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Imaging a pore network in a clay-rock at the sub-nanometer scale

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Keywords : clay, pore network, electron tomography

Mini-Symposium Description (2.22)

Clayey rocks properties are the focus of an ever-increasing interest from the geoscience community. These fine-grained sedimentary rocks (mudstone, argillite, shales etc.) are recognized as key-components for energy-related technologies, for which they could serve as isolation material (in radioactive waste disposal), caprocks (in CO₂ capture and storage systems), or as reservoir rocks for hydrocarbons (gas and oil shales) (Bourg, 2015; Tournassat et al., 2015b). For all of these applications, accurate predictions of mechanical, flow, and reactive properties at the field scale are necessary. However, macroscale properties of clayey rocks arise for a large part from the surface properties of their nano-sized clay minerals constituents and from the characteristics of associated microstructure and pore network. Pore networks in clayey rocks are highly heterogeneous with pore widths/diameters ranging in the categories of micropores (< 2 nm), mesopores (> 2 nm and < 50 nm) and macropores (> 50 nm). The fact that the pore size distribution in clayey rocks encompasses all of these pore size categories evinces the multiplicity of coupled physical processes that must be taken into account to explain observations at the core and field scales. Even if, FIB-SEM has enabled to improve the nanoscale characterization up to 5 nm (Gaboreau et al., 2016) most of the smallest pores, ensuring the connectivity, are not probed at this scale. One of the biggest challenges in the present downscaling approaches is a lack of understanding of the pore structure down to the (sub)nanometer pore sizes, which can contain up to 30 % of the total porosity, and which is also hypothesized to ensure most of the connectivity between bigger pores (Ma et al., 2016). In this study, we imaged in three dimensions the structure of a clayey rock down to the sub-nanometer scale using electron tomography. Pore network connectivity was extracted at the nanometer scale, providing key information for the building of future pore scale models.

References

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- Gaboreau, S., Robinet, J.-C., Prêt, D., 2016. Optimization of pore network characterization of compacted clay materials by TEM and FIB/SEM imaging. *Microporous and Mesoporous Materials* 224, 116–128.
- Ma, L., Taylor, K.G., Lee, P.D., Dobson, K.J., Dowey, P.J., Courtois, L., 2016. Novel 3D centimetre-to nano-scale quantification of an organic-rich mudstone: The Carboniferous Bowland Shale, Northern England. *Marine and Petroleum Geology* 72, 193–205.

Tournassat, C., Steefel, C., Bourg, I., Bergaya, F., 2015b. Natural and Engineered Clay Barriers. Elsevier.

Submission

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Submission ID: 233

Title: Imaging a pore network in a clay rock at the sub nanometer scale

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Keywords: clay, pore network, electron tomography

Abstract: Clayey rocks properties are the focus of an ever-increasing interest from the geoscience community. These fine-grained sedimentary rocks (mudstone, argillite, shales etc.) are recognized as key-components for energy-related technologies, for which they could serve as isolation material (in radioactive waste disposal), caprocks (in CO₂ capture and storage systems), or as reservoir rocks for hydrocarbons (gas and oil shales) (Bourg, 2015; Tournassat et al., 2015b). For all of these applications, accurate predictions of mechanical, flow, and reactive properties at the field scale are necessary. However, macroscale properties of clayey rocks arise for a large part from the surface properties of their nano-sized clay minerals constituents and from the characteristics of associated microstructure and pore network. Pore networks in clayey rocks are highly heterogeneous with pore widths/diameters ranging in the categories of micropores (< 2 nm), mesopores (> 2 nm and < 50 nm) and macropores (> 50 nm). The fact that the pore size distribution in clayey rocks encompasses all of these pore size categories evinces the multiplicity of coupled physical processes that must be taken into account to explain observations at the core and field scales. Even if, FIB-SEM has enabled to improve the nanoscale characterization up to 5 nm (Gaboreau et al., 2016) most of the smallest pores, ensuring the connectivity, are not probed at this scale. One of the biggest challenges in the present downscaling approaches is a lack of understanding of the pore structure down to the (sub)nanometer pore sizes, which can contain up to 30 % of the total porosity, and which is also hypothesized to ensure most of the connectivity between bigger pores (Ma et al., 2016). In this study, we imaged in three dimensions the structure of a clayey rock down to the sub-nanometer scale using electron tomography. Pore network connectivity was extracted at the nanometer scale, providing key information for the building of future pore scale models.

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