Helium in California Groundwater

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Helium isotopes were measured in ~1,700 groundwater samples collected for the GAMA Priority Basin Project, a collaboration of the California Water Boards, USGS, and LLNL, in order to investigate the influence of geologic age, lithology, and tectonic structure on the spatial variability of $^3He/^4He$ in California groundwater. $^3He/^4He$ ratios, corrected for air-entrainment, ranged from 0.01 R_A to 5.10 R_A (R_A is the $^3He/^4He$ of air 1.4 x 10^{-6}). Previous work identified mechanisms that introduce ^3He (magmatism, seismicity) and ^4He (erosion, in-situ and deep-crustal production). To identify sources of He and explain variations in the $^3He/^4He$ state wide, statistical tests were applied to evaluate correlations between the geology mapped at the well, the well's proximity to faults, and $^3He/^4He$.

Correlations between $^3He/^4He$ and categorical explanatory factors including rock type (sedimentary, plutonic, volcanic); Cenozoic age (Holocene, Pleistocene, Tertiary); and sediment type (alluvium, glacial, marine, non-marine, sand, volcanic); and correlation between the continuous variables $^3He/^4He$ and the distance of a well to the nearest fault were evaluated.

Statistical tests demonstrate that $^3He/^4He$ ratios in groundwater were positively correlated (p-value <0.05) to fault proximity. The increase of $^3He/^4He$ near faults suggests seismic activity as a source of ^3He. There also are significant differences in $^3He/^4He$ between the categorical rock types: $^3He/^4He$ is higher in volcanic than in plutonic rocks, and higher in plutonic than in sedimentary rocks. Higher $^3He/^4He$ in wells located in Cenozoic volcanics may be explained by mantle ^3He from relatively recent magmatic activity. Other comparisons reveal no significant correlations. Identifying the factors that explain the spatial variations in $^3He/^4He$ is the first step towards characterizing groundwater affected by seismic activity, ^3He from tritium decay, long residence times, and crustal degassing.