Diamonds isotope compositions indicate altered igneous oceanic crust dominates deep carbon recycling

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A long debated problem in understanding Earth's deep carbon (C) cycle is whether crustal carbon can be recycled into the deeper mantle beyond arc depths. The Isotopic compositions of several elements in eclogitic diamonds and their inclusions suggest deep recycling of crustal material, but together their systematics are inconsistent with seafloor sediments as the crustal C source, despite many models invoking this explanation.

In this study, we investigated the isotopic signatures of bulk-rock carbonate in a large number of basalts, sheeted dike, gabbros and peridotites throughout the under-characterized altered oceanic crust (AOC), which comprises 95 vol% of the subducting slab mass flux. Our results show that: (i) AOC contains isotopically variable carbonate reservoirs with $\delta^{13}C$ values as low as -24‰, indicating dominant biogenic carbonate in some samples; (ii) carbonate in AOC was mainly precipitated during low-temperature (<100ºC) alteration. Based on this temperature constraint, our modeling yields a new global C input flux of $1.5^{\pm 0.3} \times 10^{12}$ molar per year into the trench by subduction of AOC only. This number is smaller (50-90%) than previous estimates [1-2], but still at the same order of the global C input flux by subducting sediments [3].

Unlike oceanic sediments, where the ^{13}C-depleted C is mostly coupled with ^{15}N-enriched N (controlled by organic matter), the heterogeneous alteration of AOC leads to variable N [4] and C isotopic signatures which are decoupled in nature. AOC will better preserve C than sediments duing subduction making AOC the most efficient medium to carry crustal C into the deeper mantle. Mixing of subducted AOC-derived fluids with asthenospheric fluids provides the first consistent explanation of the diverse record of C and N isotopes in eclogitic diamonds, suggesting altered mafic-ultramafic oceanic crust, instead of sediment, as the key carrier of crustal carbon into deep mantle.

Reference

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