Crystal Preferred Orientation of Secondary Olivine Formed after Orthopyroxene in Mantle Wedge during Serpentinization from the Khantaishir Ophiolite, Western Mongolia

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Crystal preferred orientation (CPO) of olivine (Ol) provides significant effects on physical properties of the upper mantle, and the comparison of the Ol CPO analyses and observations of seismic anisotropy make it possible to simulate the flow pattern of upper mantle. The CPO analyses on naturally or experimentally deformed Ol samples have shown the relationship between deformation conditions (stress, temperature and H_2O content) and CPO patterns produced by the plastic deformation [3]. In contrast, some literatures suggested specific topotactic relationships between Ol and serpentine minerals as an Ol CPO formation mechanism [e.g., 2]. However, the effects of the chemical reaction (i.e., (de-)serpentinization) on the development of the mantle anisotropy is still unclear. In this study we analyzed the CPO of the secondary Ol (S-Ol) aggregates formed after Opx during antigorite (Atg) serpentinization from the Naran massif in the Khantaishir ophiolite, western Mongolia. The Naran massif is composed of metaharzburgite and metadunite, which were suffered from the multi-serpentinization in order of Atg to lizardite+brucite to crysotile in suprasubduction-zone setting [2].

The metaharzburgite contains both primary olivine (P-Ol) and S-Ol, with Mg# of 0.92-0.93 and 0.96-0.98, respectively. The S-Ol commonly exists as fine-grained aggregates with size of ca. 5 mm, and the aggregate has aligned fractures filled with Atg grains. The microstructural and chemical features of the S-Ol aggregate indicate that the S-Ol was formed after Opx by silica-releasing reaction, which is coupled with silica consuming reaction of P-Ol to produce Atg. P-Ol grains show the prominent CPO which c-axis sub-parallel to the mineral lineation defined by the grain shape of Atg in the matrix and the b-axis sub-perpendicular to the foliation defined mainly by the grain shape of minerals in the matrix. This P-Ol CPO corresponds to an apparent C-type Ol CPO [e.g., 3] in the reference frame defined by the present shapes of Atg grains. Atg in matrix shows a strong CPO, which exhibits the c-axis is sub-normal to the foliation and girdle distribution of the a- and b-axis on the foliation plane suggesting the topotactic growth after P-Ol and this relationship corresponds to the type-1 topotactic growth of Atg after Ol [2]. Each S-Ol aggregate shows a strong CPO indicating its origin to be a single Opx grain. In contrast, the CPO patterns of individual S-Ol aggregates are different in a thin section. This indicates that Ol grains were not likely to be significantly re-oriented by dislocation creep of S-Ol and that preexisting Opx might not be oriented strongly. The CPO calculated using all of these S-Ol aggregates in the same thin section shows the significantly weaker concentration for each axis than that calculated from each aggregate. Therefore, the S-Ol grains have little contribution to the bulk-rock anisotropy. The Atg bands in S-Ol are developed parallel to each other and might be directly reflected to the cleavage of original Opx. Therefore, the topotactic growth of S-Ol after Opx may be estimated using the orientation of the S-Ol aggregate and the cleavage of Opx determined by the orientation of Atg in the fracture with the (001) plane of Atg sub-normal to the fracture. The CPO of S-Ol in the aggregate has a prominent CPO, which shows mainly c-axis sub-parallel to the fractures (the cleavage of the original Opx) and the b-axis sub-normal to the fractures (type-I topotaxy).
In conclusion, the harzburgite in the Naran massif was originally composed of P-Ol with CPO and

non-orientated Opx. During hydration and S-Ol formation within the mantle wedge, topotactic S-Ol after Opx with weak CPO and type-I topotactic Atg after P-Ol were developed.

References:

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