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Facies related thermo-physical characterization of the Upper Jurassic geothermal carbonate reservoirs of the Molasse Basin, Germany

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In the early stages of hydrothermal reservoir exploration, the thermo-physical characterization of the reservoir is accomplished by evaluating drilling data and seismic surveys. Especially in carbonate reservoirs the distinction of different facies zones or heterogeneities in general is very complex and often simply not possible. For reservoir predictions, geothermal parameters such as permeability, thermal conductivity/diffusivity, specific heat capacity and reservoir heat flow have to be quantified. These thermo-physical parameters show facies related trends. Therefore, applying a thermofacies classification on the Upper Jurassic limestones is helpful to understand the heterogeneities and to identify production zones. In addition, for economic reasons a sufficient high flow rate to the production well is necessary. This flow rate is mainly controlled by the reservoir permeability. Outcrop analogue studies enable the determination and correlation of facies related thermo-physical parameters and structural geology data and thus the geothermal exploration concept becomes more precise and descriptive. The outcrops of the Swabian and Franconian Alb represent the target formations of Upper Jurassic carbonate reservoirs in the adjacent Molasse Basin. These limestone formations contain the main flow paths through tectonic elements and characteristic of limestone formations also through karstification. The type and grade of karstification is also facies related. A high variation of thermo-physical parameters is recognized within one facies zone or stratigraphic unit; variations even occur within one outcrop. However, general trends indicate that the hydraulic flow patterns are related to tectonically created weak zones in the formation and that the matrix permeability has only a minor effect on the reservoir's sustainability. The matrix permeability of all measured carbonates is quite low except for some grainstones with higher permeabilities and porosities. Mud- and wackestones show thermal conductivities around 2 ($W\,m^{-1}\,K^{-1}$), characteristic of limestones. Permeabilities range from 0.05 to 100 mD. Mudstones have lower thermal conductivities than wackestones. The permeabilitiy range of mud- and wackestones is about the same. The thermal conductivities of the rudstones show values of 1.8 to 3.0 ($W\,m^{-1}\,K^{-1}$). Reefal structures show the highest values of thermal conductivity, due to the higher content of secondary mineralized silicates. The comparatively high thermal conductivity corresponds to low permeability. The parameters are determined on oven dried samples. These values have to be corrected for water saturated rocks under the according temperature and pressure conditions. These calculated parameters can be validated in a Thermo-Triax-Cell simulating the existing temperature and pressure conditions in the reservoir and furthermore induces a pore pressure on the rock sample. Based on the investigation of the matrix parameters the sustainable heat transport into the geothermal reservoir can be assessed. Thus, the long term capacities for different utilization scenarios can be calculated more precisely. Investigations on the lateral extension and facies heterogeneity will give insight on the transmissibility of different target horizons. The facies related characterization and prediction of reservoir formations is a powerful tool for the design, operation, extension and quality management of geothermal reservoirs. The facies related petro-physical data can also be used for detailed numerical simulations of geothermal carbonate reservoirs.