The Stability of Carbonate Melts In the Mantle

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Seismic observations indicate the presence of a patchy Low-Velocity Layer (LVL) above subducting slabs stalled in the mantle transition zone. The LVL contains between 0.5 and 1 vol. % melt likely derived from melting of sab carbonates. While phase equilibrium studies are consistent with carbonate melting at this depth, these studies also suggest that the highly reducing condition of the mantle should render the melt unstable, leading to the precipitation of graphite, diamond, or metal carbides.

In this work, we reconcile the apparent difference between the seismic observation and petrological constraints by analyzing the stability of a reactive, partially molten carbonate layer atop the mantle transition zone. We tested the stability of the carbonate melt for mantle Fe concentrations of 1 wt. % and 5 wt. %, respectively, though the abundance of free Fe in the mantle is likely lower. Our results indicate that even in the presence of 5 wt. % Fe in the mantle, small amounts of carbonate melt can remain chemically stable over a period of several hundred million years. The results of our analysis indicate that the LVLs above subducting slabs are reservoirs of residual carbonate melt, characterized by a strong oxidation gradient within the LVL.