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Sensitivity of Global Carbon Cycling Models to Changing Subduction Fluxes

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Global C cycle models often inadequately represent subduction zone processes and consider C cycling as a process confined to Earth's atmosphere, oceans, land-sur-face, and crust. Here, we demonstrate the impact that consi-deration of changing subduction zone fluxes can have on predictions by carbonate-silicate global C cycle models.

Based on study of subduction-related metamorphism (Franciscan-type, Alpine), greater subduction efficiency for volatiles is thought to correlate with cooler margins where older oceanic lithosphere is rapidly subducted. Higher efficiency should lead to greater fractional return of C to the mantle (i.e., less efficient return to the surface via volcanism or forearc venting). Thus, arc volcanic C fluxes may differ from that estimated by direct proportionality to spreading rates or the size of the atmosphere-crust-oceans C reservoir. Depending on subduction rates, warmer early-Earth subduction likely resulted in less efficient C return to the mantle. Study of HP/UHP rocks indicates deep retention of much of the initially subducted reduced C (organic) and oxidized C (sediment, oceanic crust), perhaps to >100 km in cool margins. Carbon retained in accetionary prisms or in exhuming more deeply subducted rocks could be released during heating related to the subduction cessation.

Imbalance between subducted C input flux and C return by magmatism (on global basis, ~40±20% of subducted C return via arcs, and ~70±20% by all magmatism) indicates net C return to the mantle today, perhaps a reversal of earlier Archean net outgassing (despite more rapid subduction), and with long-term implications for surface C availability. Modern sedimentary C subduction flux is dominated by Central America and Makran (~50% of sedimentary C subducted at these margins, with ~70% of total subducting C in oceanic crust), thus future C cycling will be affected by the duration of C subduction pulses in these regions and any new subduction in carbonate-rich ocean basins such as the Atlantic. BLAG and WHAK models predict that ~20% change in subduction/volcanic C return to the atmosphere, feasibly produced by changing C subduction flux, could significantly modify atmospheric CO_2 levels and thus global climate.