Understanding Hydrogeological Events in sedimentary basins with 1D Modelling of Noble Gases

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A quantitative understanding of the role of groundwater in controlling gas migration is crucial for the exploration of natural resources (e.g. traditional petroleum hydrocarbons and natural gas and helium exploration) in sedimentary basin systems worldwide. Here we present noble gas isotopic and concentration data from forty-three natural gas samples collected from different locations and geological formations in a major sedimentary basin.

The noble gas isotopes of ^{20}Ne (and ^{36}Ar) in the natural gases are derived predominantly from groundwater. Hence $^{4}He/^{20}Ne$(and $^{40}Ar/^{36}Ar$) ratios allow the radiogenic ^{4}He (and ^{40}Ar) concentrations in the groundwater before gas phase formation to be determined[1]. Calculations show excess ^{4}He compared to calculated *in situ* radiogenic production in most samples, indicating the presence of an external helium flux and gas transport between different geological units.

Reference models are constracted for each well sampled by assuming the groundwaters are static in the basin and vertical transport is diffusion dominated. Basement flux is estimated by simulating ^{4}He and ^{40}Ar profiles. Basement flux maps obtained from the reference models are produced based on the calculated flux and well locations.

The average reference model helium flux estimated for the basin is smaller than both the reference crustal production value[2] and values determined for other localities such as the Williston Basin in Western Canada [3]. Variations of ^{4}He and ^{40}Ar flux are observed and areas with elevated values can be identified. Negative ^{4}He flux calculated for samples from different lithologies cannot be explained through regional variations of basement flux but may be indicative of helium loss or dilution processes, e.g. mixing with helium-deprived water.

1. Ballentine, C.J., R. Burgess, and B. Marty, Reviews in mineralogy and geochemistry, 2002. **47**(1): p. 539-614.
2. Torgersen, T., Geochemistry, Geophysics, Geosystems, 2010. **11**(6).
3. Cheng A, Sherwood Lollar B, Giunta TM, Mundle SOC & Ballentine CJ (2018) *Goldschmidt Abstracts*, **2018** 403