Relative strengths of bridgmanite ($MgSiO_3$) and periclase (MgO) in the conditions of the lower mantle

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Transport of heat from the interior of the Earth drives convection in the mantle which involves the deformation of solid rocks over billions of years. The lower mantle of the Earth is mostly composed of iron-bearing bridgmanite $MgSiO_3$ (perovskite structure) and ~25% volume ferropericlase (Mg,Fe)O. It is commonly accepted that ferropericlase is softer than bridgmanite . Considerable progress has been made in recent years to study these assemblages under the relevant mantle pressure and temperature conditions. However, the natural deformation rates are 8 to 10 orders of magnitude lower than in the laboratory, and are still inaccessible to us. Once the physical mechanisms of the deformation of rocks and their constituent minerals have been identified, it is possible to overcome this limitation thanks to multiscale numerical modeling, and to determine rheological properties for inaccessible strain rates. In this work we use 2.5D dislocation dynamics to model the low-stress creep of MgO periclase at lower mantle pressures and temperatures. We show that periclase deforms very slowly under these conditions, in particular much more slowly than bridgmanite deforming by pure climb creep. This is due to slow diffusion of oxygen in periclase under pressure. In the assemblage, this secondary phase hardly participates in the deformation, so that the rheology of the lower mantle is very well described by that of bridgmanite. Our results show that drastic changes in deformation mechanisms can occur as a function of the strain rate.