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Trace H_2O-enhanced sedimentary carbon migration from subducting slabs to the forearc mantle

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The carbon in sedimentary carbonates dominates the global carbon input flux in subduction zones and plays an important role in the deep carbon cycle, the fate of which therefore gets much attention. At forearc depths, ~32% of subducting water is released through slab dehydration and may greatly promote sedimentary carbon migration to the forearc mantle via carbonate dissolution, metamorphic devolatilization, and hydrous melting. However, it is controversial that considering the presence of external aqueous fluids, whether extremely limited or a significant portion of sedimentary carbon is extracted from subducting slabs in forearc regions. To explore to what extent hydrous fluids could facilitate carbon migration at forearc depths, hydrous carbonate-dominated sediment (1.14 wt.% H_2O)-harzburgite reaction (layered) experiments have been performed at 1.5 GPa and 600–1000 °C with various durations. For comparison, an anhydrous sediment-harzburgite reaction experiment was conducted to investigate the role of water on carbon migration. In hydrous experiments under subsolidus conditions (600–900 °C), (1) a reaction zone comprised of clinopyroxene + dolomite forms at the sediment-harzburgite interface due to the metasomatic reaction; (2) the Ca# [100*Ca / (Ca + Mg + Fe) in molar] of calcite in the sediment layer drastically deceases when approaching the reaction zone; (3) newly formed dolomite and pargasite occur in the upper harzburgite layer. While the above phenomena were not observed in the anhydrous experiment. Under supersolidus condition (1000 °C), a reaction zone composed of olivine + clinopyroxene + pargasite + CO_2 formed as a result of hydrous carbonate melt- harzburgite interaction. The experiments demonstrate that trace aqueous fluids could significantly promote the chemical reaction and component exchange between sediments and mantle peridotite, and also enhance subducting sedimentary carbon migration to the forearc mantle. It is estimated roughly that globally, ~50% of subducting sedimentary carbon may be released by downgoing slabs. The carbon and water would be fixed as carbonates (e.g., dolomite) and hydrous minerals (e.g., pargasite) in the forearc mantle, implying that the forearc mantle may be an important carbon reservoir. Our study explains the fate of some portion of carbon which is not returned to the atmosphere through arc volcanism.