On the Optical Figures produced by the Disintegrated Surfaces of Crystals.

By Sir DAVID BREWSTER, K. H., D. C. L., F. R. S.

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THERE is no branch of natural science about which we know so little as that which relates to the structure of crystalline bodies. By assuming the form of an integrant molecule, crystallographers have found no difficulty in building those geometrical solids which minerals and artificial crystals present to our observation. They conceive that these molecules unite by their homologous sides in the formation of the primitive crystal, and by supposing that they arrange themselves in plates on the faces of that crystal, each plate successively diminishing in size by the abstraction of a certain number of these molecules in lines of a given direction,—all the secondary forms of the crystal may be easily deduced.

In place of employing, as HAUY has done, integrant molecules having the form of a tetrahedron, a triangular prism, and a parallelopiped, others have suggested the more philosophical idea of constructing crystals out of spheroidal elements, including, of course, the sphere by which the oblate passes into the prolate solid. But in whatever way crystallographers shall succeed in accounting for the various secondary forms of crystals, they are then only on the threshold of their subject. The real constitution of crystals would be still unknown; and though the examination of these bodies has been pretty diligently pursued, we can at this moment form no adequate idea of the complex and beautiful organisation of these apparently simple structures. The double refraction and pyro-electricity of crystals related to certain fixed points of their primitive forms; and the phenomena of circular polarisation in quartz and amethyst, connected with the plagiedral faces of the crystal, indicate remarkable peculiarities of structure; and I have had occasion to shew that all the properties comprehended under Double Refraction and Polarisation do not exist in the ultimate molecules of the body, but are wholly the result of those forces by which these molecules are combined. Structures still more complicated have been discovered by the analysis of polarised light, and in the complex formations of *apophyllite* and *analcime*, we witness the operation of laws resembling more those which regulate the structures of animal life, than those which had previously been observed in crystalline formations.

The doubly refracting structure of crystals, or to use the language of the undulatory theory, the law according to which this structure permits the ether to

be distributed in their interior, relative to one or more axes, becomes the index as well as the measure of certain changes of structure which in some cases arise during the process of crystallisation. When the atoms approach each other in a pure and undisturbed solution, the crystal which they form will be a correct type of the species; but if the solution has been exposed to agitation,—if its electrical condition has been changed,—if foreign matter, crystallised or uncrystallised, opaque or transparent, coloured or uncoloured, amorphous or isomorphous with the crystal;—if any such matter has been introduced into the solution, we may expect a crystal deviating from the type of perfect crystallisation, in transparency, or colour, or density, or hardness, or refractive power, or in doubly refracting and polarising structure. A very remarkable example of such changes I discovered long ago in *chabasie*. When the crystal had begun to form, it possessed the structure of the perfect mineral, but the force of *positive* double refraction of each successive layer began to diminish till it wholly disappeared. The changes, however, did not stop here; a *negative* doubly refracting structure commenced at the neutral line, and gradually increased till the crystal was completed. This singular effect I ascribed to the introduction of foreign matter between the integrant molecules of *chabasie*, which weakened their force of aggregation, and consequently the double refraction produced by the mutual compression which arises from that force. By pursuing the same idea, I have been recently led to discover the cause of the beautiful but perplexing phenomena of *dichroism*, and I hope to be able to lay before the Society an artificial combination in which the actual phenomena are reproduced.

Having thus briefly adverted to the present state of our knowledge of the interior constitution of crystals, I shall now proceed to the proper subject of this paper, which is to describe the optical figures produced by the disintegrated surfaces of minerals and artificial crystals. The disintegration by which these figures are developed, is produced by three causes:—

I. By the natural action of solvents on the mineral, either at the time of its formation or at some subsequent period in the bowels of the earth.

II. By the action of acids and other solvents upon the surfaces of perfect crystals; and,

III. By mechanical abrasion.

I. The first examples of *Natural* disintegration which I met with, were in *Brazil Topaz*. In a great number of these topazes, I observed cavities filled with a white pulverulent substance, which BERZELIUS, who analyzed it at my request, found to be a sort of *marl*, consisting of *silex*, *alumina*, *lime*, and *water*, and which, as he remarks, would have formed a *zeolite* had it been crystallised. Upon examining the sides of the cavities which contained this substance, I found that

they were rough and irregular, as if they had been disintegrated by a solvent; and I observed the very same effect on the flat summits and pyramidal faces, but never on the faces of the prism. As it was impracticable to apply the goniometer to the mensuration of the angles of the minute facets which the microscope rendered visible on these disintegrated surfaces, I thought of obtaining a general idea of their position by examining the manner in which they arranged the reflected images of a luminous point placed at a distance. Upon making this experiment, I was surprised to see a beautiful optical figure, consisting of the most elegant curves of contrary flexure, studded with tufts of light, and arranged with the most perfect symmetry round the central image of the luminous point which is formed by those portions of the summit of the crystal which had escaped from the action of the solvent. This remarkable arrangement of the reflected light is shewn in Plate X, *Fig. 1*. where it consists of *three* curves of contrary flexure of the general form of *lemniscates*, having at the extremities of their greater axis two semicircular tufts of light, and at the extremities of their lesser axis two triangular tufts of light. These figures undergo considerable changes on different specimens, depending, as will afterwards be seen, either on the time during which the solvent has acted upon it, or upon its dissolving power:—but they never deviate from the general type, and in the most imperfect and rough specimens, of which I have examined more than an hundred, it is easy to recognise the elements of the perfect figure. One of these variations in the figure is shewn in *Fig. 2*, where the light of the inner curve is diffused over a nebulous figure with a crescent at each end, and an elliptical space in the centre, from which the image of the candle, or luminous point, has wholly disappeared. Hence it appears that the whole of the original surface of the flat summit of the crystal has been removed by the action of the solvent, an effect which may be imitated, as we shall presently see, in artificial crystals. The nebulous expansion of which we have been treating has sometimes rectilinear branches at its extremities, and is sometimes filled up in the middle, where the image of the candle is distinctly seen. In other specimens, this nebulous portion is the only part that is visible. The angular magnitude of the figure varies greatly in different specimens, and also its distinctness and continuity. When the elementary facets are large, the outline of the figure is marked by separate images of the candle, and when these facets are very small, the luminous tracery is soft and nebulous, and sometimes shading off into coloured tints, like the fringes produced by the interference of common or polarized light.

The optical figures produced by the faces of the pyramid are less distinct and beautiful, but not less remarkable, than those which we have been describing. Upon faces inclined about 145° to the summit plane, and which seem to be those marked *s* by HAUY,* the strange figure shewn at A, *Fig. 3*, is seen; on the ad-

* Plate 44, *Fig. 1*, &c., first edition.

Fig.1.

Fig.2.

Fig.4.

Fig.3.

Fig.5.

Fig.6.

Fig.7.

Fig.8.

Fig.9.

Fig.10.

Fig.11.

Fig.12.

Fig.15.

Fig.13.

Fig.14.

Fig. 16.

Fig. 18.

Fig. 17.

Fig. 19.

Fig. 20.

Fig. 22.

Fig. 23.

Fig. 21.
E

Fig. 24.

Fig. 25.

Fig. 27.

Fig. 26.

Fig. 29.

Fig. 28.

Fig. 31.

Fig. 32.

Fig. 30.

Fig. 33.

joining face the same figure reversed is seen as shewn at B; on the next face is seen the figure C, the same as A; and on the next face again the figure D, the same as B. I have observed other figures on faces differently inclined to the axis, but they are not of sufficient distinctness to merit delineation.

Optical figures analogous to those seen in topaz, may be observed in various other minerals; but it is very difficult to find specimens that have undergone disintegration on their surfaces.

On the cubical faces of a specimen of *White Fluor-spar* from Shaionce town, Illinois, U. S., sent to me by Professor SILLIMAN, I have observed a figure consisting of *four* radiations, inclined 90° to each other, and having the bright central image entirely obliterated. On the octohedral surfaces of the common fluor-spar, the figure consists of *three* radiations, inclined 120° to each other.

In a crystal of *Hornblende*, the four summit planes at each end of the prism give the figure of a small luminous circle, as shewn in Fig. 4, the central image being wholly obliterated. On the faces of the prism, which are not those of cleavage, the figure is a luminous rhomboid, as shewn in Fig. 5, with a nebulous image at each angle, and one in the centre, the shorter axis of the rhomboid coinciding with the axis of the prism. In some specimens the luminous lines uniting the four images at the angles are not developed.

In a specimen of *Axinite*, I observed the remarkable geometrical figure shewn in Fig. 6. It consisted of two images *a, b*, joined by a line of light, and each of them sending out, in opposite but parallel directions, luminous rectilineal branches *ac, bd*. The line *ab* is perpendicular to the edges of the prism, and *ac, bd* parallel to the sides of the reflecting face. On the opposite side of the prism the figure is reversed.

On the faces of the primitive cube of *Boracite*, the optical figure seen by reflection is a rectangular luminous cross, with a central image, the radiations being perpendicular to the edges of the square faces. *Muriate of soda* that had begun to deliquesce in a humid atmosphere exhibits the same figure.

The faces of the octohedron of *oxidulated iron* gives six luminous radii, inclined 60° to each other; but each alternate image is stronger than the one adjacent to it.

On the rhomboidal faces of the dodecahedron, *Garnet* gives an optical figure like a St Andrew's cross, the line bisecting the arms of the cross being perpendicular to the longer diagonal of the rhomboidal face.

The natural faces of a fine octohedral *Diamond* gave *three* luminous radiations, inclined 120° to each other; and the same figure was exhibited by the faces of a rough pyramid of *Amethyst*, and by some of the cleavage planes of *Oligist Iron-ore*.

As minerals with disintegrated surfaces are not to be found in mineralogical

cabinets, owing to their being in general bad specimens, I have not been able to pursue this branch of the subject any farther; but I have no doubt that if I had such a copious supply of other minerals as I had of topaz, I should be able to find among them specimens of equal interest.

II. We come now to the second and the principal branch of the subject,—to describe the optical figures produced by the action of water, acids, and other solvents, upon the surfaces of perfect crystals, both natural and artificial.

The crystals which I have found to be best adapted for exhibiting the action of solvents in producing optical figures by reflection, are *Alum*, *Fluor-spar*, and *Calcareous Spar*.

If we take a fine crystal of *Alum*, and look at the image of a candle reflected as perpendicularly as possible from one of the faces of the octohedron, it will appear perfectly distinct, and without any luminous appendages. If we now immerse it for an instant in water, and dry it quickly with a soft cloth, the reflected image will send out three luminous radiations, as shewn in Fig. 7. By a second immersion in the water, three small images of the candle will be developed at 1, 2, 3; and by a little farther action of the solvent, these images connect themselves with the central image S, by the radial lines 1 S, 2 S, 3 S, inclined 110° to each other, and 30° to the principal radiations from S. By continuing the action other three images start up at 4, 5, 6, but apparently without any radial connection with S. The principal radiations *a* S, *b* S, *c* S begin at this period to grow faint between 4 and 1, 5 and 2, and 6 and 3. Another immersion of the crystal develops the images 7, 8, 9; and by continuing the action, the images 1, 2, 3 become the brightest, and the branches A, B, C become more like images at *m*, *n*, *o*. The central image S has now transferred almost all its light to the new images, and another immersion will make it disappear altogether, leaving the central part of the figure perfectly dark, as in Fig. 8.

It is now obvious, that by repeated actions of the solvent we have removed the whole of the original surface of the crystal by which the central image S was formed, and have replaced it by a great number of facets, which reflect, in consequence of their various inclinations, the different portions of the geometrical image shewn in Fig. 8. If we carry the process of solution farther, the figure will undergo successive changes, becoming larger and more discontinuous in its outline.

The beauty and regular development of these phenomena, depend in some measure on the perfection of the original surface of the crystal, and greatly on the uniform temperature of the water, and the shortness of the period during which the crystal is immersed in it. The successive development of the figure may be pretty well seen upon an artificial surface of the octohedron of alum, provided it is nearly parallel to the original surface. When the inclination of the artificial

face is considerable, the optical figure loses its symmetry, and gradually passes into other figures produced by the other faces of the crystal towards which the artificial face is inclined.

On some occasions I have found the principal radiations united by a beautiful nebulous web of a triangular form (as shewn in Fig. 9).

All the figures above described, may be seen by reflection from the smallest portion of the face of the octahedron, and they are often more beautiful on one part than another. The principal radiations are shewn in the figures as if they were seen from the centre of the triangular face, in which case they point to the angles; but in all other cases, the radiations are perpendicular to the opposite sides of the triangle.

If we expose any of the six square faces perpendicular to the three axes of the octohedron to the action of water in the manner already described, and examine the optical figure which it produces by reflection, we shall see four rectangular radiations as in Fig. 10, each radiation being perpendicular to a side of the square, and consequently passing into one of the three radiations formed by each face of the primitive octohedron. By successive actions, these *four* radiations become shorter towards the central image, which gradually grows fainter and sometimes disappears.

If the same experiment is made with the *twelve* faces formed on the *twelve* edges of the octohedron, we shall obtain a figure with *two* radiations, forming an oval line with the image of the candle in the middle of it. This image becomes gradually nebulous and finally disappears, leaving a kind of elongated oval nebula, with a dark oval centre, as shewn in Fig. 11, where the line AB is perpendicular to the replaced edge, and parallel to an axis of the octahedron. The *two* radiations A, B, obviously pass into one of the *three* radiations given by the adjacent faces of the octohedron; and if we were to cut a great number of artificial faces variously inclined from that which gives the *two* radiations in Fig. 11, to that which gives the *four* in Fig. 10, we should observe Fig. 11. gradually passing into Fig. 7, and acquiring a third radiation, and Fig. 7. passing into Fig. 10, and acquiring a fourth radiation.

From the phenomena exhibited by *alum*, I proceed to those produced by *fluor-spar*, a mineral having the same primitive form and cleavage. Having immersed one of the faces of the octohedron for a few days in sulphuric acid, I obtained by reflection the beautiful figure shewn in Fig. 12. The three principal radiations A, B, C, with the luminous triangular centre, are first developed, and by continuing the action of the acid, *six* new images are produced at *ef*, *gh*, and *ik*, connected by lines of light with the other part of the figure. A continuance of the action developes six luminous curves proceeding from the images *ef*, *gh*, *ik*, as in Fig. 13, having each a new image within their concavity. Three insulated

images appear also at l , m , n , distant 120° from each other, and 60° from the principal radiations.

When the faces of the cube formed by planes replacing the angles of the octohedron are acted upon by the acid, the beautiful figure shewn in Fig. 14. is produced, the half moons at the four angles being more distinctly brought out in some cases than in others.

The mutual connection of these figures will be seen in Fig. 15, where the triangles represent the faces of the octohedral pyramid unfolded as it were, and the quadrangular figure the square base of the pyramid.

Among the variations of figure produced by the strength of the acid, or the duration of its action, one of the most interesting is the one represented in Fig. 16, where the three principal radiations are inclosed in a luminous equilateral triangle, having a bright image at each of its angular points. If we grind and polish the opposite surface of the octohedron, so as to have a parallel plate, we shall see Fig. 16. much more brilliantly by transmitted light.* If we now expose this second surface to the action of the acid, we shall see the optical figure shewn in Fig. 17, which is Fig. 16. inverted. The cause of this inversion is, that this second face is parallel to a face in the opposite pyramid of the octohedron, whose apex lies in an opposite direction to that of the face which gives Fig. 16. If we now look through the two faces that have been acted upon by the acid, we shall see the beautiful luminous figure shewn in Fig. 18, each image produced by the one surface being converted into an optical figure by the second. When the figure produced by the first surface of the plate of spar has its simplest form of three radiations, the multiplied figure seen by transmission contains only the twelve bright images and the central image of Fig. 18.; but when it exhibits the more compound form of Fig. 12. or 13, the transmitted figure becomes exceedingly complex. It is obvious that the figure shewn in Fig. 14. will not be altered by transmission through two surfaces. Its brilliancy, however, and distinctness will be increased.

In some specimens I have observed three beautiful luminous arches, mn , mo , no , as shewn in Fig. 12.

Upon the face of a cube of fluor-spar, which had been ground and smoothed, but not polished, before it was acted upon by dilute *muratic acid*, I observed the appearance in Fig. 19. The original image had entirely disappeared from the centre of the rounded square of light, and the interior of the cube was filled up with a faint nebulous light of uniform intensity. The *eight* round images were equidistant and equally bright, and the perimeter of the square was brightest at its angles and the middle points of its sides.

* This is the case with all the optical figures previously described.

After the specimen had been exposed for some time to the action of boiling muriatic acid, the face which had given Fig. 19, now exhibited the remarkable phenomena shewn in Fig. 20. The nebulosity had almost disappeared from the interior of the square, and collected, as it were, in its centre. The brightest parts of the figure were the curved masses at the angles, the middle parts of the sides of the figure being exceedingly faint.

From the *tessular* I proceeded to the *rhombohedral* system of crystallization, and I employed calcareous spar and sulphate of potash in the inquiry.

Having immersed a rhomb of calcareous spar in dilute *nitric acid*, four parts of water being added to one of acid, I observed the reflected figure from all the faces of the rhombohedron, to have the form shewn in Fig. 21. The obtuse angle of the crystal was in the direction CE, and the angle ACB was greater than 120° . As the obtuse angle of the opposite face has an opposite direction, the figure which it gives by reflexion is the inverse of Fig. 21, so that, by looking through the parallel faces, we obtain a figure with six luminous radiations. By varying the strength of the acid, the time of its action, and taking the surfaces of different crystals, the figure undergoes remarkable changes; but though two individual figures often occur between which no similarity exists, yet, by observing the transitions of a considerable number, we may trace the family likeness through them all.

The thin web of light AEB, BD, and DA, appear at an early stage of the action, but it is often wanting between A and B, and by continuing the action, a radiation often appears at F, sometimes united, and sometimes not, with the centre C. The radiation CD sometimes expands suddenly below C, into a diverging brush of light, and in other cases it is often wholly wanting, as well as the triangular luminous centre C. In this case we have only two luminous brushes, A, B, with a small central image at C, A and B being sometimes joined by bright light, and sometimes by a small arch of nebulous light, the centre of which was at C.

On the faces of three different crystals, a figure with *five* radiations, diverging at unequal angles, was produced. Two of these were the radiations A, B, the third was the brush developed at E, and the *fourth* and *fifth* were formed by the division of CD into two branches. Sometimes the whole of the central part of this five-rayed figure was wanting, leaving the expanded part of the radiation in the circumference of a sort of oval ring, which was sometimes luminous throughout, but studded with the five brushes of stronger light.

When the solvent was pretty strong muriatic acid and water, the figures have often a great similarity to those already described, but in some cases they have the form of luminous shields of a triangular form, as shewn in Fig. 22. The place of the central image is at C; the brightest part of the figure is at E, with a reddish margin, and the next brightest at A and B. In other crystals the lights

A, B, E, were connected with C by the radiations, and in one case, where a weaker acid was used, E was elevated farther above C, and a horizontal band of light passed below C to the sides AD, BD.

When strong vinegar was used as the solvent, I obtained the figure shewn in Fig. 23, the letters having the same indications as in the preceding figures.

I now proceeded to apply the solvents to the summit planes of the prism. My first experiment was made on an artificial face, perpendicular to the axis. By the action of vinegar it gave the figure shewn in Fig. 24, which consists of three radiations, inclined 120° to each other, having its centre sometimes dark, and sometimes occupied with a small image. The rudiments of other three radiations, inclined 60° to the former, are distinctly visible, and beside a luminous circle circumscribing the whole, there are three non-concentric circular arches, similar to those seen in fluor-spar.

The very same figure, with the exception of the circle and the circular arches, was obtained from the action of dilute muriatic acid on the natural faces of the *chaux carbonatée basée* of HAUY.

Having ground and repolished the artificial summit which exhibited Fig. 24, I exposed it to the action of dilute muriatic acid, when I was surprised to see it produce the strange figure shewn in Fig. 25. Although the symmetry of the figure is hostile to the idea that its shape might have been partly the effect of accident, yet I found it unaltered by repolishing, and again disintegrating the surface, and what is still more decisive, I obtained the very same effect twice from another crystal of calcareous spar.*

By placing the crystal which gave this remarkable figure in a stronger acid solution, it gave on both its faces the figure in Fig. 26, the light of which is strongest in the circular arches. By continuing the action of the same acid, the three inclosed radiations disappear entirely, and what is still more singular, they reappeared by a farther continuance of the action. The action being prolonged, they again disappeared, the circular arches grew wider and more confused, till they filled up the space which they at first inclosed.

Another crystal of spar exhibited the very same series of successive changes which I have now described.

I now reground and polished the faces of both these specimens. When they were plunged into strong dilute acid, their disintegrated surfaces produced no figure, but by increasing the strength of the solution the figures were developed as formerly.

In order to observe the effect produced upon faces that were not coincident either with the primary or secondary faces of the crystals, I ground down one of

* The brightest part of the figure was *a b*, the part above *a* being faint.

the acute solid angles, and replaced it by a plane inclined 71° to a face of the rhomb, the common section being parallel to the long diagonal of this last face. After being immersed in dilute nitric acid, it gave the strange branching figure shewn in Fig. 27, where abc forms the brightest portion. I obtained the same figure with another crystal, but the parts xy were wanting, and b and c were continued through a to m and n . The side a was directed to the obtuse angle of the rhomb. With another crystal, in which the artificial face was inclined 104° instead of 71° , the figure shewn in Fig. 28 was produced.

My next experiments were made with *sulphate of potash*, a crystal which belongs to the rhombohedral system. By the slightest action of water upon the flat summit of a hexagonal prism, it produced six luminous images, symmetrically arranged round the central image, each image being opposite a side of the hexagon. All these images were connected with the central image by a halo of fainter light. The faces of the hexagonal prism produce the figure shewn in Fig. 29, the line AB being coincident with the axis of the prism. By continuing the action the branches C, D vanished, and the figure appeared as in Fig. 30, the images being connected with a haze of light.

A more remarkable effect was produced with the faces of the truncated pyramid. Three of the six faces produced the effect shewn in Fig. 31, while the other three alternate faces produced the same figures, but without the wings E, E. Sometimes two images are seen below B.

My attention was now directed to the system of crystallization in which the base of the primitive crystal is a square. Having immersed a fine crystal of *Faroe apophyllite* in dilute nitric acid, the summits of the prism were alone acted upon. They produced a figure with *four* rectangular radiations directed to the angles of the summit, and four much shorter ones pointing to the sides of the square summit. The four large rays appeared first connected with a luminous web, and the four small ones were subsequently developed.

The very same figure, but with some modifications, was produced by the action of water upon the summit of the square prism of sulphate of potash and copper. The small radiations were produced last, as in apophyllite, but what is remarkable, they are directed to the angles, and not to the sides of the square face. The extreme solubility of this salt renders it difficult to develop the figure distinctly.

From another crystal of the same class, *superacetate of copper and lime*, I obtained the beautiful figure shewn in Fig. 32, where the eight radiations are of equal length, and the images at their extremities connected by beautiful curves of light concave outwards.

I have made a great number of experiments with crystals belonging to the prismatic system, such as *sulphate of magnesia*, *borax*, *tartrate of potash and soda*,

sulphate of iron, and *sulphate of copper*, but, though I have delineated many of the figures which they produce, and though some of them have considerable interest, I am not able to present the details in the form which I could wish. I expected to have been able to obtain interesting and definite results by subjecting the faces of a large class of minerals to the action of fluoric acid; but, in so far as my experiments went, I was disappointed. Dr Fyfe, many years ago, exposed several crystals of quartz and amethyst, which I sent him for this purpose, to the action of fluoric acid, but the disintegration of the surfaces was such that they would not reflect any light at all. I have no doubt, however, that, by weakening the action and carrying it on very slowly, the desired effect will be produced.

During the preceding experiments I was led to observe, that different solvents had a tendency to produce different figures, and I confirmed the truth of the observation by many experiments. When muriatic acid, for example, acts upon *alum*, it produces a figure with six radiations, not unlike those of sulphate of potash, and, by continuing the action, the central image vanishes. If in this state we immerse it in water, three of the radiations vanish, and it assumes the usual form. When again immersed in muriatic acid the six images reappear. Diluted nitric acid has the same effect as muriatic acid; but diluted sulphuric acid gives such a form to the radiations, that their extremities are included within an equilateral triangle, the larger radiations pointing to the three angles, and the shorter ones to the three sides.

Diluted *alcohol*, though it acts feebly upon *alum*, produces a figure different from water and the acids. It gives a figure with three short radiations; and, by farther dilution, the figure undergoes changes which give it a greater resemblance to the aqueous figure.

In order to retard or diminish the action of solvents upon highly soluble crystals, I conceived the idea of immersing them in solutions of the crystal of different degrees of strength. In making this experiment on *alum*, I took a crystal which gave the figure shewn in Fig. 8, and, having immersed it in a saturated solution of *alum* for a single instant, I found that it had, as it were, seized the particles of *alum* in the solution, and replaced them in their proper position on the disintegrated face. By subsequent immersion the face repassed through all the stages at which it produced the phenomena shewn in Fig. 7, and finally became perfect, reflecting a single image of the candle. *The singular fact in this experiment is, the inconceivable rapidity with which the particles in the solution fly into their proper places upon the disintegrated surface, and become a permanent portion of the solid crystal.*

In repeating and varying these experiments, I observed a number of curious facts, which it would be out of place here to describe. I immersed crystals of *alum* in saturated solutions of nitre and other salts, and observed many remark-

able changes upon the figures which they produced. The changes take place principally upon the central parts of the figure, as shewn in Fig. 33, which represents one of the forms which a solution of *nitre* gave to the figure produced by *alum*; but in other cases the whole figure suffers a change. A crystal of *sulphate of potash*, which gave the hexangular radiations already described, produced the same figure, with twice the angular magnitude, when dipped for a few seconds in a saturated solution of *nitre*.

In consequence of having observed that the natural cleavage planes of crystals gave indications of regular optical figures, similar to those produced by solution, I was led to make some experiments on the effects of *mechanical abrasion*, as produced by coarse sandstone, or by the action of a rasp or large-toothed file. Surfaces thus torn up produced, in a rude manner, the optical figure given by solution; but what was very remarkable, *the figure had a different position, or had the position which solution would have developed on the opposite face*. This is also true of the figures produced by natural cleavage planes, in which the separating surfaces have been slightly torn up.

It is scarcely necessary to observe, that the power of producing the optical figures described in this paper may be communicated to wax or isinglass, &c. The impressions on isinglass enable us to see the figure by transmitted light, and to observe its form and dimensions with greater accuracy.

ALLERLY, *February 1. 1837.*