Rhenium isotope variations in modern environments

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With this study we successfully apply the Rhenium (Re) heavy stable isotope system to three modern redox environments. $^{187}Re/^{185}Re$ is measured by MC-ICP-MS, mass bias is corrected by standard-sample-bracketing and external W-correction according to an exponential law. The external standard reproducibility of the NIST SRM 989 standard is 0.04‰ (2SD).

Variations in Re concentrations and $^{187}Re/^{185}Re$ in three different natural environments highlight the potential of this system. 1) In recent Black Sea sediments fractionation of 1‰ is observed between suboxic ($^{187}Re/^{185}Re$ = -0.47‰) and euxinic ($^{187}Re/^{185}Re$ = +0.46‰) sediments indicating that Re scavenging is strongly related to redox conditions. 2) Samples of a Devonian Ohio shale from a Kentucky weathering profile with highly variable Re concentrations have shown a range of about 0.7‰ due to changes in redox conditions during weathering. 3) Four small streams draining an abandoned Kupferschiefer mining district were analyzed in an attempt to trace their sources within this anthropogenically modified site. We observe very high concentrations in both water samples and solid materials (up to 500 ng g^{-1}) and $^{187}Re/^{185}Re$ variations of about 0.4‰.

Our findings emphasize the need for understanding the Re isotope system which may ideally complement more established molybdenum and uranium isotope systems as promising new tool for reconstructing palaeo-environmental conditions.

Semipermeability and solute transport in groundwater

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Once a popular area of research, the idea that clay-rich strata behave as semipermeable osmotic membranes was largely abandoned four decades ago. Recently, a few field, lab, and theoretical studies have provided surprising new evidence that large osmotic pressures are possible in the subsurface, reviving interest in geological membranes. Semipermeability is fundamentally an aspect of solute transport; when a solution flows through a membrane, a portion of the solute is held back, causing local concentration increases and downstream decreases. Knowledge of this phenomenon – ultrafiltration or 'reverse osmosis' – earlier fueled much speculation about brine generation by membranes. We examined the role of geological membranes mechanistically by numerically simulating flow and transport within finite-thickness semipermeable strata. The simulations, which use new findings about transport within geological membranes, reveals that they are probably incapable of making brines and, as importantly, provide a mechanistic reason. Unless highly compacted, the efficiency of clay-based membranes decreases dramatically at high concentrations. Yet clay-rich media that are highly compacted have such low permeabilities that the throughflow needed for brine generation is simply not possible. We note, however, that the simulations also show membranes may have other, and more pervasive, effects on subsurface concentration patterns. Moderate increases in concentration are possible, but occur mainly within the membrane units themselves and not upstream of them as is often supposed. Thus elevated salinity in some confining layers could be the result of throughflow and ultrafiltration rather than a remnant of unflushed paleowaters.