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Effect of grain-size evolution on the lower mantle dynamics

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Grain-size evolution is a crucial controlling factor for the lower mantle rheology. Notably, one order of grain size change can produce a viscosity change of the order of 100-1000 times. As diffusion creep dominates in the lower mantle, grain growth of lower mantle mineral assemblages, e.g., bridgmanite and ferropericlase, increase viscosity considerably. It has been quite challenging to constrain the grain-size evolution parameters for lower mantle mineral assemblages until recently; a new high-pressure experimental study (27 GPa, cf. Fei et al, 2021, EPSL) parameterised them. The experimental data found a slower grain growth of bridgmanite-ferropericlase phases than of the upper mantle mineral phases, e.g., olivine and spinel. Using the most updated knowledge of grain-size evolution, we develop 2-D spherical annulus numerical models of self-consistent mantle convection using the finite volume code StagYY and explore how grain-size evolution affects the lower mantle dynamics. We test our models with different heterogeneous grain size evolution and composite rheology that evolve self-consistently for 4.5 billion years. Our preliminary models show the self-consistent formation of thermochemical piles at the base of the core-mantle boundary where the grain size is maximum (~3 times than the surroundings). Even though the bridgmanite-ferropericlase grain growth is slower, a slight increase in the grain size of thermochemical piles can make them ~100-1000 times viscous, subsequently helping them to achieve morphological stability over billion years. In some of our models, we find sweeping stability of the piles for ~500 million years.