

## **Some mineral physics constraints on the rheology and geothermal structure of Earth's lower mantle**

**DAISUKE YAMAZAKI\* AND SHUN-ICHIRO KARATO**

### **ABSTRACT**

We explore the implications of recent mineral physics measurements of diffusion coefficients and melting temperatures of lower mantle materials on the rheological and geothermal structure of Earth's lower mantle. We show that  $\text{MgSiO}_3$  perovskite is significantly stronger than MgO periclase and therefore the rheology of the lower mantle depends strongly on the geometry of a weaker phase, periclase. We calculate viscosities of the lower mantle for two cases: (1) where periclase occurs as isolated grains and (2) where periclase occurs as continuous films, using mineral physics data and models of two-phase rheology. We find that the effective viscosity for the former is about ~10–1000 times higher than the latter. We therefore suggest that the rheology of the lower mantle is structure- and hence strain-dependent, leading to weakening at large strains due to the formation of continuous films of periclase. Overall depth variation of viscosity depends not only on the pressure dependence of creep but also on the geothermal gradient. Both  $\text{MgSiO}_3$  perovskite and periclase have relatively small activation energies ( $E^* = gRT_m$  with  $g = 10\text{--}14$ , where  $R$  is the gas constant and  $T_m$  is melting temperature), and therefore the depth variation of viscosity is rather small, even for a nearly adiabatic temperature gradient. However, the geothermal gradients consistent with the geodynamical inference of nearly depth-independent viscosity are sensitive to the pressure dependence of viscosity which is only poorly understood. A superadiabatic gradient of up to ~0.6 K/km is also consistent with mineral physics and geodynamical observations.