

XV.—*On Isomorphism, &c., and on a simple law, governing all crystalline forms, by H. B. LEESON, M.D.*

MY former papers were more especially intended to conduce to a correct reading of crystalline forms, and to show the relationship which all crystals possess to certain lines of direction, termed gubernatorial axes, such axes not being arbitrarily chosen, but coinciding with the directions of the aggregating forces, magnetic and electric, and evidenced by the state of tension existing in the interior of the crystals, as exhibited when such crystals are examined by polarized light.

I am the more anxious to impress upon all those advancing doctrines, having reference to crystalline form, the necessity of a correct understanding of the crystals on which their observations are based, because, I observe in numerous papers on Isomorphism, Dimorphism, &c., that forms have been considered primary, although only secondary modifications; and that substances have been ranked as dimorphous, although, in fact, only crystallized in different varieties of the same system or class.

If Isomorphism, as the name would imply, had reference, simply, to the same external configuration, then all substances would be polymorphous; for although, only one form may have hitherto been observed in any particular substance, still the instances are so numerous in which the same substance (as for instance: fluor spar sulphate of barytes, or, carbonate of lime,) does crystallize, in a variety of forms, that, judging from analogy, we have reason to believe, every substance may be similarly varied; or, to convey our meaning in other words; that each substance may crystallize in uniaxial biaxial, and triaxial forms, such forms being still further varied by imperfect or defective development, elongation and composition, for the understanding of which, I must refer to my former papers, as printed in the Memoirs of the Chemical Society.

The term, isomorphous, is now, then, generally employed with reference only to the *system* in which a substance is supposed to crystallize; and such system or class must be determined by the position and length of the gubernatorial axes. Perhaps I may be excused for suggesting, that the term, *omo-axed*, or *simil-axed*, would better convey the idea intended, and prevent that misconception which evidently exists in the minds of some observers.

Since I first noticed the *similarity of the series* of forms, occurring in each class, I have been enabled, very considerably, to enlarge my collection, by specimens exhibiting a regular gradation of such forms. This has enabled me to apply the goniometer, formerly described

to the measurement of the inclination of *edges*—as well as of planes, in a very extensive series of crystals. Thus it is that I have been led to observe a very simple relation, indicating the law, by which so far as my own observations extend, every variety of crystalline form seems to be engendered.*

Premising that the law itself is masked (as explained in my former papers) by the unequal development of particular planes; that such unequal development sometimes occasions the defect of certain planes, and that by elongation or combination of separate forms, the external aspect of a crystal may be still further complicated, I proceed to enunciate the principle, according to which, as I believe, all perfect forms are produced. Of course in examining a particular crystal, those planes must be selected, which belong to the same simple form, then, such form must be considered, as it would exist, if all the planes were equally developed, and any defective planes supplied, all this will be the more readily accomplished, when the method of Nature's proceeding, and the series of forms, is fully understood.

To enunciate then, the principle. *The perfect simple forms constitute a series, commencing; First, with the uniaxial form, and subsequently composed of six pyramids of four or eight sides, placed one at each extremity of the three gubernatorial axes. Such pyramids succeeding each other by a similar, and regular gradation, WHATEVER BE THE SYSTEM or disposition, and normal length of the gubernatorial axes.*

The series then may be considered as composed :

FIRST, of the uniaxial form. A six-sided parallelopiped, described in my former papers as produced by a plane, placed on each extremity of the gubernatorial axes, so as to be parallel to the other two axes. The planes of this form may be considered as the lower limit, or zero in height of the biaxial† pyramids.

SECONDLY, of *alternate triaxial and biaxial forms*, consisting each,

* In my former papers, I have already shewn, that uniformity in the measurement of the inclination of planes, is far from constant, and that the mathematical accuracy, supposed to be attainable, is not to be expected. My own goniometer and the microscope, have still further convinced me, that planes, apparently perfect and brilliant to the naked eye, are full of inequalities; and, I believe, that in fluor, want of attention thereto, and of microscopic examination, has caused inclinations to be taken for planes, which really consisted of step-like diminutions, whilst in that substance, as in bismuth and other metals, forms have been considered rhombic, resulting merely from the unequal deposition, or subsequent removal (by solution, or otherwise) of lamina, on one or more edges of the crystal.

† By referring to my preceding papers, it will be understood that the term "biaxial" means that the planes cut two of the gubernatorial axes, and are parallel to the third axis, whilst "triaxial" planes cut all three axes.

of six four-sided pyramids, replacing, or surmounting, as it were, the uniaxial planes; and placed on each extremity of the gubernatorial axes, in such a manner, as that a line joining the apices of the opposite pyramids, corresponds to the gubernatorial axis; whilst the four sides of each pyramid are parallel, in the biaxial forms, to the four edges of the uniaxial plane they respectively surmount; and, in the triaxial forms, to the diagonals of such plane.

These forms succeed each other in a series, produced by a continual replacement of the four lateral edges of the pyramid by planes; so that each succeeding or preceding pyramid differs, or revolves, as it were, 45° on the uniaxial plane.

And, **THIRDLY**, of a series of triaxial forms, composed of six eight-sided pyramids, produced as it were by a duplicature or repetition of the pyramids of the triaxial forms in the preceding or second series. Each eight-sided pyramid consisting of planes joining the four lateral edges of a pyramid of one of the triaxial forms in the preceding series, with the four lateral edges of another equal and similar pyramid, placed in the reverse or biaxial direction, so that the bases of the two pyramids, thus joined together, differ from each other 45° .

The primary triaxial form, may be considered as the first pyramid of the series, or point of departure; from which, by the continual replacement of edges, by planes, the most usual and *descending* series of pyramids, of lower height, is produced; whilst, by replacement of planes by edges, an *ascending* series of more acute pyramids may be obtained. The *ascending* series will necessarily consist of only two pyramids, joined base to base, otherwise re-entering angles, as subsequently explained, would be produced, which is inconsistent with a perfect form.

As an illustration of the principle, I will describe the series as occurring in the regular, or as I term it, the rectangular equiaxial system, as that in which the succession may be most easily comprehended; but I hope it will be fully understood, that the *same series exists in each of the other systems* and that I *possess* numerous specimens to substantiate such position, particularly in the oblique, and right oblique classes; figures of which, I am preparing for publication, in which the planes, belonging to each member of the series, will be designated by a particular colour, so as to exhibit, at one glance, the various perfect forms entering into the composition of any particular crystal.

To describe then the series as occurring in the regular system. The figures referred to being those given with my former papers.

FIRST.—*Primary uniaxial* form, Cube, Fig. 7, Pl. VII.

SECOND.—*Primary triaxial* form, Octahedron, Fig. 7, consisting

of six four-sided pyramids, placed diagonally on the faces of the cube, so as to bisect the four edges of each face. The height of the pyramid being such that the planes of the three pyramids, surrounding each corner of the cube, coincide in one plane; thus each plane of the octahedron may be considered as composed of the planes of three separate pyramids, and corresponds to the lower limit or zero of the three-sided pyramid to be observed in each succeeding triaxial form: the solid angles of the cube being the upper limit or zero of height of the three-sided pyramid.

Third.—*Primary biaxial* form, Rhomboidal dodecahedron, Fig. 8. By replacing the twelve edges of the octahedron by planes, the rhomboidal dodecahedron is produced, and it will be readily observed in Fig 8 that it consists of six four-sided pyramids placed with their sides parallel to the edges of the cube, the height of the pyramid being such, that the planes of the two pyramids adjacent to the same edge coincide, and thus form one plane. If the pyramid were of lower height, as in the succeeding biaxial forms, the planes would as it were double over the edge, and thus give rise to twenty-four instead of twelve planes. If the pyramid were of greater height, the angle across the edge would be a re-entering angle. Hence this form is the limit of the height of the pyramid in the biaxial forms.

FOURTH.—*Second triaxial* form, Trapezohedron, Fig. 21, Pl. X. This form results from a replacement of the edges of the rhomboidal dodecahedron by planes, and may be easily observed to consist of six four-sided pyramids, the sides of which are parallel to the diagonals of the sides of the cube; but in consequence of the manner in which the planes necessarily intersect each other at their bases, the planes themselves lose their triangular outline, becoming in fact trapezoidal, and thus obscuring the pyramidal nature of the form. The height of the pyramid being less than in the primary triaxial form, originates a three-sided pyramid, corresponding to each face of the octahedron, and the form might thus be considered as composed of eight three-sided pyramids. The solid angles of the cube or uniaxial form being the upper limit or zero in height of these three-sided pyramids. A line joining the opposite pyramids corresponds, of course, to a diagonal of the uniaxial form.

FIFTH.—*Second biaxial* form, Pyramidal hexahedron, Fig. 7, Pl. X., produced by planes replacing the edges of the last form, and evidently consisting of six four-sided pyramids of lower height than those of the primary biaxial form, and, therefore, doubling over the edges of the uniaxial form, as already explained. This doubling originates a six-sided pyramid, corresponding to each face of the octahedron or

primary triaxial form. Hence the diagonals of the uniaxial form join the apices of the opposite six-sided pyramids.

SIXTH.—*Third Triaxial* form, a more obtuse trapezohedron.

SEVENTH.—*Third biaxial* form, a more obtuse pyramidal hexahedron.

EIGHTH.—*Fourth triaxial* form, a trapezohedron still more obtuse.

NINTH.—*Fifth biaxial* form, a pyramidal hexahedron, with still flatter pyramids.

Unless in fluor, what I consider as step like striæ be considered planes, I have no specimens carrying this second series beyond the fifth biaxial form.

THIRD SERIES.—*First*, a duplicature of the primary triaxial form or octahedron. The Triaxisoctahedron, Fig. 24, Pl. VIII., formed of planes, joining the edges of the primary triaxial form or octahedron with those of another equal and similar octahedron resolved 45° , thus forming a figure compounded of six eight-sided pyramids, placed on the extremities of the gubernatorial axes, or of eight three-sided pyramids placed on the faces of the octahedron. The line joining the apices of the opposite three-sided pyramids corresponds to the diagonals of the uniaxial form. These three-sided pyramids are, it will be observed, in reverse position to those belonging to the trapezohedron. Compare Fig. 24, Pl. VIII. with Fig. 7, Pl. VII.

Second form, a duplicature of the second triaxial form or trapezohedron, producing the Tetraconta Octahedron, Fig. 21, Pl. VIII., composed of 48 planes, joining the four lateral edges of the six pyramids of the second triaxial form, with the four lateral edges of six other equal and similar pyramids placed in the reverse or biaxial direction, each plane of the cube or primary uniaxial form is thus surmounted or replaced by an eight-sided pyramid, and each solid angle of the cube or face of the octahedron by a six-sided pyramid.

Third form, a Tetracontahedron, derived from a duplicature of the third triaxial form, and hence more obtuse.

Fourth, a still more obtuse Tetracontahedron, derived from the fourth triaxial form.

Beyond this point, I do not possess, nor have I met with any specimen.

Thus, it is evident, that if one number of the series can be fairly made out, all the others may be deduced from it; and I have greatly assisted my labours by preparing and keeping by me a table of the successive angles of inclination, assuming $78^{\circ}, 20'$ as the most frequently occurring acute angle of the oblique uniaxial forms.

In conclusion, I would refer to a few circumstances which have tended, as I believe, to erroneous conclusions.

First, too much reliance on the perfection of planes, which on examination by the microscope, would have been found imperfect.

Next, assigning a primary position to planes of a secondary character. I have already sufficiently indicated, in my former paper many instances of this description.

I have, in my collection, perfect rhomboids of fluor spar, produced by the defect of two planes of the octahedron, as indicated in Fig. 23, plate XII.; and yet no one has hitherto ventured to pronounce fluor dimorphous. Again, I have cubes of fluor apparently rhombic, from the unequal deposition of laminæ, before referred to, and yet similar discrepancies in bismuth and antimony have induced some to consider such crystals as not belonging to the regular system.

But again, since by defect of planes, consequent on the undue development of the planes of any two opposite four-sided pyramids, every form may become octahedral. It is evident, that the apparent proportional length of the axes in different supposed octahedra of the same substance may be greatly varied, and thus a substance, actually belonging to the regular system, may be referred to the pyramidal, merely in consequence of the octahedron examined, not being the primary triaxial variety, but a portion of another form. I have crystals, both of copper and of silver, illustrating this position; and which, if they had occurred to other observers, would, I have no doubt, have induced them to class these substances, as like tin similarly circumstanced, dimorphous. Cleavage, in such cases, would evidently afford no assistance; and here again I may observe, too much reliance must not be placed on the coincidence of cleavage planes with those of the uniaxial form. In fluor it is well known the cleavage planes correspond with the primary triaxial planes; and, I believe, that in the right oblique system they frequently coincide with the primary biaxial planes.

Lastly, I would caution persons not to consider crystals as pseudomorphous, merely because they are of unusual occurrence amongst the specimens of the substance. If there is no reason to suppose the crystals have been actually moulded in the matrix of some other crystal, the term is not appropriate. I have primary uniaxial and triaxial specimens of quartz, which others would term pseudomorphous, but which, I believe, have not been formed in any matrix, and are only so termed, because persons have not been accustomed to believe in the existence of such forms.

March 19, 1849.

The President, in the Chair.

The following presents were announced :

“Memoirs upon Natural History,” collected by W. Haidinger, and published by subscription, and “Reports upon the Communications of the Friends of Natural Science in Vienna,” from W. Haidinger.

Messrs. C. F. Birnaud, G. Simpson, E. Packard and R. Prosser, were elected members of the Society.

The following papers were read :

Analysis of Berlin Porcelain, by MR. WILLIAM WILSON, Student in the Royal College of Chemistry.—The specimen analysed was taken from an evaporating dish and the quantities of the different ingredients were estimated by the usual analytical processes. The specimen as shown by the composition detailed below, was richer in silica and protoxide of iron than is usually the case, while there is a deficiency in alumina and potash.

Silicic acid	.	.	.	.	.	71·34
Alumina	.	.	.	.	.	23·763
Protoxide of iron	.	.	.	.	.	1·743
Lime	.	.	.	.	.	0·5686
Magnesia	.	.	.	.	.	0·1923
Potash	.	.	.	.	.	2·001