of the pore network, controlling the storage/sorption areas and migration pathways of fluids/solutes. [1] Pore network is thus strongly dependent on the relative arrangement and content of minerals.

Only a correlative multi-techniques approach is relevant to provide a quantitative balance of the pore size distribution. However, such a balance is not achievable when each of the different analytical methods is applied on randomly selected samples collected from an heterogeneous core. [2] First, a detailled mapping of the mineral distribution is thus needed from the core down to the clay particle scales.

Recent advances of X-ray Energy Dispersive Spectrometers (EDS) coupled with electron/X-ray microscopes allow the fast acquisition of large hyperspectral maps with a good enough counting statistic for a later accurate chemical analysis on each pixel. Applying this approach on μXRF, SEM, STEM in SEM or STEM is helpful for probing the mineral/phase distribution at different scales for hierarchical and widely heterogeneous shales. The careful treatment of the quantitative chemical maps provides the identification of the mineral/phase or mixture associated to each pixel [3][4][5]. The mineral/phase map reached then permits a robust quantification of the local phase contents and arrangements at each scale.

When coupled with the quantitative porosity mapping by autoradiography at core scale (resolution ~20 μm) and the pore mapping by mosaics of BackScattered Electron images obtained on SEM at lower scale (resolution ~5 nm), a better understanding of the variability of pore network is reached .

[1] Robinet *et al.* (2013) **48**, *Wat. Ress. Res.*, W05554. [2] Matskova *et al.* (2017) *URTEC Proceedings*, 2689299. [3] Prêt *et al.* (2010a) *Am. Min.*, **95**, 1379-1388. [4] Prêt *et al.* (2010b) *Am. Min.*, **95**, 1389-1398. [5] Gaboreau *et al.* (2017) *Cement and concrete composites*, **83**, 360-373.