Structure and Dynamics of a Hydrous Melt Layer above the Transition Zone

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The "transition zone water-filter"(Bercovici and Karato, 2003) model relies on the presence of a dense hydrous melt above the 410 km discontinuity that is formed by dehydration melting as wet wadsleyite undergoes a phase change to low-water-solubility olivine. Huang and Karato (2005) suggest that, particularly in the Pacific, there is sufficient water in the transition zone to cause dehydration melting to occur. In the original water-filter model, the melt layer is divided into two regimes: a melt production area, where wet upwelling material melts, and a slab-entrainment area, where slabs become a reservoir for water due to their cold temperatures. Here we consider an additional regime: the viscous entrainment area, where mantle is viscously entrained by slabs at ambient mantle temperatures. We propose a mechanism that allows for melt to spread from the production area to the viscous entrainment area and find that this mechanism drains the melt layer of water very efficiently. Additionally, we find that because melt recycled into the transition zone has a large (near saturation) water content and is therefore more buoyant (Angel et al. 2001), the recycling process disturbs the bulk convective circulation and may contribute to transition zone scale convective cells. This disturbance can become an important feedback, affecting both the rate of melt production and the entrainment efficiency.

References:

Bercovici D., and S. Karato (2003), Whole mantle convection and the transition-zone water filter, Nature, 425, 39-44.

Huang X., and S. Karato (2005), Water content in the transition zone from electrical conductivity of wadsleyite and ringwoodite, Nature, 434, 746-749.

Angel R.J., Frost D.J., Ross N.L. and R. Hemley. Stabilities and equations of state of dense hydrous magnesium silicate. Phys. Earth Planet. Inter., 127, 181–196, 2001.