Depth-dependent analysis of fracture patterns inferred from image logs and cores in crystalline rocks

Mohammad Javad Afshari Moein
Martin Luther University of Halle-Wittenberg, Institut of Geosciences and Geopgraphy, Halle/Saale, Germany
(javad.afshari@geo.uni-halle.de)

Enhanced Geothermal System (EGS) development requires an accurate fracture network characterization. The knowledge on the fracture network is fundamental for setting up numerical models to simulate the activated processes in hydraulic stimulation experiments. However, direct measurement of fracture network properties at great depth is limited to the data from exploration wells. Geophysical logging techniques and continuous coring, if available, provide the location and orientation of fractures that intersect the wellbore. The statistical parameters derived from borehole datasets (either from image logs or cores) constrain stochastic realizations of the rock mass, known as Discrete Fracture Network (DFN) models. However, accurate parametrization of DFN models requires sufficient knowledge on the depth-dependent spatial distribution of fractures in the earth’s crust.

This analysis includes a unique collection of fracture datasets from six deep (i.e. 2-5 km depth) boreholes drilled into crystalline basement rocks at the same tectonic settings. All the wells were drilled in the Upper Rhine Graben in Soultz-sous-Forêts Enhanced Geothermal System, France, except the well that was drilled in Basel geothermal project, Switzerland. The datasets included both borehole image logs and core samples, which have a higher resolution. Two-point correlation function was selected to characterize the power-law scaling of fracture patterns. The correlation dimension of spatial patterns showed no systematic variations with depth at one standard deviation level of uncertainty in moving windows of sufficient number of fractures along any of the boreholes. This implies that a single correlation dimension is sufficient to address the global scaling properties of the fractures in crystalline rocks. One could also anticipate the spatial distribution of deeper reservoir conditions from shallower datasets. On the contrary, the fracture density showed some variations with depth that are sometimes consistent with changes in lithology and geological settings at the time of fracture formation.