Large accumulations of He, Ar and H_2 in fracture fluids in Precambrian Shield rocks

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Throughout Precambrian Shield rocks, fracture fluids are associated with gases which can account for up to 30% He, 6% Ar and more than 50% H_2 (expressed as % volume of the free gas phase post-exsolution). Radiogenic noble gases (e.g. He & Ar), produced via decay of U, Th and K, accumulate over time in isolated fractures and provide crucial constraints on fluid residence times [1, 2]. H_2 is principally produced either via hydration reactions such as serpentinisation or by radiolysis of water [3], and can sustain isolated microbial communities [4], and/or be consumed to produce abiogenic hydrocarbons via Fischer-Troph Type reactions [5]. Known reservoirs of He, a resource integral to medical and manufacturing are rapidly depleting. H_2 is being posited as an emerging, clean, energy source for a post-hydrocarbon energy future. In both cases new reserves and innovative exploration strategies are required. Despite the cogenetic nature of H_2 and radiogenic noble gases in geologic environments, few studies have specifically focussed on establishing the relationship between these two sets of reactive and conservative tracers [3].

We investigate the dependence of H_2, He and Ar production rates on rock type and geologic setting. Through collating and combining previously published dissolved gas data for specific localities, we expand on existing studies [e.g. 3] to generate conservative estimates of H_2 production for a range of sites across the Canadian Shield. Preliminary analyses indicate that He and H_2 production dominantly depends on the associated lithology, with more mafic environments overall producing more H_2 relative to He. H_2/He ratios are typically lower in felsic environments, suggesting H_2 is dominantly produced radiolytically via U and Th decay. However, Ar appears only weakly correlated with H_2 suggesting Ar is primarily dependent on the K content of the host rock. U, Th, K, O, F contents are evaluated to understand controls on radiogenic noble gas production in these settings and to advance our ability to understand the geochemical, geological and hydrogeological controls on accumulations of these “light” gas resources.

[1] Holland *et al*. (2013) *Nature* **497**. [2] Warr et al. (2018) GCA **222**. [3] Sherwood Lollar *et al*. (2014) *Nature* **516**. [4] Lin *et al*. (2006) *Science* **314**. [5] Sherwood Lollar *et al*. (2002) *Nature* **416**.