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Applying tracer techniques to determine recharge rate, groundwater age and travel times in Permo-Triassic sandstones.

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The Eden Valley in East Cumbria is underlain by Permo-Triassic sandstone, the major aquifer in Northwest England. Rising nitrate trends in some boreholes has prompted collaborative research into flow systems and timescales in the area.

The use of slurry and artificial fertilisers following agricultural intensification during the 1980s is believed to be responsible for the rise in nitrate concentrations. The broad aim of this research is to enable prediction of future nitrate concentrations at abstraction boreholes and in groundwater discharge to surface water.

The approach taken has been to study groundwater processes along a 4km transect (approximating a groundwater flowline) in order to estimate groundwater travel timescales through the sandstone and thin superficial Till . A combination of porewater sampling during borehole coring, discrete interval sampling using a borehole packer system, geophysical logging and imaging were employed to develop physical and hydrochemical profiles.

Separate tracer techniques were used to estimate recharge rates at different parts of the transect. Tracers used were: deuterium and bromide through Till, nitrate, chloride and tritium through the unsaturated zone and CFCs and SF6 within the saturated zone.
Tracer profiles in Till demonstrated a correspondence between Till thickness, type of cultivation and recharge rate. In the thick unsaturated zone of the sandstone they suggested relatively rapid groundwater recharge rates.

Key fractures or fracture zones in the saturated sandstone were identified and sampled. The hydrochemistry (particularly nitrate) of samples from discrete intervals in the profiles exhibited a remarkably good relationship with the proportion of modern water (and year of recharge) for example, the age of groundwater increasing to c. 1950 towards the bottom of a 90m borehole.

This work demonstrates that the combination of discrete sampling and dating of groundwater is a powerful tool in characterising groundwater movement and timescales in boreholes and hence in parts of aquifers where pollution is most significant. With timescales and processes better constrained, a more reliable prediction of nitrate (and other) trends can be made.