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Neutrons Illuminate the Muddy World of Clay – Water Dynamics

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Hydrous clay minerals (smectites) have complex interactions with water that both define them as separate from other layer silicates (e.g., micas) and also impart their unique suitability as environmental barriers. Cation hydration, surface adsorption and matrix suction are processes by which water is explained to interact with clay mineral surfaces. The hydration energies of cations held within the interlayer space of montmorillonite have long been viewed as key to clay mineral hydration. Many experiments have shown that the charge and hydration energy of the interlayer cation imparts differences in the way the clay mineral hydrates, orders and interacts with its surroundings. Water adsorption to the surfaces of clay minerals are also important: halloysite contains interlayer water without the presence of interlayer cations; instead the residual charge at the gibbsite-like surface is thought to enable fairly strong hydrogen bonding. As fine-grained materials, the structure of the pore-network within a particle of clay mineral (containing perhaps many thousands of individual layers) can be shown to control water uptake and release. During either of these processes, the pore-structure can change in smectites, making complete characterization difficult.
Various approaches can be used to study the above processes and this paper serves to highlight applications of neutron scattering, particularly elastic fixed window (EFW) and quasi-elastic neutron scattering (QENS) methods to study the mobility of water within bulk pores, the interlayer space, and surrounding the interlayer cation of montmorillonite. A simple experiment will be detailed that enables full quantification of water in various hydration states within a well-characterized montmorillonite sample, and further how this can be related to applied engineering problems in determining the unfrozen water content of a bentonite (a smectite enriched rock) used as an environmental barrier for site remediation work by the Australian Antarctic Division at Casey Station, Antarctica.

Topic

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