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Petrophysical properties and 3D block model of Buntsandstein Sandstones reservoir (Upper Rhine Graben)

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Buntsandstein sandstones (upper Permian to middle Triassic), located in the Upper Rhine Graben, appear as an easy target for geothermal exploitation: this reservoir links more or less permeable argillaceous sandstones, intersected by many major faults, to the regional thermal anomaly. In this context, we propose a conceptual geological 3-D block model of the Buntsandstein reservoir which could be used as a guide for future regional geothermal exploration or exploitation. This block presents the Buntsandstein sandstones reservoir at depth with different sedimentary facies (braided rivers, playa lake and fluvio-aeolian), above the Palaeozoic Granit and below the Muschelkalk limestones, intersecting by faults oriented according regional major azimuths: (1) ≈N020°E, corresponding to Rhenish faults and (2) ≈N060°E (or ≈N130°E) corresponding to Hercynian reactivated faults.

Petrophysical properties of the reservoir are both controlled by matrix and faults/fractures characteristics. (1) Matrix properties (porosity, permeability, thermal conductivity, Pwaves velocity) have been determined from petrophysical measurements performed on cores of 15 borehole, mainly on borehole EPS1 (Soultz-sous-Forêts, France), continuously cored through Buntsandstein; (2) from thermal gradient analyses based on thermal conductivity measurements on core samples and also from borehole temperature logs run in the same borehole. This last approach allows locating fluid flow and thus permeability at reservoir scale. The flow paths appear as a composite network controlled by 'sedimentary' permeability on one hand and by 'fracture' permeability on the other. Fracturing associated with major fault zones provide pathways for the upward flowing fluids to connect with stratigraphic levels characterized by high matrix permeability and no impermeable macroscopic layers. This is why the Playa Lake and Fluvio-aeolian marginal erg facies provide a reservoir connected to a deep hot fluid source. Braided river facies, despite high matrix permeability, present a broad network of thick oblique argillaceous layers which decreases the macroscopic permeability.

Fracture network is determined from outcrops and borehole data analysis. Near Rhenish major faults zones, fracturing appears organised as corridor with high density of fractures, separated by law density fractured zones. This fractures organization was not recognized near Hercynian reactived fault. Baryte and quartz precipitation have been observed near this last fault and near Rhenish oriented fault. However, no or just very few mineral precipitations are present in fractures localized in the central part of the bloc. These kinds of mineralization indicate paleo- fluid flow zones. Furthermore, mineral precipitations drive to an important decrease of fracture porosity and permeability and thus they can constituted important fluid flow barrier.

Association of matrix and fracture data drives to the building of a 3D conceptual block model of the reservoir. It point zones where geothermal exploitation could be easier: near playa lake and fluvio-aeolian facies and near certain fault zones (with Hercynian orientation).