NOTICE ON THE EBSD ANALYSIS OF OLIVINE IN METEORITES.

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Introduction: Olivine is one of the most common constituent minerals in meteorites. It occurs in most of the meteorites including chondrites, primitive achondrites, achondrites, stony-iron meteorites, and silicate inclusion in iron-meteorites [e.g., 1 and reference therein]. Such a wide-spread occurrence of olivine in meteorites makes it a good indicator to understand the origin and evolutionary history of meteorites and their parent bodies [e.g., 2-3].

The recent advance of SEM-EBSD techniques enables us to understand easily and rapidly the crystallographic features of constituent minerals in meteorites. EBSD data helps us to understand the formation history of meteorites and their parent bodies such as accumulation processes, igneous processes, and shock metamorphism [e.g., 4-6]. However, we found that there are some points that we should pay attention to the procedure of EBSD analysis of olivine. Here we make short notices on this matter with basic crystallographic information of forsterite.

Crystallographic Data of Olivine: Olivine is a group of orthorhombic silicate mineral with the formula of M_2SiO_4. Forsterite is an Mg-endmember of the olivine (Mg_2SiO_4) and the most common mineral in meteorites. Therefore, we discussed the crystallography of forsterite. The cell length of forsterite and corresponding crystallographic axes and optical indicatrix are shown in Table 1. Laue group of forsterite is *mmm* and conventionally *Pbnm* space group is used among mineralogical and petrological studies. On the other hand, *Pnma* space group is also used for minerals with *mmm* Laue group [7], and some mineralogical studies used *Pnma* space group [e.g., 8]. The correspondence of crystallographic axes in *Pbnm* and *Pnma* space groups is the following: $a_{Pbnm} = c_{Pnma}$, $b_{Pbnm} = a_{Pnma}$, and $c_{Pbnm} = b_{Pnma}$ as shown in Table 1.

Table 1. Crystallographic parameter and optical indicatrix of forsterite.

Cell length	*Pbnm*	*Pnma*	*Opt. Ind.*
4.75 Å	*a*	*c*	*Z*
10.20 Å	*b*	*a*	*X*
5.98 Å	*c*	*b*	*Y*

We investigated the crystallographic database of olivine in the latest default database in SEM-EBSD systems. In the dataset of Oxford Instrument software, most indices are based on *Pnma* space group and two indices are based on *Pbnm*. In the dataset of EDAX software, the index is based on the *Pbnm* space group. If the EBSD data was analyzed using the default dataset of Oxford Instruments, it might be based on the *Pnma* space group. Therefore, we should be careful to choose the index of olivine to construct EBSD data. If the obtained crystallographic data mismatches other data such as grain shape, estimated crystal facets, and/or lineation texture, it could be because of the mismatch of the space group. We suggest that EBSD data analyzed based on the *Pnma* space group is needed to replace by the *Pbnm* space group and suggest noting the space group and cell parameter used on the investigation to avoid the confusion.

Recent studies found developed olivine fabrics implying ductile solid-state deformation [e.g., 9-10]. Then, the olivine fabric of meteorites is the topic of arousing interest. Although the recent studies used SEM-EBSD system to investigate the fabric, most of the previous fabric analyses used optical microscope techniques with the universal stage [e.g., 11]. Correspondence of crystallographic axes by the *Pbnm* space group and optical indicatrix is following: $a = Z$, $b = X$, and $c = Y$. Therefore, we also should be careful when comparing the crystallographic orientation data obtained by the optical microscope technique and SEM-EBSD technique.

At the last, we notice the mismatch between the crystallographic data obtained by SEM-EBSD and the SEM image [12]. It depends on the setting of SEM used for EBSD analysis, and so we do not describe in detail this topic here. The detailed procedure to confirm and correct the mismatch is described on our webpage: "http://www.kueps.kyoto-u.ac.jp/~web-min/SEM-EBSD/JpGU2016_SMP-P05_e.pdf".

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