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Dissolved noble gases and stable isotopes as tracers of groundwater dynamics in the Lower Rhine Embayment, Germany

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A multiple environmental tracer approach has been applied to achieve an improved understanding of groundwater dynamics in the Lower Rhine Embayment, Germany. The main emphasis has been to utilise dissolved noble gas and noble gas determined excess air concentrations in addition to the stable isotopes of hydrogen, oxygen, carbon and strontium. It is hypothesised that a relationship between noble gas excess air concentrations and the magnitude and frequency of water table fluctuations, both natural and as a result of large scale water abstraction can be quantified and used as an indicator of groundwater recharge, flow rate and residence times. The research has also provided further insight into the role of fault zones on local and regional groundwater dynamics.

The hydrogeology of the Lower Rhine Embayment is complex and dynamic, and consists of unconsolidated sedimentary deposits with a number of laterally continuous lignite seams. Large scale open pit mining has a significant impact on the regional groundwater system primarily due to water abstraction and subsequent lowering of the water table. The layered aquifer system is intersected by numerous NW-SE striking fault zones that have been shown to have the potential to act as both barriers to groundwater flow and as preferential flow paths.

Groundwater samples taken from observation boreholes in close proximity to fault zones have provided preliminary results that indicate hydrogen and oxygen isotope anomalies and extremely high helium-4 concentrations in the shallow aquifer layers. Groundwater exchange between the lower and upper aquifer systems is impeded by confining clay layers and a continuous lignite seam of very low permeability. This suggests that palaeowater from depth is mixing with modern water of meteoric origin in the upper aquifer as a result of conduit flow from depth towards the upper aquifer layer within the fault zone.