Art. VII—*Studies of the Etched Figures of Japanese Minerals;* by Shimmatsu Ichikawa.*

Introduction.

For the past fourteen years I have been investigating the etched figures of Japanese minerals. In December, 1920, the Keimei Society, an endowed foundation, decided to grant me a contribution towards the study to be made in 1921-23, as well as for the publication of the results. In these three years I hope to complete the study. This is the first report published under the patronage of the Keimei Society, for which I here express my gratitude.

Natural Etchings of Topaz Crystals.

The natural etchings of topaz crystals in Japan have already been described by Dr. Hiki,[1] Dr. Hahn,[2] Dr. Jimbo,[3] Mr. Takimoto,[4] Dr. Rosicky[5]; the transformations of the original form of the crystal, however, have not yet been discussed in detail. For some years, I have collected crystals with natural etchings from many topaz localities in Japan and have observed an interesting new form of elevation produced by natural etching and a few new varieties of pits or depressions that the said mineralogists had not found. The results of this study are illustrated in the accompanying pages of figures from I to XI.

Part 1.

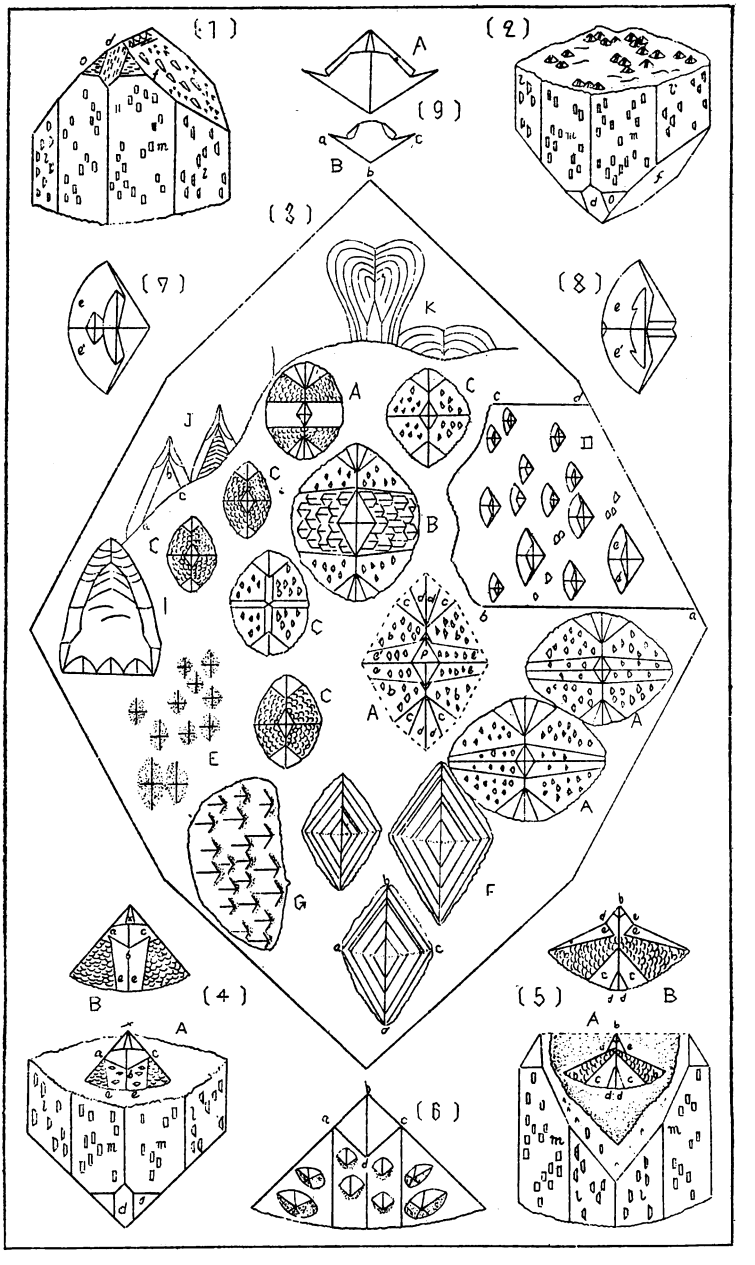
Natural Etchings of Topaz Crystals from Mino Province.

A topaz crystal with natural etchings shown on I to III was found associated with smoky quartz, orthoclase, mica,

*This paper is published in two parts, viz. in the July and August numbers. Eleven pages of illustrations are included (I to XI); of these I to VI belong to Part 1 (July), VII to XI to Part 2 (August).
All the illustrations are by the author.

[1] Hiki, Jour. Soc. Coll., 1895. (Jour. Geol. Tokyo, 3, 71, 1895.)
[2] Hahn, Zs. Kr., 21, 1893.
[3] Jimbo, Jour. Geol. Tokyo, 6, 150, 1898.
[4] Takimoto, Jour. Geol. Tokyo, 8, 398, 1900.
[5] Rosický, Rozpr. České. Akad., 18, 1909.

I.



beryl, tourmaline, etc., from a pegmatite vein in a granite at Ushiroyama near Naigi, Ena-gun, Mino Province. The crystal measured 2 cm. on the *a*-axis, 3 on *b* and *c* axes, one end of the vertical axis is terminated by dome, pyramid, etc., and the other end fractured, brown and transparent; on all crystal faces and on the fracture surfaces regularly developed etched figures were observed.

I.

Fig. 1 shows a front view of an etched topaz crystal; the crystal has the faces[6] of *m, l, d, o, f,* etc. Etchings on the *f* face and striations on the *d* and *o* faces can be barely observed by the naked eye as in the diagram; etchings on the *m* and *l* faces can only be investigated minutely under a magnification of 80 to 140 times, and the *l* face is more etched than the *m* face.

Fig. 2 shows a front view in which the vertical axis of fig. 1 is revolved 180°. Elevations on the fracture can be observed by the naked eye as in the diagram.

Fig. 3 shows varieties of natural pits and elevations on the fracture surface of fig. 2; in horizontal projection on the vertical axis of the crystal. A shows a regularly developed natural elevation, the dotted outline giving the position of the prism in the original crystal. The surface of the elevation is divided by twenty pyramidal faces, and the faces are classified as to sets of *p, b, c, d, e,* etc., and each set consists of four faces; each face is arranged in the direction of *a* or *b* axes, and four sets of *e, b, c, d* resemble the base of a rhombic pyramid. The central pyramid (*P*) is a rhombic pyramid and its lateral edges are parallel to edges formed by combination of rhombic prism and basal faces of the original crystal; the rhombic pyramid has sometimes a head of spear-like shape in both the ends of the macro-axis. The rhombic pyramid (*P*) much resembles an *o* face in the original crystal (see later). Face *b* is a trapezium and inclines on the *m* face; the face has also many warts on its surface; if the warts are magnified, semi-caps of the rhombic pyramid (*P*) are shown. The obtuse angle of the semi-

[6] The faces, here and elsewhere, have the following symbols: *m*=(110), *l*=(120), *d*=(201), *f*=(021), *o*=(221).

cap takes the place at the ends of the brachy-axis. Face *c* is a smooth scalene triangle and is inclined to the *l* face.

The face *d* is a smooth scalene triangle inclined to the *l* face. Face *e* is a long trapezium and the four faces are arranged at front and rear of rhombic pyramid (*P*), and each face is inclined on the *m* face; the face has also the semi-cap of rhombic pyramid as *b* face, but the size of these caps are usually less than that on the former, and the face also sometimes forms a smooth plane and has no cap. B is the same as A but four *e* faces are united and its intermediate edge is absent; the face has also the semi-caps of rhombic pyramid (*P*), but they look as if this semi-cap was elongated to left or right of the brachy-axis. C is the same as A, but has not the faces *e*, *d*, and *p*, etc., and each edge is formed by the combination of four *b* faces sometimes truncated. D (*abcd*) shows new faces produced by etching, and these belong to a macro-dome; etchings of Japanese fan-like shape with the cap of a rhombic pyramid are found on its surface; the faces *e'* and *e* in the etching seem parallel to *e'* and *e* faces in A. E shows rhombic depressions produced on a fracture near basal face. F shows three rhombic depressions with striations in its walls, the angles *abc*=70°, *bcd*=105°, *adc*=60°, and the diagonal *ac* is curved; the depressions have symmetry in the direction of the macro-axis. G shows a group of the semi-cap of rhombic pyramid (*P*) like those formed on *e* face of B. I, J, and K, etc., show etchings formed on a fracture surface respectively; these etchings have symmetry in the direction of the macro-axis, the angle *abc* (J)=40°.

Fig. 4, A, shows a front view of fig. 3, A (elevation) seen from the direction of the brachy-axis, the angles *afc*=94°, *abc*=120°. B shows an elevation different from A; the rhombic pyramid and two *e* faces interlock with each other, and form a head of spear-shape at both the ends of the macro-axis (compare fig. 3, A). Trigonal heads *f* and *x* in figs. A and B show indistinctly under the microscope.

Fig. 5, A, shows a front view of fig. 4, seen in the direction of the macro-axis; the vertical angles *ebd* (*P*)=62°, *bb*=125°, *cc*=90°, *dd*=40°. B shows a front view of an elevation with a rhombic pyramid of which the *f* face of the original crystal is observed horizontally, the verti-

cal angles *ebd* (*P*)=75°, *ee*=130°, *bb*=150°, *cc*=65°, *dd*=35°. Pointed head *b* in the figures A and B looks indistinct under a microscope.

Fig. 6 shows semi-caps on *e* and *b* faces of fig. 4, A, and their position is seen if the *d* face of the original crystal is placed horizontally.

Fig. 7 shows an elevation on fig. 3, D face; two rhombic pyramids are formed in Japanese fan-like etching, and edges of the pyramid are somewhat rounded.

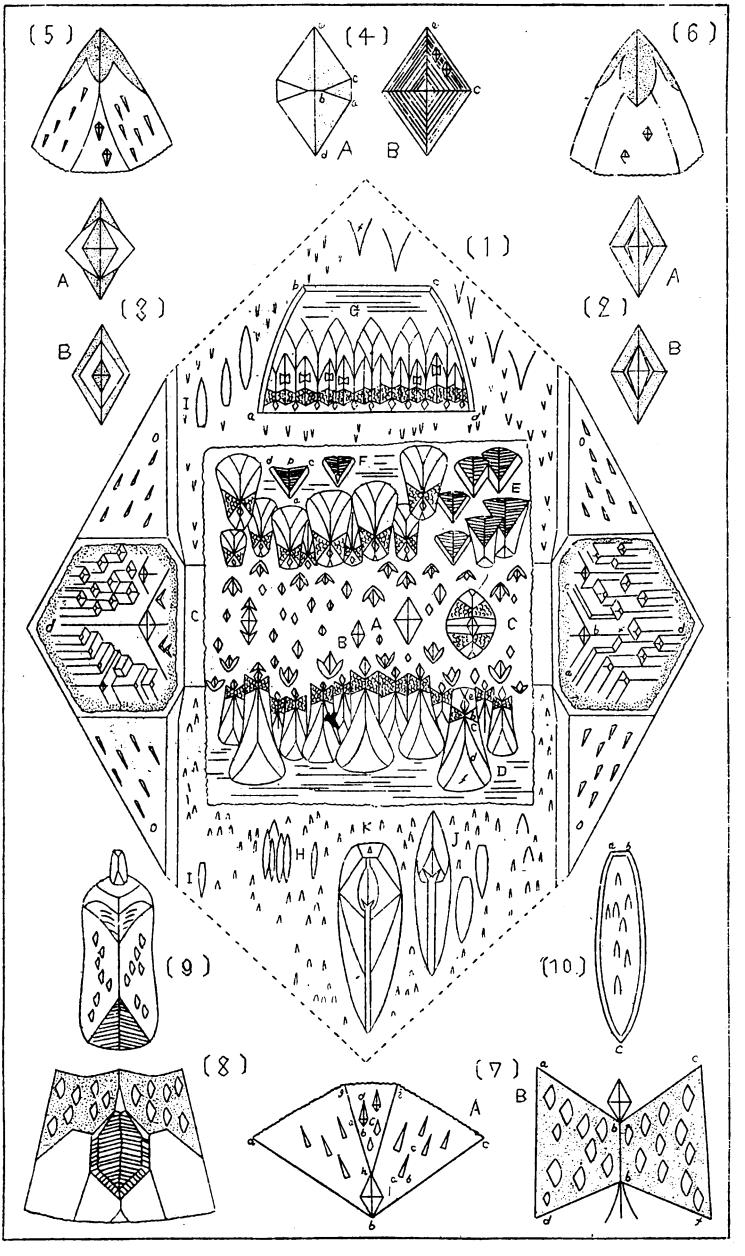
Fig. 8 is the same as fig. 7, but with the combination of two Japanese fan-like depressions; this rhombic pyramid and two *e* faces interlock with each other, and the pyramid has a head of spear-like shape at both the ends of the macro-axis.

Fig. 9 is the same as fig. 7, but the *d* face of the original crystal is placed horizontally, the cap in B is rounded, the angle *abc*=105°.

II.

Fig. 1 is a horizontal projection on the vertical axis of I, fig. 2; the dotted lines show the direction of two *f* faces extended horizontally is cut by *l* face. A is a rhombic pyramid formed on the basal face (*c*). B shows an elevation of a lepidoptera-like shape, the rhombic pyramid being the abdomen, two *e* faces its wing; the etchings occur near the edge formed by the combination of the basal face and *f* face. C is the same as the elevation (A) formed on the fracture of I, fig. 3. D shows an elevation of a doll-like shape, formed by combination of two etchings on the basal face and *f* face, resembling the rhombic pyramid as head and elevation on *f* face as trunk; we may assume that the etching was one-half of an elevation (*c*) on the basal face elongated at the end of the macro-axis. E, F, etc., show elevations with striations formed on the face *f*, the angles (F) *cad*=70°, *cpd*=160°; the striations are accompanied by elevations D, F, etc., formed by etching, G (*abcd*) showing a depression with a group of the elevations D. H, I, J, K, etc., show depressions: J and K are etched figures each one-half of two elevations (D) combined with each other. In *d* face, etched figures (*abc*) of Japanese fan-like shape are abundant. The edge *lf*, etc., is parallel to striations on

II.



d face, and faces forming the edge (*bf*) seem parallel to two *o* faces to left and right of *d* face; if we may assume that rhombic pyramid (*P*) on basal face was elongated in the direction of striations on *d* face, this will easily be understood.

Fig. 2, A, shows traces of four *e* faces formed on all sides of a rhombic pyramid; B is more etched than A.

Fig. 3, A, shows a combination of rhombic pyramid and four *e* faces interlocking with each other. B is the same as fig. 2, but the rhombic pyramid cap is separated from its original form by an *e* face. By this figure and fig. 2, it is proved that the rhombic pyramid and *e* face contend in development with each other; the former cuts its cap by aggression of the latter, and gradually dissolves away.

Fig. 4, A, is a rhombic depression formed on the basal face, the depression replaced by a face (*abc*). B shows a rhombic depression with striations within, and also two little caps of rhombic pyramid on the wall.

Fig. 5 is an elevation of lepidoptera-like shape formed by combination of *c* and *f* faces; the dotted part is indistinct under the microscope.

Fig. 6 is the same as fig. 5; the basal face accompanied by the elevation has rhombic depressions.

Fig. 7 shows rhombic pyramid of an elevation (D) in fig. 1, and three faces accompanied by it; *ghi* is a new face belonging to a brachydome, the angle *ghi* measures 35° approximately, and forms trapezium depressions on its face (compare fig. 5); and their sides *cd* are parallel to the edge *hg*, and *ad* to the edge *hi*. The other face *cbhi* is the same as *e* face, and trigonal depressions are found on its face, their sides (*bc*) parallel to the edge *hi*. B shows *b* face accompanied by the rhombic pyramid, the angles *abc*=110°, *dbf*=130°, and the face has the semi-caps of a rhombic pyramid on its surface.

Fig. 8 is the same as fig. 1, D, but the elevation has a shell-like shape on its ridge; the striations in the etching correspond to those of elevations on fig. 1, E, and F.

Fig. 9 is also an elevation formed on an *f* face; it shows a great resemblance to that of fig. 8.

Fig. 10 shows a depression formed on an *f* face, the etchings are abundant, and it can easily be observed by the naked eye.

III.

Fig. 1 shows a front view of a model crystal with faces as in I, fig. 1; the crystal is seen from the direction of the brachy-axis. Face *m* has rectangular depressions on its surface; these are shallow and do not reveal the structure inside. Face *l* is more etched than *m* face, and trapezoidal depressions are found on its surface; A has a basal face; B has not. On the *d* face, elevations A and B are found; A has *h* face beyond of rhombic pyramid and *e* face, but B has not; edges and quoins in A and B are rounded, and also innumerable cleavages parallel to *e* face are formed by etching. This *e* face is parallel to *o* face at left and right of *d* face. In the central fracture of the figure, etchings of A, B, C, D, E, F, etc., are found; A and B are elevations, C and D depressions; striations in C are parallel to the macro-axis; those on D to the principal axis. E shows caps of rhombic pyramid developed in a depression (*c*). F shows *b* face formed by etching, and striations on its surface are parallel to the principal axis. Depression on *o* face looks like a polliwog to the naked eye.

Fig. 2 shows a magnified elevation (B) formed on the fracture of fig. 1; faces *abd* and *cbd* are plane but *abc* is curved; the angles $abc=60°$, $adc=40°$, the edge *bd* parallel to *c* axis.

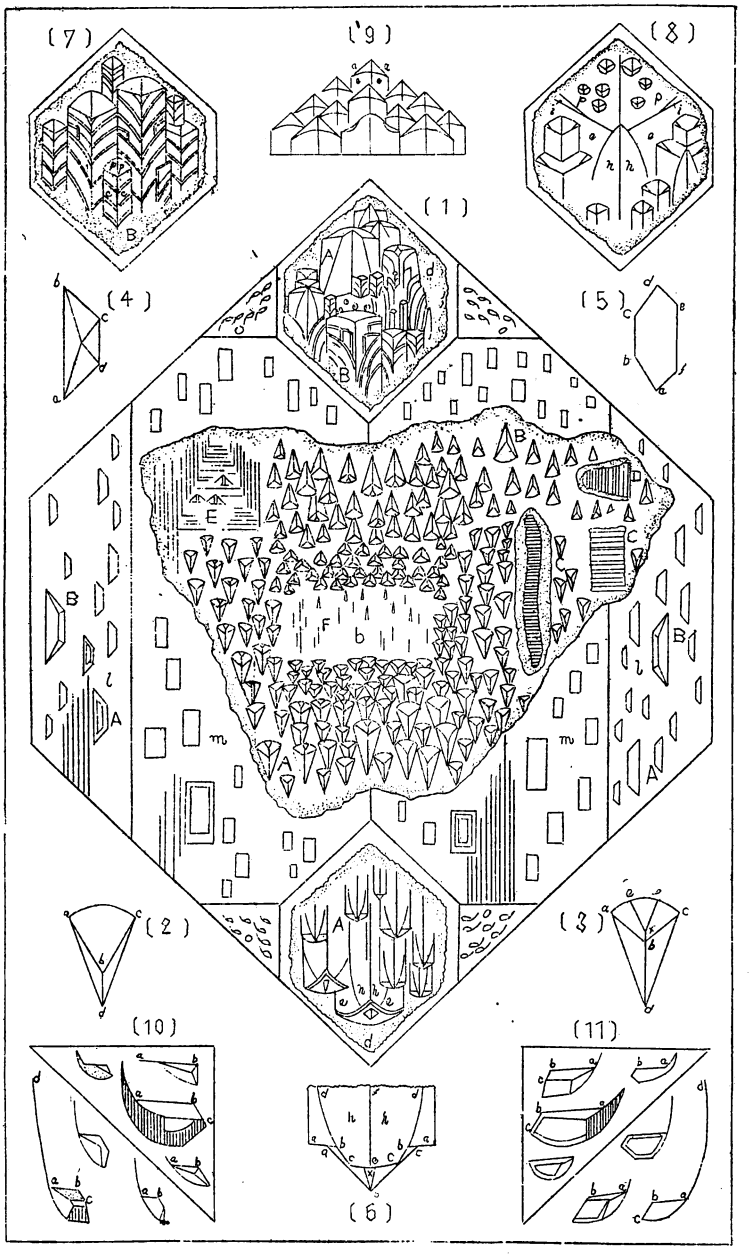
Fig. 3 shows a magnified elevation (A) formed on the same fracture, the angles $adc=40°$, $abc=100°$, $efg=55°$, the edge *fd* parallel to *c* axis.

Fig. 4 shows a depression magnified (B) formed on the same fig. *l* face; the edges *ab* and *dc* are parallel to *c* axis, the angles *abc* and *dab* each=47°.

Fig. 5 shows the outline of a hexagonal depression formed on the *l* face of the same figure; the depression is shallow and does not reveal the structure inside; it is found very rarely on the *l* face. The edges *cb* and *ef* are parallel to *c* axis; the angles *baf* and *cde* each=80°.

Fig. 6 shows an elevation formed by combination of a rhombic pyramid and *e*, *h* faces, found on the *d* face of the same figure. The vertical angle (*abc*) of the rhombic pyramid=90°; *ef* shows the edge formed by combination of two *h* faces. The position of the figure is seen if the *d* face of the original crystal is placed horizontally.

III.



Figs. 7, 8, and 9, etc., are groups of etchings formed on the *d* faces of the same figure; *p* shows etching of Japanese fan-like shape; face *i* is a trace truncated by a pyramid. The position of these figures the same as fig. 6.

Figs. 10 and 11 show a magnified depression of a polliwog-like shape found on *o* face of the same figure. In each depression, the angle *abc* is equal to *abc* in fig. 6, and also striations (*ad*) of the former are parallel to *bd* in the latter, the angle *abc*=120°.

In the above, I to III, it is proved that the symmetry of the elevations formed on the basal face corresponds to the symmetry of the group to which the given crystal belongs, and that the structure of elevations on the basal face corresponds to the phenomena of optical anomalies in a basal section of the crystal with crossed nicol (details will be discussed later); elevations on the faces *d* and *f* correspond to the elongation of one-half of elevations on the basal face (II, fig. 1, *d* and D, etc.).

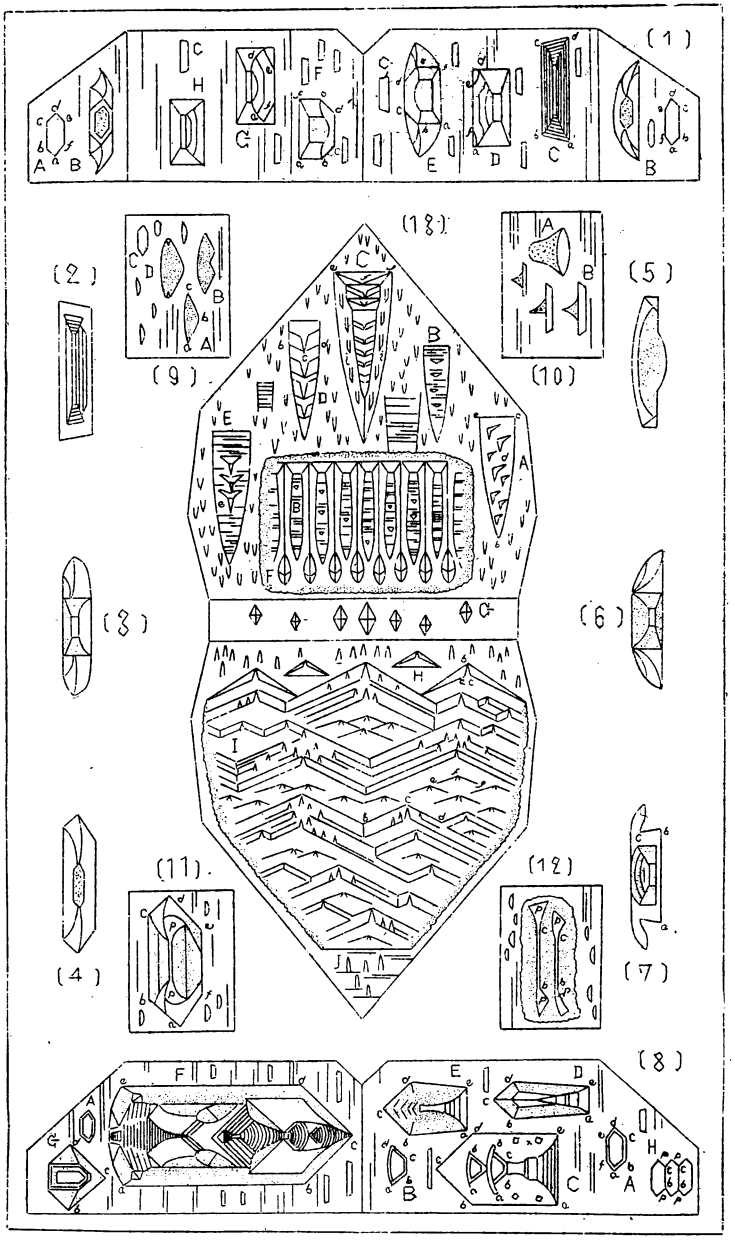
Pits and depressions on the crystal are shallow; the structure within them, therefore, can not be investigated in detail.

IV.

Specimens with the figures were obtained from pegmatite veins of a granite at Ushiroyama near Naigi. Fig. 13 was from one specimen, and the other figures from another specimen.

Fig. 1 shows depressions on prismatic faces (*m, l*) deeply etched. A, B, etc., are etchings on face *l*, and C, D, E, F, G, H, etc., those on face *m*. A is the same as III, fig. 5, the sides *fe* and *bc* parallel to striations on the prismatic face, the angles *edc* and *fab* each=80°. B shows semicircular etchings with hexagonal depression A in the center, and the dotted part is deeper than the other part. C shows trapezoidal depressions and striations in its inner walls, the angles *dcb* and *abc* each=100°. D is a rectangular depression with base, *afed* in a wall is the same as that of *afed* in fig. A. In the figure, it is proved that if the depression D is etched deeply it forms one-half of hexagonal depression (A) in its wall. E is more etched than D, the wall (*bcde*) is more curved than the others. The angles *afe* and *fab* each=90°, the

IV.



angle made by intersection of two lines *ed* and *bc*=90°. F, G, H, etc., correspond to those of D, E, etc.

Figs. 2, 3, 4, 5, 6, 7, etc., show varieties of depressions formed on *m* face, the angle *abc* (fig. 7)=80°, and that is equal to angle *abc* of depression C in fig. 1.

Fig. 8 shows varieties of depressions on a prismatic face deeply etched. A is the same as A in fig. 1, but the former deeper than the latter. B is the same as A but *ad* is formed by the curve *afed*. C shows the pentagonal depression (*abcde*) with etching of a pagoda-like shape in its base; the pagoda-like etching is formed by parallel-growth of depression B, also four quadrangular depressions (*x*) are found in the base; the angles *aed, eab, bcd,* etc., each=90°. D and E much resemble the former, the angles *dea* and *bae*=each obtuse angle; *bcd*=90°. F is the same as C, but its direction is opposite to the latter; *ae* is curved out, a complex parallel growth of hexagonal depression A is found in its base; it has a doll-like form. G much resembles fig. 1, F, the angle *bcd*=90°. H shows parallel growth of three individuals with hexagonal depressions A, each fine boundary column (*bc*) connects their up and down pyramids.

Fig. 9, A shows trigonal pits on *l* face deeply etched; the angles *acb*=50°, *abc*=140°. B is a combination of two individuals of A; C a hexagonal depression; D a magnification of A; it has traces of a trigonal plane in its two acute angles.

Fig. 10 shows the outline of a cave of trigonal pits in fig. 9, seen from the direction of macro-axis. A is a cave of a cap-like shape; the dotted part is also concave.

Fig. 11 shows a hexagonal depression A on *l* face deeply etched, two pyramids *P* are connected by a fine boundary column (compare fig. 8, H), the angles *baf* and *cde* each= 80°

Fig. 12 shows parallel growth of three individuals of hexagonal depressions A on *l* face deeply etched (compare fig. 8, H), each fine boundary column (*cb*) connects their up and down pyramids *P*.

Fig. 13 shows etchings on *c* and *f* faces observed horizontally. A shows long isosceles triangular depressions and etchings (*d*) of a shoe-like shape formed in the base, the angle *abc*=20°. B is the same as A, but the depressions have trigonal pits and striations parallel to the

brachy-axis in its base. C and D are the same as A, but the depressions have etchings of a collar-like shape in its base, and also C has etchings of a knife-like shape (*i*) in its left and right sides, the angles *efg* (C)=140°, *bcd* (D)=130°. E is the same as B, but the depression has etchings of a funnel-like shape (*e*) in its base; etchings *d* in A correspond to one-half of etchings *e* in E. F shows tops of rhombic pyramids (*P*) with a long ridge; the ridge is formed of two depressions B, the above A, C. D, E, etc., are formed by the same reason. G shows tops of rhombic pyramid (*P*) formed on *c* face. H shows trigonal depression with base; the depression is the same as those in B. I shows a group of trigonal depressions H, loking like innumerable cleavages parallel to base of the depression, the angles *abc*=20°, *efg*=140°, *bcd*=130°. J is the same as depression A, but its base has not etchings as the latter; striations accompanied by the depression are formed by etching and they are parallel to brachy-axis (see striations accompanied by II, D and F).

In this series of figures, depressions of *l, m, f,* etc., are deeper than those of I to III; studies on the depressions, therefore, were more detailed than the latter.

V.

Specimens in V were obtained from many localities near Naigi, Mino Province. Figs. 1 to 11 are horizontal projections on the vertical axis (natural size); the other figs. are magnified 75 to 140 times.

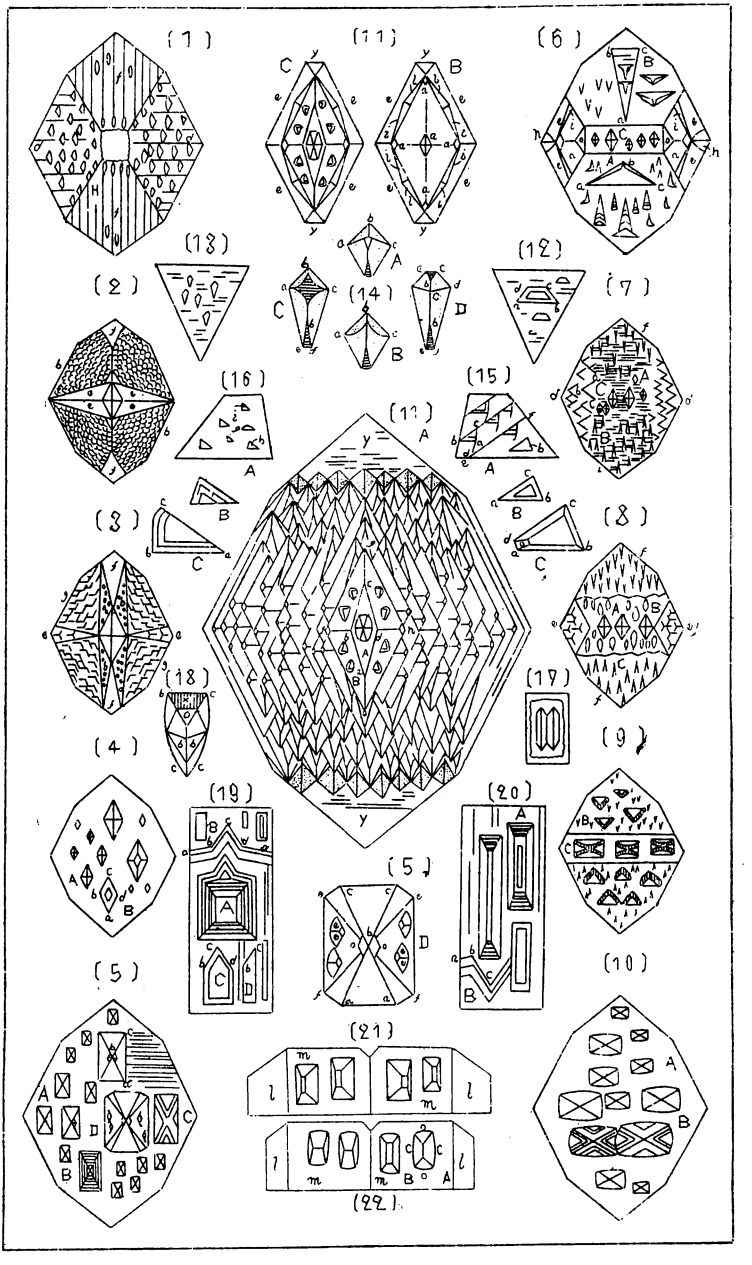
Fig. 1 shows etchings on *d* and *f* faces developed predominantly, isosceles triangles on *d* face show semi-cap of a rhombic pyramid, long ellipses H on *f* face show rhombic pyramid with long ridge (compare IV, fig. 13, F).

Fig. 2 shows etchings of the rhombic pyramids, *e, f,* and *b* face, etc.; four *e* faces surround the rhombic pyramid, and look as if cutting its cap. The face *b* has innumerable warts of rhombic pyramids on its surface.

Fig. 3 has a new face *g* beyond of *p, e, b, f,* etc.; the face *g* carries innumerable cleavages parallel to *e* face on its surface, four small *b* faces surrounding a rhombic pyramid; they have innumerable warts of minute rhombic pyramds on their surface.

Fig. 4 is a rhombic depression on cleavage face parallel

V.



to basal face *c*, A has four walls sloping toward its center; B is the same as A, but has basal face.

Fig. 5 shows rectangular depressions on the face of perfect cleavage (parallel to *c*); A, B, C, etc., are simple depressions but D is more complex than the former. In the depression D, the angle *abc*=130 nearly, the edges *ab* and *bc* are parallel to edges formed by the combination of faces *m* and *c* respectively. Two *o* in center of the depression are rhombic pyramids, and the size of these two rhombic pyramids is usually unequal; trigonal faces *ab* and *cbe* are a little curved. Though the new faces *cbc* and *aba* belonging to brachydomes have no etchings, two new faces *eof* belonging to the macrodome have etchings of Japanese fan-like shape, and the faces and etchings are similar to those in I, fig. 3, D. In figs. 4 and 5, it is proved that depressions of the former belong to pyramid and to dome.

Fig. 6 shows etchings of *c*, *f*, and *d* faces; *c* and *f* are the same as IV, fig. 13, and *d* face is the same as that in III, fig. 8, but the latter has a new face *o* beyond the stated faces.

Fig. 7, A. rhombic pyramid; B. ridges formed by transformation of rhombic pyramid; C. trigonal plane formed on face *d*. Etchings on the latter are very rarely found, angle *abc*=65°.

Fig. 8, A. rhombic pyramid; B. rounded rhombic pyramid; C. common depression on *f* face; *c*. common elevation on *d* face.

Fig. 9 shows elevations formed on *c* and *f* faces; *c* shows rectangular elevations and the vertical edges of the elevations are truncated by a face, forming striations on their section. B shows a face of elevation *c* formed on *f* face; the faces are formed by a dome.

Fig. 10 shows rectangular elevations formed on basal cleavage, the elevation is also formed by domes, and their faces are slightly curved. A. simple elevation; B. those with striations. If we compare this figure with fig. 5, it will be understood that the latter is a negative elevation of the former.

Fig. 11, A shows innumerable cleavages of Japanese fan-like shape formed by etching. Face *abcd* in the center is a basal face formed by etching, and has a hexagonal depression A in the center; the hexagonal depres-

sion consists of four pyramids and two brachydomes; four *e* faces, namely *eabf, gcbf, gcdh, eadh,* etc., have trigonal depressions B, basal face in the trigonal depression parallel to a pyramidal face of hexagonal depression in the center. Face *y* (041) has striations. B shows a magnified rhombic table on A; the rim of the table is cut by four *e* faces and two *y* faces, the edges formed by combination of basal face and *e* faces are truncated by two pyramidal faces *i* and *l,* but these are rougher than the others; the table has a rhombic pyramid on each end of principal, brachy-, macro-axis, etc. C is the same as A, but the table has rhombic pyramids on each end of its macro-axis only.

Fig. 12 is a rectangular depression formed on face *y,* the two sides *ab* and *bc* are parallel to brachy-axis, the angles *abc* and *bad* each=50°.

Fig. 13 shows also depressions of a spoon-like shape on *y* face.

Fig. 14 is fig. 13 magnified; in each depression, the angles *abc* (each wide end of A, B, C, etc.)=90°, *abf* (each narrow end of A, B, C, D, etc.)=each 30°, *abc* and *cdf* (wide end of D)=each 60, striations in each depression parallel to brachy-axis.

Fig. 15. A shows etchings on *o* face; striation *ef* is formed by etching; right-angled triangular depressions accompanied by striations at the end *ad,* and the direction of this is equal to that of *ad* of etchings on III, fig. 10; *o* face, *b* is a scalene triangular depression. B shows *b* enlarged. C shows B replaced by face *o,* side *ad* parallel to side *cb*.

Fig. 16. A shows etchings on *o* face as in fig. 15. *b* is a scalene triangular depression; *g* a semi-circular depression; *i* a right-angled triangular depression. B is the *b* magnified; C depression *i,* magnified; the angle *bca* is rounded.

Fig. 17 shows long hexagonal depressions formed on face *b*.

Fig. 18 is a triangular depression formed on face *f,* the side *bc* parallel to brachy-axis, the wall with striations (*x*) is brachypinacoid *b,* the trigonal face *o* parallel to faces *f, b* and *c* corresponds to *b* and *c* face of elevations formed on basal face (compare II, fig. 1, D and K).

Figs. 19 and 20 show etchings on face *b*. A is a rec-

tangular depression with basal face, the walls sloping at the center of the depression. B shows striations with folding, the angles *bcd*=70°, *abc* and *cde* each=130°, C is combination of A and B. D is the same as one-half of depression C.

Fig. 21 shows rectangular elevations on face *m;* the elevation has symmetry. Face *l* has no etchings.

Fig. 22 shows square elevations on face *m*. A is square pyramid; these faces *o* seem parallel to rhombic pyramids, and the face *c* parallel to *l* face. B is the same as A, but the edge formed by combination of two *c* faces is truncated by a prismatic face. The specimens are five in number, milk-white in color, and having elevations on *m* face only, but edges of the specimens are rounded by rolling in the river bed; the nature of the elevation, therefore, can not be studied in detail.

Natural Etchings of Topaz Crystals from Tanokamiyama, Kurifto-gun, Omi Province.

A specimen of VI was found associated with smoky quartz, mica, etc., from a pegmatite vein in a granite at Tanokamiyama, Kurifto-gun, Omi Province. The crystals measured each 2 cm. on *a, b, c* axes. The observed faces are *c, i* (223), *u, o, d, f, y, m, l, b,* etc. They are colorless and transparent, a cleavage face parallel to basal face is deeply etched, and has innumerable elevations on its surface; the crystal faces *c, u, o, d, f,* etc., have also etchings, but the other faces *m, l, b,* etc., are not etched.

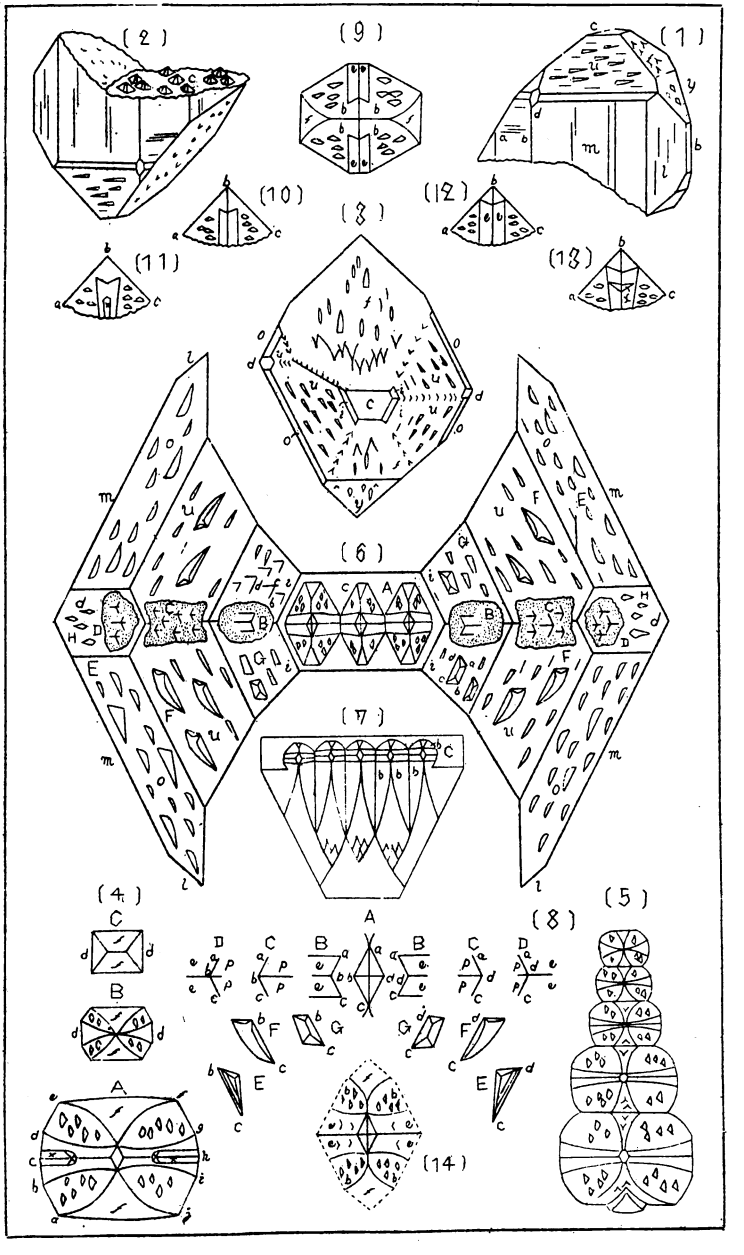
VI.

Fig. 1 shows a front view of a topaz crystal with etchings from Tanokamiyama, Omi Province. Etchings on faces *o, u, f,* etc., can be observed by the naked eye as in the diagram. Striations (*ab*) on *m* face are formed by etching.

Fig. 2 shows elevations on the basal cleavage; the vertical axis of fig. 1 revolved 180°; the elevation is magnified 75 times, but these look like dots to the naked eye.

Fig. 3 shows the transformations of the edges of fig. 1 in horizontal projection on the vertical axis. Etchings

VI.



of v-like shape (with an obtuse angle) are on the combination edge of two *u* faces; edges of *u* and *f* faces form etchings of v-like shape (with an acute angle), and also etchings of a comb-tooth-like shape are found on the edges of *f* and *u* faces. Each etching on transformed edges is related to the etching of each face formed on their edges.

Fig. 4 shows varieties of elevations formed on the cleavage face. A is elevation with faces of rhombic pyramids, *e, b, f,* etc.; the extent of face *b* is wider than the other faces, and it has warts of rhombic pyramids on its surface, the angles *jab, def, efg, ija,* etc. each=120°; *ghi* and *bcd* each=170°; faces *e* and *f* are little curved; the former is smooth; the latter has an elevation *x* on its edges. B is elevation with faces *b, d, f,* etc., and has no *p*. *C* is that with face *d, f,* etc., and face *b* is excepted (compare V, fig. 9, and 10).

Fig. 5 is a parallel growth of five indivduals of fig. 4; A, face *f* has elevations of v-like shape.

Fig. 6 is a model figure showing etchings of each face of *c, i, u, o, d,* etc., and transformations of edges formed by combination of their faces in fig. 1. A, elevations with faces *p, e, b,* etc., B. and C. those formed on edges of combination of two *i* and two *u;* D. elevations on face *d;* H. depressions on the same face; E. trigonal depressions on face *o;* F. depressions of shell-like shape on face *u;* G. trapezium-depressions on face *i*. In the figure, the direction of trigonal depression on face *o* is opposite to those in V, figs. 15 and 16, and also the etchings of E, F, G, etc., on the pyramidal face are unsymmetrical.

Fig. 7 shows combination of two etchings of elevation on *c* face and depression on *f* face.

Fig. 8 shows the relation of etchings of A, B, C, D, F, G, etc., in fig. 6. The angle and side shown by the same letter are equal or parallel with one another, namely, A, rhombic pyramid on basal face; B, C, D, etc.; E, F, G, etc., depressions; left B consists of two *e* faces, the angle *abc* parallel to *abc* of A; C consists of two *p* faces, the angle *abc* parallel to *abc* of A; D consists of two *p* faces and two *e* faces, the angle *abc* parallel to *abc* of A; each side *bc* in depression of E, F, G, etc., parallel to *bc* of A; the angle *adc* and side *dc* of right B, C, D, F, G, etc., are equal or parallel to angle *adc* or side *dc* of A. By this figure and fig. 6, it is proved that elevations of B, C, D,

etc., correspond to one-half of the left or right elevations (A) on basal face, and that each depression of E, F, G, etc., on pyramidal faces *o, u, i,* etc., correspond to hollows dissolved.

Fig. 9 shows a transformation of rhombic pyramid deprived of its extent by aggression of faces *e, b, f,* etc.

Fig. 10 is a front view of fig. 9, the angle $abc=94°$ (compare I, fig. 4).

Fig. 11 that in the other rhombic pyramid as fig. 10 face *e* has elevation *x*.

Figs. 12 and 13 are the same as fig. 11; an edge of two *e* faces in the latter is cut by a face *x*.

Fig. 14 is a model figure showing the relation between the outline of elevations as in fig. 4, A and the edges (the dotted line) of combination of *l, m,* and *c* faces. The elevation consists of faces *p, e, b, f,* etc.; if we may assume that territory of *c* and *d* in I, fig. 3, A is occupied by face *f,* structure of the elevation will easily be understood.

In the specimens, rhombic pyramids *p* on basal face and cleavage face were mostly truncations by *e* face, and remaining caps (*p*) very rare. And also if we compare appearance of elevation of basal face and cleavage face, faces of the former (figs. 9 to 13) are regularly developed, but those in the latter (figs. 4, 14) are somewhat curved.

[*To be continued.*]