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Water content in hydrous silicate melt at the topmost lower mantle conditions

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The mantle transition zone is considered to be a water reservoir because its dominant minerals, wadsleyite and ringwoodite, contain up to ~1.0 wt.% [1, 2]. In contrast, the lower mantle should be relatively dry because bridgmanite and ferropericlase can contain ≤0.1 wt.% water in their crystal structures [3]. Therefore, dehydration melting should therefore occur during the phase transformation of hydrous ringwoodite to bridgmanite and ferropericlase by mass convection when crossing the 660-km boundary [4]. The question arises regarding whether this melting layer is stabilized at 660-km depth or gravitationally unstable. This problem should be determined by the density contrast between the transition zone, lower mantle, and hydrous melt.

Because the density of silicate melt decreases with increasing water content [5, 6], here I estimated the water content in hydrous melt that coexists with ringwoodite and bridgmanite using multi-anvil experiments at 1600-2300 K and 23-23.5 GPa by mass balance calculation. The results indicate that the water content in melt systematically decreases from about 50 wt.% at 1600 K to 10 wt.% at 2300 K. The density of the hydrous melt is <3.9 g/cm^3 under the topmost lower mantle conditions, which makes it buoyant. The melt fraction at 660-km depth is >0.5 vol.%. Such a high melt fraction may significantly reduce rock viscosity and seismic velocity.

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