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Dissolved noble gases in sediment pore water as proxies for fluid transport within a lake basin?

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The recent development of analytical techniques to determine routinely noble-gas concentrations in the pore water of unconsolidated sediment allows the application of the well-established concepts of noble-gas geochemistry to sediments from lakes and oceans. In particular, the accumulation of non-atmospheric noble-gas isotopes in the sediment column allows tracing the geochemical origin and transport processes of the pore fluids.

Helium (He) is known to emanate from solid earth. Therefore, the abundance of terrigenic He isotopes can reflect the residence time and transport dynamics of the pore fluids in the sediment pore space. Moreover, different geochemical He components can be distinguished by their typical ^{3}He/^{4}He isotope ratios (~10^{-5} for mantle-type He, ~10^{-8} for crustal He). Therefore, the ^{3}He/^{4}He isotope ratios measured in the pore water of unconsolidated sediments allow characterization of the geochemical reservoir from where terrestrial He and simultaneously other transient fluids originate.

We present noble-gas data measured in the pore water of sediment samples collected from various sediment cores from Lake Van (eastern Anatolia, Turkey). Lake Van is one of the largest terminal lakes and the largest soda lake on Earth. The lake basin is situated in a tectonically active region and it is known to accumulate mantle fluids.

We determined the effective diffusivity in the uppermost ~2 m of the sediment column of Lake Van by tritium (^{3}H) analysis. The effective diffusivity allows conversion of the measured He concentration profiles into He fluxes.

The geographical distribution of the He fluxes within the lake basin is discussed in the context of the available geological and seismic data. Our measurements reveal a north-south zonation of the determined He fluxes in the lake basin whereby low He fluxes are observed near the volcanic region in the north and high He fluxes are present near the intrusive and metamorphic rocks of the Bitlis massif in the south. The strongest He emission is identified at the borders of the deep main basin of Lake Van and correlates well with seismic features that suggest the presence of preferential pathways in the sediment column (probably generated by the ongoing subsidence of the basin) that may foster the release of terrigenic fluids.

The ^{3}He/^{4}He isotope ratios in the sediment pore water identify the terrigenic He injected into Lake Van as a mixture of crustal and mantle He with a ^{3}He/^{4}He ratio of (2.6-4.1)x10^{-6}. The samples from the shallow water and the deep water have distinctly different isotopic composition. This geochemical separation suggests that the terrigenic He entering the sediments of Lake Van is further enriched in radiogenic He produced in the sediment minerals during the migration in the pore space.

Our result make a strong case that noble-gases in the pore water of unconsolidated sediments have the potential to be used as proxy to characterize differences in the petrology and lithology within basins of lakes and oceans as well as the origin and the transport processes of the pore fluids.

Keywords: terrigenic He, geogenic fluids