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Cessation of slab melting provides insight into the depth of origin of lower mantle eclogitic diamonds

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The subduction of crust into the mantle represents a pivotal carbon pathway inside Earth. Gauging the depth at which carbon is released from subducting crust and its contribution to carbon distribution in the mantle is difficult. The conspicuous existence of sublithospheric eclogitic diamonds reveals the cycling of crustal material to the asthenosphere, the mantle transition zone, and even to the lower mantle (greater than 660 km). However, among the deepest diamonds ever found, the depth of origin of lower mantle eclogitic diamonds remains largely unconstrained. Here we present laboratory experiments demonstrating that the solidus of subducted carbon-bearing crust increases from 1250 °C at depths <660 km to 1650 °C at 750 km across the post-garnet phase transition — the decomposition of garnet into bridgmanite and CF-phase. The elevated solidus intersects with slab geotherms at ~720-750 km, leading to the cessation of carbonate melting in subducting crust. The carbonatitic melt released from subducting crust may be trapped in the mantle by redox freezing, resulting in the formation of eclogitic diamonds at depths above ~720-750 km. In contrast, the inability of subducting crust to form carbonatitic melt at greater depths suggests a lack of crustal carbon cycling and eclogitic diamonds in the deep lower mantle. The post-garnet phase transition thus acts as a barrier to crustal melting and eclogitic diamond formation in the lower mantle.