Identifying zones of natural gas accumulation in unconvetional formations using crustal noble gases

B.A. LARY[1], W.K. EYMOLD[1], C.J. WHYTE[1], J. HARRINGTON[2], J. MOORTGAT[1], T.H. DARRAH[1]

[1] The Ohio State University, Columbus, OH USA
Lary.6@osu.edu

[2] Matador Resources Company, Dallas, TX USA

Growing global energy demands have largely been satisfied by increased natural gas production following the advent of hydraulic fracturing. This technology induces and reactivates existing fracture networks to serve as pathways for hydrocarbon migration from the shale to the well. Although this technique now serves as the dominant method for natural gas recovery, many wells remain unprofitable (~26% of wells account for >95% of natural gas recovery, while <1/3 of lateral segments account for a similar amount of gas production). These factors are related to uncertainties concerning fluid flow in a relatively impermeable rock, the inability to accurately model existing fractures, and the heterogeneous composition of shales. Noble gas isotopes serve as a potential tracer to identify zones of gas accumulation ("sweet spots") mitigating some economic costs of natural production by reducing the number of segments that are stimulated. Here, we evaluate the distribution of radiogenic and nucleogenic crustal noble gas isotopes (e.g. ^{4}He, $^{21}Ne^{*}$, ^{40}Ar) and their associated ratios (e.g. $^{4}He/^{21}Ne^{*}$) as geochemical tracers of fluid migration. The $^{4}He/^{21}Ne^{*}$ ratio of drill cuttings is particularly useful to find fluid accumulations due to the fixed production rate of each isotope in mineral grains ($^{4}He/^{21}Ne^{*} = 22 \times 10^{6}$). Both of these isotopes can diffuse in or out of the grain when the formation temperature exceeds the respective closure temperature. Drill cuttings were collected from the 8 horizontal Permian Basin boreholes and analyzed on a SFT Helix Mass Spectrometer. We identify localized variation in the $^{4}He/^{21}Ne^{*}$ ratios of sediments along lateral segments of natural gas wells and interrogate their relationship with hydrocarbon production volumes from associated fracking intervals.