Discovering natural hydrogen in continental interiors

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SUMMARY

Natural hydrogen can be derived from biogenic or abiogenic geological sources, with the latter likely far more significant. Most geological sources involve water-rock interaction; the dominant mechanism is thought to be oxidation of divalent iron (Fe2+) rich rocks and minerals through serpentinization. There is growing recognition of the hydrogen production potential from Precambrian crust away from active plate boundaries. Hydration of iron-rich lithologies (such as Precambrian greenstones, banded-iron formations and peralkaline and biotite-rich granites) is argued to be the leading mode of hydrogen generation in continental interiors, but radiolysis of water caused by decay of U, Th and K-bearing minerals may be significant. Critically, radiogenic decay also generates helium which can discriminate between geological sources. Another commonly cited, production mechanism is degassing of hydrogen stored in the Earth's mantle. However, no studies to date have demonstrated a definitive link between the geological production mechanism and a large-scale hydrogen accumulation, with the geological origin of discoveries in Mali and South Australia being unknown.

We are developing a sophisticated 'source-to-sink' approach to identify and appraise accumulations of natural hydrogen in continental interiors. The geographic focus of this project is the neo-tectonically and hydrologically active Paralana Fault Zone in South Australia's Flinders Ranges, with evidence for both hydrogen and helium production, that divides the highly radiogenic Precambrian Mount Painter Inlier from the sedimentary Frome Embayment. The project is currently at a desktop stage with 3D inversion of existing broadband MT responses across the Paralana Fault Zone, previously the focus of geothermal exploration (Thiel et al., 2016, https://doi.org/10.1002/2016GL071351). A 150-site MT and ambient noise tomography (ANT) array planned for 2025 will constrain crustal architecture in terms of deep geological boundaries and subsurface extent of rock units that source hydrogen generation via radiolysis and/or serpentinization. The 3D model will also enable inference of deep permeability, necessary for downward transport of meteoric water and the advective migration of generated hydrogen.

Keywords: South Australia; natural hydrogen; serpentinization; radiolysis; lithospheric faults

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