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Geophysical imaging of near subsurface layers to detect fault and fractured zones in the Tournemire Experimental Platform, France.

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IRSN (the French Institute for Radiological Protection and Nuclear Safety) is in charge of the expertise of the safety report of the French deep geological disposal site project in the East of France. With the goal of understanding the various transport and mechanical properties of clay–rocks, IRSN has conducted several research programs at the Tournemire Experimental Platform (TEP, in the Department of Aveyron in the South of France). Three major sub-horizontal layers characterize the sedimentary Jurassic formations of the TEP. At the base of the stratigraphic column, we find a sequence of limestones and dolomites, that is overlain by an argillaceous formation composed of a 250 m thick clay–rock layer. Above this layer, there is another sequence of limestones and dolomites. The TEP is characterized by a 2 km long tunnel, which allows in situ access to the Toarcian clay–rock layer. In addition to the main Cernon fault, secondary fault zones affect the clay–rock formation and have been observed in the galleries and also identified in several underground boreholes. These sub-vertical fault zones or fracture network display mainly subhorizontal offset (decametric scale) and a small vertical one (meter scale). In the upper limestone, these fault zones widen and fracturing becomes more scattered.

In an attempt to detect fault zones in clay-rock layers such as the one described above, IRSN carried out in 2001 a 3D high-resolution seismic survey from the surface in collaboration with CGG. A sub-vertical fault was successfully picked out by the seismic data at the interface between the clay-rock formation and the underlying limestones. This fault is interpreted as the downward continuation of one of the fault zones identified in the tunnel. However, because of the weak seismic impedance contrast in the clay–rock layer and the small vertical offset of sub-vertical fault zones, these fault zones could not be identified in the clay–rock formation. No fault or fracture zone could either be detected in the upper limestone formation because of the acquisition geometry.

In order to better image the clay-rock and upper limestone layers, IRSN, Mines ParisTech and UPPA conducted large-scale 2D and 3D very high-resolution seismic surveys in 2010 and 2011 from the surface in the framework of the GNR TRASSE. We analyze this new dataset with the first arrival traveltime tomography method in order to assess its potential to detect fault and fracture zones in near subsurface layers. For this purpose, we develop a new fast inversion algorithm that allows introducing a priori information and choosing a specific model parameterization. We validate our approach based on the Simultaneous Iterative Reconstruction Technique with synthetic data and present the first results of the new real dataset processing. We finally compare these results to a 2D high-resolution electrical resistivity profile acquired at the same location. These electrical resistivity data could also be considered as some a priori information in our inversion scheme.