# Using thermo-mechanical models of subduction to constrain effective mantle viscosity

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Mantle convection and plate dynamics transfer and deform solid material on scales of hundreds to thousands of km. However, viscoplastic deformation of rocks arises from motions of defects at sub-crystal scale, such as vacancies or dislocations. In this study, results from numerical experiments of dislocation dynamics in olivine for temperatures and stresses relevant for both lithospheric and asthenospheric mantle (800–1700 K and 50–500 MPa; Gouriet et al., 2019) are used to derive three sigmoid parameterizations (*erf, tanh, algebraic*), which express stress evolution as a function of temperature and strain rate. The three parameterizations fit well the results of dislocation dynamics models and may be easily incorporated into geodynamical models. Here, they are used in an upper mantle thermo-mechanical model of subduction, in association with diffusion creep and pseudo-brittle flow laws. Simulations using different dislocation creep parameterizations exhibit distinct dynamics, which could not have been predicted a priori but arise from feedbacks between slab sinking velocity, temperature, drag, and buoyancy, which are controlled by the strain rate dependence of the effective asthenosphere viscosity. Comparison of model predictions to geophysical observations shows that the *tanh* parameterization best fits both crystal-scale and Earth-scale constraints. Deriving mantle rheology cannot therefore rely solely on the extrapolation of semi-empirical flow laws. The present study shows that thermo-mechanical models of plate and mantle dynamics can be used to constrain the effective rheology of Earth's mantle in the presence of multiple deformation mechanisms.

**Mots-Clés :** olivine, dislocation creep, subduction dynamics, mantle viscosity, rheology parameterization