Crystal orientation analysis of olivine in ultra-mylonite using TKD method: progress in spatial resolution from EBSD

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Mantle, which is the dominant component consisting of the earth making up 80 %, is the key to understanding material cycle and/or formation history of the earth. The uppermost part of the mantle is composed of peridotite which is aggregate mostly of olivine [$(Mg,Fe)_2SiO_4$] grains. Olivine has orthorhombic crystal system and its mechanical property is anisotropic. Thus the olivine polycrystalline in peridotite shows various crystal-preferred orientation (CPO) patterns formed by share deformation processes (Karato et al., 2008). Therefore, the CPO pattern can be an indicator of deformation environment and is also used as a key parameter to estimate seismic anisotropy. Thus, the CPO is very important for tectonic geology.

To evaluate CPO of olivine, Scanning Electron Microscope equipped with Electron BackScatter Diffraction detector (SEM-EBSD) is widely used. The SEM-EBSD is a method to analyze crystal orientation using the Kikuchi diffraction pattern formed by the interaction between scattered electrons and lattice planes of sample surface. Recently, improvements of high-speed detectors and userfriendly computer programs have enabled automatic, rapid and easy EBSD mapping. Using the method, olivine CPO patterns in peridotite of various localities have been studied. However, effect of fine grains (<1 μm in diameter) might have been overlooked in such studies, because it is difficult to obtain clear EBSD pattern from sub-micrometric mineral grains.

On the other hand, it was reported that the Kikuchi pattern can be obtained also by transmitted electrons through thin film (~100 nm) using SEM (Keller and Geiss, 2011). This method, which is called transmission EBSD (t-EBSD) or transmission Kikuchi diffraction (TKD), can restrict area in which electrons are scattered and improve spatial resolution even by the conventional SEM-EBSD system. In this study, therefore, we tried CPO analysis for ultra-mylonite using the TKD, to investigate usefulness of this method for tectonic geology.

The analyzed sample is an ultra-mylonite from Marion Transform fault by PROTEA5 cruise. The sample contains amphibole and olivine as porphyroclasts and fine-grained matrix, with a small amount of orthopyroxene and spinel (Kakihata et al., 2018, AGU). We obtained EBSD map from petrographic-thin section of this sample, and then an ultra-thin section for TKD was made using a focused ion beam apparatus(FIB, HITACHI FB2100). Finally, TKD map of the ultra-thin section was obtained. For both of the EBSD and TKD analyses, the same SEM-EBSD system (HITACH, S-3400N + OXFORD Instruments, NordlysNano) was used.

As the result, we successfully obtained TKD map dataset, in which patterns are indexed even at the region over boundaries between sub-micrometric olivine grains. This TKD map which was obtained by W-filament gun SEM is clearer than the FESEM-EBSD map we obtained from the same sample. The TKD map dataset was able to be processed by the same software with EBSD (following configuration parameters suggested by Miyake et al., 2016, JAMS). The processed TKD map of olivine displays CPO of *b* -axis perpendicular to shear plane. In addition, spatial distribution of sub-grain boundaries and irregular shaped grains is well displayed. TKD requires much less time and labor than TEM analyses in such orientation analysis throughout the ultra-thin section, although TEM is of course much better in spatial resolution or detailed crystallographic/chemical analyses. The TKD should be useful as a pre-analysis before the detailed TEM analyses for polycristalline samples such as ultra-mylonite. Application of the

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TKD method may reveal various effects of fine grains in tectonic geology.

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