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Defining the processes that control hydrogen and helium occurrence: the Amadeus Basin, Australia

THOMAS RENSHAW[1], RŪTA KAROLYTĖ[1], ZAK MILNER[2], JON GLUYAS[2] AND CHRIS J BALLENTINE[1]

[1]University of Oxford

[2]Durham University

Presenting Author: thomas.renshaw@st-hughs.ox.ac.uk

Hydrogen is an energy rich gas that could contribute to a clean green alternative to fossil fuels, while helium, is undergoing a supply crisis, but essential for medical equipment such as MRI scanners. Analysis to build a better understanding of the processes of hydrogen and helium transport from source to ultimately long-term storage at shallow depths is needed due to their reactivity (hydrogen), diffusivity, and slow generation rates. The Amadeus Basin presents an opportunity to test these key concepts.

The Amadeus is an intracratonic basin that overlies Paleo- to Mesoproterozoic metamorphic and igneous basement. It is tectonically quiescent and at its base has an extensive salt deposit which could act as an effective and long-lived trapping structure. Drilled wells at Magee-1 and Mt Kitty-1 provide evidence of processes that focus hydrogen and helium to generate commercial gas fields in fractured basement and sedimentary layers, capped by a thick evaporite sequence.

Serpentinisation and radiolysis are the principal mechanisms by which hydrogen is generated in the subsurface. Using a basement map of the Amadeus Basin and assigning geochemical values to each individual rock type, we have produced a basin scale map of hydrogen and helium production since the first major trapping structure was emplaced about 800Ma. Other estimates of the hydrogen potential of the Amadeus Basin[1], consider only production via radiolysis. We update the hydrogen generation potential assessment of the Amadeus Basin to include production via serpentinisation (e.g.,[2]). Our calculated production rates are up to an order of magnitude higher with significant heterogeneity in production due to the basement map used. This work shows the importance of including hydration reactions and basement heterogeneities when estimating hydrogen production, as without them any estimate of possible hydrogen reserves could be significantly underestimated.

By combining our understanding of local helium and hydrogen generation rates with concepts from helium exploration we can develop a better understanding of the key processes such as diffusion and gas phase exsolution, that control the formation of gas fields in these long lived environments[3].

[1]Boreham et al., 2021, APPEA Journal

[2]Sherwood Lollar et al., 2014, Nature

[3]Cheng et al., 2023, Nature