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## Rare earth element patterns as process indicators at the water– solid interface of a post–mining area

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Rare earth element (REE, La–Lu) patterns in groundwater are the result of complex solid-water interactions and can therefore be applied as process indicators in this system. At a remediated basement area of a heap in a post-U-mining area (Ronneburg, Germany), REE patterns in near surface groundwater were studied for 10 years (2005–2014) along a groundwater flow path. The groundwater passed through Quaternary sand, silt, and sand, again resulting in increased element and ion concentrations (e.g., Al, Co, Mg, Mn, REE,  $\text{SO}_4^{2-}$ ) along the flow path, most of which decreased steadily over the 10 years. The decline in concentrations was more pronounced for observation points in the downstream area. It is likely that, during mining operations, elements were retained by sorption or buffering reactions in the silty/loamy material and have been gradually mobilized with fading subsequent delivery.

The REE patterns in groundwater were enriched in middle (Sm–Dy) and heavy REE (Ho–Lu) and featured a positive Ce anomaly. The basic pattern (without Ce anomaly) in groundwater was attributed to mobilization from the Silurian black shale that had

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