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Investigation of fluid flow paths within granitic batholiths: the Soultz-sous-Forêts 'Enhanced Geothermal System' and the Catalan Coastal Ranges examples

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Geothermal exploitation of deep and hot rocks at industrial scale requires an accurate assessment of the available resource. In particular, temperature, porosity, connected porosity, fluids path, permeability, rock volume attainable by drainage, have to be constrained to forecast the potential of an area, and to further manage the heat resource during exploitation. We will present our work devoted to structural controls on fluid circulations in deep granitic basements.

The first example is the current Soultz-sous-Forêts EGS being developed for over 20 years in the hot granite of the Upper Rhine Graben. Depth levels of naturally flowing deformation zones are known at well positions, but the fluid flow paths between the boreholes are still poorly understood. Our new developments of Vertical Seismic Profiling methods provide mapping of these permeable structures between the boreholes in 3D, below the sedimentary filling of the graben in the 1500-3500 depth range. As typical hercynian strike directions are identified, this study demonstrates the major role of inherited structures in the control of fluid flow paths. 3D representation with gOcad allows to build a reservoir model from various data. Such 3D approach is of major importance to identify the structural relations between the faults populations, especially their intersections and connectivity.

The second example is also located within the European Cenozoic Rift System. Outcropping granites of the Catalan Coastal Ranges allow to access their structures in 3D with a comprehensive set of methods. Multi-scalar fractures have been identified from Digital Elevation Model to field analysis. Carbonate fillings are observed in fractures of specific orientations. They illustrate old fluid flow paths occurring in natural conditions. Conditions of their emplacement are provided by geochemical signatures. The geometry of the veins (orientations and connections) and their distribution illustrate how a rock mass volume can be drained by fluids. In addition, intragranitic faults are investigated by seismic, electric, radar and petrophysical methods in order to characterize their control on fluid transfers.

These two granitic massifs currently present similar thermal anomalies, seismic and geothermal (hot springs) activities, and evidences of hydrothermal alteration. As the Soultz-sous-Forêts granitic basement is covered by thick sediments (1500 m), the indirect characterization led on the analogue outcropping batholith provides information about scaling of faults and fractures, and network of fluid circulations. In the two examples the reactivation of inherited structures is obvious. Periods of fault initiation and further activations are key elements to investigate the granite history. A conceptual model for the drainage of a granitic mass is proposed from regional to fracture scales.