Anisotropic high-temperature plasticity of wet single crystal olivine and its geodynamic implications

*Sagar Shrishailappa Masuti[1], Shun-ichiro Karato[2]

1. Earth Observatory of Singapore, 2. Yale University

Olivine, the most abundant and weakest upper mantle mineral, has been one of the extensively studied mineral in the last few decades. From these studies, we know the strength of polycrystalline olivine is greatly reduced by the addition of water. A similar study on the single crystal olivine shows that the effect of water is not same in all direction (Mackwell et al. 1985). Here we gather the experimental data from different studies to quantify the effect of water and pressure on olivine single crystal. The data collected from different studies include wide pressure range of 0.1 MPa to 6 GPa at temperatures around 1200ºC to 1300ºC and generally on three different orientations viz., $[110]_c$, $[101]_c$ and $[011]_c$. The normal stress is applied in between the [100] and [010] direction for $[110]_c$ orientation to activate the [100](010) slip system. Similarly, for $[011]_c$ orientations [001](010) slip system and for $[101]_c$ orientation [100](001) and [001](100) slip systems are activated. We show the effect of water on the $[110]_c$ orientation or [100](010) slip system is substantially smaller ($r_{[110]}$~0.3) than the $[011]_c$ orientation or [001](010) slip system ($r_{[011]}$ ~1.3). We propose that the easier slip system is likely to change from [100](010) slip system at low water content and low pressure to that of $[011]_c$ at high water content and high pressure. We will discuss some of the geodynamic implications of our results such as the effect of water on the long-term viscosity and short term viscosity. In addition, we also propose that the fabric transition from A-type to C-type through E-type is not only water induced but it is both water and pressure induced.

Keywords: Olivine, Anisotropy, Fabric transition

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