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Thermal and hydraulic properties of faulted crystalline crust – a stochastic approach based on seismic and petrophysical data from the Continental Deep Drillhole (KTB), Germany

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On the basis of seismic and petrophysical data collected at the 9.1 km deep Continental Deep Drillhole (KTB) we are presenting a stochastic approach to estimate geothermal and hydraulic properties of deeply fractured crystalline crust. The work is being performed as a contribution to a more general approach to realistically estimate the geothermal potential of faulted crystalline crust. The seismic part of the approach consist of applying new techniques of data analysis to 3D seismic reflection data in order to identify complex network of fractures and their interfering with major fault planes. Concentrating on a 10x10x10 km crustal cube this analysis is combined with vertical seismic profiling, petrophysical laboratory and mineralogical data in order to estimate crack porosity values in situ which can then be attributed to the fault and fracture patterns. The seismic-petrophysical analysis is based on (1) reconstructing the crack-free seismic velocity-depth function from a multi-parametric inversion of seismic velocity data gathered in the laboratory under simulated in situ conditions constrained by a mineralogical depth profile determined from the X-ray diffractometry of drill cuttings, and (2) on evaluating the difference between seismic velocities in situ and reconstructed crack-free velocities in terms of seismic anisotropy and crack porosity. Attributing these crack porosities to the 3D seismic fracture patterns leads to a hydraulic model of the brittle upper crust which can be evaluated by the outcome of the hydraulic injection experiments performed at the KTB site at different depths. In order to determine model uncertainties distribution functions are derived for all geophysical properties involved on the basis of borehole measurements and seismic modeling.