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Stable isotopes in hydrogeochemical and environmental studies of the Harz Mountains (Germany)

ELKE BOZAU[1], TANJA SCHÄFER[1] AND TOBIAS LICHA[2]

[1]TU Clausthal
[2]RU Bochum

The Harz Mountains, situated in the north of Germany, are about 120 km long and about 40 km wide. Their highest mountain is Mount Brocken (1,141 m a.s.l.). The mountain range is known for ancient silver and base metal mining. Today the Harz Mountains are an important drinking water supply region for northern Germany. Stable isotope ratios of oxygen, hydrogen, sulphur and carbon have been used in many geological and environmental studies of the Harz Mountains for a long time. This paper presents results highlighting the potential of stable isotope data to gain a deeper understanding of hydrogeochemical and environmental processes. By combining isotope ratios with specific electrical conductivities (SEC) valuable insights in the seasonal water dynamics are possible. SEC is a key parameter for the ion concentrations of spring water and the intensity of water-rock interactions. The $\delta^{18}O$ and $\delta^{2}H$ values of spring water reflect the precipitation input. Therefore, the morphological position of springs in the mountain range and their catchment size can be characterised by them. Lower SEC as well as lower $\delta^{18}O$ and $\delta^{2}H$ values are found in spring waters at higher elevations according to the rain out effect. Seasonally constant $\delta^{18}O$ and $\delta^{2}H$ values are typical for springs with large catchment areas where the waters after recharge are well mixed in the aquifers. Springs of small catchments quickly respond to precipitation events with varying SEC and isotopic values. The $\delta^{34}S$ values can be used to retrace the origin of sulphate in water samples. Atmospheric input and mining activities, especially the weathering of sulphide ore minerals are reflected by $\delta^{34}S$ values. Spring and lake water have comparable $\delta^{34}S$ values ranging from 0 up to 10 ‰ (CDT), whereas negative values are found in the adits. Microbiological activities and CO_2 outgassing from groundwater can be investigated by the carbon isotope composition of bicarbonate. The $\delta^{13}C$ values of the investigated spring waters range from −23 up to −19 ‰ (PDB) indicating that the main source of DIC is dissolved soil CO_2 originating from root respiration and the degradation of organic matter.