Reservoir characterisation of the Upper Jurassic aquifer in the Bavarian Molasse Basin using environmental isotopes and hydro-chemical data

Introduction
The Upper Jurassic aquifer in the Bavarian Molasse Basin has a great potential for hydro-geothermal energy supply. The carbonate aquifer that is composed of limestones and dolomites reaches a depth to more than 5000 m in the area south of the city of Munich. The groundwater in this heterogeneous karstic aquifer is mostly associated with fault systems, karstic structures and a rock matrix porosity. Former studies from Frisch & Huber (2000) and Birner (2013) developed a general hydraulic flow system, hydrochemical zoning and hydrochemical genesis pathways for the deep carbonate aquifer (Fig. 1). In addition, Birner (2013) showed that the groundwater chemistry is dominated by sodium and chloride and found evidence of cation exchange processes between sodium and calcium. Furthermore, the stable water isotopes indicated predominantly cold climate (Pleistocene) recharge conditions.

Fig. 1: Overview of the Bavarian Molasse Basin with hydrochemical zoning after Birner (2013) and the hydraulic flow system after Frisch & Huber (2000).
Influences of geological features on the hydro-chemical and isotopic composition of deep groundwater

The hydro-chemical and isotopic composition of the thermal used groundwater in the Upper Jurassic aquifer is likely affected by several water components such as meteoric water, ion exchange water from the overlying Pleistocene aquifer system, connate and extreme (oilfield) water, deep water from the mostly underlying basement as well as the more immobile pore water from the rock-matrix (Fig. 2).

Fig. 2: Influences on the water composition of the geothermal used groundwater in the Bavarian Molasse Basin (after Mayrhofer et al. (2014)).

Aims

Understanding the hydrogeological setting, including the location of the recharge areas of the deep water and the water-rock interactions during groundwater transition, are of key interest for a successful geothermal exploitation strategy. Therefore, the scientific goals of the PhD thesis are:

- Identification of (different) influences on the water composition of the Upper Jurassic groundwater.
- Delineation of local, regional and supra-regional flow regimes in the Molasse Basin.
- Determination of possible recharge areas of the thermal used groundwater in the Molasse Basin.

Methodology

To answer the questions of this research topic, a multi parameter approach was used. We have combined a wide spectrum of environmental isotopes such as stable water isotopes (δ¹⁸O, δD), strontium isotopes (⁸⁷Sr/⁸⁶Sr), radiocarbon dating methods (¹⁴C) as well as noble gas helium and argon isotopes (³He/⁴He, ⁴⁰Ar/³⁶Ar) with water chemistry data to identify the different geological features affecting the water flow in the deep aquifer and influences on the water composition.

We analysed more than 60 water samples and 15 rock samples originating mostly from the Upper Jurassic aquifer as well as from surrounding geological layers. As a first result we identified several reservoirs in the Bavarian Molasse Basin of different isotopic, chemical and specifiable origin using statistical cluster analyses.

References

