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Activity of olivine [001] slip in the Horoman and Uenzaru peridotites

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We evaluated the activity of olivine [001] slip in the Horoman and Uenzaru peridotites of Hokkaido by estimating active slip systems in olivine subgrains using the method described below. Slip direction is normal to tilt walls with planar arrays of edge dislocations perpendicular to the Burgers vector. Slip plane can be defined as a crystallographic plane made by the slip direction and the rotation axis determined from the crystallographic orientations of subgrains on both sides of a tilt wall. Thus universal-stage measurements of the orientations of a tilt wall and subgrains on its both sides enable us to estimate the active slip systems of edge dislocations in the tilt wall. We considered in our analyses subgrain boundaries at angles of less than 10 degrees with the rotation axis as tilt walls.

The Horoman Upper Zone is inferred to have ascent adiabatically at temperatures of 1100-1150 degrees Celsius (Ozawa and Takahashi, 1995). Olivine grains in the Upper Zone rocks exhibit a crystallographic preferred orientation (CPO) with their (010) planes subparallel to foliation and [100] axes subparallel to lineation (Sawaguchi and Takagi, 1997), suggesting a dominant activity of (010)[100], which is confirmed by our analyses. However, the activity of [001] slip systems has not been verified.

The Horoman Lower Zone and the Uenzaru eastern unit are inferred to have ascent adiabatically at temperatures of 900-950 degrees Celsius and above temperatures of 960 degrees Celsius, respectively (Ozawa and Takahashi, 1995; Furusho and Kanagawa, 1999). Olivine grains in these peridotites exhibit a CPO with their [100] axes subparallel to lineation and [010] and [001] axes distributed on a girdle around lineation (Sawaguchi and Takagi, 1997; Furusho, 1999), suggesting the dominance of {0kl}[100]. Our analyses reveal dominant activities of {0kl}[100] slip systems such as {031}[100], {011}[100], (010)[100], and (001)[100], but also a few activities of [001] slip systems such as (100)[001] and {110}[001].

Plagioclase lherzolite in the Uenzaru central unit has been mylonitized at temperatures of 760-960 degrees Celsius (Furusho and Kanagawa, 1999). Olivine grains in the mylonite exhibit a CPO with their [100] axes subparallel to lineation and [001] axes subnormal to lineation (Furusho and Kanagawa, 1999), suggesting a dominant activity of (001)[100]. Mylonites derived from spinel lherzolite in the Horoman Lower Zone also exhibit this type of olivine CPO (Sawaguchi and Takagi, 1997). However, our analyses suggest activities of {0kl}[100] slip systems such as (001)[100], {031}[100], {011}[100] and (010)[100] as well as those of [001] slip systems such as (100)[001] and {110}[001]. Tabular olivine subgrains composed of tilt walls of [100] slip subparallel to lineation and those of [001] slip subnormal to foliation are commonly developed in these mylonites. This implies that strain incompatibilities between grains caused by dominant [100] slip subparallel to lineation are accommodated by additional [001] slip subnormal to foliation. Olivine [001] concentration in the foliation-normal direction even in samples where (001)[100] is found to be inactive are attributable to this [001] slip subnormal to foliation.

Thus olivine [001] slip systems are activated at or below moderate temperatures where {0kl}[100] slip systems are dominantly active, and their activities increase with decreasing temperature. Strain incompatibilities between naturally deformed olivine grains caused by dominant [100] slip are accommodated by subsidiary [001] slip at lower temperatures, as in experimentally deformed olivine grains (Drury and FitzGerald, 1998).