Archaean sulphur in Neoproterozoic Zimmi diamonds (West Africa)

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Zimmi diamonds, derived from at least 120 km depths in the lithospheric mantle of the West African craton, contain abundant eclogitic sulphide inclusions from which Neoproterozoic (650 Ma) diamond ages have previously been well-determined [1]. We analysed sulphide inclusions from three of these Zimmi diamonds for their multiple sulfur isotopic compositions ($\delta^{33}S$, $\delta^{34}S$ and $\delta^{36}S$) by NanoSIMS. The three sulphides are all pyrrhotite + pentlandite + chalcopyrite assemblages, and based on their low Ni content (< 7 %), high Re/Os, and high initial $^{187}Os/^{188}Os$ [1] they are all eclogitic.

Zimmi sulphides have $\delta^{34}S$ values between -2 and -5 ‰, that similarly indicate that the sulphur in these sulphides could not have originated in the mantle, but rather are consistent with a recycled origin for the sulphur. The sulphur isotope data displays mass independent fractionation (MIF) trends with $\delta^{33}S$ and $\delta^{36}S$ values that deviate from the terrestrial mass fractionaction line (TMFL; expressed as $\Delta^{33}S$ and $\Delta^{36}S$). MIF sulphur was produced in the Archaean when volcanogenic sulphur was exposed to UV photolysis in the oxygen-poor Archaean upper atmosphere.

Zimmi sulphides have $\Delta^{33}S$ between 0.24 and 1.64 ‰ and $\Delta^{36}S$ between -0.27 and -2.02 ‰ that plot along the early Archaean Reference Array (ARA) with a slope around -1. This indicates that sulphur in the sulphides originated as Archaean oceanic sediments that were incorporated into the West African lithosphere through subduction. This occurred nearly 2 billion years prior to Neoproterozoic diamond formation from subduction fluids infiltrating along the margin of the West African craton. Our $\Delta^{33}S$-$\Delta^{36}S$ combined with Re-Os data for sulphides in Neoproterozoic diamonds supports a model of lateral accretion for both the construction and stabilisation of the West African cratonic lithosphere and suggests sulphur isotopes may be an excellent tracer for the process by which the subcontinental mantle keel is thickened.

[1] K. V. Smit, S. B. Shirey, W. Wang, Precambrian Research 286 (2016) 152–166.