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Impact of desiccation on compressional and shear-wave velocities in clay-rocks: a laboratory study

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Abstract: The study of the impact of desiccation on the mechanical parameters of clay-rocks is of crucial importance to characterize the desaturated zone close to the walls of a deep underground repository, excavated into clay-rocks.

Three core samples were taken from the Callovo-Oxfordian argillite formation located at the MHM-URL laboratory in Eastern France (40% of clay minerals in average); rich of illites/smectites. In order to desaturate the core samples, we followed two desiccation paths. In a first step (desaturation phase); each sample was dried at ambient air (relative humidity in the range 32 to 42 % and at average room temperature 20 ˚C). In a second step (heating phase), the same samples were heated by four temperature levels from 65˚C to 105˚C. Velocity measurements were carried out on the core samples using an ultrasonic (1 MHz) pulse transmission technique to obtain P and perpendicularly polarized shear (S_v, S_h) wave velocities during both of desaturation and heating phases.

The results show that when the degree of saturation decreased, both P and S wave velocities increased. During these desiccation paths, the initial anisotropy was not significantly enhanced. The increase in S wave velocity, by as much as 10% and the associated increase in dynamic shear modulus following desiccation, suggests the presence of desiccation-driven hardening, which is commonly observed in clay soils. The existence of a such a phenomenon proves that the classical models (e.g., the Gassmann equation) used to study the effect of saturating fluids, fail to correctly assess the influence of variations in water content on seismic velocities measured in clay-rocks. In the case of clay-rocks subjected to very low confining pressures and high desiccation conditions (high ventilation rates), new models which explicitly account for textural changes in clay will need to be developed.