

*On the Relations between the Solution-planes of Crystals and those of Secondary Twinning; and on the Mode of Development of Negative Crystals along the former. A Contribution to the Theory of Schillerization.*

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PLATE III.

IN the case of many common rock-forming minerals—the felspars, the pyroxenes, the olivines and the micas—it has been shown that the crystals which have existed in rock-masses at great depths exhibit constant and characteristic differences from the crystals of the same mineral, in rocks of identical composition, which have been formed at the surface. It has been proved, moreover, that these differences become more and more pronounced in proportion to the distance from the surface at which these rocks have originally existed.\*

Although some of these peculiarities of the crystals of deep-seated rock-masses can be satisfactorily accounted for by the conditions of pressure and slow growth under which they were originally formed, yet there are others—and these by no means the least striking of them, such as the continuous bands of fluid-enclosures, the aventurine structure and schiller, and the chatoyant phenomena—which are clearly not original, but are due to secondary actions. This is proved by the fact that such structures are in many cases not distributed uniformly through the whole of the crystals, but are developed from their exterior or along lines of accidental fissures which traverse them.† In such instances it is clear that the formation of the cracks must be posterior to that of the crystals which they traverse; and that the development of a structure which is determined by these lines of crack must be of later date still.‡

\* *Quart. Journ. Geol. Soc.* Vol XLI. (1885), pp. 374-389.

† *Loc. cit.* Plates X. to XII. with description.

‡ Mr. G. H. Williams, in his very interesting paper on "The Peridotites of the Cortlandt Series," in the *American Journal of Science* for January 1886, has written under some misapprehension of the arguments of my paper. That certain enclosures in minerals are original and were formed during the growth of the crystals, I have never denied. My arguments were intended to apply to the cases of those enclosures which I have proved, by the most conclusive evidence, to be of secondary origin. When we find structures developed having unmistakable relations with the accidental fissures of a crystal, it is as impossible to deny their secondary origin as it is to doubt that the serpentine found bounding the accidental cracks in a crystal of olivine was formed long subsequently to the crystallisation of the olivine itself.

From the study of all the facts exhibited in these interesting cases, I have been led to propose a theory of Schillerization which is based on certain postulates. These postulates are as follows :—

*First.*—If a crystal be subjected to intense strain, planes of easy solubility arise parallel to the directions along which the strain is exerted, and, in consequence of this, cavities, filled with liquids or solids, the product of the solvent action, will be formed along such planes.

*Second.*—In every crystal, in addition to the planes of least cohesion (cleavage-planes), and the planes along which slipping accompanied by a rotation of certain of the molecules occurs (gliding-planes), there is a third set of “ structure-planes,” those, namely, along which chemical action takes place most easily. These planes of chemical weakness, like the cleavage-planes and the gliding-planes, have definite relations with the symmetry of the particular system to which the crystal belongs.

*Third.*—Along these planes of chemical weakness, the solvent agencies working under great pressure operate in such a way as to produce cavities, which frequently take the form of negative crystals; and these may become more or less completely filled with secondary products. As solvent power is augmented by pressure, and pressure increases with the distance from the surface at which the crystal exists, the plane of greatest chemical weakness is first attacked at a certain depth, and at successively greater depths the other less pronounced planes of chemical weakness will be found to be in turn affected.

*Fourth.*—Although the planes of cleavage, of gliding, and of susceptibility to chemical action in a crystal are all distinct from one another, yet in most, if not in all crystals, there appear to be certain curious and very interesting relations between them.

Although I have long felt that it is impossible to account for the characteristics presented by the minerals of deep-seated rock-masses without assuming the truth of the above postulates, it is evidently most desirable to obtain experimental verifications of them. But inasmuch as our command of great pressures, and especially as our means of submitting crystals to weak chemical actions during enormous periods of time is very limited, the difficulties in the way of obtaining such experimental verifications seemed to me to be very great, if not, indeed, actually insuperable. I hope to show, however, in the present paper that very convincing evidence of the truth of all these postulates can really be adduced.

I. With respect to the production of cavities, filled with liquids or with solid decomposition products, along bands of strain, I have succeeded

in obtaining a very striking confirmation of the truth of the principle laid down. Near the gigantic fault which bounds the southern edge of the Scottish Highlands, the quartzite-pebbles of the Old-Red-Sandstone Conglomerate are found exhibiting striking evidence of the tremendous mechanical forces to which they have been subjected; sometimes one pebble is found deeply impressing another, and not unfrequently the whole of the pebbles are found to be crushed to fragments, which have been re-cemented by the deposition of secondary quartz or of calcite. In the case of a quartzite pebble which has been faulted—the mass yielding at last to the tremendous stress upon it—it occurred to me that before the pebble gave way to the force operating upon it, it must have been in a state of prolonged and violent strain along planes parallel to that in which it eventually yielded. Such being the case, if the principle which I have announced be true, we ought to find cavities filled with liquid and solid materials formed in planes parallel with that in which faulting eventually took place.

On making thin sections across such faulted pebbles, I found my anticipations to be fully realised (see Plate III. fig. 1). The quartzite is seen under the microscope to be made up of sand-grains which are portions of quartz crystals, these being cemented by secondary quartz deposited in crystallographic continuity with them, in accordance with the principle so well illustrated by Torneböhm, Sorby and Bonney. These crystalline fragments lie in every possible position, as is shown when they are viewed by polarised light, and they contain the acicular crystals of rutile and other minerals with the original liquid-cavities which distinguished the quartz of the rock from which they were derived. But running through all the grains, quite irrespectively of their orientation, we see under the microscope a series of dark lines, straight as if ruled, and showing an unmistakable parallelism with the plane along which faulting has taken place (\* \* in the figure). By the use of higher powers of the microscope these dark lines are resolved into bands of cavities containing liquids or with secondary infillings of solid matter. It is impossible to doubt that these bands of cavities with their fluid and solid inclusions have been produced by solvent action along the bands of strain.

II. With respect to the proposition which postulates the existence of definite planes of chemical weakness in crystals, it is manifestly difficult to obtain experimental verification in the case of the ordinary compound silicates with which the geologist has ordinarily to deal. It is probable that under the enormous pressures which exist at great depths in the earth's crust, the whole substance of such crystals is permeated by fluid and

gaseous materials capable of exercising a chemical action on the materials through which they pass. Even the methods employed with so much success by M. Daubrée could scarcely enable us to imitate the effects produced under such conditions as these. But in the case of crystals of calcite, aragonite and other minerals affected by weak solvents, it appeared to me not impossible to obtain experimental evidence of the existence of planes of chemical weakness, such as I have argued must exist in the case of the rock-forming silicates.

I had been for some time experimenting on calcite with this end in view, and not without successful results, when I found that the whole question had been dealt with in a very masterly manner by Professor Von Ebner of Gratz.\*

Professor Von Ebner was led to the examination of this question from a totally different starting-point to my own. The appearances presented by certain spiculæ of calcareous sponges induced him to investigate the action of various weak solvents upon minute cleavage-fragments of calcite. A discussion of all the phenomena led him to the conclusion that there are certain planes of easy solubility which he compared to planes of least cohesion (cleavage-planes), and for these he proposes the name of solution-planes (*Lösungsflächen*). From a discussion of a great number of careful experiments he arrives at the conclusion that the primary solution-planes of calcite are parallel to  $-2R$ . ( $\bar{1}11$ .)

The very complicated phenomena of the etching figures produced on the faces and the different cleavage-planes of crystals by the action of solvents have been investigated by many observers. Since the time of Daniell, who first called attention to their importance in 1816, Leydolt, Baumhauer, Klocke, Becke and many other crystallographers have obtained a number of very valuable and suggestive results.

Professor Von Ebner discusses the whole series of remarkable forms developed by the action of solvents upon the different faces and the cleavage-planes of calcite crystals. He shows that all the diversified and complicated forms thus produced, with their curved and striated surfaces—which vary with the nature, the degree of concentration, and the temperature of the solvent, and especially with the rate at which the chemical action takes place—are capable of explanation if his view of the existence of

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\* Die Lösungsflächen des Kalkspathes und des Aragonites. I. Die Lösungsflächen und Lösungsgestalten des Kalkspathes (Sitzber. der Kais. Wiener Akad. der Wissensch. 89 Bd. II. Abth. 1884, pp. 368-458. II. Die Ätzfiguren des Kalkspathes. III. Die Lösungsflächen des Aragonites (Sitzber. der Kais. Wiener Akad. der Wissensch. Bd. 91. II. Abth. (1885), pp. 760-835.

“solution-planes” be true, by the combination of and oscillation between solvent actions along different planes. He not inaptly compares the curious curved and striated figures produced by the action of acids upon calcite, to the “hardness-curves” suggested by Exner as a means of expressing the cohesive force in different parts of a crystal mass as determined by the sclerometer.

The result of Professor Von Ebner's researches is that, so far as calcite and aragonite are concerned, certain planes exist along which chemical action takes place more readily than in other directions within the crystals. It is these which Prof. Von Ebner proposes to call solution-planes (Lösungsflächen); but we must remember that the examples given are not cases of simple solution, the calcic carbonate of the crystals being actually decomposed; the circumstance which is so well illustrated by Von Ebner's experiments, that the results differ with the particular acids employed—acetic acid, formic acid, phosphoric acid or hydrochloric acid—indeed confirm the conclusion that the action ought not to be treated as one of simple solution. Perhaps, however, the name of “solution-planes,” if the qualification insisted upon be borne in mind, is the simplest and most convenient that could be employed. I have already fully explained the ground for the conclusion that such solution-planes must exist in the case of many common rock-forming crystals,\* and if their existence is regarded as proved in the case of the carbonates there can be no difficulty in accepting it in the case of the silicates.

III. That cavities, often taking the forms of negative crystals, make their appearance along the solution-planes of crystals, I have been able to show by some results obtained accidentally during my experiments with calcite. In Plate III. fig. 2 is represented a case where the acid eating into the calcite mass, along definite planes, has evidently given rise to forms with more or less rectilinear boundaries which clearly approximate in some cases to negative crystals.

But it is by the study of some of the more gigantic secondary enclosures of crystals—like those sometimes found in the labradorite of Labrador, and which impart to it its *aventurine* character—that we obtain the clearest evidence concerning the series of processes by which the negative crystals are eaten-out along the “solution-planes” of the crystal. By studying a series showing such structures in every stage of development, we may demonstrate the whole series of processes by which the negative crystals are formed and become filled with secondary products.

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\* *Quart. Journ. Geol. Soc.* Vol. XLI. (1885), p. 385.

This series of processes appears to be as follows (See Plate III. Fig. 3). :—

*First.*—In the clear body of the crystal scattered cavities of irregular form make their appearance. These cavities clearly lie in one or more sets of parallel planes traversing the crystal. The cavities have two flat sides, parallel to the planes in which they lie, but their peripheries are often quite irregular. Not unfrequently, however, there is a marked tendency to the assumption of rectilinear outlines, and the cavity may thus gradually pass into a negative crystal. Sometimes these irregular cavities are found more or less completely filled with brown secondary products. (Fig. 3, a, b, c.)

*Second.*—Not unfrequently these flat-sided and more or less irregular cavities are seen to be developed within a field which has a clear tendency to a form with rectilinear outlines. As the cavities become more and more crowded, thus encroaching upon one another, the field with scattered cavities passes into a large negative crystal. (Fig. 3, b, c, d.)

Its infilling with secondary products may take place at any stage of the development of the negative crystal; the irregular cavities may be partially or completely filled with the decomposition products before they have been made to unite by the continuation of the solvent process, or the whole negative crystal may be completely formed before the deposition of the secondary products takes place. Fig. 3, d, e, f, illustrates these different stages of development of negative cavities and their infilling by the secondary products.

*Third.*—As the final stage of this kind of action we get the large plates of brown material, presenting forms with rectilinear outlines. These produce the aventurine appearance, and have been frequently mistaken for crystals of foreign minerals caught up and included in the Labradorite crystal during its growth. (See Fig. 3, e, f, g.) Occasionally, as in Fig. 3 g., very characteristic forms of feldspar are assumed by these negative crystals; in cases like the one figured, a measurement of the angles, as exactly as is possible with such minute bodies, shows a very close correspondence with the angles characteristic of labradorite.

It is only occasionally that we get the whole series of processes so clearly exemplified as in the example from which the drawings are taken; but no one can inspect such a series without recognising the succession of processes by which the phenomenon of "aventurism" is produced in this particular case.

It will be instructive to compare this method of the formation and infilling of negative crystals in labradorite with that previously described

as taking place in the olivines of the Island of Rum.\* There is reason to believe that there is a difference in the exact *modus operandi* of the production and infilling of negative crystals in the case, not only of different mineral species, but of the same mineral under different conditions.

IV.—Bearing upon the relations between the several “structure-planes” in a crystal, we have the interesting observations of Mügge,† which seem to indicate the mutual interchangeability of the cleavage-planes and the gliding-planes. That a remarkable relation also exists between the third set of structure planes—the solution-planes—and the gliding-planes seemed to me to be indicated by my study of some of the rock-forming minerals in deep-seated masses.

Thus ordinary specimens of diallage appear to indicate that the first or easiest solution-plane in augite is parallel to the orthopinacoid, while the variety known as pseudo-hypersthene proves that the second and third solution-planes are respectively parallel to the clinopinacoid and the basal pinacoid. But Mügge has shown that augite (diopside) may be made to exhibit artificial twinning along planes parallel to the basal pinacoid.‡ The type of augite crystals first noticed in the Whin-sill by William Phillips, show that when such crystals possess the secondary lamellar twinning parallel to the basal pinacoid, these twin planes become the planes of easiest solubility in preference to the normal solution-planes. In this way we account for the interesting circumstance that the Whin-sill and similar augites exhibit a schiller structure parallel to the basal plane, and not, as in diallage, parallel to the orthopinacoid.§

My experiments with calcite have afforded me a striking proof of the conclusion that the development of secondary lamellar twinning in a crystal leads to these twin-planes becoming the planes of easiest solubility, in preference to the normal solution-planes.

A cleavage-rhomb of calcite, upon one corner of which I produced by pressure a series of twin lamellæ parallel to  $-\frac{1}{2}R(110)$ , was submitted to the slow action of dilute hydrochloric acid. Over the cleavage surfaces the usual curved and striated planes of the etched figures proper to those planes were produced (See Plate III. Fig. 4).

Where, however, twinning lamellæ had been produced, solvent action very readily took place along the twinning planes. When these twin-

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\* *Quart. Journ. Geol. Soc.* Vol. XLI. (1885), p. 382. Plate XII, Figs. 4 and 5.

† *Neues Jahrb. für Min.* 1883, I. p. 32.

‡ *Ibid.* 1886. p. 185.

§ *Quart. Journ. Geol. Soc.* Vol. XLI. (1885), p. 379.

ning planes were some distance apart, the intermediate zones of calcite showed a tendency to assume the ordinary etched figures; but where they were close together these became obscure or altogether disappeared. Hence we conclude that in a crystal of calcite where fine lamellar twinning has been produced, the twinning-planes  $-\frac{1}{2} R$  (110) would be more susceptible to the solvent action than the normal solution-planes, which Von Ebner has shown to be parallel to  $-2 R$  ( $\bar{1}11$ ).

It will be necessary, therefore, in the case of each mineral species to determine which of the solution-planes are normal ones and which are secondary ones, resulting from the previous twinning of the crystal by pressure.

I have already pointed out some of the extreme changes which may be produced in the character and appearance of a crystal by the Schillerizing process.

In some cases the development of cavities along certain planes within the crystal goes on to such an extent that the bulk of the skeleton of the crystal which is left may be less than the united bulk of the cavities which have been developed in them. This is very well seen in the plagioclase crystals in the scapolite-rock of Bamle. It is a significant circumstance that the scapolite appears to be formed at the expense of the plagioclase with its liquid cavities, which latter contain, in all probability, various soluble chlorides. MM. Fouqué and Michel-Lévy found that the scapolite and hornblende-rock, when fused, reproduced a rock made up of labradorite and pyroxene.\*

I have shown that by the multiplication of minute inclusions coloured by iron oxides the whole of the felspars in a deep seated rock may acquire a brown tint, and be rendered more or less opaque.† In cases of this kind, the relation of the solution-planes to those of pre-existing lamellar-twinning is sometimes very clearly exhibited. Certain gabbros, especially those of granulitic habit, from Scandinavia, Scotland, Saxony and North America, have the minute black enclosures in their plagioclase felspars clearly arranged parallel to the Albite and Pericline twinning-planes.‡ Where either of these planes are seen by the aid of polarised light to be developed in any part of the crystals, there the enclosures appear marking them out, and where the two twin-lamellæ exist in conjunction,

\* *Bull. Soc. Min. Fr.* II. (1879), p. 113.

† *Quart. Journ. Geol. Soc.* Vol. XLI. (1885). Pl. X. F. 7, pp. 376, 377.

‡ The crystals of these granulitic rocks often exhibit a peculiarity, for which I do not at present find myself able to suggest any explanation. An irregular outer zone of the rounded crystals appears to be free from the secondary inclusions which are beautifully developed in their central portions. This peculiarity is not exhibited by rocks with a granitic structure.



there the double structure is seen to be clearly marked out by the enclosures when the section is examined with high powers. That the twin-lamellæ are of later date than the crystal in which they interruptedly occur, is shown by their relations to the accidental cracks of the crystal. The exact correspondence of the bands of enclosures with the secondary twinning structure, however partially and interruptedly this may occur, shows that the former must have been produced at a later date than the latter. In such cases as these, as I have already shown, the solvent action by which the enclosures were produced, must have taken place while the crystals existed as parts of deep-seated rock-masses.

A very remarkable illustration of the relation between the secondary twinning of a crystal and the enclosures developed in it is exhibited by a crystal of felspar in a "diallage and hypersthene gabbro" from Humlebæk Scharf, Norway, as represented in Plate III., Fig. 5. Here the crystal has been bent, and on examination with polarised light, Albite twinning-planes are seen to be strongly developed in the middle part of the crystal where the flexure has been greatest, but are found to die away towards the ends where there has been no violent strain. In this central bent part of the crystal a few twin-lamellæ, corresponding to the Pericline system, are also seen crossing the former, though these too are wholly wanting at the ends where no flexure has been exerted. On examining the crystal in ordinary light with high powers, the two sets of twin-lamellæ are seen beautifully marked out by lines of cavities, some of which contain liquids, the position and degree of development of these lines of cavities exactly corresponding with those of secondary twinning.

Other interesting examples of the relation of solution-planes to the pre-existing lamellar twinning of crystals are afforded by some plagioclase-felspars which have undergone partial kaolinization. When such crystals are examined in ordinary light, two sets of lines, sometimes crossing one another nearly at right angles, can often be detected, along which the incipient decomposition has taken place. On examining the crystal with polarised light, these lines of incipient decomposition are also seen to coincide exactly with the Albite and Pericline twinning-planes of the felspar crystal, being displayed exactly in those areas of the crystals where either of these particular structures occur, and being seen to cross one another nearly at right angles in the parts where the two sets of twin-planes appear together. In this case the solvent action has taken place after the rocks have been brought near the surface by the denudation of overlying masses.

When the solvent action has gone still farther, enormous cavities, which

gradually become filled with secondary minerals, are developed along the planes of twinning, and sometimes also along the primary solution-planes of the crystal. This is admirably shown in a granulite from Arendal, Norway (Plate III. Fig. 6). Here we see a group of felspar crystals, along the solution-planes of which plates of secondary minerals have been formed, clearly marking out the original twin-structure of the felspar. Among the secondary minerals which appear to be thus formed are scapolite, wollastonite and zoisite.

As a final stage in this process of solution we find the skeleton of the original felspar crystal disappearing altogether, and the secondary product forming a pseudomorph after it. In this manner solvent action becomes an important adjunct to pressure in the transformation of the minerals of a rock from one species into another in metamorphosed rock-masses.

#### EXPLANATION OF PLATE III:

Fig. I. represents a section of a faulted quartzite pebble from Stonehaven (see p. 83), as viewed with a magnifying power of 100 diameters. The separate sand-grains of which it is made up can be clearly distinguished, especially in polarised light. These grains of quartz contain the usual inclusions found in the quartzes of granitic rocks, such as irregular cavities with liquids and moving bubbles, acicular crystals of rutile, &c. But in addition to these, longer or shorter streams of bubbles are seen running through all the grains of quartz, quite irrespective of their orientation. Viewed with high powers, the cavities in these streams are seen to be of various sizes; they sometimes contain a liquid with moving bubble, and at other times are more or less completely filled with solid matter. The line of faulting in the pebble (\* \*) is clearly seen, filled up as it is with secondary calcite and quartz, and the general parallelism of these bands of cavities which run through all the grains, quite irrespective of their optical orientation, is well marked and quite unmistakeable.

Fig. 2. Portion of a crystal of calcite which has been acted upon by very weak hydrochloric acid. The outer portion has been broken up into the solution-forms described by Von Ebner, but in the interior irregular cavities are making their appearance along certain planes, and some of these are beginning to assume the rectilinear outlines characteristic of negative crystals. The specimen is represented as seen with a magnifying power of 250 diameters. (See page 85.)

Fig. 3. Series of enclosures in a specimen of labradorite from Labrador, to illustrate the mode of development of negative crystals and

their infilling in that mineral. *a*, *b*, *c*, are magnified 100 diameters; *d*, *e*, *f*, *g*, 250 diameters. (See page 86.)

3 a. Group of irregular cavities all lying in one of the secondary solution-planes of the crystal, which in this case seems to be parallel to the basal-pinacoid (001). This appears to be determined as a solution-plane by the pre-existent lamellar "Pericline" twinning. Some of these cavities have been filled with secondary products, while others are apparently empty.

3 b. Similar group of cavities, some of which are assuming the rectilinear outlines of negative crystals. Moreover, the cavities lie within a field also bounded by rectilinear outlines.

3 c. Similar group of cavities lying within the field of a negative crystal; some of the cavities assume ramifying forms and are filled with secondary products.

3 d. Large enclosure made up of ramifying cavities, all lying parallel to the solution-plane, and terminating abruptly at the lines marking the boundary of a negative crystal. In one part, however, solution has gone farther, and the whole of this part of the negative crystal has been hollowed out. The areas in which solution has gone on are marked by the secondary deposits which have filled the spaces.

3 e. Negative crystal filled with secondary products. One half of the crystal is marked out by the ramifying cavities, similar to those shown in 3d. The other half is completely hollowed out and filled with a continuous deposit of secondary materials.

3 f. Similar negative crystals almost filled by a continuous deposit of secondary materials. While three of the sides are sharply defined by the edges of the negative crystal, the fourth side has the rugged outline so often seen in secondary inclusions, such for example as those of the hypersthene of Labrador.

3 g. Very perfect negative crystal, showing the characteristic forms of a labradorite crystal. The flat sides parallel to the solution-plane are the basal pinacoid (001), the outlines of the plate are formed by the two prism-planes (110) ( $\bar{1}\bar{1}0$ ) and the brachypinacoid (010).

This negative crystal, like the irregular spaces in the others figured, is filled with a yellowish and brownish isotropic substance. It varies greatly in depth of colour in different parts, and has none of the characters of a definite mineral species. It probably consists of hydrated silica (opal), more or less intensely coloured with the hydrated ferric oxides and other similar materials of secondary origin.

Fig. 4. Cleavage-rhomb of calcite which has been first twinned by

pressure on one of its corners, and then submitted to the action of weak hydrochloric acid. Owing to the combination and oscillation of the solvent actions along the normal solution-planes,  $-2R$  ( $\bar{1}11$ ), according to Von Ebner, the well-known etching figures with curved and striated surfaces have been formed on the cleavage faces. But where twinning has been produced, the secondary twin-plane  $-\frac{1}{2}R$  (110), has become the solution-plane. In the intervals between these planes, an attempt to produce the ordinary etching figures has resulted in their partial development, but they are always cut off sharply by the new solution-planes, along which the solvent action has evidently been very energetic. The specimen is shown magnified 5 diameters. In other examples, I have succeeded in producing secondary twinning-planes so closely crowded together, that any tendency to form the ordinary etching figures seems to have been completely overcome. (See p. 87.)

Fig. 5. Section of a bent felspar-crystal in a gabbro from Humlebæk Scharf, Norway. Seen magnified 100 diameters. Following the secondary Albite and Pericline twinning-planes, cavities have been formed. Viewing the section between crossed Nicols, it is seen that not only do the lines of cavities exactly coincide in position with the twinning-planes, but that where the lamellar structure is well developed, there the cavities are largest and most abundant, while they altogether die out and disappear in the untwinned portions of the crystals. The relation of the twinning structure to the flexure of the crystal is unmistakable. (See p. 89.)

Fig. 6. Group of felspar-crystals in a granulitic rock from Arendal, Norway. Magnified 50 diameters. More than half of these felspars has been replaced by secondary minerals. These are found to be developed in large cavities that have evidently been formed along the two great series of gliding planes in the crystals—the Albite and the Pericline systems. In addition to these, other sets of secondary inclusions, coinciding probably with the normal solution-planes, can in some cases be detected. (See p. 90.)

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