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NMR imaging and cryoporometry of swelling clays

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Compacted bentonite clay is currently attracting attention as a promising "self-sealing" buffer material to build in-ground barriers for the encapsulation of radioactive waste. It is expected to fill up the space between waste canister and surrounding ground by swelling and thus delay flow and migration from the host rock to the canister. In environmental sciences, evaluation and understanding of the swelling properties of pre-compacted clay are of uttermost importance for designing such buffers.
Major goal of present study was to provide, in a non-invasive manner, a quantitative measure of bentonite distribution in extended samples during different physical processes in an aqueous environment such as swelling, dissolution, and sedimentation on the time scale from minutes to years. The propagation of the swelling front during clay expansion depending on the geometry of the confining space was also studied.
Magnetic resonance imaging and nuclear magnetic resonance spectroscopy were adapted and used as main experimental techniques. With this approach, spatially resolved movement of the clay/water interface as well as clay particle distributions in gel phase can be monitored [1]. Bulk samples with swelling in a vertical tube and in a horizontal channel were investigated and clay content distribution profiles in the concentration range over five orders of magnitude and with sub-millimetre spatial resolution were obtained. Expansion rates for bulk swelling and swelling in narrow slits were compared. For sodium-exchanged montmorillonite in contact with de-ionised water, we observed a remarkable acceleration of expansion as compared to that obtained in the bulk. To characterize the porosity of the clay a cryoporometric study [2] has been performed.
Our results have important implications to waste repository designs and for the assessment of its long-term performance. Further research exploring clay–water interaction over a wide variety of clay composition and water ionic strength as well as investigating the effect of the confining geometry and material surface properties seem to be worth to pursue.

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References:
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