Regional stress distribution to help with locating exploration areas

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Stress distribution as an indicator for exploration well siting

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When it comes to electricity generation using geothermal systems, a fluid is injected in a host rock where it circulates in natural fault zones and vaporizes under high temperatures, and is finally extracted through one or more production wells. The injection and production wells must be drilled so that they intersect at least one major fault zone in order to ensure sufficient flowrates through the system. In most cases, the regions where such high temperatures are reached are located several kilometers deep, and little to no error can be tolerated for the siting of the wells due to economic concerns. Prior to the operational wells, an exploration well may be drilled in order to give evidences of the geometry and physical parameters *in situ* and corroborate the information acquired indirectly (mainly from geophysics and surface/analogous structural geology). But again, the well should be sited as accurately as possible in order to retrieve the most relevant evidences that will help positioning the injection and production wells.

Gathering indirect information from additional disciplines (geochemistry, hydrology, geomechanics…) brings more objectivity to the choice of the well siting. Indeed, each discipline independently suggests a best location, but comparing their suggestions should highlight a region where the well has best chances to be well positioned. As far as geomechanics is concerned, the stress distribution around the fault zones is a key indicator for the success of a geothermal system. The stresses acting on a fault zone condition its response to the injection of an overpressured fluid, i.e., its ability to open (jacking) and to slide (soft stimulation in Enhanced Geothermal Systems). Conversely, the fault zones affect the stress distribution in the rock mass. These fault zones are part of a broader fault network inherited from the regional tectonic history. Although estimates of the tectonical stresses are usually available, the high complexity of the network makes it impossible to infer the stress state around the fault zones directly from the tectonical stresses. Numerical models become a necessity for studying the mechanical behavior of such networks.

In this context, we propose a methodology based on numerical simulations to retrieve the stresses acting on the fault zones. The fault network is modelled at the regional scale using a mechanical code (3DEC™) and is subjected to the tectonical stresses, assumed to be homogeneous at this scale. The code results give a stress distribution throughout the whole model, including the region surrounding the fault zones aimed at for the geothermal system. The work presented here is based on the Rhine Graben fault network. The already evidenced fault network must be simplified so that it can be handled by 3DEC™. This step must be carried out with the help of structural geology, which highlights *a priori* the faults playing a greater role in the stress distribution. The tectonic stresses associated with the Alpine orogeny are then applied to the model, and the stresses obtained can be compared to that measured at Soultz-sous-Forêts Enhanced Geothermal System.