Tracing fluid migration in the East Texas basin using noble gas isotopes

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The noble gases and their isotopes are widely used as tracers in crustal fluids, such as petroleum and groundwater systems [1]. Due to their inert nature they constitute an ideal tool for constraining fluid provenance and interaction in the subsurface. The advent of production from unconventional source-rock reservoirs allows us to directly measure the noble gas composition of petroleum within the source-rock, and observe the geochemical evolution as the hydrocarbons migrate throughout the basin into conventional accumulations.

By sampling natural gases from wells sourced from the Haynesville shale (n=9), and the overlying conventional accumulations in the Cotton Valley (n=7), Travis Peak (n=9) and James limestone (n=5) groups, we are able to track changes in the noble gas signature from source to trap. We present full noble gas isotope and abundance data for all wells sampled.

Concentrations of groundwater-derived ^{36}Ar and ^{20}Ne are consistently lower in the unconventional Haynesville shale, reflecting the lower exposure to external groundwaters in these more isolated, low-permeability reservoirs [2].

Helium isotope ratios ($^{3}He/^{4}He$) are strongly radiogenic in the Haynesville shale, but show small and variable contributions of mantle helium in the overlying reservoirs. Argon isotope ratios ($^{40}Ar/^{36}Ar$) range from air-like in the Haynesville, to strongly radiogenic in the overlying strata, and show a strong non-linear relationship with $^{3}He/^{4}He$. We interpret this relationship to represent mixing between a pure source-rock endmember with air-like Ar isotopes and radiogenic He isotopes, and an endmember characterised by exposure to wider basin circulation, having acquired mantle ^{3}He and radiogenic ^{40}Ar from interaction with large volumes of rock [3]. The prevalence of this external endmember is spatially correlated laterally and vertically, and can be used to trace the flow of fluid through the basin. We discuss potential mechanisms by which this fluid transport could have occurred.

[1] Byrne et al., 2017, **GSL-SP** 468.5; [2] Barry et al., 2016, **GCA** 194, pp291-309; [3] Ballentine & Burnard, 2002, **RiMG** 47.1