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# Laser based S isotope analysis of weathered 'super-heavy' Neoproterozoic sulphides and Rb–Sr dating of illite from Kapunda, South Australia

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Biogeochemical cycling of elements can be used to vector subsurface ore deposits via analysis of the cover and the interactions across the soil-water-plant system. Tracing isotopic fraction of certain elements from their original depositional environment, through a range of alterations to in-situ weathering and creation of supergene zones. This study couples new sulphide laser based S isotopes data and Rb–Sr dating of illite both measured via LA ICPMS/MS. Kapunda is located 90 km north of Adelaide, South Australia, and is the oldest commercial copper mine in Australia. This sediment-hosted Cu deposit is hosted in carbonaceous siltstone host-rocks of the Neoproterozoic Tapley Hill Formation, in-situ weathering reaches depths of up to 100 metres and result in a Cu-rich supergene environment. Previously published S isotope data from sulphides at Kapunda displaying 'super-heavy' $\delta^{34}S$ (CDT) signatures of up to 40‰ in both syn-sedimentary and vein chalcopyrite and pyrite. Samples for this study were taken across 500 metres of core, covering a complete regolith profile. SEM MLA images of specific samples were used to identify sulphides for isotopic analysis and illite for Rb–Sr dating. These results indicated alteration of the Tapley Hill Formation at ca. 527 ± 44 Ma during the Delamerian Orogen. These 'super-heavy' sedimentary pyrite in the Tapley Hill Formation have $\delta^{34}S$ values that fall within globally reported marine pyrite $\delta^{34}S$ datasets recording a time interval between the Sturtian and Marinoan glaciations (ca. 715–650 Ma). Novel laser-based S isotope techniques on sulphides and sedimentary rocks allow the observation of diagenetic redox conditions, fluid sources and weathering alteration of mineralisation via laser based stable S isotopic analysis. Our results reveal $\delta^{34}S$ of all samples taken from the Tapley Hill Formation at Kapunda is within 12-50‰ for both chalcopyrite and pyrite. Overall $\delta^{34}S$ results from Tapley Hill Formation track the global sulphur isotope anomaly (ranging from 20-50‰), but the data becomes more scattered and variable in the shallower and more weathered horizons.