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Thermal properties of the sedimentary cover (Muschelkalk and Buntsandstein) at the Soultz-sous-Forêts (France) geothermal site

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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-Forêts (France) in the Upper Rhine Graben. We source intact material from a 100 m-thick unit of Triassic Muschelkalk (930-1008 m.b.s.l.) and a 400 m-thick unit of Permo-Triassic sandstone (predominantly Buntsandstein; 1008-1417 m.b.s.l.) sampled from the EPS-1 exploration well near Soultz-sous-Forêts. While the underlying granitic basement is currently being exploited as a geothermal reservoir at numerous geothermal sites within the Upper Rhine Graben, the Permo-Triassic sandstones that lie directly over this granitic basement 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 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. Connected porosity was measured using helium pycnometry. Thermal diffusivity and thermal conductivity were measured using a Hot-Disk 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 and the Muschelkalk is between 0.3 and 1.3 $MJm^{-3}K^{-1}$and between 1.4 and 2.6 $MJm^{-3}K^{-1}$, respectively. Overall, thermal conductivity and specific heat capacity decrease 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.