Helium Distribution in the Williston and the Southwest Ontario Basins

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Identifying the processes that control helium production in basin settings is critical in developing our understanding of commercial helium occurrence. Here we compare helium profiles in two intracratonic basins: (1) The Southwest Ontario Basin in which Cambrian to Devonian sediments overlay the Algonquin Arch; and (2) the Williston basin which preserves multiple Cambrian to Pleistocene units. We collected 33 natural gas samples from producing wells in Southwest Ontario and 48 from the Williston to provide a depth profile throughout each basin system.

^{4}He concentrations range from 1.85×10^{-6} to 4.9×10^{-3} cc STP/cc in Southwest Ontario and from 2.84×10^{-5} to 2.84×10^{-2} cc STP/cc in the Williston Basin. ^{3}He/^{4}He, normalised to the atmospheric ratio Ra, varies between 0.0087 to 0.0558 Ra and between 0.08 to 0.36 Ra in the two systems respectively. Resolvable mantle ^{3}He is observed throughout the units in the Williston Basin but shows no obvious vertical trend. ^{3}He/^{4}He in the S Ontario Basin averages ~ 0.021 Ra for Silurian samples but ratios increase to 0.0558 Ra for Ordovician and Cambrian samples.

Assuming a closed system, a reference model ^{4}He concentration for each lithology can be calculated from the lithology age and U-Th concentrations. Measured results from the Williston Basin show lower helium concentrations for the deepest units and higher concentrations in the shallower units compared to those predicted based on the model. Southwest Ontario also has higher helium concentrations in the shallower samples than predicted. A 1D advective/diffusive model can account for the Williston Basin helium profile and the shallow Southwest Ontario lithologies. The higher ^{3}He/^{4}He in the Williston Basin is also accompanied by a higher modelled ^{4}He basement flux and we discuss possible reasons for this in the context of helium exploration. In contrast, the deeper lithologies in Southwest Ontario, have a more complex ^{4}He profile in addition to higher ^{3}He/^{4}He. Additional processes are needed to account for the ^{4}He and ^{3}He/^{4}He in the Cambrian and Ordovician here, such as the hydrothermal fluid contribution posited by previous studies.