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# An Open-System Model for Coupled $H_2O$ and $CO_2$ Transport in Subducting Slabs

Meng Tian, Richard Katz, David Rees Jones, and Dave May
Department of Earth Sciences, University of Oxford, South Parks Road, Oxford, OX1 3AN, UK

Subduction zones are sites where carbon and water actively cycle between Earth's exosphere and interior over geological timescales. However, it is debated how much $H_2O$ and $CO_2$ are transferred from subducting slabs to the mantle wedge and eventually to arc volcanoes. To model the $H_2O$ and $CO_2$ transport within slabs, we first parameterize the coupled dehydration and decarbonation reactions for representative subducting lithologies based on phase diagram calculations using Perple_X. Such a parameterization allows efficient computation of the $H_2O$ and $CO_2$ partitioning between pore fluids and rocks, and captures two important open-system behaviors—infiltration and chemical fractionation. A two-dimensional reactive transport model is then constructed to simulate the chemically open-system behaviors of $H_2O$ and $CO_2$ transport within slabs. Model results show that porous flow within slabs must be upward and nearly slab parallel to be able to supply maximum amount of $H_2O$ and $CO_2$ at depths directly below volcanic arcs. This finding on the within-slab flow direction is consistent with previous fluid dynamical studies about the effect of compaction pressures on subduction-zone fluid migration. In addition, our models show that infiltration of $H_2O$ sourced from hydrated slab mantle (serpentinite) can significantly increase slab surface $H_2O$ and $CO_2$ fluxes and redistribute $CO_2$ from slab's basaltic and gabbroic layers to overlying sediments. As a result, diapiric removal or partial melting of slab surface sediments can promote carbon transfer from subducting slabs to the mantle wedge. In all cases, subducting slabs cannot completely release their $CO_2$ and therefore sequester carbon into the deeper mantle.