Structure of hydrothermal convection in the Upper Rhine Graben as inferred from corrected temperature data and basin-scale numerical models

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Geothermal anomalies in sedimentary basins are strongly controlled by fluid circulation within permeable zones. This study presents a new compilation of newly corrected bottom-hole temperature data in the French part of the Upper Rhine Graben, where the Soultz-sous-Forêts temperature anomaly is locked beneath a local horst structure. After a geostatistically constrained interpolation procedure, maps and cross-sections are extracted from the 3D thermal block, together with the associated standard deviations. Thermal anomalies are preferentially associated with the thickest zones of the permeable fractured Buntsandstein (sandstones) formation, in apparent contradiction with previous models where two major fault zones were suggested to control fluid flow. The underlying fractured granitic basement hosts fluid circulation patterns which are apparently controlled at large-scale by the inclined basement-sediments interface.

Based on these observations, numerical models of hydrothermal convection including an inclined basement-sediments interface, a local horst structure, and realistic petrophysical properties have been carried out. The depth-decrease of permeability, the inclination of the interface and the fixed heat flow condition at the base of the model, explain why only a few upwellings can be triggered. Thermal anomalies and a measured temperature profile can be reproduced when fault permeability equals 10^{-14} m^2. Interestingly, structure of convective patterns also exhibits a second hotter upwelling, 8 km east of the Soultz-sous-Forêts upwelling zone, where another geothermal exploration project is now underway. The understanding of hydrothermal convection with realistic fluid and rock properties clearly appears as a predictive tool for geothermal exploration strategies.

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