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Evolution of petrophysical properties of across natural faults: a study on cores from the Tournemire underground research laboratory (France)

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Faults in general, and in clay materials in particular, have complex structures that can be linked to both a polyphased tectonic history and the anisotropic nature of the material. Drilling through faults in shaly materials allows one to measure properties such as the structure, the mineralogical composition, the stress orientation or physical properties. These relations can be investigated in the laboratory in order to have a better understanding on in-situ mechanisms. In this study we used shales of Toarcian age from the Tournemire underground research laboratory (France).
We decided to couple different petrophysical measurements on core samples retrieved from a borehole drilled perpendicularly to a fault plane, and the fault size is of the order of tens of meters. This 25m long borehole was sampled in order to perform several types of measurements: density, porosity, saturation directly in the field, and velocity of elastic waves and magnetic susceptibility anisotropy in the laboratory. For all these measurements, special protocols were developed in order to preserve as much as possible the saturation state of the samples. All these measurements were carried out in three zones that intersects the borehole: the intact zone , the damaged zone and the fault core zone.
From our measurements, we were able to associate specific properties to each zone of the fault. We then calculated Thomsen's parameters in order to quantify the elastic anisotropy across the fault. Our results show strong variations of the elastic anisotropy with the distance to the fault core as well as the occurrence of anisotropy reversal.