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Extensive decarbonation of continuously hydrated subducting slabs

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CO_2 release from subducting slabs is a key element of Earth's carbon cycle, consigning slab carbon either to mantle burial or recycling to the surface through arc volcanism, however, what controls subducted carbon's fate is poorly understood. Fluids mobilized by devolatilization of subducting slabs play a fundamental role in the melting of mantle wedges and in global geochemical cycles [1]. The effect of such fluids on decarbonation in subducting lithologies has been investigated recently [2-5], but several thermodynamic models [2-3], and experimental studies [6] suggest that carbon-bearing phases are stable at sub-arc depths (80–140 km; 2.6–4.5 GPa), implying that this carbon can be carried to mantle depths of >140 km. This is inconsistent with observations of voluminous CO_2 release from arc volcanoes [7-10], located above slabs that are at 2.6-4.5 GPa pressure. The aim of this study is to re-evaluate the role of metamorphic decarbonation, showing if decarbonation reactions could be feasible at sub-arc depths combined with a continuous hydration scenario. We used the Perple_X software combined with a custom-designed algorithm to simulate a pervasive fluid infiltration characterized by "continuous hydration" combined with a distillation model, in which is possible to remove CO_2 when decarbonation occurs, to obtain an open-system scenario. This is performed by repeatedly flushing the sediment with pure H_2O at 0.5, 1.0 or 5 wt.% until no further decarbonation occurs. Here we show that continuous hydrated of sediment veneers on subducting slabs by H_2O released from oceanic crust and serpentinised mantle lithosphere [11-13], produces extensive slab decarbonation over a narrow, sub-arc pressure range, even for low temperature subduction pathways. This explains the location of CO_2-rich volcanism, quantitatively links the sedimentary composition of slab material to the degree of decarbonation and greatly increases estimates for the magnitude of carbon flux through the arc in subduction zones.

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