Evaluation of excess helium isotopic compositions from groundwaters of the continental United States

A.G. HUNT[1*], P.B. MCMAHON[2], B.C. JURGENS[3], AND K. LECH[1]

[1]USGS Noble Gas Laboratory, Denver CO, 80225, USA (*correspondence: AHunt@usgs.gov, KLech@usgs.gov)

2USGS Water Science Center, Denver, CO, 80225, USA (PMcMahon@usgs.gov)

3USGS Water Science Center, Sacramento, CA, 95819, USA (BJurgens@usgs.gov)

The evaluation of excess helium (He_{ex}) compositions for groundwater studies is commonplace for the determination of helium components from individual samples. While some small scale studies link He_{ex} to nearby studies or relate to a specific area, rarely is a large scale evaluation using hundreds of samples either attempted or considered. Utilizing the noble gas data collected by U.S. Geological Survey's National Water Quality Assessment Project, an evaluation of isotopic composition of He_{ex} was performed on a national scale. For this evaluation helium compositions were corrected for solubility based components using neon to produce atmospherically corrected concentrations for He_{ex} and helium isotopic composition (R_C/R_A [$^3He/^4He$ sample corrected for atmosphere, normalized to $^3He/^4He$ ratio in air]). The isotopic variation observed in He_{ex} values for samples less than 2 times solubility is mainly controlled by tritiogenic derived ^3He dominating the R_C/R_A values. Even samples with low to moderate He_{ex} (less than 5 times solubility) show evidence of tritiogenic ^3He and could be interpreted as mixing of modern waters with older water containing higher He_{ex} concentrations. The remaining higher He_{ex} values (greater than 5 times solubility) fall into three approximate end-member compositions. Samples with high R_C/R_A values of approximately 1.0 and greater appear to be associated with large scale geothermal activity and can be characterized as interaction with modern magmatic based systems (e.g. samples from the Rio Grande Rift in Texas, New Mexico and Colorado). The remaining samples fall into a grouping near crustal production values of helium at approximately 0.01 R_C/R_A but extending to values ranging from 0.1 to 0.4. Values greater than production are typically interpreted as mixing between a MORB type helium end-member and production end-member but review of spatial distributions of these values reveals very uncharacteristic patterns that cannot be explained by simple two component mixing. These elevated values above production may represent their own end-member composition.