Carbonate-rich melts in the oceanic low-velocity zone and deep mantle

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ABSTRACT
Deep extensions of low seismic velocities in the mantle beneath volcanic centers are commonly attributed to high temperatures and have been used as a possible characteristic of hot plumes originating at the core-mantle boundary. To address this issue, we examine the effect of volatiles on melting to determine if regions of low seismic velocities may also be interpreted as regions of melting without elevated temperatures. We find that for the very small amounts of H_2O in the oceanic mantle, the effect on solidus temperatures is a reduction of at most ~13 °C, which can be neglected. In contrast, even the smallest amount of carbonate reduces solidus temperatures more than 300 °C at pressures greater than 1.9 GPa. The close match between detailed seismic imaging of the upper boundary of the low-velocity zone on the East Pacific Rise and the sharp temperature decrease for the carbonated lherzolite solidus at ~1.9 GPa supports earlier suggestions that the low-velocity zone (~70–150 km depth) is caused by melting due to the presence of carbonate. For locally elevated concentrations of carbonate subducted into the mantle along with oceanic crust, melting of the resulting carbonated lherzolite and carbonated eclogite could also occur at greater depths, possibly into the lower mantle, without elevated temperatures. Thus seismic imaging of deep low-velocity regions may reveal the locations of old subducted crust rather than hot plumes.