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Large scale hydro-thermal circulation in the deep geothermal reservoir of Soultz-sous-Forêts (France)

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Many numerical models of the deep geothermal reservoir at Soultz-sous-Forêts (France) have been developed over the past decades. However, a reservoir model that integrates most of the geophysical large scale measurements is still missing. For this purpose, we developed a simplified thermo-hydro-mechanical (THM) model in two-dimensions (10 km in horizontal scale and 5 km in depth) based on a finite element method. Our approach neglects the details of the fluid flow along the major faults using a representative elementary volume of 100 m. The specificity of our approach is to invert from large scale temperature and stress profiles, several key parameters through the reservoir like thermal conductivity, permeability, Young's modulus and Poisson's ratio. Our study provides new insights on the extension of the hydro-thermal convection cells through depth, on the interpretation of the linear temperature gradient at shallow depth and on the up-scaling of rock physics properties from laboratory scale to field scale. It supports a weak influence of the lithological transition between the sediments and the granitic basement on the hydro-thermal circulation contrary to previous studies. We also show the significant effect of the brine viscosity on the hydro-thermal circulation. Lateral variability of temperature profiles with depth in the Upper Rhine Graben is shown to be consistent with the predictions of this simple model.