American Mineralogist, Volume 92, pages 1346–1357, 2007

Modeling the plastic deformation of olivine by dislocation dynamics simulations

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ABSTRACT

This work addresses the modeling of dislocation interactions and dynamics in olivine. A 3D dislocation dynamics (DD) simulation developed for cubic and hexagonal metals is adapted to the orthorhombic symmetry of this mineral. Dislocation core effects and mobilities are introduced through available models or phenomenological laws and fitted based on available experimental results on single crystals. The stress dependencies of the mobilities of [100] and [001] dislocations are emphasized. Dislocations interactions are studied through a simple elastic analysis and further using a more realistic approach based on DD simulations. It is shown that no junction formation results from the interaction between [100] and [001] dislocations. The collinear interaction is thus the only potential mechanism for forest hardening although its efficiency is significantly reduced by lattice friction on screw dislocations, which decreases the probability for dislocation reactions. The Taylor relationship is often used to model the dependence of the flow stress with the dislocation density. In the presence of a strong lattice friction, Taylor strengthening is shown here to be only a minor contribution to the flow stress and should not be responsible for it.

Keywords: Olivine, plastic deformation, simulation, dislocation dynamics