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Pb isotopes in vein chert illuminate origin and reactivation of a synsedimentary hydrothermal dike complex of the 3.43 Ga Strelley Pool Formation.

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Cherts are widely used chemical sedimentary rocks for paleoenvironmental reconstructions but being composed primarily of SiO_2, most geochemical and isotopic proxies are present at very low concentrations (ppb) and potentially prone to contamination and overprint. Before using chert geochemistry to understand the original nature of ancient environments and searching for signs of early life, it is therefore desirable to test for primary vs. secondary signals.

We investigated black chert of a deep-seated synsedimentary dike complex of the 3.43 Ga Strelley Pool Formation (SPF). Hand specimens of vein cherts were crushed, washed, and meticulously hand-picked into optically distinguishable sub-samples before agate grinding. Pulverized samples were acid-leached to dissolve trace carbonate and triple-cleaned in water before HF acid digestion. The digested silicate fraction was used to obtain two datasets: an extended suite of high-precision trace element concentrations as well as Pb-isotope ratios.

In common Pb isotope space, the dataset yielded two clearly discernible linear populations – one with a slope corresponding to the known Paleoarchean age of the hydrothermal system; the other with a less well-defined slope corresponding to a Neoarchean age. This result shows that many of the chert samples preserve original isotopic and chemical vestiges of Paleoarchean age associated with the hydrothermalism that was active during the deposition of the SPF. However, other samples show isotopic re-equilibration and Pb remobilization almost one billion years later. Raman spectra of organic matter preserved in the chert veins also suggest different thermal histories.

There is significant variability in transition metal concentrations in the Paleoarchean population. While this could indicate modern MORB vents, initial Pb isotope ratios strongly argue against a mantle source of metals. Instead, there is no evidence to attribute the chert veins to black smoker type vent activity and the hydrothermal system appears intracrustal. The rare earth element data further show that the hydrothermal veins were re-circulating seawater that was emitted as metal-enriched hydrothermal fluids into a shallow water environment. The presence of fossilized stromatolites could imply that such hydrothermal systems were of biological significance, potentially as a source of nutrients or other forms of energy to evolving early microbial communities.