Tear-figures on Certain Minerals. III.

By

Mikio Kuhara.

In the previous papers[1] upon the same subject, the tear-figures on stibnite, galena, sphalerite, pyrite, vivianite, enargite, calcite, gypsum, and barite were described. The characteristics of those on aragonite, alum and borax will be explained hereinafter.

Aragonite.

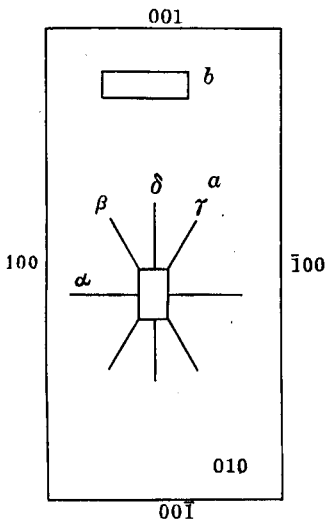
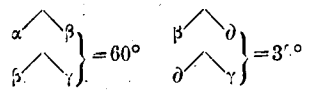


Fig. 12.



The specimen under examination was a transparent, prismatic crystal developing the faces {110}, {010} and {011}. *H*-3, 5; cleavage {010} and {110} distinct, and {011} imperfect.

With a light percussion of a needle-point on {010}, a rectangular figure accompanied by four cracks is produced. Its sides are parallel to {001} and {100}. Of the four cracks, α, β and γ make angle of 60° with one another, α being parallel to {001}; and ∂, bisecting the angle between β and γ, parallel to {100} (Fig. 12a and Fig. 1, PL. XV.) The symmetry axes of the figure are parallel to the planes of symmetry. On the same face, the author happened to observe a rectangular, natural etched-figure, horizontally elongated

1) Mikio Kuhara, "Tear-figures on Certain Minerals. I and II." These Memoirs, Vol. I, No. 8, pp. 267-74, 1916 and Vol. I, No. 10, pp. 279-86, 1917.

(Fig. 12b), with two symmetry axes parallel to those of the tear-figure.

A tear-figure on an artificial face, cut and polished nearly parallel to {100}, is a rectangular one elongated in the direction of the c-axis, the sides being parallel to {001} and {010} (Fig. 13 and Fig. 2, PL.XV). At each termination of the figure, there are two cracks intersecting at an average[1] angle of 83°, which is nearly equal to the angle between $(0\bar{3}2)$ and (032). Thus, the figure has two symmetry axes parallel to the planes of symmetry.

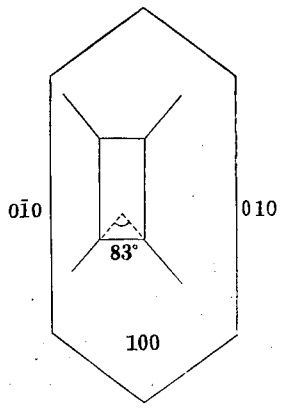


Fig. 13.

A tear-figure on {110} has only one symmetry axis parallel to the plane of symmetry and shows two forms, one being triangular and the other butterfly-shaped. The base of the triangular figure is parallel to {010} and the sides perhaps to {021} (Fig. 14a and Fig. 1, PL. XVI). The apex is always situated on the opposite side from the adjacent brachypinacoid.

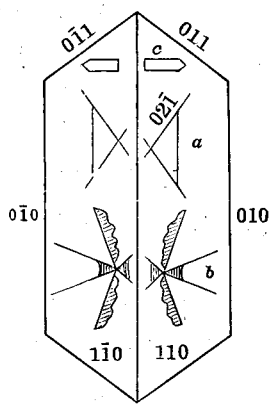


Fig 14.

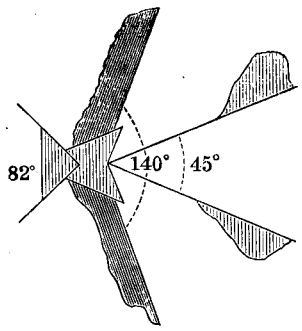


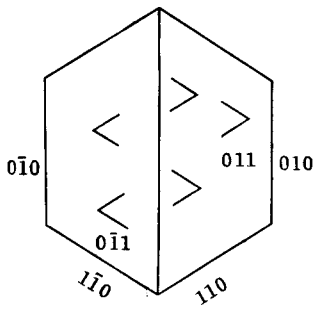
Fig. 15.

The butterfly-shaped figure is composed of a polygonal figure and six cracks, the former making the trunk and the latter the limbs (Fig. 14b, Fig. 15 and Fig. 2. PL. XVI). The average angle between the tentacles is either

1) Averaged from the angles measured in ten figures. The term "average angle" has the same meaning throughout this paper.

45° or 82,° the wings 140°, and the tails either 82° or 45°. The trunk is hourglass-shaped bounded by sides parallel to the limbs (Fig. 15). The wings are perhaps parallel to {051}; but it is unknown to what faces the tentacles and the tails may be parallel, because the angles between them do not accord with any angle between faces usually found at the termination of aragonite crystals. The tails of the butterfly are always situated on the same side as the apex of the triangular figure (Fig. 14b). The production of the two different figures, triangular and butterfly, seems to be dependent upon the intensity of the pressure of the needle-point. When pressure is stronger the butterfly-shaped is produced and when weaker the triangular. On the same face the author has found natural etched-figure of bomb-like shape, the symmetry of which was in perfect harmony with that of the tear-figure (Fig. 14c and Fig. 1, PL. XVII).

A tear-figure on {011} is V-shaped with the point toward the adjacent brachypinacoid, and with the arms parallel to {110} (Fig. 16 and Fig. 2, PL. XVII). This figure has only one symmetry axis parallel to the plane of symmetry.



Ftg. 16.

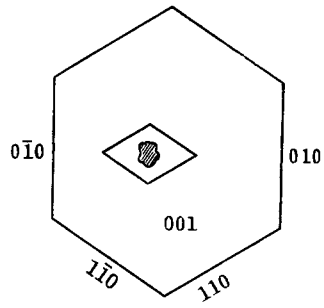


Fig. 17.

On an artificial face, cut and polished nearly parallel to {001}, a tear-figure is of rhombic form bounded by sides parallel to {110}. The figure is symmetrical to own diagonals parallel to the planes of symmetry (Fig. 17 and Fig. 1, PL. XVIII). During the investigation of tear-figures on the same face under microscope, the author found an illuminating cross passing through the two diagonals of the rhombic figure (Fig. 2, PL. XVIII). This cross is seen most clearly when the image is a little out of focus.

This phenomenon is assumed to be a result of an abnormality in the index of refraction produced by gliding along a- and b-axes. The illuminating cross is almost always found at every trace of the needle-point. The lines connecting the points of the cross coincide with the sides of a rhombic figure.

In the study of tear-figures on aragonite, we have touched two important problems: the first concerning the distinction of aragonite from calcite, the second the determination of the twinning-plane and the composition-face. In such a case aragonite and calcite both consist of hexagonal prismatic crystal whose terminations are wanting, merely a single percussion of a needle-point on the basal sections easily solves the problem, calcite showing a hexagonal tear-figure aragonite a rhombic one. The second problem is solved by tear-figures produced on the vertical faces of aragonite. For example, assume that there is a twinned-crystal of aragonite with a crossed section as shown in Fig. 18, and on the faces of 1, 2, 3, and 6

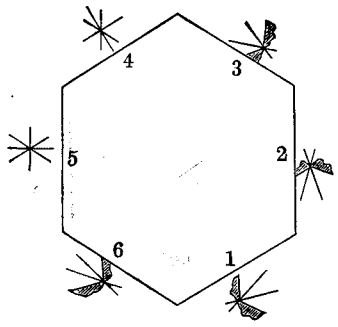


Fig. 18.

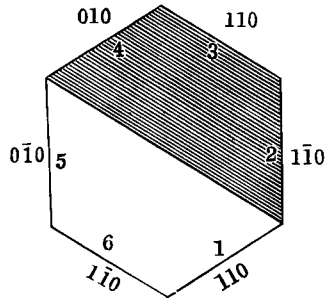


Fig. 19.

Hatched and not hatched areas indicate different individual crystals.

triangular or butterfly-shaped figures have been produced, and on 4 and 5 six-rayed figures, all orienting as in the same Figure, then 1, 2, 3, and 6 are determined to be {110}, 4 and 5 to be {010}. Thus we determine the crystal to be a twin composed of two individual crystals with {110} as the twinning-plane and composition-face, arranging the position of each face as shown in Fig. 19.

Potassium alum.[1]

The specimen under examination was an artificial crystal of a combination of cube and octahedron. H–2.5, cleavage practically none.

On {100}, a very slight pressure of a pin's point produces a square tear-figure with four accompanying rays (Fig. 20, Fig. 1, PL. XIX and Fig. 2a, PL. XIX). The sides of the figure are parallel to {111} and the cracks perpendicular to the sides from which they radiate. The tear-figure has four symmetry axes which are parallel to the plane of symmetry. This type of figure is common, but sometimes it has sides parallel to other cubic faces than those on which themselves stand (Fig. 21 and Fig. 2b, PL. XIX). Sometimes the figure has another crack bisecting the angle between the foregoing cracks (Fig. 21 and Fig. 2b, PL. XIX). Thus the author assumes that the perfect figure is an eight-sided one with

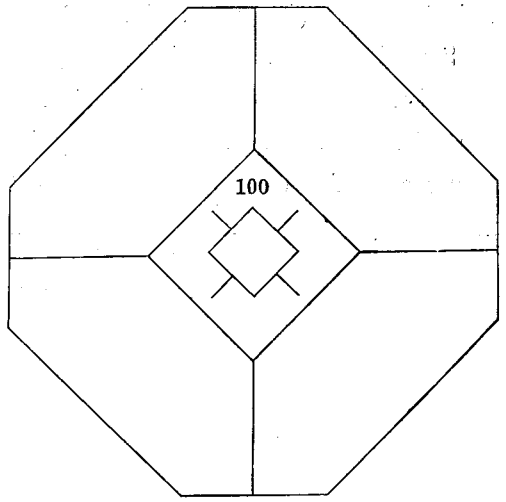


Fig. 20.

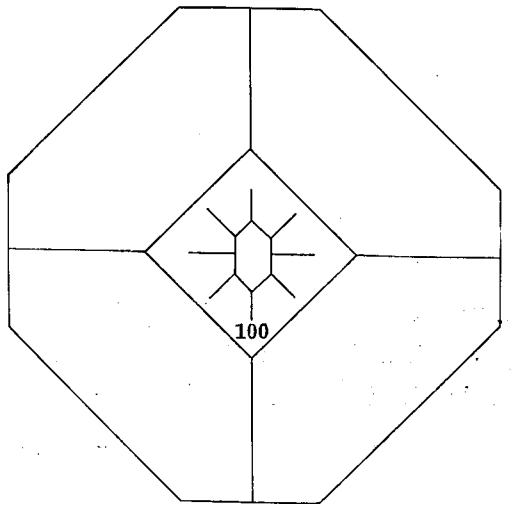


Fig. 21.

1). In photographing a tear-figure on an easily dehydrating crystal a beautiful picture is rarely taken with either vertical illumination or transmitted light, owing to the opacity of the coating caused on the surface by the heat of the condenced light used for illumination, unless a light filter is placed between the object and the source of light.

eight rays, which whenever the conditions are most favourable, can be produced.

On {111}, a tear-figure is triangular with sides parallel to adjacent octahedral faces (Fig. 22a and Fig. 1, PL. XX).

Sometimes cracks passing through the sides of the triangle are found to produce a six-rayed starlike figure (Fig. 22b and c, and Fig. 2, PL. XX). Besides this figure, a three-rayed one consisting of three cracks which are perpendicular to the edges of the octahedron is produced with or without a triangle at the centre (Fig. 22d and e; and Fig. 1c, PL. XX). The

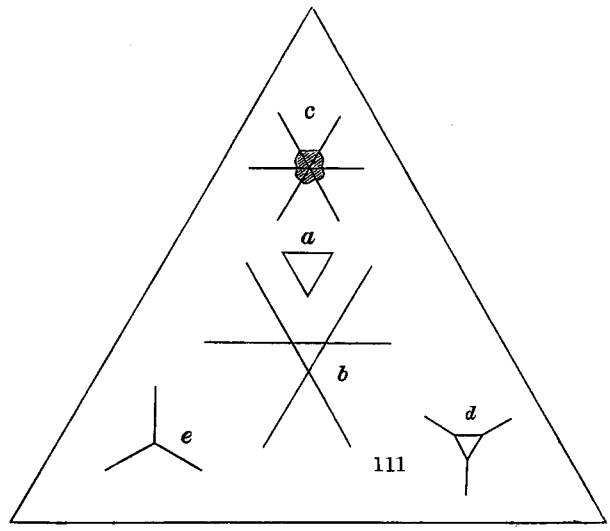


Fig. 22.

central triangle of the six-rayed figure usually remains as merely an irregular pit and only under the most favourable conditions is a clear figure produced. The figures, both six- and three-rayed, have three symmetry axes coinciding with the planes of symmetry.

Borax.

The specimen under examination was an artificial crystal of a transparent well-defined form, developing the faces {001}, {111}, {010}, and {100} and reducing {041}, {221} and {110} to rather microscopic size.

H-2; cleavage {100} perfect, {110} less so, {010} in trace; rather brittle; system monoclinic.

A tear-figur on each face of this crystal consists of a polygonal figure with associated radiating cracks.

On {111}, a tear-figure is asymmetric "monoplane-" or "dragonfly-" shaped, the trunk being a parallelogram bounded by sides parallel to {100} and {041}, the tail parallel to {100}, the wings to {111} and the tentacles to {110} (Fig. 23 and Fig. 1, PL. XXI).

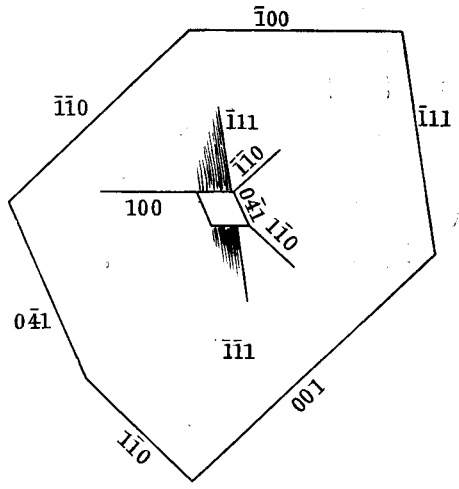


Fig. 23.

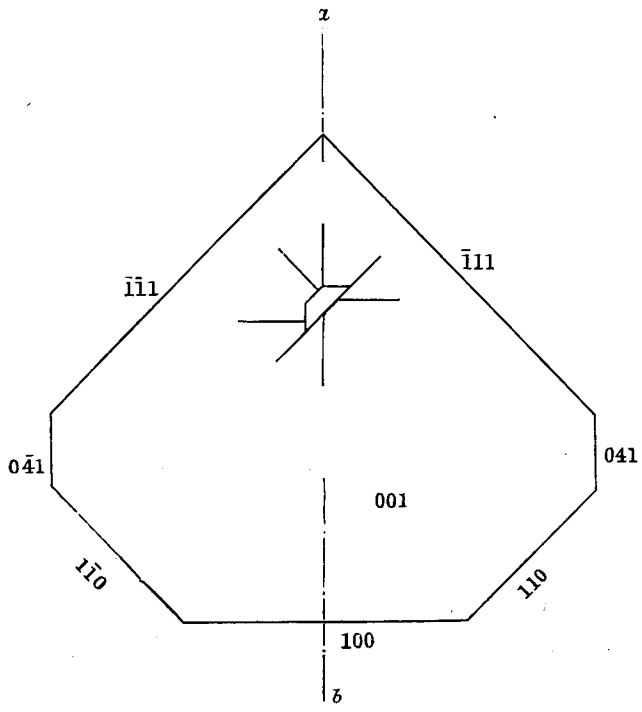


Fig. 24.

a b.....axis of sym.

A tear-figure on {001} is composed of a polygonal figure and its accompanying cracks, the sides of the former being parallel to {100}, {111} and {041}, and the cracks parallel to {100}, {111} and {041} (Fig. 24 and Fig. 2a, PL. XXI). The perfect figure, therefore, is assumed to be one having an eight-sided trunk with eight rays parallel to the same faces (Fig. 25). This perfect figure is symmetrical to an axis perpendicularly passing the side parallel to {100}.

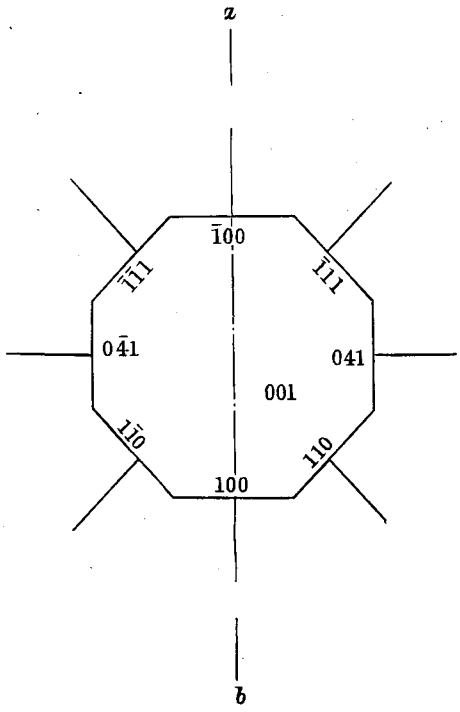


Fig. 25.
a b.....axis of sym.

On {100}, a tear-figure is six- or four-sided, the former being bounded by sides parallel to {010}, {111}, and {221}, and the latter by sides parallel to {010}, and {111}. Diverging cracks, parallel to {111} {010} and {221}, are found to radiate from the six-sided figure (Fig. 26 *a* and *b*, and Fig. 1a, PL. XXII). Sometimes a crack parallel to {001} is also present (Fig. 26*c*); but a crack parallel to {041} has never been seen, though its pre-

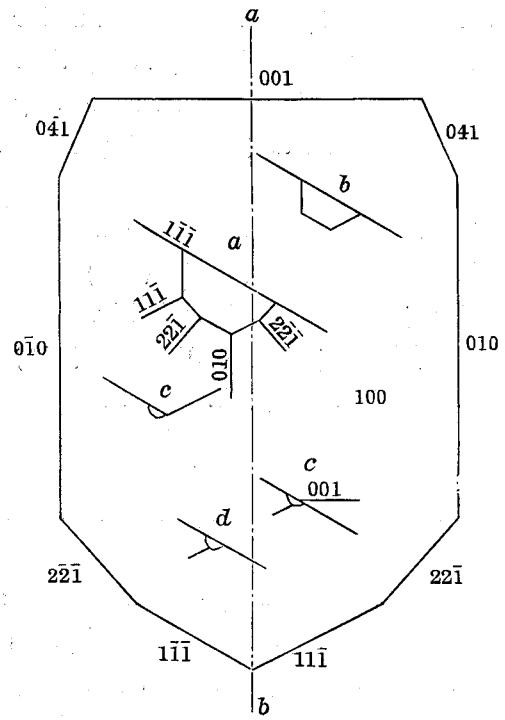


Fig. 26.
a b.....axis of sym.

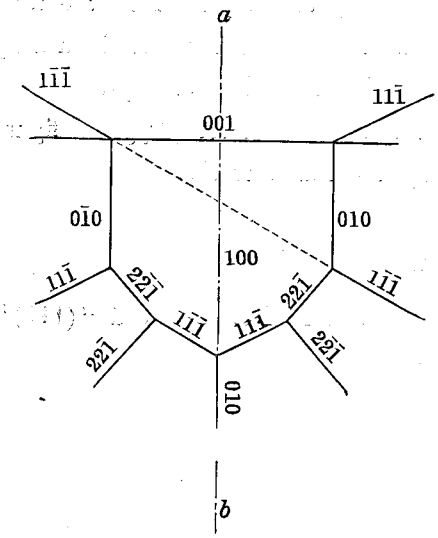


Fig. 27.
a b.....axis of sym.

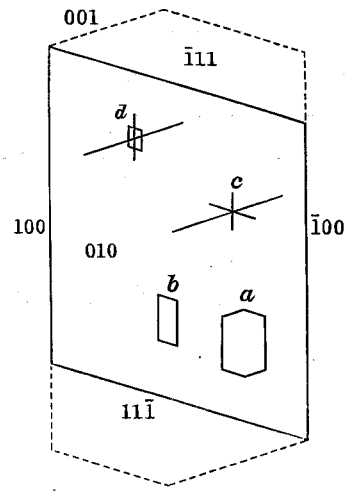


Fig. 28.

sence is possible. Sometimes a figure with a less number of rays is also found (Fig. 26 *c*, *d* and *e*). The perfect figure is, therefore, assumed to be the one shown in Fig. 27, which is symmetrial to only one axis perpendicularly passing the side parallel to {001} and parallel to the planes of symmetry.

On {010}, a tear-figure is an asymmetrical six- or four-sided, the sides of the former being parallel to {001}, {100} and {111}, and the latter to {100} and {111} (Fig. 28 *a*, *b* and Fig. 2 *a* and *b*, PL. XXII). The radial cracks parallel to {100}, {001} and {111} are also present (Fig. 28 *c* and *d*, and Fig. 1*a* and *b*, PL. XXIII).

From the data of the foregoing experiments the following may be concluded:

From studies thus far made on aragonite it appears that the symmetrical conditions of an etched-figure and of a tear-figure on the same face are quite concordant, though the shape of the figures may vary.

By examination of the tear-figure we can know the character of the twinning-plane and of the composition-face of certain mineral.

When the needle-point is applied obliquely to a crystal face, the tear-figure has an imperfect or defective form. In such a case, it is usually reduced to simpler form through the lack of certain sides or rays.

It seems that when the needle-point is dull a distinct polygonal figure is produced, and when the point is sharp, the radial cracks.

Errata.

Page 282, 3rd. line, these Memoirs Vol. I, No. 10, read "($\bar{1}11$)" for ($\bar{1}10$).

Fig. 1. Square tear-figures, accompanied by the three cracks, on (010) of aragonite. They have two symmetry axes. The central squares are distinctly seen in (a) and (b); the cracks in (c), in which the square is concealed by the irregular pit of the needle-point.
Transm. light. Mag. 60 diam.

Fig. 2. Tear-figures on (100) of aragonite, composed of rectangular bodies and four accompanying cracks. The figures have two symmetry axes. The average angle made by the cracks at each termination is nearly equal to that made by {032}.
Vertical illum. Mag. 80 diam.

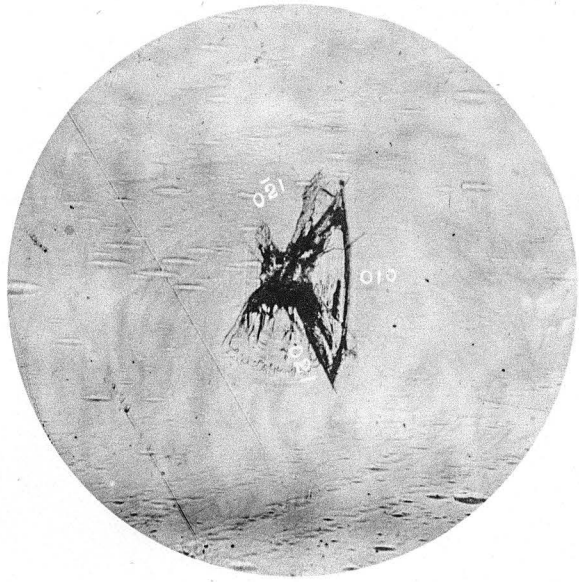


Fig. 1. A triangular tear-figure on (110) of aragonite, the apex opposite (010). The average apical angle is nearly equal to the angle between (021) and ($0\bar{2}1$).
Transm. light. Mag. 60 diam.

Fig. 2. Butterfly-shaped tear-figures on (110) of aragonite. The tentacles of the butterfly are always on the side of (010).
Transm. light. Mag. 60 diam.

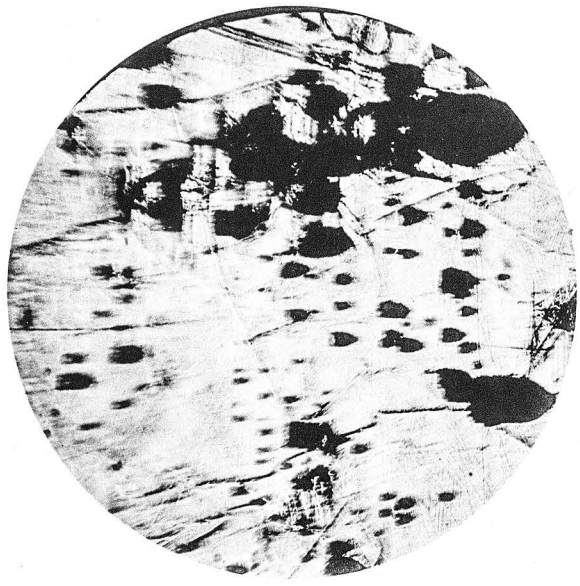


Fig. 1. Bomb-like natural etched-figures on (110) of aragonite. The symmetry axis is parallel to that of the tear-figure on the same face. The head of the bomb is always on the same side as the tentacles of the butterfly-shaped figure.
Vertical illum. Mag. 60 diam.

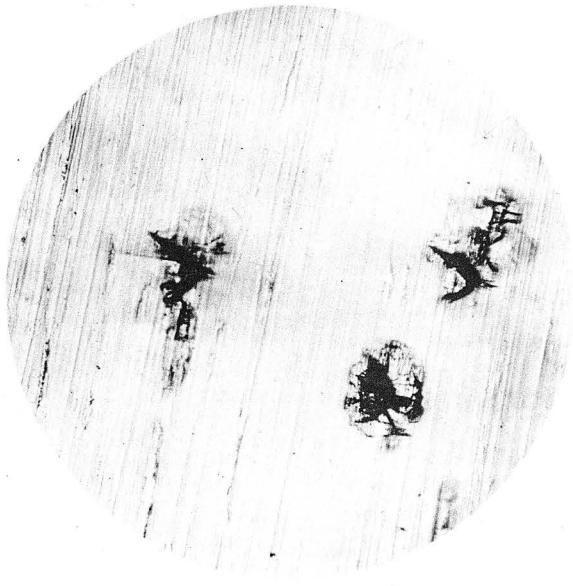


Fig. 2. V-shaped tear-figures on (011) of aragonite. The arms are parallel to {110}.
Transm. light. Mag. 60 diam.

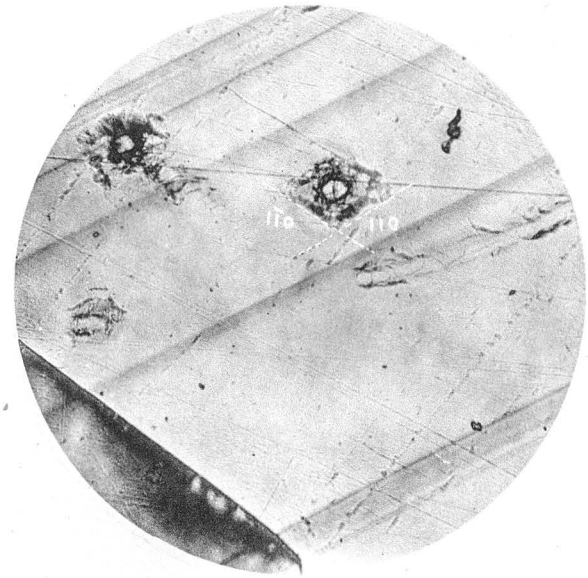


Fig. 1. A rhombic tear-figure on a basal section of aragonite. The figure is bounded by sides parallel to {110}. The rounded spot at the middle of the figure is the pit of the needle-point.
Transm. light. Mag. 60 diam.

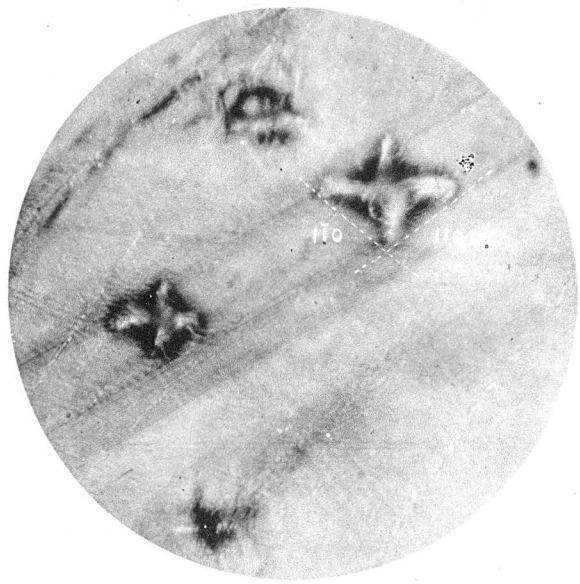


Fig. 2. The same as Fig. 1.
The photomicrograph shows an abnormality in the index of refraction, resulted from gliding along the a- and b-axes by the pressure of the needle-point. The picture was taken a little out of focus.
Transm. light. Mag. 80 diam.

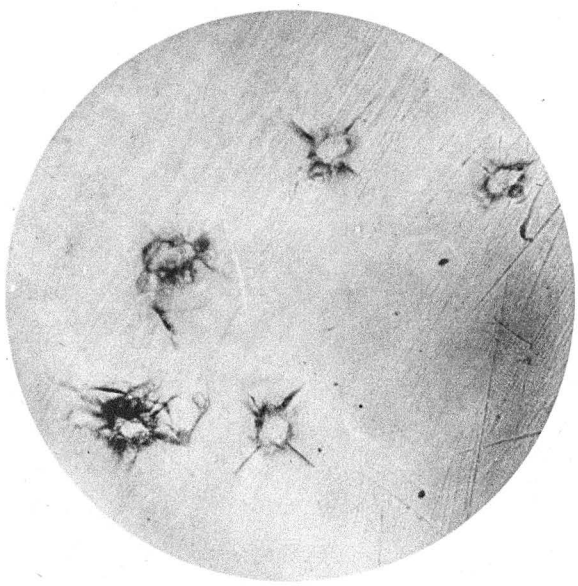


Fig. 1. Square tear-figures with four cracks on the cubic face of alum.
Transm. light. Mag. 60 diam.

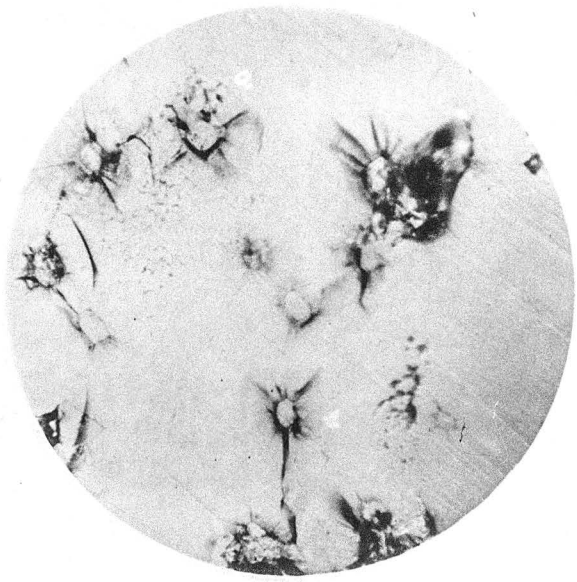


Fig. 2. Square (a) and six-sided (b) tear-figures on the cubic face of alum. (b) is composed of sides parallel to the cubic and octahedral faces, and rays parallel to the octahedral and other cubic faces.
Transm. light. Mag. 60 diam.

Fig. 1. Triangular (a and b) and three-rayed (c) figures on (111) of alum.
Transm. light. Mag. 60 diam.

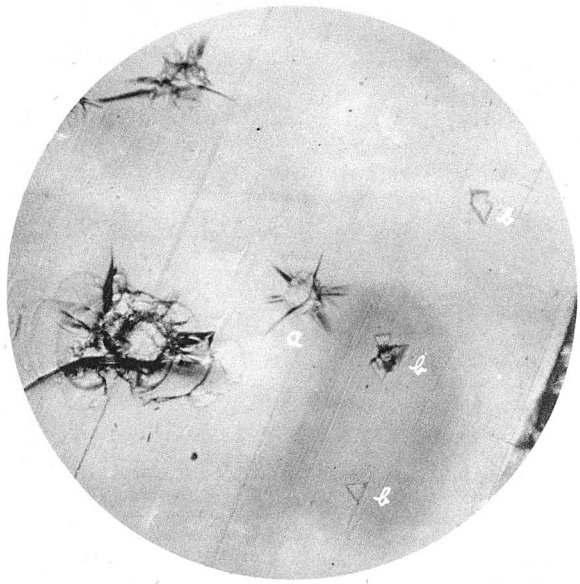


Fig. 2. A six-rayed figure (a) on an octahedral face of alum. The triangle at its centre is concealed by the pit of the needle-point. The triangles marked (b) are etched-figures which are bounded by sides parallel to the three cracks of which the six-rayed figure is composed.
Transm. light. Mag. 100 diam.

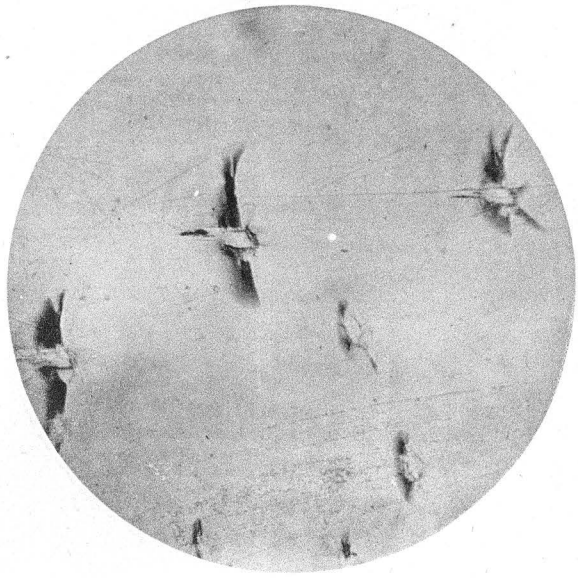


Fig. 1. Monoplane-shaped tear-figures on $(\overline{1}\overline{1}1)$ of borax, composed of parallelogrammic bodies, wings, tails and tentacles. They have no symmetry axis.
Transm. light. Mag. 90 diam.

Fig. 2. A imperfect tear-figure (a) on (001) of borax, composed of a trapezoidal body and accompanying cracks. A symmetry axis is shown by arrow.
Transm. light. Mag. 150 diam.

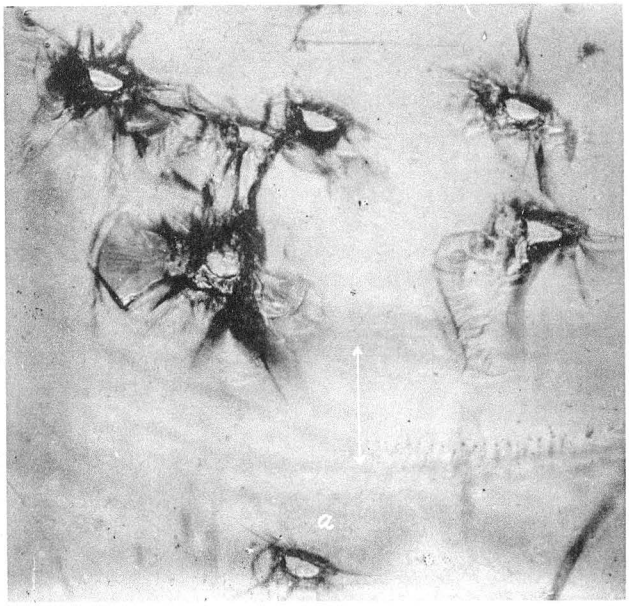


Fig. 1. Tear-figures on (100) of borax. The bright semi-circular figures are irregular hexagons from which six rays radiate (a). The direction of a symmetry axis of their perfect figure is shown by arrow.
Transm. light. Mag. 150 diam.

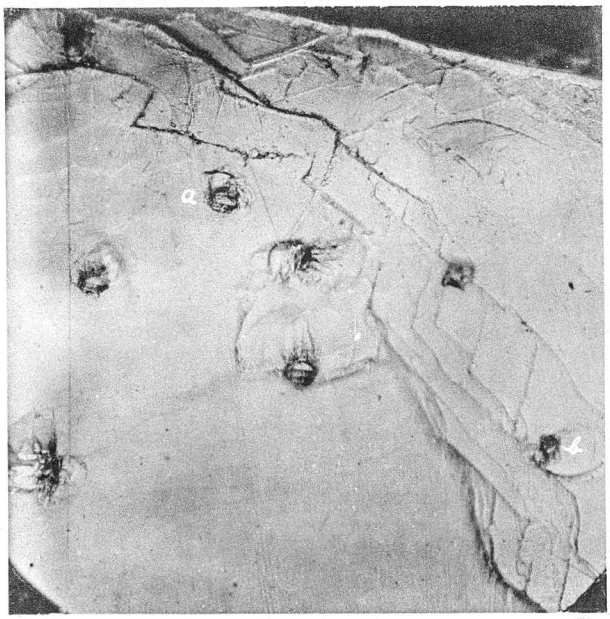


Fig. 2. A six- (a) and a four-sided (b) tear-figure on (010) of borax. They have no symmetry axis.
Transm. light. Mag. 80 diam.

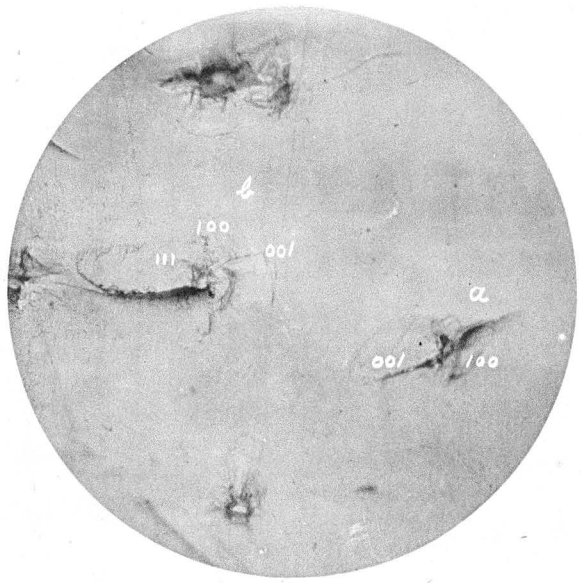


Fig. 1. Tear-figures on (010) of borax, (a) being composed of two cracks parallel to {001} and {100}, and (b) of three cracks parallel to {001}, {100} and (111). Transm. light. Mag. 80 diam.