Quantifying past water-table depths from high-precision noble gas isotope ratios in groundwater

ALAN M. SELTZER[1], JESSICA NG[1], JUSTIN KULONGOSKI[2], MARTIN STUTE[3], JEFFREY P. SEVERINGHAUS[1]

[1] Scripps Institution of Oceanography, CA 92037, USA
[2] USGS Calfornia Water Science Center, CA 92101, USA
[3] Lamont-Doherty Earth Observatory, NY 10964, USA

Precise knowledge of past water-table depths may improve our understanding of long-term changes in local hydroclimate and aid in quantifying the influence of human activity on groundwater levels. For example, constraining the magnitude of glacial-interglacial changes in water-table depth provides local precipitation-evapotranspiration-runoff balance information and may serve as a benchmark against which to test paleoclimate model reconstructions.

The stable isotope ratios of heavy noble gases in the unsaturated zone (UZ) are sensitive to gravitational settling and, therefore, to depth, as predicted by theory and confirmed by a recent study of soil air [1]. Because UZ gases dissolve into groundwater at the water table, measurement of these isotope ratios in groundwater facilitates the quantification of mean water-table depth at the time of recharge, once fractionation due to solubility, excess air, thermal diffusion, and water-vapor fluxes are accounted for.

We have recently developed an extraction and analysis system for two-liter groundwater samples to measure Ar, Kr, and Xe isotope ratios at 1-σ precision ≤ 0.005 ‰ amu^{-1}. With this new system, we have experimentally determined the relevant solubility and kinetic fractionation factors necessary for modeling past water-table depths. At Goldschmidt 2018, we will discuss these findings and present results from two recent case studies: 1) decades-to-centuries-old groundwater from Fresno, California, studied as an evaluation of our noble gas isotope water-table depth tool by comparison with historical records; and 2) last glacial period-to-Holocene changes in water-table depth in southern California.

[1] Seltzer et al. (2017), *Water Resources Research* 53, 4, 2716-32.