# Investigations into the highest reported He concentration in a natural gas sample: Mt Kitty, Amadeus Basin, Northern Territory

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A "wet" ($C_1/C_2+$= ~3.08), unusually $H_2$-rich, natural gas sample from the Mount Kitty#1 (MK#1) well in the Amadeus Basin in the Northern Territory, Australia, produces from U/Th-rich, fractured granitoid basement rocks. The MK#1 well contains one of the highest reported He concentrations on Earth (9% He, 61% $N_2$, 13% $CH_4$, 4% $C_2H_6$ and 11% $H_2$).

He in the MK#1 well displays a low $^3He/^4He$ ratio of 0.031 $R_A$ ± 0.001, indicating a dominantly crustal source of He. The exceptionally low $CO_2/^3He$ ($4.46 \times 10^7$) is between 2 and 5 orders of magnitude lower than He-rich gases in other sedimentary basins and typical crustal levels, respectively, indicating that the $CO_2$ content has been buffered by the precipitation of carbonate minerals.

Bulk and noble gas analyses provide evidence for an extensive influence of air-saturated water ($N_2/Ar$≈107), long-range multi-phase fluid migration ($^{20}Ne/^{36}Ar$), and potentially prior interactions with oil/liquid hydrocarbons ($^{84}Kr/^{36}Ar$=0.0062; $^{132}Xe/^{84}Kr$=0.142). The exceptionally high He concentrations presumably indicate that the evaporitic mudstones have produced a highly efficient stratigraphic seal, which in combination, with radiogenic noble gas isotopes (e.g., $^{21}Ne^*/^{22}Ne$, $^{40}Ar^*/^{36}Ar$, $^{136}Xe/^{130}Xe$), suggests that fluids have been isolated (accumulating radiogenic gases) since the Neoproterozoic.

A working hypothesis for the derivation of the unusual MK#1 gas composition involves mixing of wet hydrocarbon gases (or oil-associated gases) from overlying Gillen Member sediments (up to 3% TOC) with highly radiogenic gases within the fractured basement reservoir. The peculiarly high $H_2$ content could result from either hydrocarbon oxidation or as an abiogenic breakdown product of hydrocarbons in the granite reservoir, as has been reported in gases from the Canadian Shield [1].

[1] Sherwood Lollar *et al*. (2003) *Nature* **416**, 522-524.