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A laboratory approach for seismic data interpretation: the borehole Humilly-2 (France)

Mahmoud Hefny (1), Alba Zappone (2,3), Claudio Madonna (1), Andrea Moscariello (4), and Jean-Pierre Burg (1)

(1) Geological Institute, ETH Zürich, Switzerland (mahmoud.hefny@erdw.ethz.ch), (2) Swiss Seismological Service, ETH Zürich, Switzerland, (3) Institute of Process Engineering, ETH Zürich, Switzerland, (4) Department of Earth Sciences, University of Geneva, Switzerland

Reservoirs-characterization of geothermal systems, integrating multiscale seismic data, is key towards predicting reservoir-performances. Three main aquifer/aquitard pairs in the western Swiss Molasse Basin have been reported as potential reservoirs for deep geothermal energy and CO_2 sequestration. From the bottom to the top, these aquifer/aquitard pairs are Buntsandstein/Anhydrite Group, Upper Muschelkalk/Gipskeuper, and Upper Malm/Lower Freshwater Molasse (USM). They have been studied to quantify the dependence of seismic velocities on the intrinsic rock properties.
Laboratory measurements have been performed on 60 cylindrical plugs from the aforementioned aquifer/aquitard pairs. Plugs 25.4 mm in diameter and ca. 30 mm long were cut mutually perpendicular from the same rock-type from the Humilly-2 borehole core, France. Ultrasound P- and S-waves propagation experiments have been accomplished inside a hydrostatic pressure cell, following the pulse transmission method, under two loading/unloading cycles, and at room temperature. Seismic velocities (m.s-1) at the atmospheric pressure vary from 6771 $\pm$16 to 4339 $\pm$20 m/s and 3975 $\pm$6 to 2460 for P- and S-waves propagation modes, respectively. The seismic anisotropy (%) ranges from 19.677 $\pm$0.013 to 0.257 $\pm$0.003 and 6.593 $\pm$0.006 to 0.511 $\pm$0.002 for the compressional and shear waves anisotropy, respectively. Grain densities (kg.m-3) measured at ambient condition range from 2630 $\pm$1 to 2948 $\pm$1. The most significant seismic-reflections coefficients were calculated for interfaces between the Oxfordian and the Kimmeridgian carbonates and between the evaporitic facies of the Keuper (Lettenkohle) and the overlying Liassic carbonates.
The measurements of seismic velocities, grain densities, effective porosity, fluid permeability, and mineral compositional model have made it possible to characterize the elastic properties in high-resolution. They allow interpreting and calibrating the pre-defined seismic reflectivity zones and reveal the microfeatures (i.e. seismic anisotropy), which cannot be detected either from wire-logs or seismic field survey, in Greater Geneva basin. These results represent an improvement of the seismic data, in particular to the poorly-imaged horizon beneath the anhydrite sequence due to the seismic attenuation.