Fluid geochemistry monitoring and fractured zones characterization in the GRT1 borehole (ECOGI project, Rittershoffen, Alsace, France)

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The GRT1 borehole has been drilled in 2012, in the framework of the ECOGI project. This project, associating Roquette frères, Electricité de Strasbourg and Caisse des Dépôts, aims at producing geothermal steam to dry starch in the Roquette factory located close to the Rhine river. This borehole is located within the Rhine Graben, 6 km south-east to the Soultz site, the first experimental EGS power plant in the world.

According to its Soultz experience and its knowledge of the deep fluid circulation, BRGM has led a research project to acquire new knowledge about the fracture network and the nature of fluid in the deeper part of the Rhine Graben. In this framework, during the drilling, Helium and Radon gas contents were monitored; fluids were sampled and analyzed, also including during the hydraulic tests. The fracture network was characterized based on the borehole image UBI and fracture filling minerals were determined.

The Radon concentration remained at low levels and was correlated with the basement geology rather than the deep circulations. On the contrary, the Helium concentration showed high enrichment in relation with fractures observed on the borehole images, as this was observed during the drilling of the Soultz wells (Sanjuan *et al*., 2006).

The fluids discharged from the borehole and collected during the drilling and hydraulic tests are probably still perturbed by the drilling mud. However, the chemical analyses show a high salinity and characteristics similar to those of the Soultz deep native geothermal brine. Like in Soultz, these results suggest that the fluid is in equilibrium within deep sedimentary formations at the temperature of about 220 ± 20°C (Sanjuan *et al*., 2010).

A structural analysis has been performed based on the observation of borehole images UBI recorded in the deeper part of the basin, from Keuper to Permian and the top of the granitic basement. In the sedimentary part, the orientation of fractures is rather homogeneous, mainly in the rhenan directions. We note that in the Muschelkalk, the density of fractures is high and organized in cluster. Two large fractures have been identified in this Muschelkalk part which have shown fluid lost during the drilling. In the contrary, in the Buntsandstein, the density of fractures is less important and very regularly, with the major part of fractures deepening to the west. It is the same in the upper part of the Permian, which corresponds to the Annweiler sandstones. The lower Permian and the top of granitic basement are intensely fractured. The orientation of fractures is very scattered, comparatively to the sedimentary part, including hercynian directions, with high dip to the west. Several large fractures showing fluid circulation during the drilling have been observed with a sub-meridian direction and a dip weaker than for the meso-fractures. As at Soultz, the fracture network is constituted by meso-fractures organized in cluster and crossed cut by large fractures (Dezayes *et al.*, 2010).

A mineralogical determination of cutting sampling within the high fractured zones and the large fractures shows two stages of micro-fracturing at the grain scale: a cataclase stage observed in all samples with microcrystalline quartz and illite, and a vein filling stage with quartz, carbonate and anhydrite observed only at the top of the granite. These two stages have been observed at Soultz but the barite constitutes the mineralogical of vein filling (Genter & Traineau, 1996) instead of the anhydrite. This difference can be due to a variation of the nature of the alteration fluid or a variation of the physic-chemical conditions of precipitation.

The correlation of the different geochemical, mineralogical and structural analyses permits us to highlight fluid circulations in the borehole. These fluid circulations are controlled by two or three fracture zones showing also paleo-circulation indices.

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