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Diamonds from the Juina-5 kimberlite provide evidence for crustal volatile recycling into the deep Earth

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'Superdeep' diamonds originate from a depth range spanning the asthenospheric upper mantle, transition zone and shallowest parts of the lower mantle [1]. Sporadically they entrap small inclusions of pre-existing or co-precipitating minerals during their crystallisation from volatile-rich melts or fluids. Such samples therefore preserve important petrologic, tectonic and geodynamic information about their growth environment together with evidence of the deep volatile cycling.

The Juina-5 kimberlite has previously been recognised as a source of 'superdeep' diamonds [2]. Here we present and discuss data from an extended collection of Juina-5 diamonds. This work has revealed that these diamonds are dominantly composed of isotopically light carbon and contain a mineral inclusion cargo mostly of eclogitic affinity consisting of many former Mg- and Ca-perovskite, NAL-phase, CF-phase, stishovite, majoritic garnet, sodic pyroxene, ferropericlase, Fe or Fe-carbide and sulphide minerals. Together these observations suggest that the diamonds form from material of a subducted crustal origin. The high enrichment of the inclusions' trace element compositions implies that they cannot represent trapped fragments of formerly subsolidus mantle material. Geochemical modelling instead allows the compositions of Ca-perovskite and majorite inclusions to be directly linked to formation from a slab-derived carbonate bearing melt. It is suggested that the formation of 'superdeep' diamonds, and their inclusions, is the result of 'redox-freezing' during the interaction of oxidised slab melts and reducing mantle rocks [3]. It is expected that such melts will be produced during slab foundering and thermal equilibration in the upper/lower mantle boundary region, where tomographic evidence suggests slab subduction often stalls [4].

This hypothesis has been tested with experiments performed at transition zone pressures using the multi-anvil apparatus. At 20 GPa the composition of a low degree melt of carbonated MORB is a Na-rich carbonatite. During the reaction of this comparatively oxidised melt with a mantle peridotite assemblage, $Ca(Si,Ti)O_3$ perovskite, majoritic garnet and Na-bearing ferropericlase were formed. The compositions of these experimental phases are very similar to diamond hosted inclusions, confirming that this type of 'redox-freezing' interaction is a viable diamond formation mechanism. We conclude that superdeep diamonds provide a direct snapshot of the Earth's deep carbon cycle.

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