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Wave velocity and density characteristics of carbonated subducted oceanic crust in the lower mantle

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Seismological studies have previously detected abundant scatterers in the lower mantle, potentially linked to long-term slab subduction, and petrology studies suggest carbonates can be sequestrated within the oceanic crust and transported into the lower mantle via subduction. Here, we calculated the densities, elasticities, and velocities of the Ca-Mg-Fe carbonates and determined the phase boundary between different high-pressure phases of $CaCO_3$ and the spin transition boundaries for (Mg, Fe)CO_3 with varying iron content. Based on the densities and velocities of these carbonates and their stable temperature-pressure ranges in the mantle, we determined the wave velocity and density characteristics of the carbonated subducted oceanic crust in the lower mantle. When the carbonate content does not exceed 10 vol.%, the carbonated subducted oceanic crust is still denser than the surrounding mantle. While carbonates exhibit much lower wave velocities than silicates in the oceanic crust, the moderately carbonated oceanic crust still displays positive wave velocity anomalies in the lower mantle, except at mid-mantle depths. In the specific cases of iron content and extremely cold subducted slabs, (Mg, Fe)CO_3 undergoes a spin transition at a depth of ~1600 km, causing a significant negative anomaly in V_P, while V_S barely changed. Carbonates would react with silicates at the depth of ~1900 km, accompanied by negative velocity jumps in V_S, which may explain the scatterers observed in the Tonga region. Additionally, at a depth of ~1100 km, the V_S of carbonated subducted oceanic crust is similar to that of the surrounding mantle, potentially making scatterers at this depth less detectable by seismology.