

pleteness and want of symmetry. In the latter case the determination of the forms is often difficult. In the albite crystal (figs. 134, 135) *P* is the basal pinacoid ∞P ; *M* the brachydiagonal pinacoid ∞P ; *s* the upper right pyramid *P'*; *l* the right hemiprism $\infty P'$; *T* the left hemiprism $\infty P'$; and *x* the hemidome $P'\infty$. Figs. 136 and 137 are crystals of axinite, the former from Dauphiné,

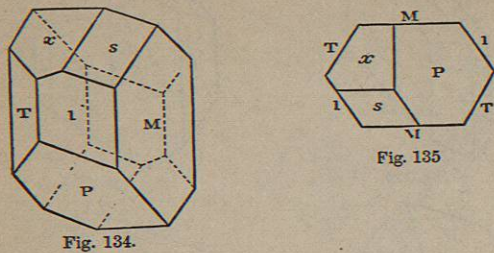


Fig. 134.



Fig. 135.

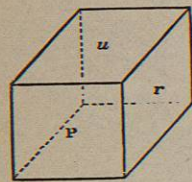


Fig. 136.

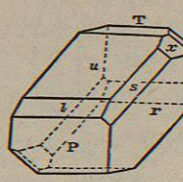


Fig. 137.

the latter from Cornwall, of whose faces the following is the development:—*r* the macropinacoid ∞P ; *P* the left hemiprism $\infty P'$; *u* the left upper quarter-pyramid *P'*; *l* the left upper quarter-pyramid $2P'$; *s* the left upper partial form of the macropinacoid $3P'$; and *x* the hemidome $2P'\infty$.

The Measurement of the Angles of Crystals.

The permanence of the angular dimensions of crystals shows the importance of some accurate method of measuring their angles,—that is, the inclination of two faces to each other. Instruments for this purpose are called goniometers.

Goniometers.

Two have been specially used for this purpose—the common or contact goniometer, invented by Caringeau, and the reflecting goniometer of Wollaston. The former is simply two brass rulers turning on a common centre, between which the crystal is so placed that its faces coincide with the edges of the rulers, and the angle is then measured on a graduated arc. This instrument is sufficiently accurate for many purposes and for large crystals, but for precise determination is far inferior to the reflecting goniometer. This requires smooth and even faces, but these may be very small, even the hundredth of an inch; and, as small crystals are generally the most perfect, far greater accuracy can be attained.

The reflecting goniometer is represented in fig. 138. It consists essentially of a graduated circle *mm*, divided on its edge into twice 180°, or more frequently into half-degrees, the minutes being read off by the vernier *hh*. This circle turns on an axis connected with *u*, so that by turning this the circle is moved round, but it is stopped at 180°, when moving in one direction, by a spring at *k*. The other part of the instrument is intended to attach and adjust the crystal to be measured. The first axis of *mm* is hollow, and a second axis, *aa*, passes through it from *s*, so that this and all the connected parts from *b* to *f* can be turned without moving the circle *mm*. The axis *d* passes through a hole in *bc*, so that it can turn the arm *de* into any required position; *f* is a similar axis turning the arm *og*, and *pg* a fourth axis, in like manner movable in *g*, and with a small knob at *q*, to which the crystal to be measured is attached.

When about to be used, the instrument should be placed on a table, with its base horizontal (which is readily done by the screws in it), and opposite to a window at about 12 or 15 feet distance, so that its axis shall be parallel to the horizontal bars of the window. One of the upper bars of the window, and also the lower bar, or, instead of the latter, a white line on the floor or table parallel to the window, should then be chosen, in order to adjust the crystal. The observer places himself behind the instrument with the side *a* at his right hand. The crystal is then attached to *g* by a piece of wax, with the two faces to be measured upwards, and the

edge of union of the faces, including the angle to be measured, as nearly as possible in the line of *aa*. The eye being brought near to the first face of the crystal, the axes *aa* and *p* are turned till the image of the window is seen reflected in the face with the horizontal and vertical bars in their position. The axis *d* is then turned through a considerable angle (say 60°), and the image of the window again sought and brought into its proper place by turning the axis *f*, without moving *p*. When this is done that face is brought into its true position, normal to *d*, so that no motion of *d* can disarrange it. Hence the image of the window may now be sought in the second face, and brought into its true position, with the horizontal bars seen horizontal, by moving the axes *d* and *a*. When this is done the crystal is properly "adjusted." The angle is measured in the following manner. First bring the zero of the circle and vernier to coincide, and then turn the inner axis *a* or *ss*, and move the eye till the image of the upper bar of the window reflected from the more distant face of the crystal coincides with the lower bar or horizontal line seen directly. Keeping the eye in its place, turn the other axis *u* till the reflected image of the upper bar in the other face in like manner coincides with the lower line; the angle of the two faces is then read off on the divided circle. As the angle measured is not directly that of the faces but of the rays of light reflected from them, or the difference between the angle wanted and 180°, the circle has the degrees numbered in the reverse direction, so as to give the angle without the trouble of subtracting the one from the other.

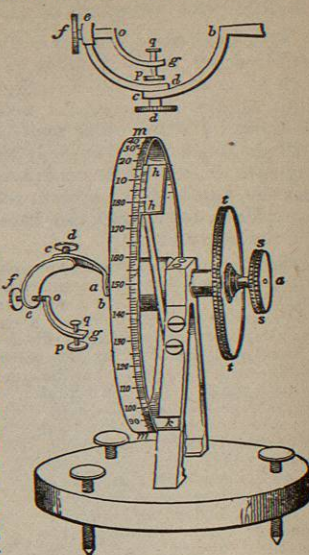


Fig. 138.

The apparatus figured is for adjusting the crystal, and is an improvement suggested by Naumann. In the original instrument the axis *fo* was made to push in or out in a sheath, and had a small brass plate, bent at right angles, inserted in a cleft at *o*, to which the crystal was attached. The crystal was adjusted as formerly by moving the plate, or the axis *fo*, and by slight motion of the arm *de*, which should be at right angles nearly to *bc* when used. A very marked improvement is to have a small mirror fixed on the stand below the crystal, with its face parallel to the axis *aa*, and inclined at 45° to the window, when the lower line can be dispensed with, and the instrument used for various other purposes of angular measurement. Many more perfect instruments have been introduced for the purpose of insuring greater accuracy; but the simple instrument is sufficient for all purposes of determinative mineralogy, and the error from the instrument will, in most cases, be less than the actual variations in the angles of the crystals.

Departure from Geometric Simplicity and Loss of Regularity in Crystals.

Such departures may be regulated by law, or may result from an undue operation of the force of accretion in certain directions.

1. Regular Departures from Simplicity.—There are three varieties of this:—parallel groupings, twin forms, hemitrope forms.

Parallel Groupings.—A plurality of individuals are here arranged either so that a line which joins their centres becomes a prolongation of one or other of their crystallographic axes, or so that their axes are parallel.

Fig. 20 shows the first, where cohesion sufficient for stability requires that the minute octahedra must mutually penetrate somewhat into each other. Fig. 139 shows the same in baryte. If we suppose octahedra united, the upper left-hand face of the one with the lower right-hand face of the other, there would be parallelism of their axes. Re-entering angles would, in such cases, prove a plurality of individuals, but if a number of cubes were superimposed in similar position, no such angles would occur, an elongated square prism resulting; and such arrangements, if

repeated, are linear, or, with diminishing size in the individual, acicular.

repeated, are linear, or, with diminishing size in the individual, acicular.

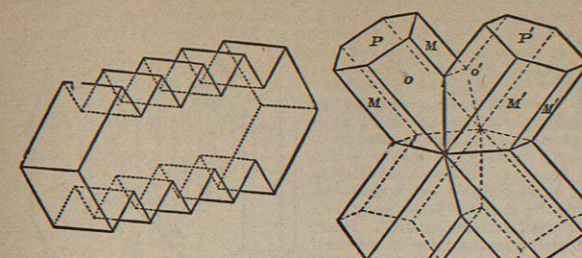


Fig. 139.

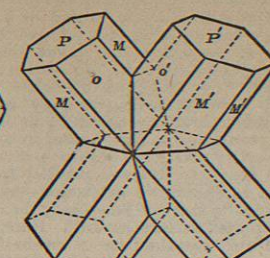


Fig. 140.

Complex crystals.

Twins and Hemitropes.—Though closely related, formed under the operation of very similar laws, and to a certain extent passing into one another, these are not the same. In the first case a plurality of individuals must be present; in the second this is not necessary. In fig. 140 two individuals evidently intersect one another; in figs. 141, 142 one individual may be supposed to have been bisected in a certain direction, and the two halves reattached, but in a position differing in some definite manner from their relative position before the separation.

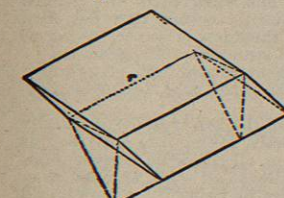


Fig. 141.

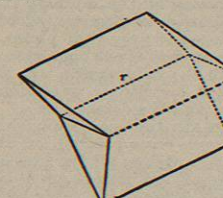


Fig. 142.

There are four varieties of true twins: those of apposition, of intersection, of partial or completed interpenetration, and of incorporation.

The first is exemplified by spinel, as in fig. 143; the second by

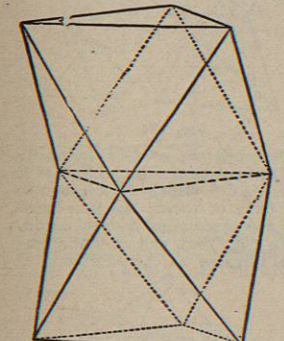


Fig. 143.

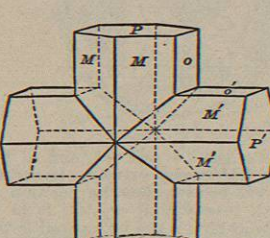


Fig. 144.

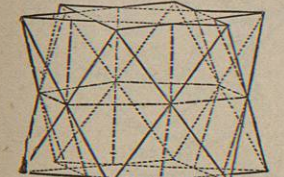


Fig. 145.

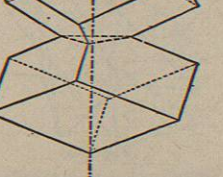


Fig. 146.

staurolite, as in fig. 144; the third by calcite, as in fig. 146, and by blende, as in fig. 145, where the two individuals of fig. 143 may

be supposed to have been forced vertically into one another; and the last by quartz, as in fig. 147.

The following are the laws of union of twins. 1. The face of union of twins, termed the "face of composition," must be either twinning, a plane which does occur in the mineral twinned, or which can occur in accordance with the fifth law of symmetry. A face of

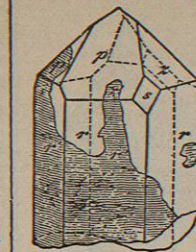


Fig. 147.

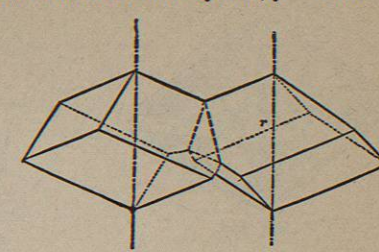


Fig. 148.

union in twins is also a face of union in hemitropes of the same mineral. 2. From the above it results that the axes of the united crystals are either parallel (fig. 148) or inclined (fig. 149). The former generally occur among hemihedral forms; and the two crystals are combined in the exact position in which they would be derived from or would reproduce the primary holohedral form. The class with oblique axes occur both in holohedral and in hemihedral forms; and the two individuals are then placed in perfect symmetry, in accordance with law 1.

Twins are generally recognized by having re-entering angles (figs. 150, 151); but sometimes the crossed faces coincide in one plane, when the combination appears as a single individual (figs. 152, 153). The line of union may then be imperceptible, or it may be disclosed by the intersection of two sets of striae (figs. 154, 155), or by some physical diversity in the characters of the two faces.

The formation of twin crystals may be again, or many times, repeated,—forming groups of three, four, twenty-four, or more. When the faces of union are parallel to each other, the crystals form

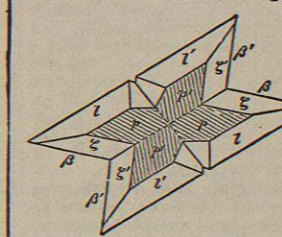


Fig. 150.

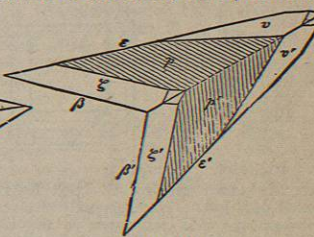


Fig. 151.

rows of indeterminate extent. When they are not parallel, they may return into each other in circles, as in rutile; or form bouquet or rosette groups, as in chrysoberyl (fig. 156); or stellate groups, as in calcite (fig. 157) and in cerussite (figs. 158, 159).

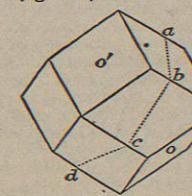


Fig. 152.

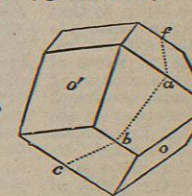


Fig. 153.

When the crystals are of different size, greater complexity results; but a number of minute crystals are frequently arranged upon a larger at those points where the angles of a single large crystal would protrude. Occasionally a simple form is twinned with a more complex one, as in chabasite (fig. 160).

Hemitrope crystals we may imagine as having been formed from a single crystal, which has been cut into two halves in a particular direction, and one half turned round 180°, or 90°, or 60°. The line about which the revolution is supposed to take place is called the "axis of revolution." From the amount of turn usually being 180°, Haily gave the name hemitrope. The position of the two

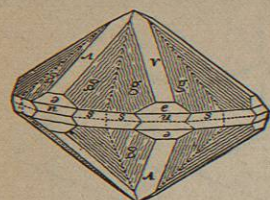


Fig. 154.

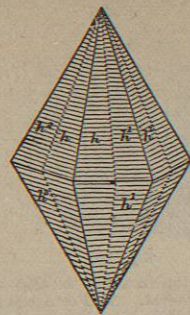


Fig. 155.

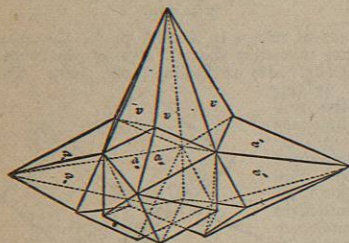


Fig. 157.

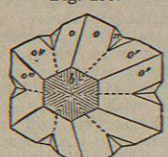


Fig. 156.

Laws of hemitropism.

The following are the laws of hemitropism. The axis of revolution is always a possible crystallographic line, either an axis, a line parallel to an axis, or a normal to a possible crystalline plane. The plane normal to the axis of revolution is called the twin plane; it is either an occurring or a possible plane, and usually one of the more frequently recurring planes. Both the axis and the twin plane

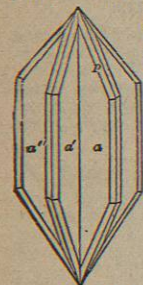


Fig. 158.

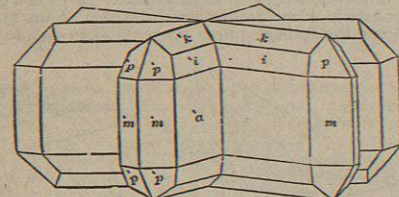


Fig. 159.

bear the same relation to both halves of the crystal in their reversed positions; consequently the parts of hemitrope crystals are symmetrical with reference to the twin plane (except in triclinic forms and some hemihedral crystals). The face of composition very frequently coincides with the twin plane; when not coinciding, the twin plane and the face of composition are generally at right angles to each other, so that the composition face is parallel to the axis of revolution. But in twins of incorporation the surfaces of composition have exercised a disturbing influence on one another, so that the surface of union is exceedingly irregular. Still in these cases the axis and the plane of twinning retain a definite position; but the face of composition, being no longer defined, is useless as a determinant.

There are three modes in which the composition may take place in hemitropes. These may be explained by dividing a crystal into halves, with the plane of division vertical, and then turning one of the halves round.

1. One of the halves may be inverted, as if by revolution through 180° on a horizontal axis at right angles to the plane of section, and the two faces again united by the surfaces which were separated. Here the surfaces of union are the original ones, but the base of one of the halves has taken the place of its summit. Examples: selenite (fig. 161) and orthoclase.

2. One of the halves may be turned round through 180°, as if by revolution on a horizontal axis, parallel to the plane of section, and the face opposite and parallel to that of the plane of section—an originally external face—may then be applied to the other half. Here, not only has the base of one-half become a summit, but a lateral and external face of the original crystal has been thrust to its centre so as to become a face of internal union. Example: labradorite (fig. 162).

3. One of the halves may be turned round through 180°, as if by revolution on a vertical axis, parallel to the plane of section, the external face opposite and parallel to the plane of section becoming a face of union. Here, however, both the original summits retain their position as summits. Example: orthoclase.

The first of these modes of composition may occur in each of the systems, but it is not always apparent until disclosed by optical properties. The second is rare, and the third still more so.

In hemitrope crystals (less frequently in true twins) the halves of the crystal are frequently reduced in thickness in the direction of the ordinary twin axis; and when there is a parallel repetition of hemitropes, which frequently occurs, they are often reduced to very thin plates, not the thickness of paper, giving to the surface of the aggregate a striated structure and appearance.

In the cubic system the faces of composition, both of twinning and of hemitropic revolution, are those of the cube, the dodecahedron, and the octahedron.

In the first case we have the axes of the two crystals necessarily in some cases parallel, or, more correctly, falling into one; but, as in this system all the axes are alike, or all the cubic faces similar, composition may occur along or parallel to all alike, and double or triple twins occur. We have examples in twins of the pentagonal dodecahedron (fig. 163) made up by the interpenetration of a right

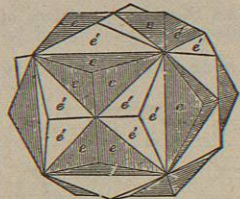


Fig. 163.

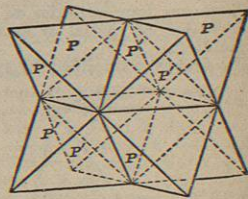


Fig. 164.

and a left (+ and -), and of the tetrahedron, as seen in pyrite and fahlerz respectively. In virtue of the position required by law 2, it will be seen that the position of the solid which is common to both intersecting crystals is in the twin of pyrite the four-faced cube, which is the holohedral form of the pentagonal dodecahedron, while in the case of the fahlerz twin (fig. 164), the common portion is an octahedron, the holohedral form of the tetrahedron.

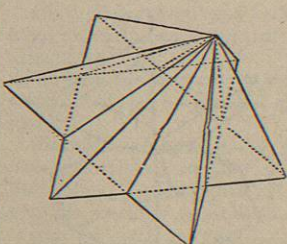


Fig. 165.

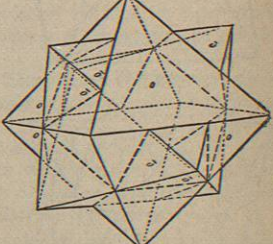


Fig. 166.

Twinning on an octahedral face is seen in the apposition twin of spial (fig. 143), the tetrahedral twin of blende (fig. 165), the interpenetrative octahedral twin of blende seen in fig. 166, and the intersecting cubes of fluor (fig. 167).

This is also the usual twin face for hemitropes of the cubic system.

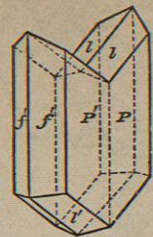


Fig. 161.



Fig. 162.

It is seen in fig. 168 of blende, where the two parts of the rhombic dodecahedron are united by it. Magnetite, spinel, and diamond

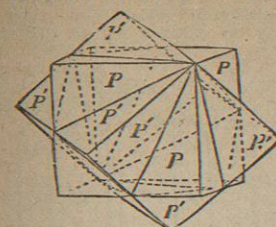


Fig. 167.

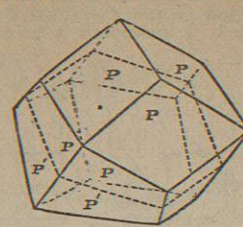


Fig. 168.

frequently occur in octahedral hemitropes of the same composition (fig. 169).

This is also the face of composition for tetartohedral hemitropes. Fig. 170 is that of the diamond. Here six of the faces of the six-

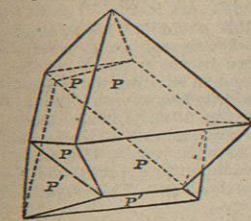


Fig. 169.

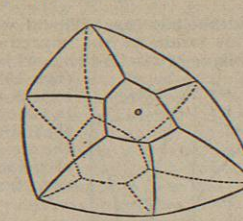


Fig. 170.

faceted octahedron, with six faces diagonally opposite, form a low double six-sided pyramid (a portion of an octahedral face truncating each) through an 180° revolution of one set of these. Garnet sometimes shows both twins and hemitropes of the dodecahedron, of dodecahedral composition.

In the tetragonal system, twin crystals are very uncommon, but hemitropes frequent. With parallel axes they very seldom occur, but are seen in chalcopyrite. When the axes are inclined, the plane of union is usually one of the faces of the primary pyramid; and, as these faces are all similar, composition may take place simultaneously parallel to all. Very complicated forms hence result, as seen in chalcopyrite and in cassiterite (fig. 171).

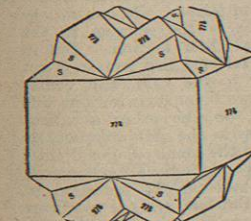


Fig. 171.

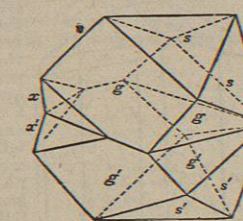


Fig. 172.

In cassiterite the plane of union is frequently one of the faces of the pyramid P_∞, sometimes one of those faces that replace the polar edges of P (figs. 172-173). From the bend the latter form is termed geniculated.

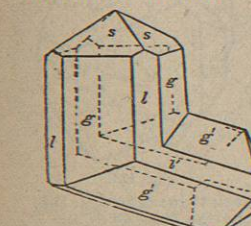


Fig. 173.

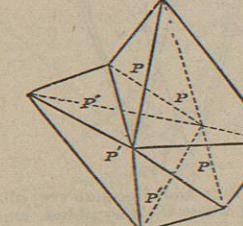


Fig. 174.

Hausmannite occurs in hemitropes of the primary P, and on the polar edges of this other twins are symmetrically repeated, a central individual appearing like a support to the others (figs. 174, 175).

In the hexagonal system twins are very common among the rhombohedral (the hemihedral) and the tetartohedral forms; while hemitropes prevail among the hexagonal or holohedral forms. The

twins are generally formed by the interpenetration of two rhombohedrons, a + and a -, the vertical axis being the axis of composition; as in chabasite (fig. 176), cinnabar, levynite, calcite, &c. Sometimes six or more crystals, united parallel to the prismatic planes,

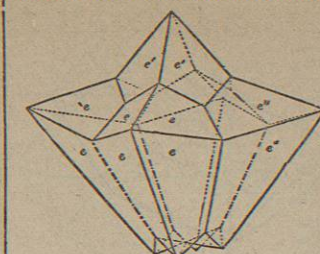


Fig. 175.

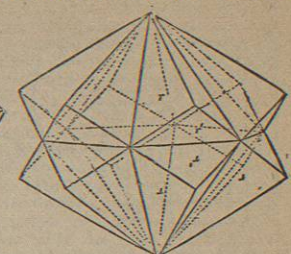


Fig. 176.

form rosettes; as in chabasite from Giant's Causeway. The almost endless stellate forms of crystals of snow are built up in this manner. Many of the most beautiful combinations to be seen among crystals result from this mode of arrangement.

Parallel groupings of hexagonal prisms also occur, as in apatite (fig. 177).

Rock crystal, in consequence of the tetartohedral character of its crystallization, exhibits twins in which the double hexagonal pyramid P may be said to be separated into two rhombohedrons P and P'; these, though geometrically similar, are physi-

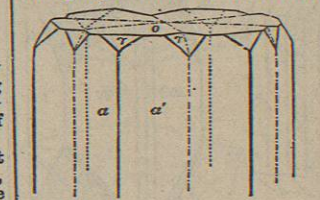


Fig. 177.

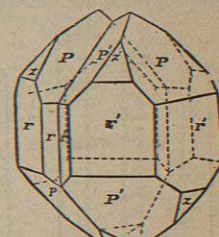


Fig. 178.

cally distinct. In fig. 178 the two individuals have not entirely interpenetrated, and might be regarded as simply grown together with parallel axes; but in fig. 147 there is so complete an interpenetration that the composite character of the crystal is only evidenced through a difference in the character of the surfaces of the two halves, which are most irregularly disposed.

The hemitropes of this system often form regular crystals, when the two halves have been united by a plane parallel to the base, so as to appear like a simple crystal,

as in fig. 179. Here each end shows the forms ∞R , $-\frac{1}{2}R$, but the terminal faces appear in parallel instead of alternate position. Something of the same is seen in fig. 180, a hemitrope scalenohedron from Derbyshire. Hemitropes with the face of the primitive rhombohedron as the face of composition are also common; and they are sometimes joined by a face of $-\frac{1}{2}R$, the two axes forming an angle of 127° 34'. Occasionally a third individual is interposed in a lamellar form, as in fig. 181, where the faces of the two outer portions become parallel. This is found in some pieces of Iceland spar. When the crystals unite in a face of the primary rhombohedron, they form an angle of 89° 8'; hemitropes on this law are easily recognized by their differing so little from a right angle in the re-entering bend (figs. 182, 183).

The faces which in this species act as faces of composition are exceedingly numerous; other examples are figs. 142, 146, 148, and 149.

In the right prismatic system twin crystals with parallel axes are right rare, but with oblique axes common, the faces of union being one of prismatic faces of the prism ∞P . Twins of this kind occur frequently in twins.

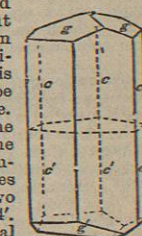


Fig. 179.

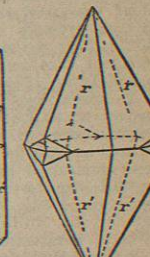


Fig. 180.

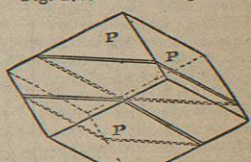
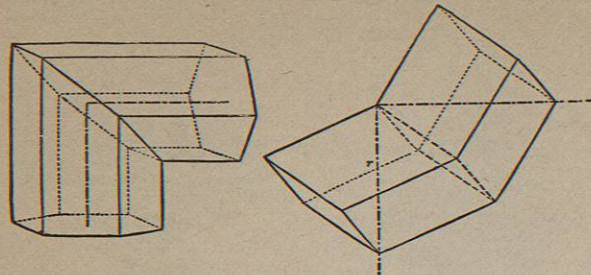


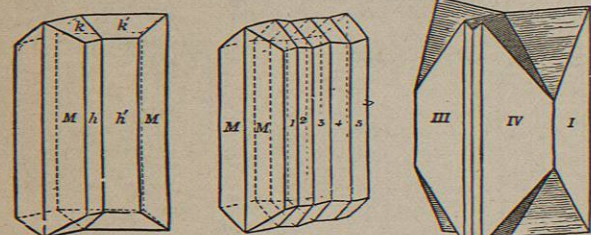
Fig. 181.

aragonite, cerussite, mispickel, and marcasite. In aragonite the crystals are partly interpenetrating, and partly merely in juxtaposition, as in fig. 184, where the individuals are formed by the



combination $\infty P(M), \infty P^{\infty}(h), \bar{P}\infty(k)$. In fig. 185 several crystals of the same combination form a series with parallel planes of union, the inner members of which are often so shortened that they form mere films, which appear as striae on the faces $\bar{P}\infty$ and ∞P^{∞} of the twin.

In fig. 186 four crystals, each of the combination $\infty P, 2P^{\infty}$, having united in inclined planes, form a circular group, which returns into

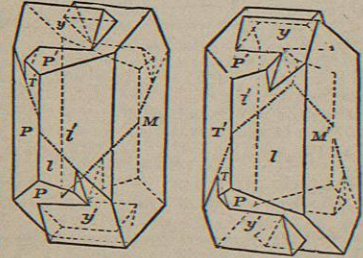


itself. Cerussite occurs in similar groups, building up a composite hexagonal crystal. It also occurs in stellate twins of two or three individuals, as in figs. 158, 159. Similar stellate combinations are also common in chrysoberyl. In staurolite, individuals of the prismatic combination $\infty P, \infty P^{\infty}, OP$ combine, either as in fig. 144 by a face of the brachydome, having their chief axes almost at right angles, or as in fig. 140 by a face of the brachyprism $\frac{1}{2}P^{\infty}$, the chief axes and the brachypinacoids (o) of each of the crystals meeting at an angle of about 60° . This mineral, which is very frequently twinned, also forms combinations with the axes parallel (fig. 187).

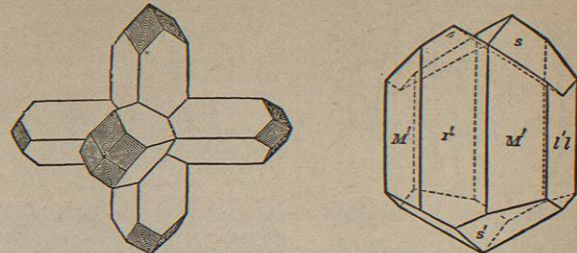
Oblique prismatic twins.

In the oblique prismatic system, twins are by no means so frequent as hemitropes. Twins of interpenetration with parallel axes, but the one turned as regards the other round a vertical axis, are common in orthoclase (figs. 188, 189). Such crystals are termed right-handed (fig. 188) and left-handed (fig. 189), according to the side of the crystal which has been turned. In this mineral hemitropes occur around an axis normal to M , to P , and to n (fig. 529); double twins of the last two are common (fig. 530).

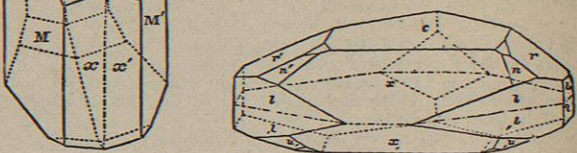
Harmotome and philipsite form first hemitropes, and then twins of these, which are arranged sometimes as crosses and sometimes as double crosses (fig. 190). In hemitropes of gypsum the two halves are united by a face parallel to the orthodiagonal section, as in fig. 161, where the two halves have united so regularly that the faces P, P form only one plane. In a similar manner the two halves of the augite crystal represented in fig.



180 are in fig. 191 united so perfectly and symmetrically that the line of junction cannot be observed on the clinopinacoid. The two hemipyramids $P(s)$ (like $-P(t)$ in the gypsum crystal) form at one end of the crystal a re-entering, at the other a salient angle.

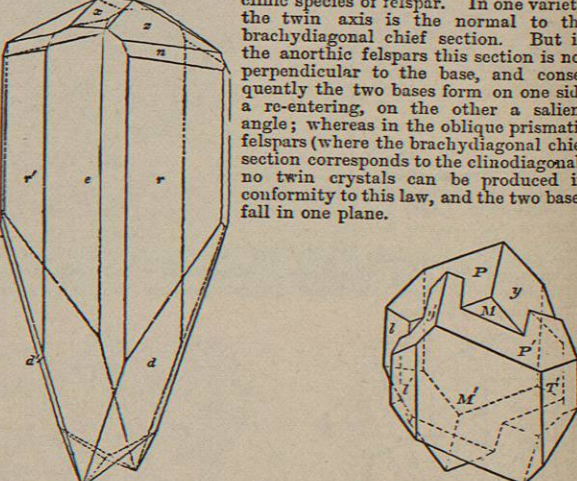


Hornblende (fig. 192) and wolfram exhibit a similar appearance. This results in the imparting a pseudo-hemimorphism to certain oblique prismatic twins, which is well seen in the twins of sphene (figs. 193 and 589), and in exalting the characteristic appearance of true hemimorphs, as seen in the twin of acmite (fig. 194). In other cases the individuals partially penetrate each other in the direction of the orthodiagonal. This mode of union is not uncommon in gypsum, and is very frequent in orthoclase. Two crystals



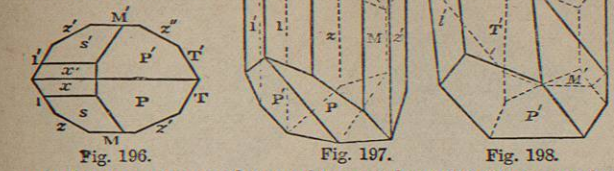
of the latter of the combination $(\infty P^{\infty}), \infty P, OP, 2P^{\infty}$, as in fig. 131, are often pushed into each other, as shown in fig. 195.

In the anorthic system some twin formations are of great importance, e.g., as a means of distinguishing the triclinic from the monoclinic species of feldspar. In one variety the twin axis is the normal to the brachydiagonal chief section. But in the anorthic feldspars this section is not perpendicular to the base, and consequently the two bases form on one side a re-entering, on the other a salient angle; whereas in the oblique prismatic feldspars (where the brachydiagonal chief section corresponds to the clinodiagonal) no twin crystals can be produced in conformity to this law, and the two bases fall in one plane.



Albite and oligoclase very often exhibit such twins as in figs. 196, 197, where the very obtuse angles formed by the faces of OP^{∞} , or P and P' (as well as those of P^{∞} , or z and z'), are a very characteristic appearance, marking out this mineral at once as a triclinic species. Usually the twin formation is repeated, three or more crystals being combined, when those in the centre are reduced to mere plates. When very numerous, the surface P and z are covered with fine striae, often only perceptible with a microscope. A second law observed in triclinic feldspars, particularly in albite and labradorite,

is that the twin axis corresponds with that normal of the brachydiagonal which is situated in the plane of the base. In pericline, a variety of albite, these twins appear as in fig. 198, where the two crystals are united by a face of the basal pinacoid P , whilst the faces of the two brachypinacoids (M

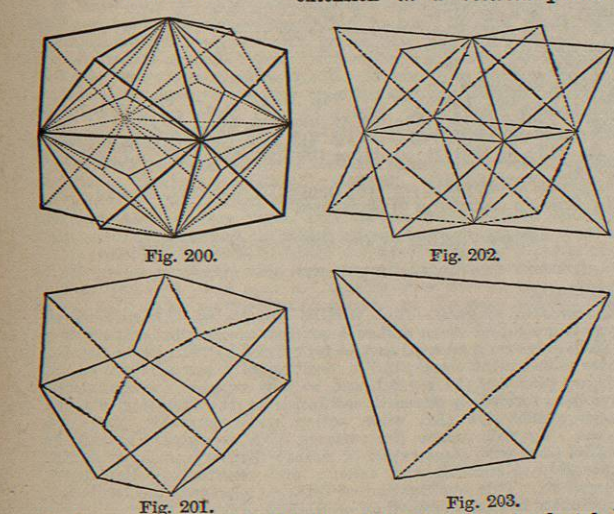


and M') form edges with very obtuse angles ($173^{\circ} 22'$), re-entering on the one side and salient on the other. These edges, or the line of junction between M and M' , are also parallel to the edges formed by these faces and the base, or those between M and P . In this case also the twins are occasionally several times repeated, when the faces appear covered by fine striae.

Cause of the Formation of Twins and Hemitropes.—It has been shown above that the relative position of the molecules of crystals is determined by a polarity in the molecules themselves. This polarity must exist along three lines which intersect in the centre of the molecules; and unlike poles must attract each other. It has been supposed that compound crystals result from a reversion of the original polarity of the molecules of a crystal, after it has attained a certain size. Heat and electricity, resulting from movements in strata, might occasion such reversion during the formation of a crystal, and this would suffice for the explanation of hemitropes, though not directly of geniculated crystals, and still less of intersecting twins.

Twin growth.

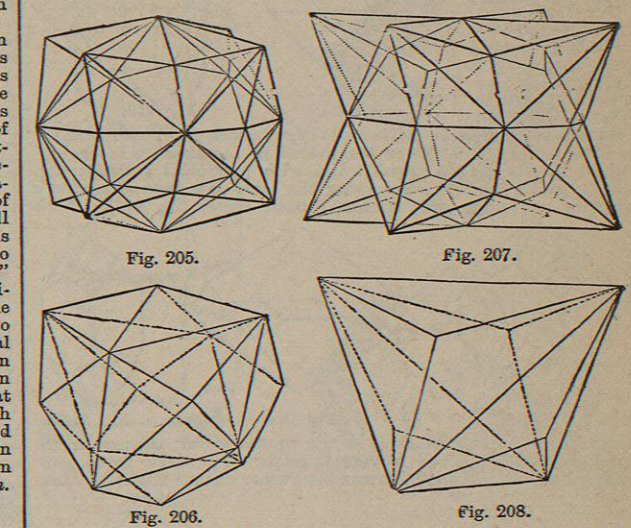
Twins have accordingly been divided into "paragenetic" and "metagenetic." The first term is applied to the ordinarily occurring twins, in which the compound structure is supposed to have had its beginning in a nuclear compound molecule, or to have been compound in its very origin. In metagenetic twins the crystal was at first simple, but afterwards, through some change in the material furnished for its increase or possibly induced in itself, it received new layers, or an extension in a reversed position.



Rutile occurs in crystals like fig. 173, but with a bend at both extremities, instead of one only. Here the middle portion of the crystal is supposed to have attained a length of half an inch, and then it became geniculated simultaneously at both extremities; indeed, in this mineral such geniculations are frequently repeated until the ends are bent into one another, and produce short hexagonal prisms with central depressions or even vacuities. The repeated twinning which produces striation, as in calcite and the

feldspars, and the peculiar rippled structure of amethyst, are ascribed to a similar operation, acting in an oscillatory manner.

Certain intersecting twins in the cubic system may be explained simply through excessive or undue accretion of molecules along certain lines. At page 351 it was shown how the three-faced octahedron (fig. 39) was formed through an accretion of molecules upon the faces of the octahedron along axes joining the centres of its faces (those which connect the solid angles of the cube). It was also shown that when through this accretion two faces of the triakis-octahedron (fig. 199), adjacent along the edge of the octahedron, rose into one plane the rhombic dodecahedron resulted. If now accretion still goes on along the same axes, so that the trihedral pyramid rises above the level of the dodecahedral planes, fig. 200 results. This is the twin of the three-faced tetrahedron (fig. 201).



If the accretion is still along the same axes until the lateral edges of the adjacent pyramids fall into the same line, fig. 202 results; and this is the twin of the simple tetrahedron (fig. 203). Here accretion upon the faces of a complex holohedral form has produced a twin of a simple hemihedral form.

Again, starting from the six-faced octahedron (fig. 204), there is produced by the same process first fig. 205, the twin of the six-faced tetrahedron (fig. 206), and ultimately fig. 207, the twin of the three-faced tetrahedron (fig. 208).

2. Departure from Regularity on Account of Undue Accretion in certain Directions.—Distortion of Crystals.—The Distorsion laws of crystallization should produce crystal forms of perfect symmetry; these laws, however, are subject, not only to the influence of other laws, but also frequently to disturbing influences which are subject to no law. Absolute symmetry, therefore, is very uncommon, crystals being generally so distorted and disguised through interference during their formation that either familiarity on the one hand or skill on the other is necessary for their recognition. As the magnitude of the angles may vary somewhat, even this guide may sometimes perplex. Hence it is necessary to be familiar with such departures from symmetry; and some of the more common are here noticed.

In the cubic system a cube (fig. 26), lengthened or shortened along one axis, becomes a right square prism (fig. 209), and if elongated in the direction of two axes is changed to a rectangular prism (fig. 7). Cubes of pyrites, galena, fluor-spar, &c., are generally thus distorted. It is very unusual to find a cubic crystal that is a true symmetrical cube. In some species the cube or octahedron (or other monometric form) is lengthened into a capillary