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Modeling (Mg,Fe)O creep at Lowermost Mantle conditions

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The viscosity of the lower mantle results from the rheological behavior of its two main constituent minerals, aluminous (Mg,Fe)SiO_3 bridgmanite and (Mg,Fe)O ferropericlase. Understanding the rheology of lower mantle aggregates is of primary importance in geophysics and it is a challenging task, due to the extreme time-varying conditions to which such aggregates are subjected.

Here we focus on the creep behavior of (Mg,Fe)O at the bottom of the lower mantle, and how it may contribute to the peculiar properties of thermo-chemical anomalies such as ultralow-velocity zones (ULVZ). Two different iron concentrations of (Mg1-xFex)O are considered: one mirroring the average composition of ferropericlase throughout most of the lower mantle (x = 0.20) and another representing a candidate component of ULVZs near the base of the mantle (x = 0.84) (Wicks et al., 2017). The investigated pressure-temperature conditions span from 120 GPa and 2800 K, corresponding to the geotherm at this depth, to core-mantle conditions of 135 GPa and 3800 K.

In this study, dislocation creep of (Mg,Fe)O is investigated by Dislocation Dynamics (DD) simulations, a modeling tool which considers the collective motion and interactions of dislocations. To model their behavior, a 2.5 Dimensional Dislocation Dynamics approach (2.5D-DD) is employed. Within this method, both glide and climb mechanisms can be taken into account, and the interplay of these features results in a steady-state condition. This allows the retrieval of the creep strain rates at different temperatures, pressures, applied stresses and iron concentrations across the (Mg,Fe)O solid solution, providing information on the viscosity for these materials. This numerical approach has been validated at ambient conditions, where it was benchmarked with respect to experimental data on MgO (Reali et al., 2017).

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