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# Magnetic resonance imaging of clays: swelling, sedimentation, dissolution

Sergey Dvinskikh and Istvan Furo

Department of Chemistry and Industrial NMR center, Royal Institute of Technology, Stockholm, Sweden
(sergey@physchem.kth.se / +46 8 7908207)

While most magnetic resonance imaging (MRI) applications concern medical research, there is a rapidly increasing number of MRI studies in the field of environmental science and technology. In this presentation, MRI will be introduced from the latter perspective. While many processes in these areas are similar to those addressed in medical applications of MRI, parameters and experimental implementations are often quite different and, in many respects, far more demanding. This hinders direct transfer of existing methods developed for biomedical research, especially when facing the challenging task of obtaining spatially resolved quantitative information. In MRI investigation of soils, clays, and rocks, mainly water signal is detected, similarly to MRI of biological and medical samples. However, a strong variation of water mobility and a wide spread of water spin relaxation properties in these materials make it difficult to use standard MRI approaches. Other significant limitations can be identified as following: T2 relaxation and probe dead time effects; molecular diffusion artifacts; varying dielectric losses and induced currents in conductive samples; limited dynamic range; blurring artifacts accompanying drive for increasing sensitivity and/or imaging speed. Despite these limitations, by combining MRI techniques developed for solid and liquid states and using independent information on relaxation properties of water, interacting with the material of interest, true images of distributions of both water, material and molecular properties in a wide range of concentrations can be obtained.

Examples of MRI application will be given in the areas of soil and mineral research where understanding water transport and erosion processes is one of the key challenges. Efforts in developing and adapting MRI approaches to study these kinds of systems will be outlined as well. Extensive studies of clay/water interaction have been carried out in order to provide a quantitative measure of clay distribution in extended samples during different physical processes such as swelling, dissolution, and sedimentation on the time scale from minutes to years [1-3]. To characterize the state of colloids that form after/during clay swelling the water self-diffusion coefficient was measured on a spatially resolved manner. Both natural clays and purified and ion-exchanged montmorillonite clays were investigated. The primary variables were clay composition and water ionic strength. These results have a significant impact for engineering barriers for storage of spent nuclear fuel where clay erosion by low salinity water must be addressed.

Presented methods were developed under the motivation of using bentonite clays as a buffer medium to build in-ground barriers for the encapsulation of radioactive waste. Nevertheless, the same approaches can be found suitable in other applications in soil and environmental science to study other types of materials as they swell, dissolve, erode, or sediment.

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