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Analysis of EBSD mapping data of antigorite schist from the Sanbagawa belt, SW Japan and implication of a grain boundary sliding as an antigorite CPO formation mechanism

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Antigorite (Atg) is predicted to be the dominant serpentine mineral throughout large parts of the hydrated forearc mantle. One of the characteristics of Atg is its very strong elastic and frictional anisotropy. In addition, the presence of aligned Atg grains in foliated serpentinite causes a strong anisotropy in permeability. Identifying and quantifying the crystallographic alignment of Atg is therefore an important goal in studies of convergent margins. Natural and experimental studies have shown several different types of Atg crystal preferred orientation (CPO) patterns. There is also evidence for Atg CPO patterns formed both by crystal plastic deformation and growth in a preferred orientation. However, the conditions under which these different types are likely to develop are not well known.

Here, we examine progressive development of Atg CPO by using strain gradients preserved in natural serpentinite shear zones. In order to identify the Atg CPO formation mechanism in the shear zones, we combine EBSD mapping data to determine the grain size, aspect ratio and shape preferred orientation (SPO) with EPMA analyses to compare chemical compositions.

The results show a clear rotation of the c-axes of Atg grains towards the normal to the shear zone with increasing strain. The Atg CPO within the shear zone shows the b-axis of Atg aligned parallel to the shear direction referred to as B-type CPO or CPO-II. There is only limited evidence for internal plastic deformation of individual antigorite grains within the shear zone. In addition, there are no significant differences seen in the size, aspect ratios and major element chemical compositions of the Atg grains within and outside of the shear zone. Finite strain ellipses estimated using March's model for passive rotation of elongate shapes show increasing strain ratios associated with progressive rotation of the maximum stretching direction towards the shear plane of the shear zone.

The above observations suggest reorientation of Atg grains occurred with increasing strain but without internal deformation or grain size reduction as would be expected for deformation by dislocation creep. Therefore, we propose the B-type Atg CPO, in this case at least, formed by mechanical rotation of grains associated with grain-boundary sliding.

Atg has a curved plate crystal structure and the b-axis of Atg is parallel to the basal plane and the fold axis of the crystal structure. The association of grain boundary sliding with the formation of B-type Atg CPO in the present shear zones is in agreement with the experimental observation that the low-friction direction of Atg is parallel to the b-axis. The development of similar Atg CPOs along the slab-mantle boundary in subduction zones could play a significant role in developing aseismic deformation associated with the slow slip events in the shallow mantle wedge.