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Crustal thickness and resolution controls on basalt entrainment in the lower mantle

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Signatures from hotspot lavas fed by mantle plumes suggest a heterogenous mantle source. Deep plumes sample the core-mantle boundary (CMB) region and this region is thought to host primordial and recycled crustal material, possibly in the form of thermochemical piles. The formation of these piles depends on the amount of oceanic crust subducted into the lower mantle and how much is entrained back toward the surface. However, it is unclear how and under which conditions the oceanic crust can segregate from subducted slabs to form these piles and eventually be entrained in ascending mantle plumes. It has been suggested that the bridgmanite to post-perovskite phase transition facilitates this segregation, as low viscosity post-perovskite allows for thinning and stretching of crustal material. This process is difficult to model numerically, since crustal material is often thinned to very small length scales. Thus, it usually cannot be resolved in global convection models, leading to over-estimates of entrainment and consequently impacting the predicted formation of basaltic piles. Furthermore, the deformation of the crust as the slab descends into the lower mantle changes the initial surface crustal thickness and hence how likely the material is to form piles or become entrained. To address these uncertainties, we model a descending slab in the lower mantle to re-assess basalt entrainment and accumulation near the CMB. We use an adaptive mesh and tracers in order to track the deformation of the crust to achieve high resolution and also test different crustal thicknesses. These models provide insights into how material is added and removed from reservoirs in the lowermost mantle, and how these rates of material exchange have varied throughout Earth history.