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A Study on the Polarization of Epidote

By

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Abstract

It has been determined that the general direction of the dipole of epidote inclines about 30–40 degrees from the optic elasticity X-axis on the optical plane and approximately coincides with one direction of the optic axes.

Introduction

When a mineral contains the polar components in its crystal structure, the orientation polarization should be accompanied with the atomic and electronic polarization within the range of suitable frequency wave. Therefore, the dielectric constant of the mineral determined under these conditions may be large. As the absorption of energy must occur most vigorously on the resonanced frequency, the dielectric loss also indicates a maximum value. Even if the mineral is dipolar, if the dipole is fixed to such a definite direction as to give a minimum potential energy, the mineral is accompanied with no orientation polarization. By heating, when enough energy is given to rotate the dipole to another minimum potential energy level, this mineral can be activated to a so-called disorder state.[1] Under these circumstances, if the rotation period of the dipole is resonanced with the frequency of the magnetic wave, the dipole of the mineral will orientate most intensely accompanying the maximum dielectric[2] loss.

If the dipole of the mineral is directed to a definite direction, the maximum intensity of dielectric loss will show a different value according to the direction of the applied electromagnetic wave. To investigate this relation, the dielectric characters of the epidote were studied.

Experimental method[3][4]

The minerals were polished into thin plates about 1–2mm. in thickness and heated gradually in a small electric furnace by holding them between the electrodes of two platinum plates. The variation of electric capacity and dielectric loss of each specimen was measured by means of a Q-meter. In order to make the reactance of the circuit as little as possible, a short circuit connecting the terminals of the Q-meter and the condenser was effected by using a small furnace, and to eliminate the dielectric loss derived from the insulating materials, a special glass of excelent dielectric character was adopted. To keep the sample in a definite condition between the platinum plates, the intermittence of the circuit was operated by manipulating back and forward the Q-meter equipped with the two terminals filled with mercury. Accordingly even in various frequencies, the results were obtained under the same contact condition. The temperature of the furnace was measured by a thermo-couple. The heating and cooling velocity of sample was adjusted at the rate of 3–4°C. per minute and each specimen was heated up to 600°C. The whole apparatus is shown in Fig. 1.

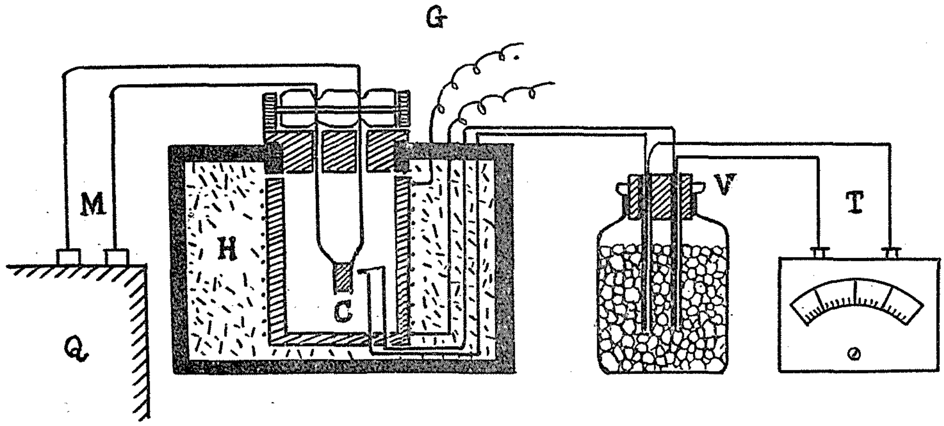

Fig. 1 Apparatus

M Mercury
G Glass Holder
Q Q-meter
H Heater
T Thermometer
V Vacuum Bottle
C Condenser

The axial directions of each specimen were determined accurately by the universal stage. The inclinations of each plate to three optic elasticity axes and the components of rotation power along the optical plane were calculated from the stereographic projections. The optical property of this specimen is as follows:

indices $Nx = 1.7367$, $Nz = 1.7653$, $Nz - Nx = 0.0286$, $2V = (-)\ 75°$.

TABLE 1

No.	QX	QY	QZ	Inclination to optic axes		Component of rotation power		
				θ_1	θ_2	ST_1	ST_2	ST_1+ST_2
1	84°	90°	6°	46.5°	58.5°	0.7254	0.8526	1.5780
2	82	88	8	44.5	60.5	0.6997	0.8699	1.5696
3	79	88	11	41.5	63.5	0.6622	0.8944	1.5566
4	64	90	26	26.5	78.5	0.4462	0.9799	1.4261
5	56	88	34	18.5	86.5	0.3171	0.9975	1.3146
6	15	88	75	22.5	52.5	0.3825	0.7929	1.1754
7	7	90	83	30.5	44.5	0.5075	0.7009	1.2084
8	83	12	80	13.0	88.0	0.0468	0.2078	0.2546

The calculation of the rotation power is illustrated in the following figure.

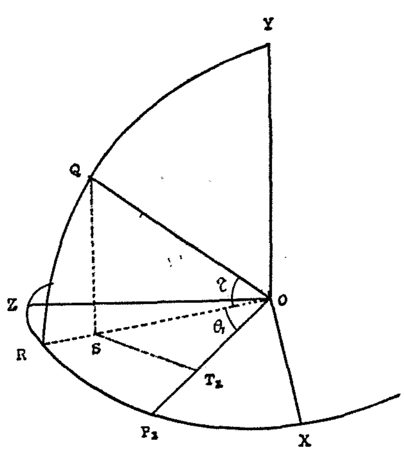

Fig. 2 Component of rotation power
$\tau=90°-\hat{QY}$ $OS=OQ \cos\tau$, $ST_1=OQ \cos\tau \sin\theta_1$, $ST_2=OQ \cos\tau \sin\theta_2$.

Experimental results

The temperatures which show the maximum peak of dielectric loss are nearly equal[5)] with all specimens, the temperature measured by 100 K. C./sec. wave being about 400°C. and that measured by 500 K. C./sec. wave about 520°C. But the amount of maximum intensity of dielectric loss has been found to be exceedingly different according to the inclination to the crystal axes. These relationships are indicated in the following figure and table.

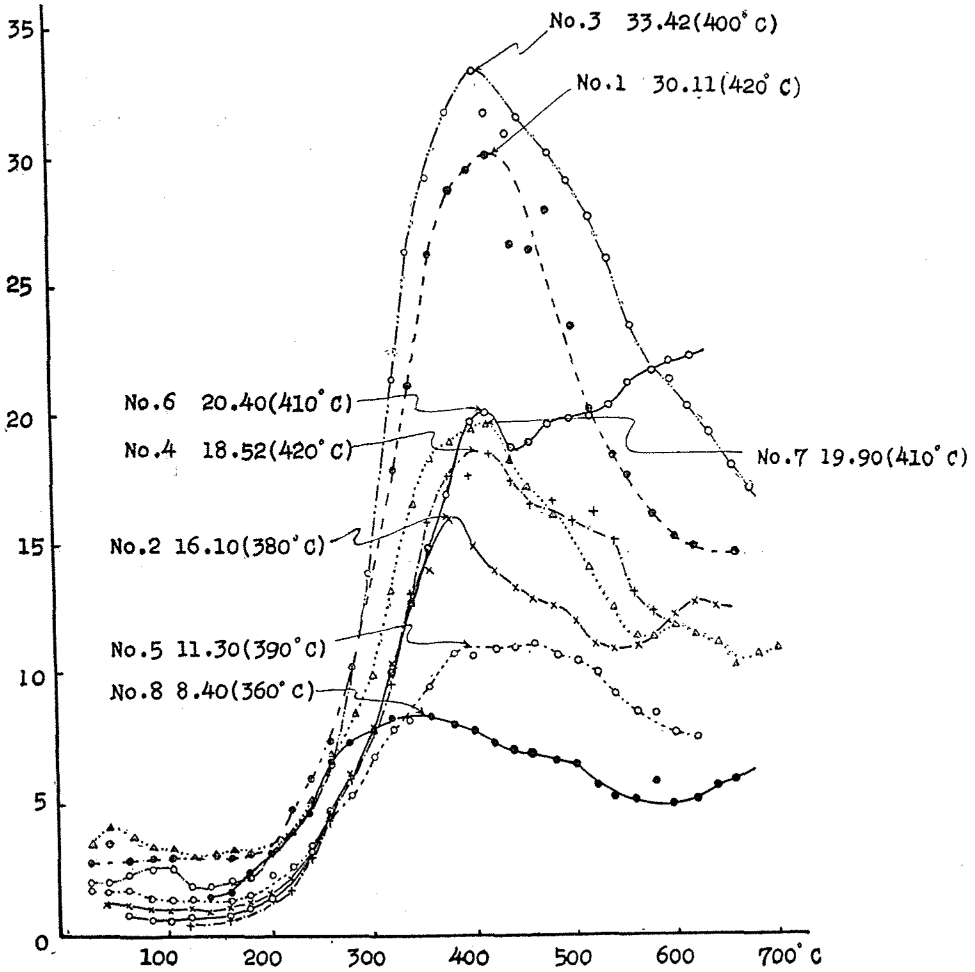

Fig. 3 Variation diagram of Tan δ at 100 K. C.

With the exception of No. 8, each specimen is parallel or nearly parallel to the Y-axis. Therefore the relation between the maximum intensity of dielcetric loss and the inclination to optic elasticity axes is shown in the following diagramatic figure.

No. 8 specimen which is cut nearly perpendicularly to Y-axis shows the smallest dielectric loss as is expected from the calculated orientation power. Accordingly the general direction of the dipole may be considered to incline 30–40 degrees from the X-axis on the optical plane and coincides approximately with the direction of optic axis. The electromagnetic wave acting perpendicularly

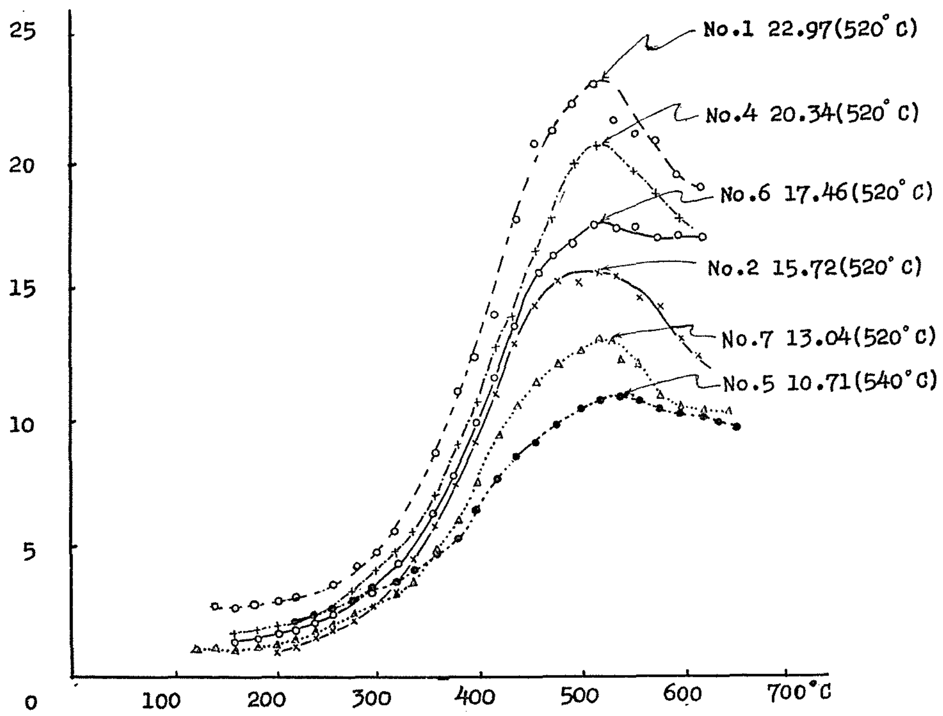

Fig. 4 Variation diagram of Tan δ at 500 K. C.

TABLE 2

No.	100 K. C.		500 K. C.	
	Max. Tan δ %	Temp. °C.	Max. Tan δ %	Temp. °C.
1	30.11	420	22.97	520
2	16.10	380	15.72	520
3	33.42	400	—	—
4	18.52	420	20.34	520
5	11.30	390	10.71	540
6	20.40	410	17.46	520
7	19.90	410	13.04	520
8	8.40	360	—	—

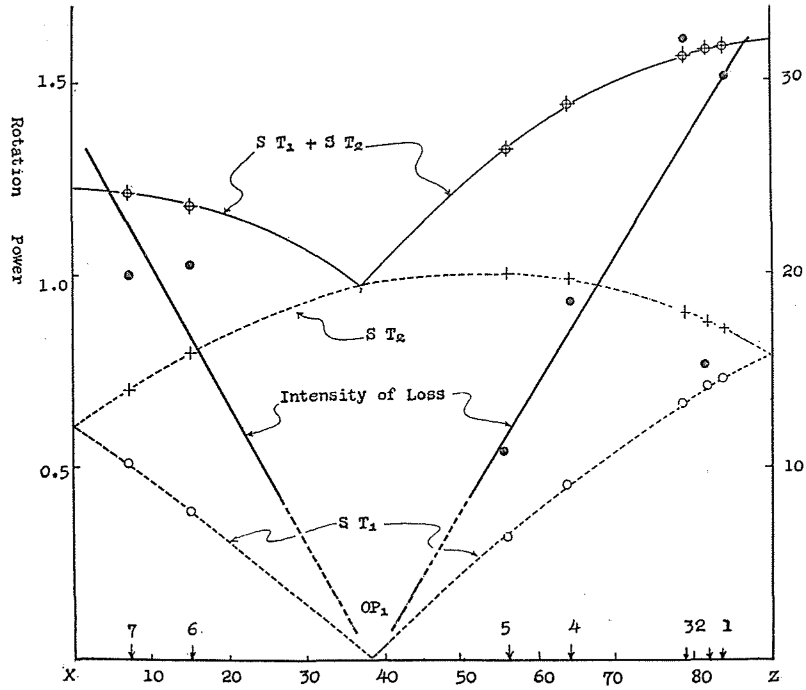

Fig. 5 Maximum intensity of dielectric loss and inclination to optic elasticity axes.

on the acute bisectrix will orientate the dipole most effectively between the two optic axes.

Relation between the dielectric capacity[6] and loss

The dielectric capacity also begins to enlarge its value from the temperature at which the dielectric loss begins to show the maximum intensity. After keeping the capacity constant till about 600°C., it increases abruptly again. The first enlargement may be due to the orientation polarization of the dipole and the second enlargement may be the effect of electric conductivity effected by raising the temperature. The behaviour of the dielectric capacity relating to temperature is indicated in Fig. 6.

The relative increase of dielectric capacity is proportional to the increase of the dielectric constant which is attributed to the orientation polarization. It is impossible to determine the additional part of the dielectric constant absolutely from the increased capacity but the relative value of each specimen is approximately proportional to the intensity of the dielectric loss. That is, the

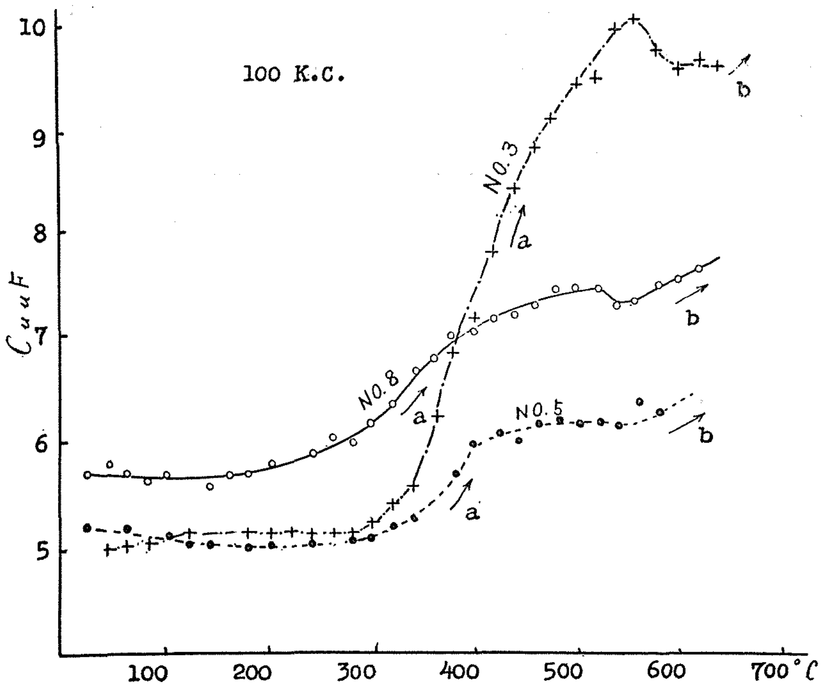

Fig. 6 Variation of dielectric capacity in 100 K. C. wave

dielectric constant of the plate cut perpendicularly to Z-axis is most enlarged by the orientation polarization.

In short, some minerals which have the OH radical in its crystal structure show an orientation polarization by heating at an appropriate temperature. The mechanism of orientation polarization was investigated on the epidote.

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