

Surely the fact thus established, that each term of a series of relative altitudes of the hexagonal pyramids in which a particular substance crystallises always has to some term of the series thus theoretically derived a particular ratio peculiar to the substance, constrains us to conclude that the above fourteen "root" forms are those to which all crystal forms involving regular six-sided pyramids are referable, and that the actual forms are produced from the "root" forms by difference in the degree of expansion in the direction of the axis of the crystal as compared with other directions at the time of crystallisation.

Other allied forms, as allied octahedra or rhombohedra, can be in the same way connected with some one of the five kinds of internal symmetry.

The peculiarities of *crystal-grouping* displayed in twin crystals can be shown to favour the supposition that we have in crystals symmetrical arrangement rather than symmetrical shape of atoms or small particles. Thus if an octahedron be cut in half by a plane parallel to two opposite faces, and the hexagonal faces of separation, while kept in contact and their centres coincident, are turned one upon the other through 60° , we know that we get a familiar example of a form found in some twin crystals. And a stack can be made of layers of spheres placed triangularly in contact to depict this form as readily as to depict a regular octahedron, the only modification necessary being for the layers above the centre layer to be placed as though turned bodily through 60° from the position necessary to depict an octahedron (compare Figs. 7 and 8). The modification, as we see,

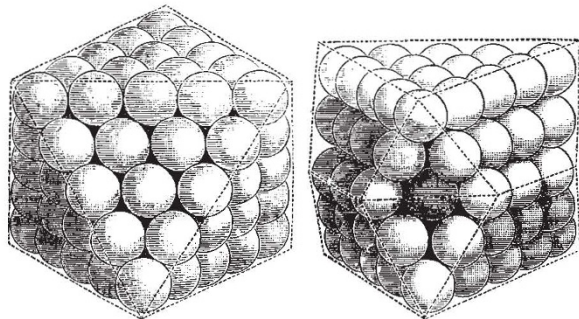


FIG. 7.

FIG. 8.

involves no departure from the condition that each particle is equidistant from the twelve nearest particles.

Before closing, a few words may be said on the bearing of the conclusions of this paper on *isomorphism* and *dimorphism*.

First, as to isomorphism.

The conclusion that there are but five kinds of internal symmetry possible, three of which indicate a cubic form, evidently accords with the fact that not only the simplest combinations—those in which two kinds of atoms are present in equal proportions—but also many very complicated compounds crystallise in cubes.

Out of the regular system we generally find that for the angles of crystals of different compounds to be the same there must be some resemblance in their atom-composition, and the explanation suggested is that the atoms which are common to two isomorphous compounds, *e.g.* the carbon and oxygen atoms in calc-spar and spathic iron ore, have similar situations in the two different crystals, and that the change of bulk which occurs when crystallisation takes place is due to a change in *these atoms only*, the atoms not found in both remaining *passive*.

There are, however, some cases which do not at first seem to be met by this view—cases in which the atom composition of isomorphous compounds has only a very partial similarity. Ammonia compounds may be specially mentioned. Thus, ammoniac sulphate, $(\text{NH}_3)_2\text{H}_2\text{SO}_4$, is isomorphous with potassic sulphate K_2SO_4 .

The following suggestion would seem to enable us to suppose that in this, as in other cases of isomorphism, the phenomenon is referable to the passivity of some of the atoms in the change of bulk which accompanies crystallisation. Let us write ammoniac sulphate thus $(\text{NH}_3)_2\text{H}_2\text{SO}_4$, and let us suppose that the symmetrical arrangement is such that the groups, $(\text{NH}_3)_2$ just occupy places which might, without altering the symmetry, be filled by additional groups H_2SO_4 ; that, in other words, the relative position of the groups H_2SO_4 which are present in the

symmetrical arrangement is precisely the same as it would be if the entire mass consisted of these groups instead of consisting partly of NH_3 groups. If now, in addition to supposing that in both compounds the active atoms in the process of crystallisation are the sulphur and oxygen atoms, and these only, we suppose that the expansion of some of the atoms of the active kind checks the expansion of others; that only a certain proportion of these atoms expands, we perceive that we may have both the same amount and kind of atom expansion in the two cases, and, as the natural result, isomorphism.

Next, as to dimorphism.

It is evident that a very small change is requisite to convert one kind of internal symmetry into another. Thus we have already had occasion to notice that the only difference in depicting the third and fourth kinds of symmetry is that for the former the centres of the spheres in the first and fourth layers, those in the second and fifth, and so on, range vertically, while for the latter the centres in the first and third, in the second and fourth, and so on, range in this way.

In the case of a dimorphic compound consisting of two kinds of atoms in the proportion of 2 : 1, *e.g.* water, H_2O , we have only to suppose therefore that the same layers of atoms which under one set of conditions produce hexagonal prisms, are by some alteration in conditions arranged in the slightly different way necessary to produce rhombohedral forms. Other cases of dimorphism are probably to be accounted for much in the same way.

Thus the following interpretation of the fact that calcic carbonate, which we have seen crystallises in obtuse rhombohedra as calc-spar, sometimes crystallises in six-sided trimetric prisms as aragonite may be offered.

We have already endeavoured to show that the first or second kind of internal symmetry is that proper to calc-spar. We will now endeavour to show that the fifth kind of internal symmetry (Fig. 6) is proper to aragonite.

Alternate layers of spheres (plan *b*) will represent the oxygen atoms, and the other alternate layers the calcium and carbon atoms; the central layers of the triplets above alluded to, *viz.* the second, the fourth, the sixth, &c., being the oxygen layers; the calcium and carbon atoms in the remaining layers will be symmetrically arranged (plan *f*). From the fact of the crystals being trimetric, the layers containing the last-named atoms, which, considered apart from the oxygen layers, are in the fourth kind of symmetry, probably have the arrangement above described, in which the less numerous spheres form zigzags, the stack in this case having a different symmetry about three axes at right angles to each other (Fig. 6).

The fact that the dimorphic varieties of the same substance have different densities is in harmony with the supposition that different sets of the atoms are concerned in the different cases; that the active atoms which produce one form are not those, or those only, which produce the other.

It is not always necessary to refer two incompatible crystal forms of the same substance to two different kinds of internal symmetry: for example, from the third kind of internal symmetry we can produce square-based octahedra, and we can also produce right-rhombic prisms, and in accord with this we have the well-known fact that right-rhombic prisms of sulphate of nickel, $\text{N}_2\text{SO}_4\cdot\text{H}_2\text{O}$, when exposed to sunlight are molecularly transformed, and, though they neither liquefy nor lose their form, when they are broken are found to be made up of square-based octahedra several lines in length.

WILLIAM BARLOW

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—The following awards (among others) have been made at St. John's College on the results of the examination for candidates who have not yet commenced residence:—

For Mathematics: H. F. Baker (Perse Grammar School, Cambridge), Foundation Scholarship, raised for two years to 75*l.* a year; A. W. Flux (Portsmouth Grammar School), Minor Scholarship of 75*l.* a year; P. T. Fagan (Highwood School, Weston), Exhibition of 50*l.* a year; H. R. Norris (University College School), Exhibition of 30*l.* a year.

For Natural Science: G. S. Turpin (Nottingham High School and Owens College, Manchester), Foundation Scholarship raised for two years to 75*l.* a year; P. Lake (Newcastle College of Science), Minor Scholarship of 75*l.* a year; W. Harris (Bradford Grammar School), Exhibition of 50*l.* a year; W. M. Mee

(Trinity College, Dublin), Exhibition of 3*l.* a year [Mathematics and Physics].

For Hebrew: G. C. Ewing (Merchant Taylors' School, London), Exhibition of 33*l.* 6*s.* 8*d.* a year.

SOCIETIES AND ACADEMIES

LONDON

Royal Meteorological Society, December 19.—Mr. J. K. Laughton, M.A., F.R.A.S., president, in the chair.—The following were elected Fellows:—R. Bentley, W. Bonallo, Miss E. Brooke, Rev. A. Conder, T. H. Cowl, J. A. W. Oliver, C. M. Powell, W. B. Tripp, and Fung Yee. The papers read were:—On the explanation of certain weather prognostics, by the Hon. Ralph Abercromby. The author explains about forty-four well-known prognostics belonging to the following groups—(1) diurnal; (2) sun, moon, and stars; (3) sky; (4) rain, snow, and hail; and (5) wells, springs, and coal-mines—by referring them to the isobaric conditions in which they are observed. By this means he is able to indicate the circumstances under which any prognostic fails, as well as those under which it succeeds.—Preliminary inquiry into the causes of the variations in the reading of black-bulb thermometers *in vacuo*, by G. M. Whipple, B.Sc. It has long been known that there is a want of accordance between the different instruments used for measuring the intensity of radiation, and with a view of ascertaining the cause of the variations in the readings of the black-bulb thermometers *in vacuo*, the author has made a comparison with a number of these thermometers, the results of which are given in the paper. It is shown distinctly that the effect of an increased coating of lamp-black on the bulb is to raise the temperature, and also that the size of the thermometer-bulb is a most important factor in the case of this instrument.—Report on the phenological observations for 1883, by the Rev. T. A. Preston, M.A.—Mr. J. S. Dyason exhibited a series of coloured sketches illustrating the recent atmospheric phenomena during November and December.

Geological Society, December 5.—J. W. Hulke, F.R.S., president, in the chair.—George Jonathan Binns, Horace T. Brown, James Dairon, Rodolph De Salis, Hugh Exton, John Forrest, Prof. Bernard J. Harrington, James Patrick Howley, John Sylvester Hughes, Prof. George T. Kennedy, Rev. Arthur Noel Malan, Robert Sydney Milles, Edwin Radford, Edward Pierson Ramsay, William Henry Rands, Thomas Roberts, Joseph Ridgway, and Harry Page Woodward were elected Fellows of the Society.—On the Cambrian conglomerates resting upon and in the vicinity of some pre-Cambrian Rocks (the so-called intrusive masses) in Anglesey and Carnarvonshire, by Henry Hicks, M.D., F.G.S. In a former paper the author had maintained that there was no evidence to show that the so-called intrusive granite in Anglesey had altered the Cambrian and Silurian rocks in its immediate vicinity, or that they had been entangled in it as described, but that it seemed to be a rock of metamorphic origin, varying much in its general appearance at different points. He contended that, instead of being an intrusive granite, as supposed by the officers of the Survey, it was in all probability the oldest rock in Anglesey. The basal Cambrian conglomerate in contact with it is in an unaltered condition, and at Llanfaellog contains an extraordinary proportion of well-rolled pebbles, identical in mineral composition with the so-called granite immediately below. Fragments of all the varieties of rock found in the granitoid axis are recognisable in the conglomerate, and in precisely the same condition as in the parent rock. Fragments of the various schists of the area were also present; so that he thought there cannot be the shadow of a doubt that the so-called granite and the metamorphic schists are older than the conglomerate, and therefore pre-Cambrian. The view maintained by the Survey that the schists are altered Cambrian and Silurian strata, and the granitoid rock an intrusive granite of Lower Silurian age, is consequently quite untenable. In Carnarvonshire equally conclusive evidence was obtained from many areas. Fragments of the Dimetian (Twt Hill type) occurred abundantly in the basal Cambrian conglomerates at Dinas Dinorwig, Pont Rothel, Moel Tryfane, and Glyn Llifon. Quartz-felsite pebbles in every respect identical with the varieties found in the so-called intrusive ridges between Bangor and Carnarvon, and to the north and south of Llyn Padarn, were found on the shores of the Menai Straits, in the railway-cutting at Bangor, at Llandeiniolen, Dinas Dinorwig, Llyn Padarn, and

elsewhere. This evidence, supplementary to that previously furnished by Prof. Hughes, Prof. Bonney, and the author, is conclusive as to these areas, since the basal Cambrian conglomerates, which are in contact with these supposed intrusive masses, are composed almost entirely of rocks identical with the latter; and this could not possibly be the case if the granitoid masses had been intruded among the conglomerates after their deposition.—On some rock-specimens collected by Dr. Hicks in Anglesey and North-West Carnarvonshire, by Prof. T. G. Bonney, F.R.S., Sec.G.S. The author stated that pebbles in the blocks of conglomerate collected by Dr. Hicks to the north of Llanfaellog were practically undistinguishable macroscopically and microscopically from the granitoid and gneissic rocks which occur *in situ* between that place and Ty Croes, and that the matrix contained smaller fragments, probably from the same rock, with schist bearing a general resemblance to members of the group of schists so largely developed in Anglesey, and with grits, argillites, &c. Pebbles of granitoid aspect in the Cambrian conglomerate near Dinas Dinorwig, &c., bear a very close resemblance to the Twt Hill rock, and are associated with abundant rolled fragments of rhyolite resembling those already described from the Cambrian conglomerate and the underlying conglomeratic beds and rhyolites. Two pebbles of rather granitoid aspect in the Cambrian conglomerate by the shore of the Menai Straits, near Garth, prove to be spherulitic felsite, somewhat resembling that already described by the author from Tan-y-maes. He pointed out that the evidence of these specimens collected by Dr. Hicks, added to that already obtained, led irresistibly to one of two conclusions—either that, when the Cambrian was formed, an area of very ancient metamorphic rock was exposed near Ty Croes and in the Carnarvonshire district, or that the rhyolitic volcanoes were so much older than the Cambrian time that their granitic cores were already laid bare by denudation. Hence, in either case, the existence of Archæan rock in North Wales was proved. To one or other of these conclusions he could see no possible alternative, and he considered the former to be (even if some of the granitoid rock were granite) far the most probable.—On some post-Glacial ravines in the Chalk Wolds of Lincolnshire, by A. J. Jukes-Browne, F.G.S.

EDINBURGH

Mathematical Society, December 14.—Mr. Thomas Muir, president, in the chair.—Mr. J. S. Mackay read a paper on the medioscribed circle of a triangle with its analogous and associated circles viewed from their centres of similitude.—Prof. Chrystal stated some propositions in geometry for which he wished proofs.—Mr. Muir made a communication on determinants with β -termed elements.—The Secretary gave a new construction by the Rev. G. McArthur for Euclid ii. 9, 10; and Mr. James Taylor Dollar proposed for solution a theorem in elementary geometry.

CONTENTS

	PAGE
Vortex Rings. By Prof. Osborne Reynolds, F.R.S.	193
Our Book Shelf:—	
Brezina's "Krystallographische Untersuchungen an homologen und isomeren Reihen"	195
Letters to the Editor:—	
The Remarkable Sunsets.—D. Pidgeon; Hon. F. A. R. Russell; Prof. Lewis Campbell	195
Peripatus.—Prof. H. N. Moseley, F.R.S., and A. Sedgwick	196
A New Rock.—Dr. Karl Pettersen	196
Diffusion of Scientific Memoirs.—W. M. Hicks; Prof. P. G. Tait	196
The "Talisman" Expedition. By Prof. Alphonse Milne-Edwards	197
Music and Science. By Dr. W. H. Stone	198
The Remarkable Sunsets. By Edward Whymper	199
Notes	200
International Polar Observatories. By Robert H. Scott, F.R.S., and Dr. Wild	201
Movements of the Earth, III. By J. Norman Lockyer, F.R.S. (<i>With Illustrations</i>)	201
Probable Nature of the Internal Symmetry of Crystals. By William Barlow (<i>With Diagrams</i>)	205
University and Educational Intelligence	207
Societies and Academies	208