Influence of the water table oscillation on the mechanical and petrophysical properties of chalk

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It is well known that pore fluids can affect rock physical properties, like Young's modulus, mechanical strength and elastic wave propagation, especially in environments where gas and water coexist in the pores and a cyclic saturation/desaturation produces mechanical weakening.

We performed a series of mechanical tests on the Ciply chalk, a phosphatic rock from the Mons basin (Belgium), collected from "La Malogne" underground quarry in which the rock strata cyclically imbibe due to the oscillation of the water table.

We designed different experiments at different pressure conditions to highlight how the cyclic capillary imbibition or the injection of water influence the static and dynamic Young's modulus and the peak failure through uniaxial and triaxial tests. Furthermore, piezoelectric sensors are installed onto the sample's surface for P-wave ultrasonic surveys.

It is likely an interplay between the strengthening due to the closure of the initial crack content and a weakening triggered by the water that influence the mechanical properties of this chalk. Indeed, in 1 cycle of loading/unloading in unconfined uniaxial stress conditions and up to 55% of the peak strength (i.e. in the elastic domain), this chalk can accumulate 0.16% of irreversible plastic deformation (compared to 0.52% of axial strain at failure), which results in a strengthening of the Young's modulus observed in the sequent cycles, in a similar manner as the Kaiser effect for acoustic emissions. On the other hand, a water-induced strain rate acceleration caused by a reduction in strength is observed when water is injected in constantly axially loaded samples.

Results from the active seismic monitoring showed that the P-wave velocity is affected by the water saturation, providing useful information about the distribution of the air-water mixture while imbibition/injection is taking place.

We conclude that the outcomes of these experiments can provide interesting information on water-induced variations on the fatigue behaviour of chalk, which is recognised to control the stability of underground quarries.