Noble gas evidence for the mechanisms creating commercial helium reservoirs

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Since its first economic discovery in Kansas in 1903, helium has become an integral resource for today's society. With known reserves declining, discoveries of helium are still only serendipitously found with some petroleum discoveries; there are no viable exploration strategies in place for helium.

Radiogenic ^{4}He accumulates in the crust during quiescent periods and is subsequently released during periods of active tectonism [1]. In the Hugoton-Panhandle He-rich gas field (Texas/Oklahoma/Kansas), ^{4}He correlates with water-derived ^{20}Ne. This relationship is used to suggest that helium released from basement rock is dissolved in overlying groundwater and then quantitatively degassed following migration and contact with a pre-existing hydrocarbon gas phase [2]. To test whether this mechanism is common to other helium-rich natural gas fields, we have collected 22 natural gas samples to analyse for noble gas abundance and isotope determination.

Preliminary data from the Kansas Basin, Central Kansas Uplift, the Harley Dome field in Utah, and two exploration wells in Montana and Saskatchewan, Canada, have helium contents that vary between 0.009 cc STP and 0.080 cc STP. The helium isotope ratio, $^{3}He/^{4}He$, ranges from 0.08 R_A to 0.66 R_A ($R_A = {}^{3}He/{}^{4}He_{air}$) showing a predominantly crustal He source with a small mantle input for most samples. Argon isotope ($^{40}Ar/^{36}Ar$) ratios range from 589-1435 in the Kansas samples and from 4586-8963 in the Harley Dome, Montana and Saskatchewan samples. $^{4}He/^{20}Ne$ in the Hugoton-Panhandle averages 3.4×10^{4} [2]. Kansas samples range from $^{4}He/^{20}Ne = 3.5\text{-}7.8 \times 10^{4}$, showing the same degree of water involvement as the Hugoton-Panhandle for the lowest values. Harley Dome, Montana and Saskatchewan samples have $^{4}He/^{20}Ne = 1.0\text{-}2.3 \times 10^{5}$ showing a 3-7 times lower involvement of the groundwater system, consistent with the elevated $^{40}Ar/^{36}Ar$ ratios.

[1] Ballentine and Burnard (2002), *RiMG,* **47(1)**, 481-538, [2] Ballentine and Sherwood-Lollar (2002), *GCA*, **66(14)**, 2483-2497