Commercial helium gas fields: identifying the source of the helium

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The impending global shortage of helium is well recognised by the science and commercial communities [1], but exploration beyond re-extracting from closed-in smaller gas fields is in its infancy. It is simple to show that in the Canadian Shield alone, for example, enough helium has been produced by the radioactive decay of U and Th since its formation to supply the world's current needs for over 0.5Ma. This will never be realised because at depth helium is dispersed thoughout a large volume of rock and not viable to extract. In contrast, sediments proximal to high helium brearing gas fields could account for the helium observed in some gas fields, but only if both the regional release from the U-Th bearing minerals and transport to the gas trap are close to 100% efficient [2,3]. Only a small proportion of the accumulated crystalline basement helium needs to contribute to the overlying sedimentary-generated helium to transform a marginal helium-rich province into a commercialy viable exploration prospect. Is a baesment source an essential element in forming helium rich gases? What geological processes control this? How do we recognise such systems?

The Hugoton-Panhandle giant gas field spans some 350 Km across SW Kansas and the Oklahoma/Texas Panhandle. Dominantly thermogenic methane and nitrogen, the gas also contains helium at concentrations high enough to warrant separation for sale (>0.3%) and forms a world class case-type commercial helium gas resource. The nitrogen in this field has two distinct sources, one of which is correlated with both the ^{4}He and ^{20}Ne [2]. The correlation with ^{20}Ne shows that both the nitrogen and helium likely accumulated in the groundwater system before being stripped out of solution by the thermogenic methane. New data from the helium rich fields from the Kansas basin and Central Uplift proximal to the Hugoton-Panhandle [3] shows at least two distinct $^{4}He/N_2$ sources in the gas fields, that the majority were degassed from water, that the helium associated nitrogen has a similar $\delta^{14}N$ isotopic content irrespective of the $^{4}He/N_2$ - and that all systems contain ^{3}He derived from the mantle. The occurance of ^{3}He across the entire Hugoton-Panhandle helium province is direct evidence of a deep 'fluid' contribution to the region, likely acompanied by basment ^{4}He. Models to identify the mechanism and proportion of basement to sediment-derived helium are discussed.

[1] Bare *et al*, (2016), Washington DC: *APS* [2] Ballentine and Sherwood Lollar (2012) *GCA* **66**. [3] Tolstikhin et al., 2017 *Chemical Geology* **471** [4] Danabalan (2017) *PhD thesis, U Durham*