

#### 40. A Natural Pyroxene with the Space Group $C_{2h}^4$ -P2/n

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Single-crystal X-ray diffraction studies of clinopyroxenes were carried out by Warren and Bragg<sup>1)</sup> and Warren and Biscoe,<sup>2)</sup> who showed that clinopyroxenes belong to the same space group  $C_{2h}^6$ -C2/c. On the basis of the twinned space group theory, Ito<sup>3)</sup> suggested that there might exist a kind of clinopyroxenes with space group  $C_{2h}^5$ -P2<sub>1</sub>/c. Morimoto<sup>4),5)</sup> found that the symmetry of pigeonite and clinoenstatite is actually P2<sub>1</sub>/c. Lindemann<sup>6),7)</sup> reported later a clinoenstatite that has  $C_{2h}^5$ -P2<sub>1</sub>/n symmetry. Recently spodumene was found to have  $C_2^3$ -C2 symmetry by Appleman and Stewart,<sup>8)</sup> and the eclogite clinopyroxene omphacite was considered to have  $C_2^3$ -P2 symmetry by Clark and Papike.<sup>9),10)</sup> Thus five kinds of space groups in clinopyroxenes—C2/c, P2<sub>1</sub>/c, P2<sub>1</sub>/n, C2 and P2—, have been reported. Theoretically, many space groups as the subgroups of  $C_{2h}^6$ -C2/c in clinopyroxenes are possible (Matsumoto<sup>11)</sup>). In the course of study of pyroxenes in our laboratory a new type of clinopyroxene having primitive lattice with n-glide planes perpendicular to [010] in diopside setting, was found.

The material is the omphacite from a hornblende-bearing eclogite of the Iratu mass, Bessi area, Japan, which is a low temperature eclogite belonging to the epidote amphibolite facies (Banno<sup>12)</sup>). The petrography of the rock will be described elsewhere by Banno and Oki.<sup>13)</sup> The chemistry of the omphacite is SiO<sub>2</sub>=53.01, TiO<sub>2</sub>=0.19, Al<sub>2</sub>O<sub>3</sub>=11.25, Fe<sub>2</sub>O<sub>3</sub>=5.04, FeO=2.56, MnO=0.02, MgO=7.34, CaO=13.21, Na<sub>2</sub>O=6.90, K<sub>2</sub>O=0.04, H<sub>2</sub>O(+)=0.25, H<sub>2</sub>O(-)=0.09, P<sub>2</sub>O<sub>5</sub>=0.01, Total=99.91. The atomic ratio for 6 oxygens (anhydrous basis) is as follows: Si=1.918, Al<sup>IV</sup>=0.082, Al<sup>VI</sup>=0.398, Fe<sup>3+</sup>=0.137, Fe<sup>2+</sup>=0.077, Ti=0.005, Mn=0.001, Mg=0.392, Ca=0.516, Na=0.484, K=0.001. Thus it is a typical omphacite containing appreciable amount of acmite component.

The Weissenberg photographs were taken about the b- and c-axes, and [110]-direction of the omphacite, up to the second layer, using Cu K $\alpha$  radiation with Ni filter. The unit cell dimensions of omphacite are as follows;

$$\begin{aligned} a &= 9.59 \pm 0.01 \text{ \AA} \\ b &= 8.76 \pm 0.01 \text{ \AA} \end{aligned}$$

$$c = 5.24 \pm 0.02 \text{ \AA}$$

$$\beta = 106.9 \pm 0.2^\circ$$

These values are in rather good agreement with those obtained by Clark and Papike.

The extinction rules of the X-ray reflections of the omphacite are definitely not those of  $C_{2h}^6-C2/c$ , nor  $C_{2h}^5-P2_1/c$ , the reflections of  $hkl$  being present even when  $h+k$  is odd, those of  $0k0$  also being present even when  $k$  is odd. In order to clarify the existence of glide planes, the Weissenberg  $h0l$  photograph was exposed for 200 hours. The photograph and the corresponding diagram are shown in Figs. 1 and 2 respectively. Careful examinations of this photograph revealed the

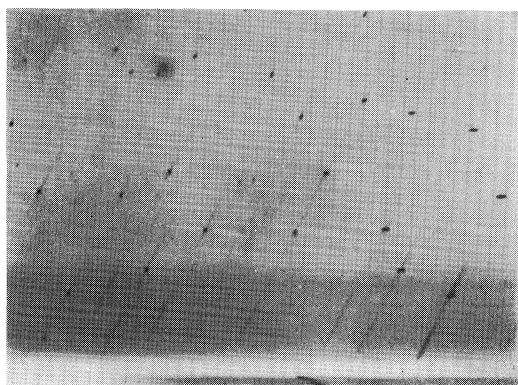


Fig. 1. The Weissenberg photograph of omphacite (rotation about  $b$ -axis, zero-layer). Reflections with  $h+l=2n$  are observed.

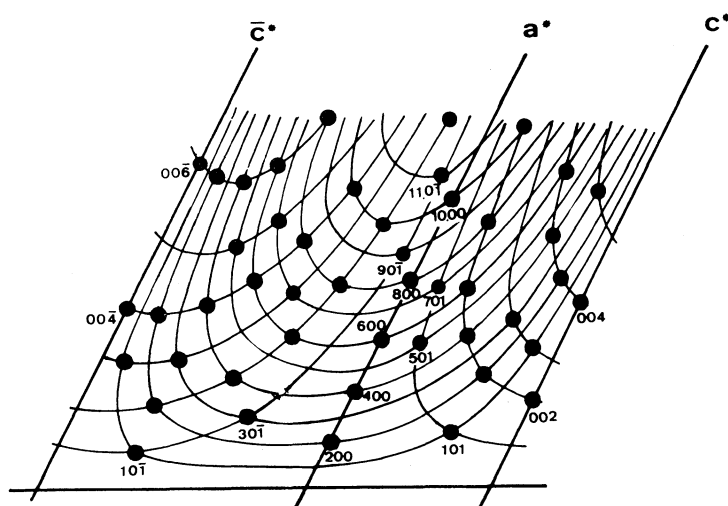


Fig. 2. The Weissenberg diagram of omphacite, corresponding to Fig. 1.

fact that the reflections of  $h0l$  are present only when  $h+l=2n$ . The same extinction rule was confirmed by counter method on another omphacite crystal.

Therefore it is concluded that the omphacite has  $n$ -glide planes, the diffraction symbol is  $2/m P-/n$  and the possible space group is  $C_{2h}^4$ -P2/n or  $C_s^2$ -Pn. It seems more plausible that the space group is P2/n, rather than Pn. If the omphacite structure is derived from diposide type C2/c by the ordering of metallic cations, the subgroups of space group will become lower with the increasing degree of orderness, so that P2/n, that represents higher order of subgroup than Pn does, may be realized more easily than the other.

The structure analysis of this  $n$ -glide omphacite is now in progress here in cooperation with N. Morimoto and M. Tokonami, Osaka Univ. and A. Kawahara, Okayama Univ.

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