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Paleozoic subduction into the deeper mantle recorded by superdeep diamonds

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The timing of the onset of modern-style plate tectonics, characterised by subduction into the deeper mantle, remains hotly debated and is an issue crucial to temporal models of the recycling of volatiles such as carbon and water. The geochronology of lithospheric eclogitic diamonds documents shallow subduction in the upper mantle since 2.9 Ga [1]. Sub-lithospheric “superdeep” diamonds can provide unique constraints on the timing of subduction because of their intimate relationship with slabs [2] and melting of carbonated lithologies. The few attempts to date superdeep diamonds indicate young formation ages e.g., [3].

In a campaign to date superdeep diamonds from the Rio Sorriso alluvial, and Juina-5 and Collier-4 kimberlites, Juina, Brazil, we present new Rb-Sr, Sm-Nd, and U-Pb isotope systematics of Ca-silicate inclusions, interpreted as former Ca-silicate perovskite formed in the transition zone or lower mantle. Highly variable $^{87}Sr/^{86}Sr$ (0.7027 to 0.7259) correlate with Rb/Sr ratios. Two ages are recorded: 5 inclusions define a ~ 460 Ma array with initial $^{87}Sr/^{86}Sr$ of 0.7027, and 4 inclusions, two from the same diamond, define a ~ 360 Ma isochron with initial $^{87}Sr/^{86}Sr$ of 0.7095. The distinct initial $^{87}Sr/^{86}Sr$ ratios indicate formation from different portions of a subducted slab interacting to variable degrees with overlying mantle, consistent with variable O isotope data [4].

A poorly defined Sm-Nd isochron of <500 Ma and “modern” Pb-Pb compositions are consistent with the Rb-Sr ages for Juina superdeep diamonds and document subduction into the deeper mantle active at 460 Ma, possibly linked to the onset of widespread continental UHP domains and deep subduction of continental material at 650 Ma [5]. Our data indicate the Phanerozoic inception of subduction, cycling carbon to >300 km depth and its return to Earth's surface via kimberlite magmatism. Other superdeep diamond localities will reveal whether older ages exist.

[1] Shirey & Richardson (2011), *Science* 333, 434-436. [2] Shirey et al. (2021), *AGU Advances* 2, e2020AV000304. [3] Bulanova et al. (2010), *CTMP* 160, 489-510. [4] Burnham et al. (2015), *EPSL* 432, 374-380. [5] Brown & Johnson (2019), *Mineral Mag* 83, 323-338.