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Radionuclides in groundwater flow system understanding

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Using radionuclides is a novel approach to characterize fluids of groundwater flow systems and understand their mixing. Particularly, in regional discharge areas, where different order flow systems convey waters with different temperature, composition and redox-state to the discharge zone. Radium and uranium are redox-sensitive parameters, which causes fractionation along groundwater flow paths. Discharging waters of regional flow systems are characterized by elevated total dissolved solid content (TDS), temperature and by reducing conditions, and therefore with negligible uranium content, whereas local flow systems have lower TDS and temperature and represent oxidizing environments, and therefore their radium content is low. Due to the short transit time, radon may appear in local systems' discharge, where its source is the soil zone. However, our studies revealed the importance of FeOOH precipitates as local radon sources throughout the adsorption of radium transported by the thermal waters of regional flow systems. These precipitates can form either by direct oxidizing of thermal waters at discharge, or by mixing of waters with different redox state. Therefore elevated radon content often occurs in regional discharge areas as well.
This study compares the results of geochemical studies in three thermal karst areas in Hungary, focusing on radionuclides as natural tracers.
In the Buda Thermal Karst, the waters of the distinct discharge areas are characterized by different temperature and chemical composition. In the central discharge area both lukewarm (20-35°C, 770-980 mg/l TDS) and thermal waters (40-65°C, 800-1350 mg/l TDS), in the South only thermal water discharge (33-43°C, 1450-1700 mg/l TDS) occur. Radionuclides helped to identify mixing of fluids and to infer the temperature and chemical composition of the end members for the central discharge area. For the southern discharge zone mixing components could not be identified, which suggests different cave formation.
The Bükk karst area is largely compartmentalized owing to the complex geological and structural build-up. Majority of the waters is low mineralized (TDS < 600 mg/l) regardless of their temperatures (8–77 °C). This may indicate deep but relatively fast/short flow paths. Thermal wells, characterized by higher TDS (1000-2500 mg/l) and radium content (400-1900 mBq/l), show the effects of hydrocarbon reservoir fluids.
In the Villány Thermal Karst area the majority of the springs have lukewarm (20-26°C) waters with 712-930 mg/l TDS. Natural thermal water discharge (52-62°C, 1100 mg/l TDS) can be found only in Harkány. Here the highest concentration of radionuclides (226Ra: 230 mBq/l, 238+234U: 66 mBq/l, 222Rn: 43 Bq/l) suggest mixing of different flow systems. The results reflect the effect of different hydrogeological environments and flow regimes but similarities also could be revealed.
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