



Evolution of groundwater from Permian and Triassic aquifers in the Thuringian basin, Germany

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The hydrochemical properties of shallow and deep groundwater with special emphasis on stable isotopes (2H , 18O , 34SSO_4 , 18OSO_4) as well as rare earth elements (REE) are investigated to study the evolution of groundwater in the edge areas of the Thuringian basin (central Germany). The Thuringian basin is a syncline structure with an extension of 160 km in northwest-southeast and 100 km in northeast-southwest direction. It consists of sandstones, limestones, clays, gypsum and salts, that were deposited from the Late Permian until the Early Jurassic (approximately 250 to 180 million years ago). At the edge areas of the basin, sediments of Zechstein (Permian) and Bunter Sandstone (Early Triassic) are cropping out over a wide area being the catchment areas for ground water recharge of the main aquifers in Bunter Sandstone and Zechstein formations. In addition to the infiltration of atmospheric water, highly mineralized ascending groundwater occurs at fault systems leading to interactions between the aquifers.

The isotope data of dissolved sulfates (34SSO_4) indicate a terrestrial origin of sulfates in Early Bunter Sandstone as well as marine conditions for sulfate formation in Late Bunter Sandstone and Late Zechstein. Thus, sulfate isotopes can be used to identify the origin of water and to estimate the proportions of sulfates of different sources in mixing water. The isotopic composition of water in Bunter Sandstone aquifers in the eastern part of the basin indicate an increasing influence of sulfates from Late Bunter Sandstone in aquifers of Middle Bunter Sandstone along the groundwater flow towards the center of the basin. On the other hand there is no indication for mixing with Zechstein associated water in these aquifers. In contrast, in the northern part of the Thuringian basin and southward of the basin (south of the Thuringian forest) an interaction of Zechstein and Bunter Sandstone aquifers bound on fault systems becomes evident.

The fractionations of rare earth elements in groundwater were determined after an enrichment procedure based on the method of Shabani (1992). Positive and negative Ce anomalies on PAAS (Post Achaean Australian shale) normalized REE fractionation pattern give hints on different redox conditions during groundwater evolution. Positive Ce anomalies were identified only on samples originated at Zechstein aquifers, whereas groundwaters in Bunter Sandstone aquifers with high redox potential show negative Ce anomalies, generally.

References:

Shabani, M.B., T. Akagi, and A. Masuda (1992): Preconcentration of trace rare earth elements in seawater by complexation with (2-ethylhexyl) hydrogen phosphate and 2-ethylhexyl dihydrogen phosphate adsorbed on a C18 cartridge and determination by inductively coupled plasma mass spectrometry: *Anal. Chem.* 64, 737-743.