Assessing continental weathering rates and actinide transport in the Great Artesian Basin

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The Great Artesian Basin in Queensland, Australia, is the world's largest confined aquifer system, containing extremely old groundwaters which provide an opportunity to investigate in-situ chemical weathering, where vadose zone inputs are comparatively minor. Examination of this basin using uranium-series disequilibria has the potential to provide information on both continental weathering processes and on transport and residence times of radionuclides in groundwater systems.

Samples from over 400km (up to 700 kyr) of groundwater-flow through the Basin have been sampled in order to separate a dissolved ($<0.2\mu m$) and colloidal fraction ($10kDa < x < 0.2\mu m$) for measurements of U, Th and Ra activity ratios and concentrations, as well as δ^7Li (a tracer for chemical weathering intensities). Concentrations of ^{228}Ra, ^{226}Ra and ^{232}Th increase with groundwater age, however, U concentrations dramatically decrease with groundwater age in both the filtered and colloidal fractions. There are no simple isotopic trends in activity ratios with groundwater age.

The activities of short-lived ^{222}Rn gas are relatively uniform, hence changes in ^{226}Ra activty are due to changing sorption/incorporation processes in the aquifer. Colloidal U activity ratios are generally lower than the corresponding dissolved load suggesting limited exchange and significant transport of U in colloids between heterogeneities within the aquifer. ^{232}Th conccencentrations are around the solubility limit within the colloidal fraction, but are elevated in the dissolved fraction due to formation of complexes. The increasing dissolved concentrations of both Th and Ra indicate less adsorption and lower retardation factors evolving along the flow path.

PHREEQC-modelled saturation indices and redox conditions indicate that irreversible sorption processes are the primary control on U activity, rather than simple anoxic reducing conditions forming insoluble U, whilst chemcial weathering within the aquifer system is a principal control on dissolved activity ratios, rather than purely α-recoil decay. This is illustrated by both the covariation of dissolved ($^{234}U/^{238}U$) and ($^{230}Th/^{232}Th$) with δ^7Li and secondary clay mineral saturation.