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Potential of electrical resistivity tomography and muon density imaging to study spatio-temporal variations in the sub-surface

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We explore the capacity of electrical resistivity tomography and muon density imaging to detect spatio-temporal variations of the medium surrounding a regional fault crossing the underground platform of Tournemire (Aveyron, France). The studied Cernon fault is sub-vertical and intersects perpendicularly the tunnel of Tournemire and extends to surface. The fault separates clay and limestones layers of the Dogger from limestones layers of the Lias. The Cernon fault presents a thickness of a ten of meters and drives water from an aquifer circulating at the top of the Dogger clay layer to the tunnel. An experiment combining electrical resistivity imaging and muon density imaging was setup taking advantage of the tunnel presence. A specific array of electrodes were set up, adapted for the characterization of the fault. Electrodes were placed along the tunnel as well as at the surface above the tunnel on both sides of the fault in order to acquire data in transmission across the massif to better cover the sounded medium. Electrical resistivity is particularly sensitive to water presence in the medium and thus carry information on the main water flow paths and on the pore space saturation. At the same time a muon sensor was placed in the tunnel under the fault region to detect muons coming from the sky after their crossing of the rock medium. Since the muon flux is attenuated as function of the quantity of matter crossed, muons flux measurements supply information on the medium average density along muons paths. The sensor presents 961 angles of view so measurements performed from one station allows a comparison of the muon flux temporal variations along the fault as well as in the medium surrounding the fault. As the water saturation of the porous medium fluctuates through time the medium density might indeed present sensible variations as shown by gravimetric studies. During the experiment important rainfalls occurred leading variations of the medium properties affecting density and electrical resistivity physical parameters. We show with data sets acquired before and after an important rainfall event how muon density and electrical resistivity imaging may complementary characterize variations of the medium properties. The development of such innovative experiments for hydrogeophysical studies presents then the ability to supply new information on fluid dynamics in the sub-surface.