The fate of carbonate in oceanic crust subducted into Earth's mantle

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The H/C ratio in earth's exosphere is higher than it is in the source region of primitive basalts, suggesting an enriched carbon reservoir in the mantle[1]. A plausible explanation is that subduction of carbon may have enriched the mantle in recycled carbon over time. Average basaltic crust contains ~ 2 wt.% CO_2 [2], and modeling of slab devolatilisation suggests that subducted carbonate may survive to be transported deeper into the mantle [3]. Carbonated oceanic crust should melt in the transition zone along most subduction geotherms due to a deep trough in the carbonated basalt solidus, and mineral inclusions in superdeep diamonds testify to carbonate melt in their formation [4]. Along cool subduction geotherms carbonate may subduct into the lower mantle, potentially enriching the deep mantle in carbon. Here we report on laser-heated diamond anvil cell experiments in the CaO-MgO-SiO_2-CO_2 and FeO-MgO-SiO_2-CO_2 systems at lower mantle pressures where we investigate the stability of carbonate in oceanic crust, and test for decarbonation and diamond forming reactions involving carbonate and coexisiting free silica. We find that carbonate reacts with silica to form bridgmanite ± Ca-perovskite + CO_2 at pressures in the range of ~50 to 70 GPa. These decarbonation reactions form an impenetrable barrier to subduction of carbonate into the deeper lower mantle, however, slabs may carry solid CO_2 (Phase V) into the deeper lower mantle. We also identify reactions where carbonate or CO_2 dissociate to form diamond plus oxygen. We suggest that the deep lower mantle may become enriched in carbon in the form of diamond over time due to subduction of carbonate and solid CO_2 and its eventual dissociation to form diamond plus oxygen. Release of oxygen during diamond formation may also provide a mechanism for locally oxidizing the deep mantle.

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