Geophysical Research Abstracts
Vol. 12, EGU2010-4725-3, 2010
EGU General Assembly 2010

Assessment of biogeochemical interactions in geothermal energy systems and their effects on the working reliability

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For a reliable operation mode of a geothermal energy system, it is substantial to understand the bio-geochemical interactions between the natural groundwater system and the technical geothermal plant. Problems can occur e.g. in terms of corrosion, scaling and iron clogging which all lead to a reduced porosity of geothermally used aquifers and thus reduce the working reliability of the geothermal plants. In this context, we present our results from the biogeochemical investigation of one shallow cold storage (depth of 30 m below surface) and one deep heat storage energy system (depth of 1250 m below surface), located in the North German Basin.
Since 2006 two underground energy storages have been investigated using fluid and filter bag samples taken during water charge as well as discharge operation mode. The fluid samples were analysed by ion chromatography for inorganic and organic anions like sulfate and low molecular weight organic acids (LMWOA) to detect and quantify the potential nutrients and metabolites of microbial processes. These compounds are known to be involved in microbial growth and respiration which may result in microbiologically influenced corrosion (MIC) [1]. LMWOA are detected in the fluid of the cold storage up to 0.5 mg/L as well as for the heat storage (<2 mg/L). The cold storage represents a quaternary freshwater aquifer with chloride and sulfate concentrations of around 60 and 200 mg/L, respectively. The deep heat storage (lower Jurassic) is characterized by a highly saline aquifer system with chloride and sulfate concentrations of around 78 and 1 g/L, respectively.
Furthermore, dissolved organic carbon (DOC), which is defined by 0.45 µm filtration, serves as an energy and carbon source for microorganisms and has been investigated in detail by liquid chromatography-organic carbon detection (LC-OCD) for a better understanding of its composition and possible variation over time. For the freshwater aquifer there is a mean average of 4 mg C/L, while for the high saline deep energy system the DOC content shows a larger variability (0.2 to 19 mg C/L). In addition, isotopic analysis of the DOC is done with LC IsoLink to characterize the origin and source of these compounds. Within the cold storage, during a period of reduced injectivity, the δ^{13}C signal of the DOC shows a trend to heavier values from -27.3 to -26.6‰. These results may imply an increased bacterial activity, which can alter the molecular and isotopic composition of the DOC.
The presence of living microbial cells could be demonstrated by the detection of intact phospholipids in the filter bag material from the energy storages as these phospholipids are only stable in living organisms. The major constituents of these “life markers” are phosphatidylglycerols (PGs) and phosphatidylethanolamines (PEs) representing the indigenous bacterial community. For a detailed characterisation of the microbial communities, analysis of the phospholipid fatty acids (PLFA) is done and the results show seasonal changes depending on charge and discharge operation mode, probably due to temperature adaptations.

References:
[1] Coetser, S.E., Cloete, T.E. (2005) Crit. Rev. Microbiol. 31, 213-232.