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Noble gas analyses of fluid inclusions in the deep Hiltaba Suite Granite (South Australia) reveal fluid circulation on the billion year time scale

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Noble gas isotopes and their isotope ratios, alongside petrographic data, can be used to infer residence times and the provenance of deep crustal fluids. This study examined the fluid natural containment and isolation capacity within crystalline rock, particularly in the the Hiltaba Suite granite, South Australia. We investigated core samples from a geothermal exploration well drilled close to the Olympic Dam iron oxide-copper-gold (IOCG) ore deposits. The cores intersected the Hiltaba Suite granite at depths ranging between 718 m and 1935 m. Petrographic analyses identified alteration of the original mineral assemblage that can be attributed to tectonic deformation and hydrothermal fluid circulation mostly in the shallower and in the deeper part of the granite core. Most of the fluid inclusions in the grains as well as in the healed fractures contain a water and gas phase. $d^{18}O$ profiles across fractures filled with quartz and the temperature and salinity of fluid inclusions along these profiles show different fluids circulating through and being trapped in the granite over different times. Additionally, the influence of secondary mineral alterations, such as both bulk granite and separated quartz fractions, on noble gas isotope ratios in fluid inclusions was analyzed. Neon isotopes (^{20}Ne, ^{21}Ne, ^{22}Ne) on bulk granite grains (1-2 mm) generally showed an increasing crustal production along individual nucleogenic production lines. Sections with mineral alterations contain “younger” fluids with smaller nucleogenic components, thus deviating from the general trend. Separated quartz fractions display nucleogenic production with smaller $^{21}Ne/^{22}Ne$ ratios. All noble gas ratios indicate very old fluid components that display long-term isolation from the meteoric water cycle. These results have implications for future geological disposal of appropriately conditioned long-lived intermediate level waste.