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A billion years of fluid history is concealed in the central Australian basement

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Dating minerals in hydrothermal intrusive systems allows tracking of the interaction of the lithosphere and hydrosphere. A combination of U–Pb and Lu–Hf dating of calcite, with C–O–Sr isotope analysis across four drill core locations, reveals fluid activity spanning 1288 ± 62 to 65.8 ± 1.3 Ma in the Aileron and Warumpi basement provinces in the southwestern North Australian Craton, central Australia. These ages, novel to central Australian history, reveal the inadequacy of high-closure minerals like zircons for recording low-temperature fluid events.

Older Proterozoic vein systems proximal to the Central Australian Suture record fluid ages predating and synchronous with the Neoproterozoic Central Superbasin development during Rodinia, whereas veins within the craton-margin Lasseter Shear Zone system yield younger Paleozoic-Mesozoic ages tracking younger basin-related activity possibly related to the overlying Canning basin. Despite the large age spread, the calcite $\delta^{18}O$–$\delta^{13}C$ values form drill core-specific clusters, indicating a local lithological buffer in the fluids. Vein activity is not confined to, nor is it directly sourced to, the major defined events in the region. Rather, we find evidence of hydrothermal activity related to far-field and regional-scale events and local rock-buffered signatures.

Challenging the previous view of calcite's difficulty in preserving Precambrian ages in hydrothermal systems, we find evidence of closed-system behaviour and well-defined primary ages spanning over a billion years, with minimal later alteration. Concordant U–Pb and Lu–Hf ages and minimal dispersion on isochrons support the use of calcite as a robust geochronometer in long-lived vein systems, where later fluid interaction has had negligible impact, preserving ages otherwise blind to other geochronometers.