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# Internal Structure and Stability of Carbonate-rich Melts atop the Mantle Transition Zone

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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, especially beneath the western US. The LVL contains 0.5 - 1 vol% melt, likely derived from carbonated melts, as indicated by phase equilibrium studies of carbonatite solidus. While the carbonatite solidus shows a kink at depth similar to the LVL, the presence of free Fe in the mantle and low oxygen fugacity can potentially lead to complete consumption of the melt, a process known as redox freezing.
To reconcile the difference between the observed signature of potentially carbonate derived melting and the prediction of redox freezing, we test the stability of the carbonate melt atop a stalled slab as a function of the free Fe concentration in the deep mantle, the chemical reaction rate, and the rate of carbon input from subducted sediments. We carried out marginal stability analyses of small perturbations in the melt fraction and 2D numerical models of melt advection-reaction in the mantle.
Our results demonstrate that large scale partially molten structures can remain stable in the mantle over geological time. Our results also indicate that for a realistic mantle Fe concentration of 1 wt% and a carbonate concentration of 0.3 wt% in the subducted oceanic crust, the LVL can grow at a rate of 100 m/Ma or greater. The correlation between the carbon input rate and the thickness of the melt-rich layer suggests that convergent margins enriched in a carbonate component are likely to be spatially associated with prominent LVLs.