Calcite precipitation in the Costa Rican forearc reduces long-term carbon recycling into Earth's deep mantle

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Carbon and other volatiles are transported from Earth's surface into the deep mantle through subduction at convergent margins. The efficiency of this transfer impacts the nature and scale of geochemical heterogeneities in Earth's mantle and shallow crustal reservoirs. However, the proportion of volatiles released at forearcs is under-constrained relative to fluxes from volcanic arcs.

Here, we present He and C isotope data from deeply-sourced springs from 23 sites in northern and central Costa Rica, traversing the forearc (Nicoya Peninsula), arc and backarc regions. The $\delta^{13}C$ and C content of dissolved inorganic and organic carbon (DIC and DOC) within spring fluids decreased systematically trenchward across the entire arc and defined Rayleigh distillation curves, with spring fluids showing consistently higher $\delta^{13}C$ for both DIC and DOC at a given DIC content. The parallel trends of decreasing $\delta^{13}C$ with decreasing DIC are consistent with isothermal (~65°C) precipitation of isotopically heavy calcite from forearc fluids.

We used these data to calculate the fraction of C lost through calcite deposition; the two cross-arc transects show that ~91% of carbon released from the slab/mantle beneath the Costa Rican forearc is sequestered within the crust by calcite deposition. Additionally, ~3% may be incorporated into biomass through microbial chemolithoautotrophy[1]. We estimate that ~1.2×10^8 to 1.3×10^{10} mol CO_2/yr are released from the slab beneath the Costa Rican forearc, resulting in the transfer of up to ~19% less carbon into Earth's deep mantle than previously estimated. This observation has wide ranging implications for the volatile inventory of the mantle and the temporal evolution of Earth reservoirs.

[1] Barry et al., *Nature*, 2019 In Press.