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Noble gas isotopic signatures in thermal waters of the Dead Sea Transform

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Noble gas isotope composition in thermal groundwater provides information about crust-mantle interactions, in form of geotectonic activity, volcanism and advective heat transfer. The knowledge of the geothermal state of the crust is useful for the indication of thermal energy resources, which are of significant environmental and economic importance. In this study, groundwater samples were collected in Israel and Jordan in 2012, along the east and west sides of the central Dead Sea Transform.

The helium isotope ratio, ^{3}He/^{4}He, is a well-established marker to discriminate three different geochemical reservoirs: Atmosphere, crust and mantle. The distinct isotope ratios in each reservoir make it possible to separate the total helium concentration in groundwater into mantle, crustal (radiogenic) and atmospheric components. The ^{3}He/^{4}He ratios of all sampled waters exceed the typical crustal ratio, indicating contributions of mantle-derived helium to the total helium concentration. Most of the samples contain less than 3% atmospheric helium, whereas the mantle-derived helium component ranges from 1% to 61%. In Israel, a clear trend is observed. Samples from the northern parts of the sampling area show higher ^{3}He/^{4}He ratios than samples from southern parts. These findings confirm Torfstein et al. [1], who analyzed thermal groundwaters from Israel. In our data from Jordan, however, no north-south trend is seen, but a local anomaly is observed in the area between the Dead Sea and the Sea of Galilee, with a ^{3}He/^{4}He ratio that is 5 times higher than the atmospheric ^{3}He/^{4}He ratio. Moreover, some samples from North Jordan exhibit only minor mantle contributions, compared to the samples from the north of Israel. Our results emphasize the importance of local faulting patterns, which enable a better transfer of mantle derived helium into the shallow crust.

In addition to helium, the origin of CO_2 in the water was examined. Measurements of δ^{13}C suggest that CO_2 originates from metamorphic processes rather than from the mantle. Furthermore, δ^{18}O and δ^{2}H data indicate a water reservoir temperature above 100°C only at one location.

References:
[1] Torfstein, A. et al. 2013: Helium isotopes in Dead Sea Transform waters. Chemical Geology, 352, 188-201