Tracing Crustal Fluid Source, Migration and Residence Using Noble Gases

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Major science challenges in the Earth Sciences often revolve around uncertainty in quantifying the role of fluids in a variety of systems. These include: the origin and nature of fluids sourcing economic hydrogen and helium resources; determination of the safety case for anthropgenic waste disposal (nuclear and CO_2), safe recovery of tight trapped hydrocarbons employing high volume high pressure recovery techniques (fracking) and the migration and residence of hydrocarbons to conventional geological traps.

All require an understanding of the fluid sources, the mechanism of transport (e.g. diffusion vs advection) and the residence time within the system of interest. Noble gases isotopes provide a unique tracer set that is often distinct depending on fluid source, is sensitive to different physical processes and can provide temporal information from distinct radiogenic isotopes such as ^{4}He, ^{21}Ne and ^{40}Ar.

Recently we have seen a richness of application. Shalegas sourcerock correlations between ^{36}Ar and $\delta^{13}C(CH_4)$ are used to determine the hydrocarbon expulsion efficiency [1]. Within these shales and other basin systems ^{4}He excesses require cross formational transport of the helium which in turn can be modeled and basinal scale fluid behaviour infered [2]. Systems that approach closed-system radiogenic noble gas concentrations can be used to indicate crustal fluid regimes that are essentialy static [3, 4] and one key indicator for safe anthropogenic waste disposal. In contrast, the migration pathlength and mass of hydrocarbon that has swept discrete geological structures can be infered from the noble gas content of existing natural gas and oil fields [5,6]. As our understanding of basinal fluids develops, using noble gases to identify their incursion into environmentaly sensitive shallow groundwater systems becomes possible and our ability to find future helium and hydrogen resources is greatly enhanced.

[1] Byrne et al., 2018, GCA, 241. 240–254.
[2] Cheng et al 2018, Goldschmidt Abstracts, 403
[3] Barry et al., 2017 Geology 10.1130/G38900.1
[4] Warr et al., 2018 GCA 222. 140-362
[5] Barry et al., 2018, G3, 10.1029/2018GC007654
[6] Barry et al., 2016, GCA 194. 291-309

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