27. *Problem of Discontinuity in the MgSiO_3 - $\text{CaMgSi}_2\text{O}_6$ Series of Clinopyroxenes*

By Seitarô TSUBOI, M.J.A.

Geological Institute, Faculty of Science, University of Tokyo

(Comm. March 12, 1962)

As long ago as 1914, N. L. Bowen showed, in his study of the ternary system $\text{CaMgSi}_2\text{O}_6$ - Mg_2SiO_4 - SiO_2 , that MgSiO_3 (En) forms a continuous series of solid solutions with $\text{CaMgSi}_2\text{O}_6$ (Di), crystallizing in forms corresponding with clinopyroxenes. Further, he showed that the optical properties of the solid solutions vary continuously throughout the whole series, and especially that the optic axial angle passes through zero as the optic axial plane changes from the direction normal to 010 in En to that parallel to 010 in Di.

In 1923, A. N. Winchell constructed, on the basis of the above-cited Bowen's study, a diagram showing the variation of the optical properties in this series with the variation in composition. The diagram, without any essential modification, is reproduced in Winchell's book "Elements of Optical Mineralogy, Part II", up to its third edition (1933). Fig. 1 is a sketch of the variation curve of the optic axial angle ($2V$) in the diagram (Fig. 141 on p. 223 of the third edition). There, the curve of $2V$ is wrongly drawn to cut the line for $2V=0^\circ$ obliquely. (Cf. S. Tsuboi, preceding paper.)

In the fourth edition of Winchell's book (1951), a new diagram (Fig. 288 on p. 410) is presented, replacing the one in the third edition. In the new diagram the curve of $2V$ is drawn, as sketched in Fig. 2, with a gap or discontinuity near the point corresponding to the composition $\text{En}_{70}\text{Di}_{30}$ (in mol. %), and the legend under the diagram reads: "Properties of the clinoenstatite-diopside discontinuous series". Nothing is mentioned by Winchell of the reason for supposing discontinuity. Presumably, however, the reason may be in the fact that actual plots of values of $2V$ (marked with $\times$ in Fig. 2 as well as in the original figure) are in great departure from Winchell's previous curve of $2V$, as in Fig. 1, but are arranged in such a manner as if they belonged to two distinctive curves, as in Fig. 2, discontinuous with each other. Winchell's new diagram is, in the present writer's view, not acceptable as correct for the reason which follows:

As has been shown in the preceding paper (S. Tsuboi, 1962), the variation curve of $2V$ in the En-Di clinopyroxene series now at issue must cut perpendicularly the line for $2V=0^\circ$. One continuous curve, which fulfils this condition, can be drawn so that all the plots marked

Fig. 1. A sketch of the variation curve of $2V$ in the En-Di clinopyroxene series in Winchell's diagram of 1923-1933.

Fig. 2. A sketch of the variation curve of $2V$ in the En-Di clinopyroxene series in Winchell's diagram of 1951.

Fig. 3. The variation curve of $2V$ in the En-Di clinopyroxene series, by the present writer. The curve drawn is merely to show its approximate course.

with $\times$ are arranged close thereto, as in Fig. 3. Then, the arrangement of actual plots of values of the optic axial angle is interpreted as affording an example of what has been stated in the preceding paper, but not as indicating the existence of discontinuity in the $2V$ curve. It is emphasized that, in so far as the *known* optical data are concerned, there is nothing which tends to disprove the complete continuity of the En-Di clinopyroxene series.

In recent years much has been added to the knowledge of clino-

pyroxenes, especially of those whose compositions (neglecting minor components) lie in the quadrilateral MgSiO_3 - $\text{CaMgSi}_2\text{O}_6$ - $\text{CaFeSi}_2\text{O}_6$ - FeSiO_3 (En-Di-Hd-Fs). Among recent investigations there is one by F. R. Boyd, Jr., and J. F. Schairer (1957), in which they found that there is not a complete solid solution series of clinopyroxenes between En and Di, the solvus intersecting the solidus in the system consisting of these two components. According to B. E. Warren and J. Biscoe (1931) and N. Morimoto et al. (1956, 1958, 1960), clinopyroxenes in the Di-Hd join belong to space group C_{2h}^6-C2/c , while those in the En-Fs join to space group $C_{2h}^5-P2_1/c$. On the basis of the knowledge of clinopyroxenes recently added, more particularly by the works cited above, it would not be unreasonable if one suspected now the existence of a gap or discontinuity in the variation of physical properties of the En-Di clinopyroxene series. Such being the situation at present, warning is given against an apprehended misinterpretation of Winchell's gap or discontinuity, which is thought to be unreal, as corresponding with a possible, real one, which might be suspected to exist.

References

- N. L. Bowen (1914): The ternary system: diopside-forsterite-silica, *Amer. Jour. Sci.*, **38**, 207-264.
- F. R. Boyd, Jr., and J. F. Schairer (1957): Annual Report of the Director of the Geophysical Laboratory, 1956-1957, 223-225.
- N. Morimoto (1956): The existence of monoclinic pyroxenes with the space group $C_{2h}^5-P2_1/c$, *Proc. Japan Acad.*, **32**, 750-752.
- N. Morimoto et al. (1958): Annual Report of the Director of the Geophysical Laboratory, 1957-1958, 249-252.
- N. Morimoto, D. E. Appleman, and H. T. Evans, Jr. (1960): The crystal structure of clinoenstatite and pigeonite, *Zeitschr. Krist.*, **114**, 120-147.
- S. Tsuboi (1962): Variation of optic axial angle through zero, *Proc. Japan Acad.*, **38**, 114-116.
- B. E. Warren and J. Biscoe (1931): The crystal structure of the monoclinic pyroxenes, *Zeitschr. Krist.*, **80**, 391-401.
- A. N. Winchell (1923): Studies in the pyroxene group, *Amer. Jour. Sci.*, **6**, 513.
- A. N. Winchell (1933): Elements of Optical Mineralogy, Part II, Third Edition.
- A. N. Winchell (1951): Ditto, Fourth Edition.