ABSTRACTS OF CRYSTALLOGRAPHIC LITERATURE

Introductory Note

The close association between mineralogy and crystallography has led to the inclusion of both subjects within the scope of this magazine. In addition to publishing original articles in these fields, we have endeavored to abstract as fully as space would permit every article which has appeared elsewhere since the beginning of 1916. The total number of articles published thus far, either in full or in abstract, is about 300, and of these perhaps $\frac{1}{3}$ are either entirely or dominantly crystallographic in character.

It has been impracticable heretofore to classify or arrange abstracts otherwise than chronologically, but in order to furnish an idea of the special directions in which the work of the great founder of crystallography, to whose memory this number of the magazine is dedicated, is being extended at the present day, the abstracts in this number are separated into more or less well-defined classes. Under each heading the combined numbers of articles and abstracts which have been previously published are included.

CRYSTALLOGRAPHY—GENERAL

Theoretical

THE FUNDAMENTAL LAW OF CRYSTALLOCHEMISTRY. E. S. Fedorov. *Bull. Russ. Acad. Sci.*, **1916**, 435–454; CHEMICAL SIDE OF CRYSTALLINE STRUCTURE. *Ibid.*, 547–553; NOTE ON THE DETERMINATION OF DENSITY OF ATOMS IN CRYSTAL FACES. *Ibid.*, 1675–1688; *Chem. Abstr.*, **12** (1), 8–13, 1918.

Brief abstracts of these papers are given in the article by Edgar T. Wherry, published elsewhere in this number.

CRYSTALLINE SYSTEMS. Carlo Viola. *Atti. accad. Lincei*, **25**, II, 193–206, 1916; thru *Chem. Abstr.*, **11** (10), 1351, 1917.

The six crystal systems are discussed mathematically with reference to zones, symmetry being left out of consideration. E. T. W.

THE LAWS OF GIBBS, CURIE, AND HAÜY RELATIVE TO CRYSTALS. Carlo Viola. *Atti. accad. Lincei*, **25**, II, 401–410, 1916, thru *Chem. Abstr.*, **11** (10), 1351, 1917.

A mathematical paper in which it is pointed out that the areas of the faces of crystals in stable equilibrium are inversely proportional to their capillary constants, or directly proportional to their densities. Further, extending Haüy's law of the rationality of indices, the principal components of the perpendicular increases at the faces are directly proportional to their respective indices. E. T. W.

Previously published: Vol. 1, 4; vol. 2, 5;

DESCRIPTIVE

A REMARKABLE CRYSTAL OF APATITE FROM MT. APATITE, AUBURN, MAINE. W. E. FORD, Yale Univ. *Am. J. Sci.* [4], **44**, (3), 245–246, 1917.

Description of an apatite crystal of unusual size, violet color, and crystal development. S. G. G.

CRYSTALLOGRAPHIC NOTES ON PYRITE FROM SEVERAL FRENCH LOCALITIES. H. UNGEMACH. *Bull. soc. franc. min.*, **39** (7), 213–226, 1916.

Crystals from 7 localities are described and figured. They are mostly very rich in forms, of which several are new. E. T. W.

CRYSTALLOGRAPHIC NOTE ON PYRITE FROM GILPIN COUNTY, COLORADO. H. UNGEMACH. *Bull. soc. franc. min.*, **39** (7), 226–230, 1916.

The development of 3 crystals is described. They are highly modified, and on one the new forms η (11.10.5) and χ (14.1.6) were recognized. W.

THE ORIENTATION OF ANISOTROPIC LIQUIDS ON CRYSTALS. F. GRANDJEAN. *Bull. soc. franc. min.*, **39** (7), 164–213, 1916.

It is shown that "liquid crystals" take up definite directions, related to the symmetry, when they develop on cleavage surfaces and crystal faces.

E. T. W.

THE GROWTH OF ETCH FIGURES. WILLIAM HARVEY MCNAIRN. Advance separate (Univ. of Toronto Press) from *Trans. Roy. Can. Inst.*, **11**, 231–267, 1916.

A study of the processes involved in the origin and growth of etch figures, by special methods of investigation, with various monoclinic minerals, chiefly colemanite, spodumene and diopside, which were found most suitable for the experiments. In two parts: 1, experimental, and 2, theoretical. Concludes that the new generalizations to be deduced are: first, that the points of origin and selective distribution of the pits depend upon the molecular structure of the crystal and not upon any external and adventitious cause: second, that a pit passes thru a regular series of stages comprising growth, maturity and decay; third, that there is a relationship between the faces of the pits developed on the various faces of a crystal; and fourth, that certain projections (called beaks) from the bottoms of the pits are of three kinds.

W. G. L.

Previously published: Vol. 1, 3; vol. 2, 25;

CRYSTAL STRUCTURE

In order that the references in abstracts to space-lattices may be intelligible, diagrams of several fundamental ones are here introduced. They are drawn in clinographic projection like that used for ordinary crystal drawings. The heavy dots represent the positions of centers of gravity of atoms; the atoms themselves are undoubtedly in contact, and the shapes of the spaces available for them—which may perhaps be regarded as the "integral molecules" sought by Haüy—are also shown by diagrams.

1. THE DOUBLE FACE-CENTERED CUBIC OR DIAMOND LATTICE[1]

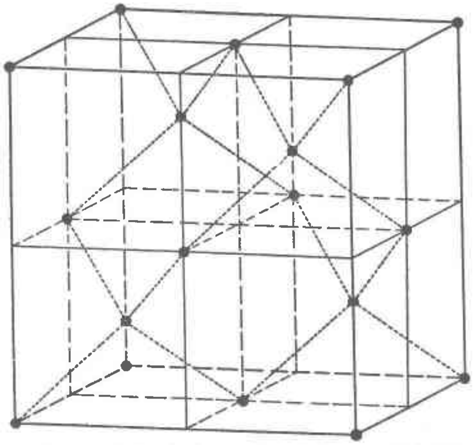

Fig. 1. Eight-atom cell of diamond lattice; valence of atoms 4, in directions shown by dotted lines.

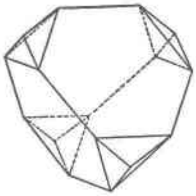

Fig. 2. Shape of each atom[3] (when all are alike).

Case 1. All Atoms Alike

Symmetry, cubic-tetrahedral in some respects, but holohedral by compensation.

Representatives, diamond,[1] C; silicon,[2] Si.

Case 2. Two Kinds of Atoms Present

Arrangement, alternate points in the diagram occupied by different atoms.

Symmetry, cubic-tetrahedral.

Representatives, sphalerite,[1] ZnS; no doubt other members of sphalerite group.

Case 3. Three or More Kinds of Atoms Present

Arrangement, calling the different atoms Nos. 1, 2, and 3, and reading from top layer downwards: 1, 2, 3, 2, 1. For instance, in chalcopyrite, Cu is 1, S is

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[1] W. H. and W. L. Bragg, *X-rays and crystal structure*, 1915.

[2] See abstracts below.

[3] E. Q. Adams, *J. Wash Acad. Sci.*, **3**, 240, 1918.

The same notes apply to subsequent pages.

2, and Fe is 3, alternate layers vertically consisting exclusively of each kind in turn. Symmetry, tetragonal-sphenoidal (scalenohedral).

Representatives, chalcopyrite,[2] $CuFeS_2$; probably stannite,[3] Cu_2FeSnS_4.

CASE 4. ALL ATOMS ALIKE, BUT VALENCE MORE THAN 4

Arrangement, two valences extend toward one cube corner, causing elongation in that direction.

Symmetry, hexagonal-trigonal, rhombohedral.

Representatives, antimony,[1] Sb; bismuth,[1] Bi; probably also arsenic, As, and tellurium, Te.

2. THE SIMPLE CUBIC LATTICE

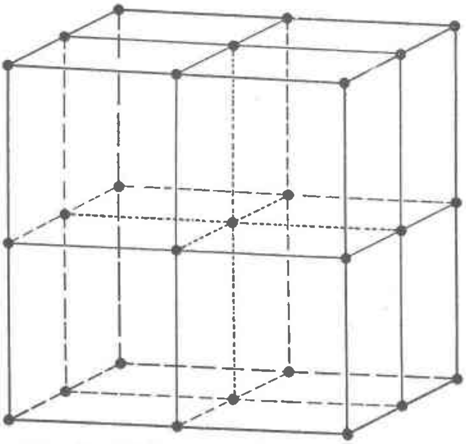

FIG. 3. Eight-atom cell of simple cubic lattice; valence of atoms 6, in directions shown by dotted lines around central one.

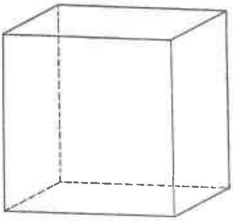

FIG. 4. Shape of each atom (when all are equal in size).

CASE 1. ATOMS ALL EQUAL IN SIZE

Symmetry, cubic-holohedral.

Representatives, halite[1] NaCl; galena,[1] PbS; no doubt other members of galena group.

CASE 2. ATOMS OF TWO SIZES PRESENT

Symmetry, cubic-gyroidal (plagihedral).

Representatives, sylvite,[1] KCl; potassium bromide,[1] KBr; probably other halides.

Note: The valence of 6 exhibited in this structure is not necessarily the usual chemical valence of the elements in question, but represents in part subsidiary or secondary valence, such as is indicated by the Werner coördination numbers.

3. THE BODY-CENTERED CUBIC LATTICE

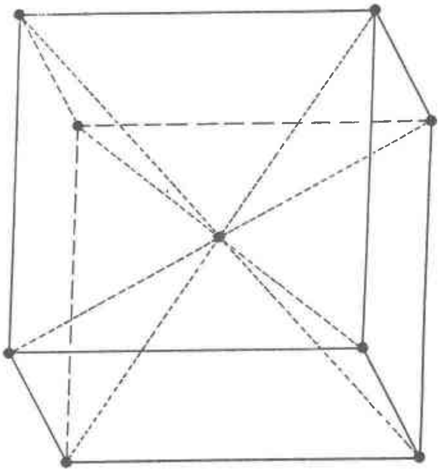

FIG. 5. Two-atom cell of body-centered cubic lattice; valence of atoms 8, in directions shown by dotted lines.

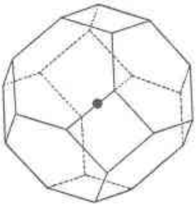

FIG. 6. Shape of each atom (when all are alike).

Case 1. Symmetry, cubic-holohedral.

Representatives, iron,[2] Fe; nickel (in part),[2] Ni; sodium,[2] Na; probably lithium,[2] Li; in the last two the valence of 8 is chiefly secondary valence.

4. THE FACE-CENTERED CUBIC LATTICE

Case 1. All atoms alike. Symmetry, cubic-holohedral.

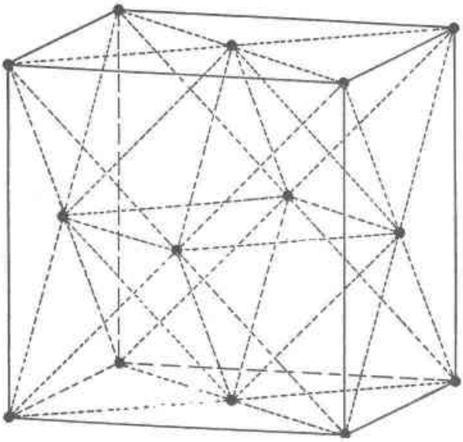

FIG. 7. Four-atom cell of face-centered cubic lattice; valence of atoms 12, in directions partly shown by dotted lines; four additional valences extend from each atom outward from the cell shown.

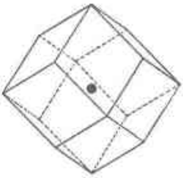

FIG. 8. Shape of each atom (when all are alike).

Representatives, copper,[1] Cu; silver,[2] Ag; gold,[2] Au; lead,[2] Pb; aluminium,[2] Al; nickel (in part),[2] Ni; and no doubt other elements.

5. COMBINATIONS OF DIFFERENT LATTICES

Case 1. Two atoms of one kind and one of another; former on a simple cubic lattice, interpenetrating symmetrically a face-centered cubic lattice containing the second kind of atom.

Symmetry, cubic-holohedral.

Representative, fluorite,[1] CaF_2.

Case 2. Like Case 1, except that the simple cube lattice is distorted.

Symmetry, cubic-pyritohedral.

Representatives, hauerite,[1] MnS_2; pyrite,[1] FeS_2 (in part; some pyrite shows tetartohedral features, and must come under case 3).

Case 3. Like case 2 except that the atoms on the simple cubic lattice are of two kinds.

Symmetry, cubic-tetartohedral.

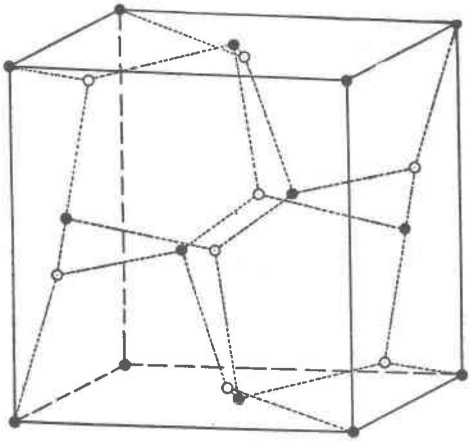

FIG. 9. Twelve-atom cell of face-centered lattice with interpenetrating distorted simple cubic lattice. Atoms on former lattice shown by dots, on latter by rings. Valence directions shown by dotted lines between unlike atoms; this type of valence amounts to 3 for each atom, but there may be additional valence between like atoms.

Representatives, cobaltite,[1] CoSAs; other members of cobaltite group; some pyrite must belong here, altho it is uncertain whether the two sulfur atoms are unlike or one of them is partially replaced by arsenic.

Case 4. Two atoms of one kind and one of another; former on body-centered cubic lattice, latter on interpenetrating distorted face-centered lattice.

Symmetry, cubic-gyroidal.

Representative, cuprite,[1] Cu_2O.

Additional Cases, for details see original papers.

Representatives, spinel, $MgAl_2O_4$; other members of spinel group; garnet;[1] calcite,[1] corundum,[1] zincite,[1] and other members of their respective groups.

CRYSTAL STRUCTURE—ABSTRACTS

PRESENTATION OF CRYSTALLOGRAPHY AS A MUSEUM EXHIBIT. HERBERT P. WHITLOCK. *Proc. Am. Ass. Museums*, 11, 36–39, 1917.

A description of an exhibit in the N. Y. State Museum at Albany, N. Y., entitled "The phenomena of crystallization," consisting of "the 14 principal groupings of crystal particles shown by models constructed of glass beads of different colors mounted on black wire rods with black bases, and disposed before a black background. As lighted, the particle groupings (space lattices) appear as tho suspended in space. Supplementary models constructed of cardboard, thin glass rods, and beads, and mineral specimens illustrating cleavage, symmetry and natural crystals, link the exhibits together. The series consists of sixty-one mounts occupying 37 feet of shelf space.

W. G. L.

SOAP BUBBLES AS MODELS OF CRYSTAL STRUCTURE. M. J. MARSHALL, McGill University. *J. Am. Chem. Soc.*, 39 (11), 2386–2387, 1917.

Bubbles produced on a soap solution can be used as models of crystal structure. Combinations of the bubbles form spontaneously in symmetrical patterns by the attraction existing between the bubbles, or they can be easily produced by moving the individual bubbles about by means of a glass rod. The models of soap bubbles are useful in helping the student to understand the causes of the existence of crystal structure. S. G. G.

CRYSTALLOGRAPHY, OLD AND NEW. F. RINNE. *Naturw. Rundsch.*, 4, 221–226, 233–239, 1916; abstract by E. B. MILLARD, reprinted by permission from *Chem. Abstr.*, 11 (10), 1351–1352, 1917.

Two popular papers extending the material in papers by Sommerfeld, emphasizing the crystallographic side. The development of the space lattice is given in detail from the work of Haüy to the latest work. Numerous crystal-structure diagrams are given.

THE ULTIMATE STRUCTURE OF CRYSTALS. F. RINNE. *Neues Jahrb. Min. Geol.* 1916, II, 47–108; thru *J. Chem. Soc.* 112, II, 266–267, 1917.

A theoretical discussion of the results of X-ray investigation. E. T. W.

CRYSTALLOGRAPHY AND ROENTGEN RAYS. M. VON LAUE. *Ber.* 50, 8–20, 1917; thru *J. Chem. Soc.* 112, II, 166, 1917.

A lecture describing the author's work on the space-lattices of crystals.

E. T. W.

THE SYMMETRY OF ROENTGEN-RAY CRYSTAL PATTERNS. M. VON LAUE. *Ann. Physik*, 50, 433–446, 1916; thru *Chem. Abstr.*, 11 (23), 3169–3170, 1917.

It is pointed out that in general only 11 of the 32 crystal classes can be recognized by X-ray examination. E. T. W.

THE DEFORMATION OF SPACE LATTICES THRU GLIDING. A. Johnsen. *Centr. Min. Geol.*, **1916**, 121–130; thru *Chem. Abstr.*, **11**, (14), 2081–2082, 1917.

The possible gliding planes are calculated for the space lattices of calcite, aragonite, diopside, millerite and a double barium-calcium chloride.
E. T. W.

TABLE OF SCHÖNFLIES' CUBIC SPACE-LATTICES. Paul Niggli. *Centr. Min. Geol.*, **1916**, 497–505; thru *J. Chem. Soc.*, **112**, II, 129, 1917.

Nine point systems are tabulated, and the crystals which exhibit them, as shown by X-ray studies, are discussed. E. T. W.

CRYSTALS AS MOLECULAR COMPOUNDS. Paul Pfeiffer. *Z. anorg. allgem. Chem.*, **97**, 161–174, 1916; thru *Chem. Abstr.*, **11** (5), 418, 1917.

The structures of crystals found by X-ray examination are thought to be in accord with the Werner theory of molecular configuration. The coördination number of sodium is 6, and NaCl crystals actually show Na_6Cl and $NaCl_6$ arrangements. Negative radicals, as SO_4 and CO_3, act as units in both the Werner structure and that demonstrated by X-rays. E. T. W.

CRYSTAL STEREOCHEMISTRY. F. Rinne. *Z. anorg. allgem. Chem.*, **96**, 317–352, 1916; thru *J. Chem. Soc.*, **112**, II, 18–19, 1917.

The structures shown to exist in crystals by the X-ray method are discussed, and it is concluded that the inference often drawn that there are no molecules in them is false. Groups which correspond to molecules, tho often different from the chemical molecules, can be recognized. E. T. W.

THE EXISTENCE, MAGNITUDE, AND DETERMINATION OF CRYSTAL MOLECULES. A. Fock. *Centr. Min. Geol.*, **1916**, 392–396; thru *Chem. Abstr.*, **11** (20), 2747, 1917.

It is urged that the view now widely accepted, that chemical molecules in general do not exist in crystals, is erroneous. Even tho X-ray study shows each sodium atom in the sodium chloride crystal to be surrounded by six chlorines, this in the opinion of the author does not prove that one chlorine is not directly combined with the sodium atom. Many phenomena, such as isomorphism, electrical conductivity, and the yielding of the same molecular weight by crystals as by solutions of the same substances, are thought to demonstrate the continued existence of molecules. E. T. W.

THE INTERPRETATION OF THE "ROENTGENOGRAM" AND ROENTGEN SPECTRA OF CRYSTALS. A. Smits and F. E. C. Scheffer. *Proc. Acad. Sci. Amsterdam*, **19**, 432–438, 1916; thru *Chem. Abstr.*, **11** (5), 418, 1917.

As the crystal structures shown by X-rays do not, in the opinion of the writers, accord with the chemical data as to valence, it is suggested that since the distances between atoms in the solid state are small compared to their diameters, the atoms belonging to the same molecule can be but slightly closer together than those belonging to different ones, and the difference can not be detected by X-rays. The structure of the chlorides deduced by Bragg is accordingly changed, so as to leave many vacant spaces. E. T. W.

ROENTGENOGRAPHY OF CRYSTALS. A. L. W. E. VAN DER VEEN. *Versl. Akad. Wet.*, **25**, 993–995, 1917; thru *Chem. Abstr.*, **11** (23), 3169.

This writer agrees with those referred to in the preceding abstract.
E. T. W.

CRYSTAL STRUCTURE AND CHEMICAL VALENCE. J. BECKENKAMP. *Centr. Min. Geol.*, **1917**, 97–110; thru *J. Chem. Soc.*, **112**, II, 296, 1917.

This author is another opponent of the view that molecules are lacking in crystals, and thinks that the ultimate structures of crystals are triclinic, but that, by submicroscopic twinning, systems of higher symmetry are produced. The X-ray study may then give merely the average positions of the atoms.
E. T. W.

RESULTS OF CRYSTAL ANALYSIS. L. VEGARD. Univ. Kristiania. All in *Phil. Mag.* [series 6], as follows:

1. SILVER. **31**, 83, 1915. Crystallized silver is found to give X-ray spectra corresponding to those of the face-centered cubic space-lattice.

2. GOLD, LEAD AND THE ZIRCON GROUP. **32**, 65–96, 1916. The space-lattices of gold and lead are identical with that of silver. Zircon, cassiterite, and rutile yield effects which are very complicated, but which seem to agree with a theoretical structure in which the metal atoms are arranged in a diamond-type lattice, with the oxygens on either side of them in sphenoidal arrangement. It is assumed that the space-lattice need not possess the symmetry of the crystal because the individual atoms are too minute to affect light waves.

3. XENOTIME AND ANATASE. **32**, 505–518, 1916. The first mineral seems to have alternating layers composed of yttrium atoms and PO_4 groups. Anatase (octahedrite in American nomenclature), appears to be made up of titanium atoms arranged in a diamond-type lattice with the oxygens ranged on either side of them in the direction of the vertical crystal axis.

4. AMMONIUM IODIDE, TETRAMETHYLAMMONIUM IODIDE AND XENOTIME. **33**, 395–428, 1917. The structures of the first two substances appear to be entirely different, indicating that their supposed morphotropic relationship does not exist. Previous results on xenotime prove to have been misleading, and its structure is now found to be essentially identical with that of zircon. It is, in the author's opinion, therefore not a phosphate but a combination of oxides. E. T. W.

X-RAY ANALYSIS OF THE CRYSTAL STRUCTURE OF RUTILE AND CASSITERITE. C. M. Williams. *Proc. Roy. Soc.* (A), **93**, 418–427, 1917.

Employing the Bragg methods of study the author finds these minerals to possess a structure which in the unit cells shows a sort of trapezohedral symmetry, but which by compensation becomes holohedral in the lattice as a whole. This fails to confirm the independent work of Vegard (abstracted above) which appeared to indicate the structure to be sphenoidal. E. T. W.

THE CRYSTAL STRUCTURE OF CHALCOPYRITE DETERMINED BY X-RAYS. Charles L. Burdick and James H. Ellis. *J. Am. Chem. Soc.*, **39** (12), 2518–2525, 1917.

A crystal from Falls of French Creek, Pa. was studied by X-rays, and the space lattice found to be composed vertically of alternating layers of copper and iron atoms in face-centered arrangement, the sulfur atoms occupying the centers of diagonally arranged intermediate cells. E. T. W.

THE CRYSTAL STRUCTURE OF A GARNET. S. Nishikawa. *Proc. Tokyo Math. Phys. Soc.*, [2] **9**, 194–197, 1917.

By X-ray examination the arrangement of the atoms in the garnet crystal is partially worked out. The trivalent metal atoms lie at the centers and corners of unit cubes, the other metals and silicon atoms in the faces of these cubes. E. T. W.

THE STRUCTURE OF THE NITRATES OF LEAD, BARIUM AND STRONTIUM. S. Nishikawa and K. Hudinuki. *Proc. Tokyo Math. Phys. Soc.* [2], **9**, 197, 1917.

The structure of these substances is found by X-ray examination to resemble that of pyrite, as determined by the Braggs. E. T. W.

A NEW METHOD OF X-RAY CRYSTAL ANALYSIS. A. W. Hull. *Phys. Review* [2], **10** (6), 661–696, 1917.

The substance is reduced to fine state of division, placed in a small glass tube, and rotated while subjected to a beam of X-rays. The diffracted rays are allowed to fall on photographic plates for some hours, and concentric bands are obtained, which represent X-rays reflected from all the important layers of atoms instead of from one at a time as in previous methods. The spacings to be expected with the different types of lattices are calculated and tabulated, and by studying the photographs from individual substances their lattices can as a rule be recognized at once. Iron proves to have a body-centered cubic lattice; silicon, a diamond lattice; aluminium, face-centered cubic; sodium and probably lithium, body-centered cubic, like iron; nickel gives different effects with different samples, and apparently may be either body-centered cubic like iron or again face-centered cubic like aluminium (and copper); two trigonal elements, magnesium and graphite, have also been studied, and complicated triangular prism lattices found to be present. The results with diamond agreed exactly with those of the Braggs, demonstrating the dependability of the method. E. T. W.

THE SYMMETRY OF THE ROENTGEN PATTERNS OF TETRAGONAL CRYSTALS. H. HAGA AND F. M. JAEGER. *Proc. Akad. Wetensch,,* **18**, 1350–1357, 1916; thru *Chem. Abstr.* **10** (16), 2069, 1916.

The prints obtained with many substances were normal, but scheelite and wulfenite gave abnormal increase of symmetry, which may be due to twinning. E. T. W.

ROENTGEN PATTERNS OF ISOMORPHOUS CRYSTALS. F. M. JAEGER AND H. HAGA. *Proc. Acad. Wetensch.*, **18**, 1357–1364, 1916; thru *Chem. Abstr.* **10** (16), 2069; 1916.

Isomorphous substances yield similar patterns, altho the relative intensities of the spots are often different. E. T. W.

ROENTGEN-RAY SPECTRA PRODUCED ON CURVED CRYSTAL FACES. P. CERMAK. *Physik. Z.*, **17**, 405–409 and 556, 1916; thru *Chem. Abstr.*, **11** (21), 2857–2858, 1917.

Some substances such as mica and gypsum when bent yield the same X-ray reflections as in the normal condition. Others, such as sodium chloride and stibnite, show breaking up of the usual spectrum lines, indicating actual rearrangement of the atoms. This is regarded as definite proof of the space-lattice conception and of Haüy's crystal units. E. T. W.

CONSTITUTION OF MIXED CRYSTALS. L. VEGARD and H. SCHJELDERUP. *Physik. Z.*, **18**, 93–96, 1917; thru *Science Abstr.*, **20A**, 300–301, 1917.

X-ray study of mixed crystals of KCl-KBr and KBr-NH_4 Br showed that no separate laminas of the different substances are present, as has usually been considered probable in mixed crystals, but that new configurations of the atoms are developed, the unit cells of the space-lattices changing in volume.
E. T. W.

THE STRUCTURE OF SIMPLE CRYSTALS OF THE SAME TYPE, AND THE INFLUENCE OF EXTERNAL FACTORS ON THE CRYSTAL STRUCTURE. PAUL NIGGLI. *Ber. k. Sachs. Ges. Wiss.* (Math-phys.), **67**, 364–395, 1916; thru *Chem. Abstr.*, **11** (11), 1586, 1917.

A theoretical study of mixed crystals of Fe_2O_3-$FeTiO_3$ and K_2SO_4-Rb_2SO_4.
E. T. W.

Previously published: Vol. **1**, 1; vol. **2**, 2.