Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)
©2015. Japan Geoscience Union. All Rights Reserved.

SIT04-06 会場:106 時間:5 月 28 日 14:15-14:30

Anisotropic viscosity of olivine aggregates: A laboratory, field, and numerical approach
Anisotropic viscosity of olivine aggregates: A laboratory, field, and numerical approach

Hansen Lars N.[1*] ; CONRAD Clinton[2] ; WARREN Jessica[3] ; KOHLSTEDT David[4]
HANSEN, Lars N.[1*] ; CONRAD, Clinton[2] ; WARREN, Jessica[3] ; KOHLSTEDT, David[4]

[1]University of Oxford, [2]University of Hawaii, [3]Stanford University, [4]University of Minnesota
[1]University of Oxford, [2]University of Hawaii, [3]Stanford University, [4]University of Minnesota

Shearing of mantle rocks within Earth's lithosphere and asthenosphere causes mantle minerals, particularly olivine, to develop crystallographic textures that can be detected seismically. In laboratory studies, such crystallographic textures have also been associated with dependence of the viscosity of a mineral on the orientation of an applied stress. This anisotropic viscosity may affect tectonic plate motions and the stability of the lithospheric base, but it is highly dependent on 1) the rate of fabric development and 2) the poorly constrained viscosity tensor, which relates the stress applied to an olivine crystal of known orientation to the resulting strain-rate.

Here we constrain the importance of viscous anisotropy in the upper mantle using deformation experiments conducted in a gas-medium apparatus. Olivine aggregates were deformed at a temperature of 1200 ^{o} C and a confining pressure of 300 MPa. One set of samples was initially deformed in torsion and subsequently deformed in tension. A second set of samples was initially deformed in tension and subsequently deformed in torsion. Torsion experiments reached a maximum shear strain of ˜20. This combination of strain paths allowed us to quantify the effect of evolving crystallographic texture on multiple components of the viscosity tensor.

We developed a micromechanical model that allows estimation of the complete viscosity tensor based on a measured texture and a single-crystal viscosity tensor. We then used the laboratory-derived mechanical data in conjunction with this model to invert for the values of the single-crystal viscosity tensor. We developed a second, independent model of olivine textural development that takes into account the strength of individual slip systems yet is stable to high strains. We calibrate this texture model through comparison to the strengths and shapes of measured textures in experimental samples. Together, these two calibrated models allow us to constrain both the rate of texture development in an arbitrary deformation geometry and also the resulting macroscopic viscosity tensor. Our results indicate that olivine textural development can yield viscosities that vary by over an order of magnitude depending on the orientation of the applied stress relative to the dominant crystallographic texture.

We tested our mechanical and textural evolution model through comparison to natural peridotite shear zones exposed in the Josephine Peridotite. We find that (1) the natural textural development is well approximated by our numerical model and (2) a significant portion of the strain localization can be attributed to the development of viscous anisotropy.

キーワード: rheology, olivine, crystallographic preferred orientation, viscosity, rock deformation, shear zones
Keywords: rheology, olivine, crystallographic preferred orientation, viscosity, rock deformation, shear zones