Tracing the evolution of groundwater by Rare Earth Element patterns and stable isotopes

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The evolution of shallow and deep groundwater from the Thuringian basin (central Germany) was investigated with special emphasis on rare earth elements (REE) and stable isotopes ($34S_{SO4}$, $18O_{SO4}$). The Thuringian basin covers about 2700 km^2 and 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 periphery 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.

Water originating from Zechstein aquifers is of Na-Cl-(HCO_3) type and can be clearly distinguished from water originating from Bunter Sandstone (Ca-Mg-SO_4 or Ca-Mg-HCO3-type) and from limestone aquifers (Ca-(Na)-HCO_3-type).

Positive and negative Ce anomalies in Post Archean Australian shale normalized REE fractionation patterns of groundwater give hints on different redox conditions during groundwater evolution.

The isotopic data ($34S_{SO4}$ and $18O_{SO4}$) of dissolved sulfates indicate a terrestrial origin of sulfates in Early Bunter Sandstone and limestone aquifers as well as marine origin of sulfate in Late Bunter Sandstone and Late Zechstein. Isotopic data thus allows estimation of mixing of water of different aquifers/lithologies. An interaction of Zechstein and Bunter Sandstone aquifers bound on fault systems becomes evident for the northern part of the basin.