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Activation of [100](001) slip system by water incorporation in olivine and the cause of seismic anisotropy decrease with depth in the asthenosphere

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Abstract

A transition from A-type to E-type fabrics in olivine may be the cause of a decrease in seismic anisotropy with depth in the upper mantle. To better understand upper mantle seismic signals, we investigate the origin of E-type fabrics using a natural olivine by deformation experiments. An olivine crystal was first hydrated at 5 GPa and 1473 K (with 4–60 ppm H_2O), or dehydrated at room pressure at 1473 K at an oxygen fugacity near the enstatite-magnesite-olivine-graphite (EMOG) buffer. This hydrated/dehydrated olivine was then sheared in the [100] direction on the (001) plane at pressures of 2 to 5 GPa and temperatures of 1473 or 1573 K. The deformed samples were observed by transmission electron microscopy (TEM) on the (001) plane to determine whether the [100](001) slip system was activated or not. Only ***c***-elongated [100] dislocations were observed for the anhydrous samples, while [100](001) dislocations dominated in the hydrous samples. The dislocation structure of the [100](001) slip system developed under hydrous and relatively low-temperature conditions indicates different slip mechanism which is detected under anhydrous and high-temperature conditions in previous studies. We conclude that the incorporation of water into olivine helps to activate the [100](001) slip system by reducing its Peierls stress. This supports the idea that E-type fabrics can exist under hydrous conditions and that a transition to this fabric may be the cause of seismic anisotropy decrease with depth in the asthenosphere.

Keywords: Slip system, E-type olivine fabric, hydrous olivine, TEM, dislocation structure