Deep geothermal reservoir analysis in the Upper Rhine Graben using a geochemical and isotopical multi-tracer method - first results

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It is state of the art in geothermal exploration to use various geophysical methods (eg. 3D-seismic), which are rather expensive. This work presents the first results of a new characterization of a hydrogeochemical reservoir in the Upper Rhine Graben with a combination of methods from hydrogeochemistry and isotope hydrology in near surface groundwater. For this purpose natural geochemical tracers as well as rare earth elements, $^3He/^4He$ ratios, and radiogenic isotopes (Sr, Nd, Pb) are investigated in the northern Upper Rhine Graben, close to Groß-Gerau, Germany.

Geochemical analysis show three different types of fluids and various mixtures. $CaHCO_3$-dominated waters represent quaternary aquifer conditions whereas $MgSO_4$-dominated waters have a tertiary origin. Higher saline NaCl-dominated waters show an impact of mantle fluids revealed by $^3He/^4He$ isotope analysis [1]. The ratio is highest where the main fault of the northern Upper Rhine Graben crosses the Rhine river. This suggests that the fault is hydraulically active and connects deep fluids with the shallow aquifer.

Further investigations of rare earth element patterns as well as radiogenic isotopes (Sr, Nd and Pb) identify the origin, the ascent as well as the retention time of the deep fluids more precisely [2]. Water-rock interactions and mixtures of different fluids in the reservoir and during the ascent are estimated and simulated using geochemical and hydraulic models. Thus, the geometry of the aquifer, the temperature and the quantity of the ascending deep fluid in the reservoir is estimated.

The region was chosen to test the multi-tracer method due to its well-studied geology and the marked saltwater anomaly. The aim is to identify the most useful tracers of deep geothermal fluid circulation, which consecutively can be applied to other regions with less prior information.

[1] Kenned & van Soest (2007) *Science* **318**, 1433-1436. [2] Loges *et al* (2012) *Applied Geochemistry* **27**, 1153-1169.

Se(IV) uptake by Äspö diorite: Micro-scale distribution

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Selenium is one of the radionuclides with major contribution to the total radiation dose in nuclear waste geological repositories. The performance assessment of a repository demands sound retention data sets with minimised uncertainties, for all the material composing the natural and engineered barriers. The high heterogeneity of crystalline rock necessarily contributes to the high uncertainties on sorption parameters. Furthermore, Se is a redox sensitive element, with a complex geochemical speciation, for which to maintain controlled redox conditions during the whole experiment is particularly relevant.

In this study, Se(IV) sorption onto diorite samples from the Äspö underground research laboratory was studied by micro-Particle Induced X-ray Emission (μPIXE). Äspö diorite samples were extracted, handled and transported under anoxic conditions. Sorption experiments were carried out in Äspö groundwater (pH 7.9 and EC = 13.36 mS/cm), both under oxic and anoxic conditions, for comparison.

Selenite distribution on Äspö diorite surface was heterogeneous both under oxic and anoxic conditions, being higher its retention under anoxic conditions. The main retentive minerals were identified and surface distribution coefficients (Ka) were determined on main diorite minerals. Sorption values ranged from zero, on quartz or K-feldspars, to higher values in Fe-bearing minerals (Ka $\sim 7 \cdot 10^{-5}$ m) under anoxic conditions.

Average surface distribution coefficients could be determined accounting for the mineral occurrence (%) of diorite samples and the obtained values were compared to the bulk distribution coefficients (Kd) determined on same samples by batch experiments (Se-Kd (oxic) $\sim$ 2 mL/g and Se-Kd (anoxic) $\sim$ 8 mL/g).