Variation of olivine fabrics with thermo-chemical environment: An interdisciplinary study

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In the majority of studies of seismic anisotropy in the upper mantle, the experimental results published more than 30 years ago ([*Carter and Avé Lallemant*, 1970; *Nicolas et al.*, 1973]) have been used (e.g., [*Ben Ismail and Mainprice*, 1998]) with minor modifications to deformation geometry (for experimental studies [*Zhang and Karato*, 1995]; for numerical modeling see e.g., [*Tommasi et al.*, 2000]). Based on well-known physics of deformation fabrics and the known anisotropic role of water to enhance of olivine deformation ([*Mackwell et al.*, 1985]), [*Karato*, 1995] proposed that water might play an important role in deformation fabrics in olivine.

We have made extensive experimental studies to test this hypothesis ([*Jung and Karato*, 2001; *Jung et al.*, 2005; *Katayama et al.*, 2004; *Katayama and Karato*, 2005]) and investigated the deformation fabrics of naturally deformed peridotites ([*Katayama et al.*, 2005; *Skemer et al.*, 2005]). Experimental studies were performed in simple shear geometry under a range of water contents, strain-rates and temperatures. Laboratory studies are used to establish a functional relationship between fabric types and thermo-chemical conditions of deformation, and geological observations are used to pin down fabric boundaries at conditions that are impossible to reproduce in the laboratory (i.e., deformation at low temperatures and low stresses). We found that the laboratory data extrapolated to lower temperatures with a help of theoretical analysis ([*Karato*, 2005]) agree well with the geological observations, supporting that our laboratory data can be applied to Earth.

Our mineral physics results predict that (1) the B-type fabric is dominant in a cold region if some water is present and (2) in the asthenosphere of the ocean mantle, olivine E-type fabric (not the A-type fabric) will be dominant, although conventional A-type fabric should be dominant in the depleted lithosphere. The B-type olivine fabric is of particular importance since it predicts that the direction of the polarization of the faster S-wave is normal to the shear direction as opposed to parallel as in the case of A-, C- and E-type fabrics. Consequently, we have conducted a detailed numerical modeling to map out the regions where olivine B-type fabric might play an important role under the subduction zone environment ([*Kneller et al.*, 2005]). In this modeling, details of rheological properties are incorporated including linear and non-linear rheology as well as temperature and pressure sensitivity. We find that the olivine B-type fabric plays an important role in the cold corner of the mantle wedge which could explain an enigmatic shear wave splitting observed in many subduction zones (e.g., [*Smith et al.*, 2001]).

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