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Natural hydrogen in low temperature geofluids in a Mesoproterozoic granite, South Australia

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Natural hydrogen (H_2) has the potential for achieving a clean, secure, and affordable energy future. However, for hydrogen exploration to become cost-effective, the generation, migration, and accumulation of H_2 in the subsurface need to be better constrained. Granite has been identified as a source for H_2 [1-2] and hydrogen-dominated natural gas has been reported in some vintage drilling wells in Yorke Peninsula and Kangaroo Island [3], South Australia, in Precambrian terranes containing iron, copper or gold ore deposits. As an analogue to these, we investigated rock samples from the Roxby Downs granite, a pluton of the Mesoproterozoic Hiltaba Suite event (1.6 Ga), from a continuously cored geothermal borehole, 8km west of the Olympic Dam Iron-ore copper gold deposit (IOCG). The granite shows alteration of feldspar typical of hydrothermal fluid circulation and discrete cemented fractures. Hydrogen-bearing water and hydrogen free gas inclusions were found in some of the fracture-fill cements that formed at paleo-temperatures from 170°C to present day 55°C. In-situ oxygen isotope values of the quartz cements showed either a marine water signature or a mixture of a marine and a crustal magmatic source of the oxygen in water that precipitated the quartz cements. In addition to an expected radiolytic hydrogen source, petrographic analyses identified alterations of biotite into chlorite and iron oxide, and hydrolytic alterations of magnetite to hematite as potential source of hydrogen. Neon isotopes extracted from fluid inclusions on whole granite grains (1-2 mm) and separated quartz grains showed continental crust signatures with nucleogenic production of neon isotopes increasing with depths along specific production lines. Granite and its alterations were found to be sources of natural hydrogen at low temperatures; the study also revealed mechanisms of fluid-rock interactions and fluid behaviour critical for understanding natural hydrogen occurrence and targeting it as an energy source.

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