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Mesoscopic changes of a model clay soil due to the microscopic swelling of its crystallites

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We study a model soil consisting in a weakly-hydrated clay assembly obtained by dehydrating an aqueous suspension of smectite clay crystallites, under uni-axial constraint. The resulting material possesses both a mesoporosity at the particle scale (100 nm to 1 μm), and a microporosity (10 nm) within the nano-layered clay crystallites themselves. The strong anisotropy in the particles' shape results in an anisotropy of the mesoporous space, with the silicate sheets of the particles being predominantly perpendicular to the direction of the principal constraint applied during dehydration. Under humid conditions, absorption of water occurs in the mesoporosity but also through the swelling of the crystallites by intercalation of water inside them. The step-wise swelling of smectite clay crystallites due to water intercalation is a well-known phenomenon. Here, we study what impact that swelling has on the crystallites' relative positioning inside the material. We use Wide Angle X-Ray Scattering so as to determine the orientation distribution probability (ODP) function of the crystallites around their mean orientation, while monitoring their hydration state (number of water layers intercalated inside them). The method[1] is based on the analysis of scattering data provided by a two-dimensional detector. The data was collected at the European Synchrotron Radiation Facility (ESRF), on beamline BM01A. The width of the angular distribution (ODP) is found to decrease during water absorption, showing that particle swelling goes along with an increased

ordering of the assembly[2]. We attribute this phenomenon to steric effects. We further studied samples prepared at two very different magnitudes of the unixial constraint (0.25 and 25.00 MPa), and observed that the samples prepared at higher pressures appear significantly less ordered than those prepared at lower pressures[2]. Hence, the mesoscopic orientational ordering of a clay soil can depend on the mechanical conditions under which it consolidates.

[1] Y. Méheust, K. Knudsen and J. O. Fossum, *J. Appl. Cryst.* (2006), **39**, 661.
[2] Y. Méheust, K. D. Knudsen, J. O. Fossum, K. J. Måløy and G. Helgesen, "Mesostructural changes in a clay intercalation compound during hydration transitions", unpublished.