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Convective instability rising out of the underbelly of stagnant slabs in the Mantle Transition Zone

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The study of volcanism can further our understanding of Earth's mantle processes and composition. Continental intraplate volcanism commonly occurs above subducted slabs that stagnate in the Mantle Transition Zone (MTZ), such as in Europe, eastern China, and western North America. Here, we use two-dimensional numerical models to explore the evolution of stagnant slabs in the MTZ and their potential to sustain mantle upwellings that can support volcanism. We find [1] that weak slabs may go convectively unstable within tens of Myr. Upwellings rise out of the relatively warm underbelly of the slab, are entrained by ambient-mantle flow and reach the base of the lithosphere. The first and most vigorous upwellings rise adjacent to lateral heterogeneity within the slab. Ultimately, convective instability also acts to separate the compositional components of the slab, harzburgite and eclogite, from each other with harzburgite rising into the upper mantle and eclogite sinking toward the base of the MTZ, and potentially into the lower mantle. Such a physical filtering process may sustain a long-term compositional stratification across the mantle [2].

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[2] Ballmer, M. D., N. C. Schmerr, T. Nakagawa, and J. Ritsema (2015): Compositional mantle layering revealed by slab stagnation at $\sim$1,000 km depth, Science Advances, doi:10.1126/sciadv.1500815