# Mis-indexing of antigorite crystallographic orientations in EBSD measurements

*Takayoshi Nagaya[1,2], Simon Wallis[2], Yusuke Seto[3], Akira Miyake[4], Yusuke Soda[2,5], Seiichiro Uehara[6], Megumi Matsumoto[7]

1. Graduate School of Environmental Studies, Tohoku University, 2. Graduate School of Environmental Studies, Nagoya University, 3. Department of Planetology, Graduate School of Science, Kobe University, 4. Department of Earth and Planetary Science, Faculty of Science, Kyoto University, 5. School of Natural System, College of Science and Engineering, Kanazawa University, 6. Department of Earth and Planetary Science, Faculty of Sciences, Kyushu University, 7. Center for Supports to Research and Education Activities, Kobe University

Antigorite (Atg) is the dominant serpentine mineral in the hydrated mantle wedge above subducting slabs. Atg is a platy mineral and commonly shows strong crystallographic preferred orientation (CPO) either due to deformation or growth in a preferred orientation. The presence of an Atg CPO imparts a strong mechanical anisotropy to the host serpentinized peridotite. There have been many recent studies examining the elastic, permeability and frictional anisotropies of Atg and the consequences for shear wave splitting, fluid flow and seismicity in the shallow wedge mantle. To make a quantitative analysis of how Atg affects the anisotropic properties of hydrated wedge mantle it is essential to obtain reliable measurement of the pattern and the strength of Atg CPOs. Nearly all Atg CPOs are measured using an EBSD system and several distinct types have been reported. Most natural and experimental samples show point concentrations of the crystallographic axes with the *c*-axes perpendicular to the foliation and either the *a*- (A-type) or *b*-axes (B-type) parallel to the maximum finite extension direction. Others show general girdle distributions of *a*- and *b*-axes lying within the foliation. However, there are several potential difficulties in obtaining an accurate measurement of the crystal orientation of Atg by EBSD, in particular mis-indexing in the measurements and sample preparation affecting crystallographic orientation of the surface material. We use a combination of FIB-TEM and SEM-EBSD measurements in the same sample to examine the extent to which mis-indexing is an issue when Atg CPOs are determined using EBSD. We compare these results with Atg CPOs measured using synchrotron X-rays and U-stage techniques. In addition, we propose procedures for sample preparation and EBSD measurement that minimize the uncertainties in crystal orientation detection and are appropriate for automatic orientation mapping of samples.
Our conclusions concerning (1) mis-indexing and (2) sample preparation issues are as follows.
(1) The most likely mis-indexing results in an apparent rotation of the *a*- and *b*-axes around the *c*-axis. Similar problems may also affect the *c*-axes measurements but these are less significant than for the *a*- and *b*-axes when data are filtered using relatively low Mean Angular Deviation (MAD) values. Filtering using MAD values of less than 0.7˚ can significantly change the resulting CPO from A- to B-type. The EBSD results with low MAD values of less than 0.7˚ are in good agreement with the orientations determined by TEM observations. However, mis-indexing of the *a*- and *b*-axes rotated by 60˚ with respect to the *c*-axis occurs even for low MAD values.
(2) When thin sections prepared parallel to the foliation are used for EBSD measurements, the resulting Atg CPOs are independent of filtering using MAD values. This difference by the prepared sample plane is thought to be related to the weaker bonding in the *c*-axis direction of Atg than the *a*- and *b*-axes. We propose mis-indexing problems can be minimized by using thin sections cut parallel to the foliation or Atg orientations with MAD values of < 0.7˚.
All of the previous limited reports of Atg CPOs in which MAD values have been described use a maximum value of 1.3˚. In this study, all Atg CPOs obtained using thin sections parallel to the foliation or MAD value of < 0.7˚ show the strongest concentration of the *a*-axis parallel to the foliation and normal to the

 

lineation (B-type CPO). Mis-indexing by a rotation about the *c*-axis can in part help explain the variation in point clusters of the *a*- and *b*-axes commonly observed in reported Atg CPOs.

Keywords: Antigorite CPO, EBSD, MAD, FIB-TEM, Anisotropy

 