Geophysical signature of the sedimentary/basement transition zone from seismic and CSEM. Analysis from a shallow analogue of the Rhine Graben

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SUMMARY

Exploiting high temperatures geothermal resources in sedimentary and basement rocks, rifts or flexural basins to produce electricity is now possible because of the development of binary geothermal power plant technology. However it remains challenging because the presence of fluid and permeability at 4–5 km depth is necessary. A multi-scale and multi-disciplinary approach to increase our knowledge of the transition zone between the sedimentary cover and the basement have been undertaken to provide fundamental knowledge for the assessment of its geothermal potential. We report out the results of a study performed on an exhumed transition zone in the Ringelbach area in the Vosges Mountain, on the flank of the Rhine graben. In this analogue of a deeply buried transition zone of the Rhine Graben, Triassic sandstones are still present on the top of the fractured and altered granitic basement providing the unique opportunity to study in-situ the physical properties of this transition zone. We focused here on both electrical (from CSEM) and seismic properties of the transition zone as they are the main physical parameters usually assessed with the help of geophysical methods during the exploration phase of a geothermal project. We show that altered porous and potentially permeable granite targeted in deep geothermal exploration has a clear signature on both electrical conductivity and seismic measurements that can be measured at core scale, borehole scale, and are still visible with surface geophysical methods such as refraction and reflection seismic and Controlled Source EM at a few hundred meter depth. The results suggest that best discrimination between permeable and non permeable rocks may be provided by the joint interpretation of both resistivity and seismic velocities.

Keywords: Geothermal exploration in sedimentary basins, CSEM, transition zone, multi-physics / multi-scale

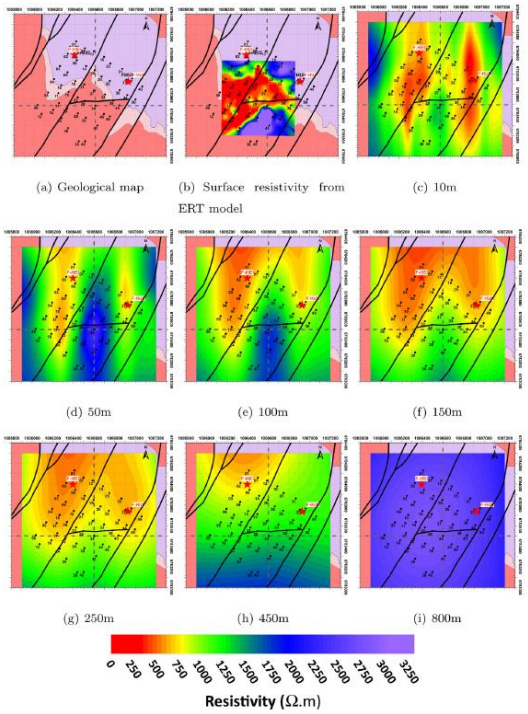

Figure 1: 3D CSEM resistivity model showing 1) a 200m thick conductive layer above the fresh granite associated with granite alteration, 2) very large variations of alteration marked by blocks with very high variation of resistivity.

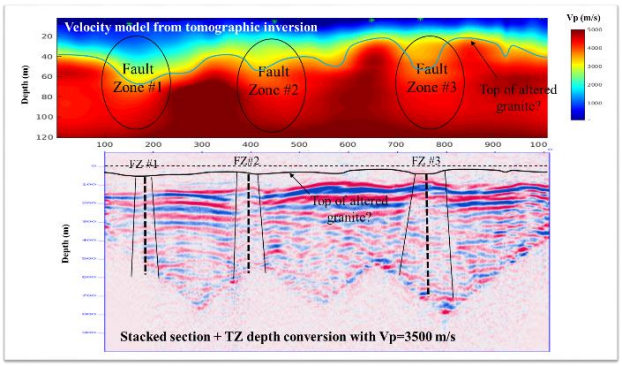

Figure 2: Seismic refraction velocity model and shallow seismic reflection showing 1) reflection on the top of the unaltered granite, 2) very large velocity variations associated to level of alteration and correlated with the known faults.