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Deciphering the origin of methane in fracture fluids at Virginia gas field using clumped isotope tracers.

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The Witwatersrand Basin is a well-known area due to the immense gold mineralisation and mining activities, which have been ongoing since the late 19th century. The Virginia Gas Field, located in the southernmost extent of the basin, has recently gained further attention due to the discovery of gases with remarkable helium content of up to 12% and methane content between 75-99%. While the helium generation is likely straightforward and linked to the U-rich Dominion (2.9-3.0 Ga) and Central Rand (2.7-2.8 Ga) groups (Lippmann-Pipke et al., 2003), the origin of methane seems more complex but ultimately significant, with economic potential and implications for the evolution of life .

Stable isotopic compositions of carbon and hydrogen ($\delta^{13}C$ and δD) along with molecular compositions (C1/C2+) are traditionally considered useful for understanding the origin of methane in natural gas reservoirs but can often be ambiguous or misleading. The recent development of HR-IRMS allows us to delve deeper into the distribution of isotopes beyond bulk ratios by introducing two additional tracers, the clumped isotopic compositions $\Delta^{13}CH_3D$ and $\Delta^{12}CH_2D_2$. These novel tracers offer two additional dimensions which can potentially provide insights into the formation pathways and formation or re-equilibration temperature of methane.

For this study, we measured bulk and clumped isotopic compositions along with molecular compositions for samples collected from shallow boreholes (300-700m depth) within the Virginia gas field production area. Here, we present evidence that the bulk and clumped isotopic compositions are governed by the microbial cycling of CH_4 due to the presence of ancient microbial communities of methanogens and methanotrophs at depths below 1km (Omar et al., 2003). We also consider the possibility of mixing microbial methane with abiotic gas resulting from water-rock interactions occurring in the deep subsurface.

References

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