Thermal properties of the Muschelkalk and Buntsandstein from the EPS-1 borehole at the Soultz-sous-Forêts (France)

Alexandra R. L. Kushnir[a], Julien Schneider[a], Michael J. Heap[a], Olivier Lengliné[a], Patrick Baud[a]

a. Institut de Physique du Globe de Strasbourg, UMR 7516 CNRS, Université de Strasbourg/EOST, 5 rue René Descartes, 67084 Strasbourg, France

alexandra.kushnir@unistra.fr

Keywords: thermal conductivity, Upper Rhine Graben, geothermal energy

ABSTRACT

Quantifying the thermal properties (thermal conductivity, thermal diffusivity, and specific heat capacity) of geothermal reservoir rock is essential to our assessment of the economic feasibility of energy exploitation. Here we investigate the thermal properties of the intact rock that makes up the sedimentary sequences directly overlying the granitic geothermal reservoir near Soultz-sous-Fôrets (France) in the Upper Rhine Graben. We source intact material from a 100 m-thick unit of Triassic Muschelkalk and a 400 m-thick unit of Permo-Triassic sandstone (predominantly Buntsandstein) sampled from the EPS-1 exploration well near Soultz-sous-Forêts. While the underlying granitic basement is currently being exploited as a geothermal reservoir, the Permo-Triassic sandstones lie directly over the granitic basement and are critical to continued regional hydrothermal convection. Further, the Triassic Muschelkalk unit, which directly overlies the Permo-Triassic sandstones, is considered to act as a regional thermal cap throughout the Upper Rhine Graben. The connected gas porosity and thermal properties of the dry intact (i.e. fracture-free) rocks were measured on cylindrical cores 20 mm in diameter and 40 mm long. Thermal diffusivity and thermal conductivity were measured using a HotDisk TPS 500 Thermal Constants Analyser using the Hot Disk method. A Kapton sensor 3.189 mm in radius was sandwiched between two samples and measurements were conducted at a system output power between 200 and 350 mW for 5 s. All measurements were conducted at an ambient temperature of 21°C. Specific heat capacity was calculated by the system after measurement. The connected porosity of the Permo-Triassic sandstones ranges between 0.03 and 0.19; thermal conductivity ranges between 2.3 and 4.0 $Wm^{-1}K^{-1}$; and thermal diffusivity ranges between 2.7 and 6.5 mm^2s^{-1}. The connected porosity of the Muschelkalk rocks ranges between 0.0047 and 0.10. The thermal conductivity of the Muschelkalk is between 2.3 and 5.8 $Wm^{-1}K^{-1}$ and thermal diffusivity ranges between 1.1 and 2.5 mm^2s^{-1}. The specific heat capacity of the Permo-Triassic sandstones is between 0.3 and 1.3 $MJm^{-3}K^{-1}$; specific heat capacity of the Muschelkalk is between 1.4 and 2.6 $MJm^{-3}K^{-1}$. Overall, thermal conductivity decreases with increasing porosity. These data will help constrain thermal modelling in the Upper Rhine Graben, further informing the locations for exploratory drilling for future geothermal feasibility studies.