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**EXSOLVED KIRSCHSTEINITE IN ANGRITE LEW86010 OLIVINE;**

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Mineralogy of kirschsteinite exsolution in olivine from Antarctic meteorite LEW86010 has been studied by single crystal X-ray diffraction technique. The LEW86010 olivine crystals have exsolution lamellae of kirschsteinite about 15  $\mu\text{m}$  wide[1]. Determination of crystallographic orientation of exsolved kirschsteinite in an olivine grain has been made. Weak reflections of exsolved kirschsteinite share common crystallographic orientation with the host olivine. The cell dimensions of the exsolved phase ( $a$  4.87 $\pm$ 0.05 $\text{\AA}$ ,  $b$  11.14 $\pm$ 0.10 $\text{\AA}$ ,  $c$  6.36 $\pm$ 0.05 $\text{\AA}$ ) and intensities were well accord with those of kirschsteinite previously reported[2]. Oriented section perpendicular to the  $a$  axis shows exsolution lamellae in two directions parallel to (031) and (0 $\bar{3}$ 1). The lamellae are up to 10  $\mu\text{m}$  in width and spacings between them were usually 50-100  $\mu\text{m}$ .

**INTRODUCTION**

Angrite group with only four total meteorites, are classified as a unique achondrite with remarkably high Ca, Al and Ti never seen in any other achondrites[1,3]. They have very small Rb/Sr ratio which is less than BABI (Basaltic Achondrite Best Initial)[4] and show many chemical and mineralogical properties distinct from other groups. They have conspicuously high Ca content. Olivine has 2% CaO bulk composition[1] and kirschsteinite ( $\text{CaFeSiO}_4$ ) is exsolved from the host olivine during subsolidus cooling. Spectacular M shaped diffusion profile of the exsolution lamellae of kirschsteinite in the LEW86010 olivine offer a chance to estimate the cooling history[5]. It is reported that the lamellae are commonly parallel to (001), (011) or (031)[6], but no crystallographic study has been performed. They are typically up to 20  $\mu\text{m}$  in width, while the spacings between them are a few hundred  $\mu\text{m}$ [1]. We performed determination of crystallographic orientation of LEW86010 olivine by single crystal X-ray diffraction technique and examine the crystallographic relation between olivine host and exsolved kirschsteinite. Then, we will be able to observe real diffusion profile of Ca of the exsolved kirschsteinite perpendicular to the lamellae after slicing parallel to (100).

**METHODS**

Five LEW86010 olivine grains (up to 0.5mm) were supplied from the consortium leader for this study to estimate its cooling rate. Each of them was yellowish, prismatic single crystal as far as observed through an optical microscope before taking X-ray photographs. For the determination of the crystallographic orientation of olivine host, we employed an X-ray precession camera with  $\text{CuK}\alpha$  ( $\lambda=1.5418\text{\AA}$ ) and  $\text{MoK}\alpha$  ( $\lambda=0.7107\text{\AA}$ ) radiations. Exposure time was 50-120 hours with 40kV, 15mA. At first, we obtained X-ray photographs of ( $hk0$ ) and ( $h0l$ ) planes by a precession camera. After determining orientation of the host olivine, another reflection that does not belong to the host olivine was searched and ascertained whether it is reflection from kirschsteinite. Then the crystal was mounted in resin and sliced perpendicular to the  $a$  axis. The direction, width and spacings of exsolved kirschsteinite were examined through an optical microscope and scanning electron microscope(SEM).

**RESULTS & DISCUSSION**

According to the precession X-ray photographs the cell dimensions of the host olivine were;  $a$  4.79 $\pm$ 0.03 $\text{\AA}$ ,  $b$  10.39 $\pm$ 0.05 $\text{\AA}$  and  $c$  6.06 $\pm$ 0.03 $\text{\AA}$ . These data suggest that its Mg/(Mg+Fe) ratio was approximately 0.3 ( $\text{Fo}_{30}\text{Fa}_{70}$ ) without consideration of Ca content[7].

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This ratio agrees with formerly reported value[1].

The faint reflections just inside the host olivine were recognized on the  $(hk0)$  and  $(h0l)$  planes(Fig.1). If the orientations of kirschsteinite were the same direction as olivine, the cell dimensions are;  $a$   $4.87 \pm 0.05 \text{ \AA}$ ,  $b$   $11.14 \pm 0.10 \text{ \AA}$  and  $c$   $6.36 \pm 0.05 \text{ \AA}$ . These values are in accord with the reported cell dimensions of kirschsteinite ( $a$   $4.875 \text{ \AA}$ ,  $b$   $11.153 \text{ \AA}$  and  $c$   $6.438 \text{ \AA}$ [2]). The kirschsteinite-like reflections were also detected on the planes parallel and perpendicular to  $(011)$ . Furthermore, the indices of intense reflections which were found easily on the photographs were as intense as those of the powder diffraction reported for kirschsteinite[2]. It is concluded that these reflections are undoubtedly exsolved kirschsteinite. Olivine and kirschsteinite share common crystallographic orientations.

Then we mounted the crystal in resin and sliced perpendicular to the  $a$  axis. After grinding and polishing, we examined through an optical microscope and SEM. Ca-rich lamellae in two directions and spherical inclusion of anorthite were observed(Fig.2). The lamellae occur as two symmetrically related sets parallel to  $(031)$  and  $(0\bar{3}1)$ . They were typically up to  $10 \mu\text{m}$  in width, while the spacings between them were  $50\text{-}100 \mu\text{m}$ . Spherical inclusion of anorthite  $70 \mu\text{m}$  in diameter is also observed.

These results confirm that kirschsteinite was formed by diffusion during the cooling process of olivine. Sharing common crystallographic orientation suggests that diffusion profiles of Ca between olivine host and exsolved kirschsteinite are useful for estimating cooling rate.

## REFERENCES

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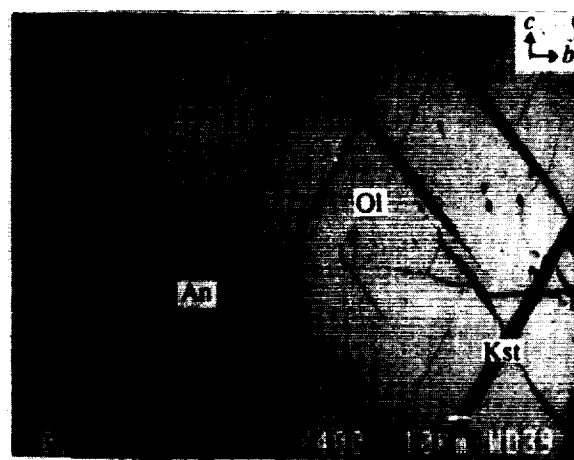
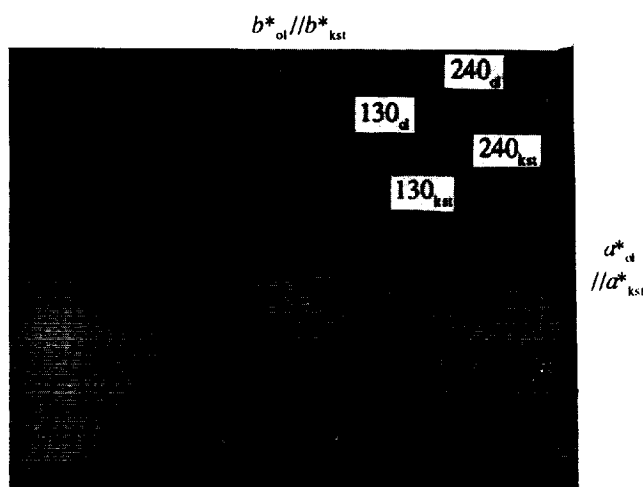


Fig.1 : Precession X-ray(MoK $\alpha$ ) photograph  $(hk0)$ plane including exsolved kirschsteinite reflections

Fig.2 : Backscattered electron image of olivine perpendicular to the  $a$  axis