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THE CAMBRIDGE CRYSTALLOGRAPHY.

A Treatise on Crystallography. By W. J. Lewis, M.A., Professor of Mineralogy in the University of Cambridge. Pp. xii + 612; 553 figures. (Cambridge: University Press, 1899.)

It is now more than sixty years since Prof. Miller, of Cambridge, published his famous "Treatise on Crystallography." At that time crystallography was a new science, and studied by few. Since that date it has entered into the educational programme of most universities, and at Cambridge is now (combined with mineralogy) a recognised Tripos subject, pursued by a considerable number of students.

Miller's successor, under whose hands the Cambridge School has developed its present activity, now issues a volume the substantial dimensions and weighty contents of which are worthy of a university publication; this volume and Maskelyne's "Morphology of Crystals" provide English students with a pair of adequate text-books on the geometry of crystals.

Prof. Lewis preserves in his book all Miller's results and methods; his treatment of the subject, however, resembles that of Maskelyne and other recent authors, in attaching primary importance to the subject of symmetry; the general relations of crystal symmetry are, in fact, briefly stated in the third chapter; although the mathematical development of these principles is reserved for Chapter ix. Chapters iv. to viii., being devoted to the law of rational indices, the relation of zones, the methods of drawing and projecting crystals, and the anharmonic ratio of four planes, are almost necessarily an exposition of the work of Miller, Mohs and Naumann.

It is to Chapter ix. that the critical student will first turn for possible novelty of treatment; here he will find a series of thirteen propositions establishing the nature, order, number and disposition of axes and planes of symmetry; a footnote on p. 119 gives for the first time the interesting information that the trigonometrical proof now familiar to all students is due to Prof. Story-Maskelyne, and was given by him in lectures in 1869, two years before the *publication* of Gadolin's classical memoir, in which a similar proof was independently employed. The author calls the reader's attention to the assumption that an axis of symmetry is parallel to a possible edge and perpendicular to a possible face of the crystal, and points out that this cannot be proved for a three-fold axis. The fact is commonly ignored, but does not affect the main object of the argument, which is to show that four-fold and six-fold axes are the only axes of symmetry of degree higher than three which are possible. Euler's theorem is then employed to show how axes of symmetry may be combined, and how two or more such axes involve the presence of others; and the number possible in a crystal is deduced from the expression for the area of a regular closed polygon on a sphere. At this point complaint may fairly be made of a serious omission, for the whole course of the argument in Chapter ix. prepares the reader to expect that the thirty-two classes of crystals are about to be established, whereas the following chapters which contain the detailed description of the various classes are not preceded by any proof that they alone are possible. A link is wanting in the logical sequence, and since the principle of merohedrism is expressly rejected (see p. 259), there remains no principle of development or classification to correlate the thirty-two classes.

The author, in his preface, expresses the opinion that the accurate drawing of crystals develops the student's power of solving crystallographic problems, and his book differs from other text-books above all in the attention paid to the construction of diagrams, and in the number of examples by which this subject is illustrated. An early chapter describes the methods of crystal drawing, including orthographic and clinographic projections, and they are constantly illustrated in the subsequent chapters. The greater portion, the systematic section of the book, consists of a detailed discussion of the various classes; each of these is treated in a very complete manner; formulæ and methods of calculation are established; numerous propositions concerning the elements of symmetry and their mutual relations are proved, many of them new; crystals of many substances are figured and described, and (a special feature of the book) a number of fully worked examples are given as exercises in computation and drawing; this affords opportunity for the description of several specimens in the University collection. Excellent also in its wealth of detail is the long chapter on twin crystals, which follows the systematic section, and here again each substance described is treated as an exercise in crystallographic determination, calculation and drawing. To gain an idea of the unusually elaborate, as well as practical, manner in which these various problems are treated, let the reader refer, for example, to the geometrical propositions concerning rhombohedral crystals on pp. 365-403, to the four pages relating to Gypsum in Chapter xii., and to the nine pages devoted to the twinning of Cassiterite in Chapter xviii.

In the systematic treatment of the thirty-two classes, the less symmetrical systems are treated first, an arrangement introduced by Groth in a non-mathematical treatise, but one which introduces the most difficult calculations at the outset; unfortunately also, the somewhat arbitrary sequence adopted in the present book does not bring the most symmetrical (holohedral) class to the end, or even to the same place, in each system.

It is really difficult to make an elementary treatise on geometrical crystallography a readable book. The principles of symmetry must be established by the aid of the zone law, so that propositions on indices and anharmonic ratios must precede the description of the crystals and their symmetry, and yet these propositions are scarcely intelligible without some knowledge of the crystals. Prof. Lewis makes no attempt to surmount this difficulty—and, in fact, recommends his reader to travel backwards and forwards rather than to read consecutively; but he succeeds in his main object of presenting the essential features of the science to a student who is not required to possess more than elementary mathematical knowledge, and gives him a handbook full of information, and illustrated by examples excellently chosen and ably elaborated.

A little adverse criticism may be devoted to the following points:—Proof should surely be given of the important problem (5) on p. 82, for which the reader is referred to works on spherical trigonometry, where he may not find it, or to Reusch's treatise on stereographic projection, which is probably not accessible to him; tetrahedral is a misleading name for the class to which sodium chlorate belongs; τ, being used to indicate tetartohedral classes (p. 149), should scarcely be applied to the trigonal bipyramidal class considered as belonging to the rhombohedral system; the nature of this class and of some others would be much simplified by the modern conception of the simultaneous action of an axis and plane known as "composite symmetry," as one of the general elements of crystal symmetry; this is only alluded to on p. 274, but its introduction as a mode of crystal symmetry would render possible a definition of the tetragonal system by means of its tetragonal axis instead of the somewhat awkward definition on p. 139. Similarly, the joint action of an axis and plane of *twinning* has to be taken into account to explain certain twins of sodium periodate mentioned on p. 359, and is overlooked in the discussion on p. 463. Most readers will find the argument on pp. 258-9 that the conception of merohedrism leads to inconsistencies far from convincing.

In describing the stereographic projection, it is really confusing to the student, and unnecessary, to speak of his eye as being situated on the surface of the sphere. Mention might have been made of the convenient device for crystal drawing described by Maskelyne, under the name crystallograph; and the method of finding the edge between two faces in a perspective drawing by reducing them to a common intercept on an axis, and finding their trace on the other two, might have been introduced into Chapter vi.

If the above be some defects of the book, many are the features in which it is superior to its predecessors.

Among new or specially instructive propositions may be noted the proof relating to tetrad axes on pp. 276-278, and the discussion of indices on pp. 288-295; the proof of the relation between a face and its inverse on p. 356; the propositions in the rhombohedral system relating to Millerian and Naumannian symbols, to indices referred to three and four axes, and to the drawing of the rhombohedron (p. 376). The useful proposition relating to a small circle (p. 83), and its application, are not generally found in text-books. Especially to be commended are the examples illustrative of the drawing of twin crystals. Among the new terms introduced, "stereogram" will doubtless be found serviceable. Finally, as evidence of the up-to-date character of the book, we may note the adoption of Cesaro's proof of the anharmonic ratio, the discussion of Wellsite, and the description of Mr. Smith's three-circle goniometer.

Owing to the author's desire to avoid analytical methods and spherical trigonometry, many of the proofs are somewhat tedious; but Chapter xix. contains analytical proofs and much suggestive material for the more mathematical reader, particularly some propositions relating to the rhombohedral system; *e.g.* the expression for the length of a trapezohedron edge (p. 578).

The book is an eloquent witness to the scientific method of the teaching which Prof. Lewis has carried on at Cambridge for nearly twenty years—teaching to which the present writer is glad to acknowledge his own indebtedness.

The author and the University Press may be congratulated on the completion of a treatise worthy of the subject and of the University. H. A. MIERS.

THE CORRESPONDENCE OF OLBERS AND GAUSS.

Wilhelm Olbers, sein Leben und seine Werke. Im Auftrage der Nachkommen herausgegeben von Dr. C. Schilling. Zweiter Band. Briefwechsel zwischen Olbers und Gauss, Erste Abtheilung. Pp. viii + 767. 8vo. (Berlin: Springer, 1900.)

THE first volume of this work, published in 1894 (NATURE, li. p. 74), contained the collected scientific papers of Olbers; the present one gives the first half (1802-19) of his correspondence with Gauss. These old letters will nearly all be read with great attention by any one interested in the history of astronomy during the early part of this century, as the two correspondents were equally devoted to theoretical and practical astronomy, and discussed new publications and new discoveries in all their bearings. Many readers will perhaps think with the reviewer that here and there some parts of the letters might with advantage have been omitted, and that the editor when leaving out ephemerides of comets and minor planets might have gone further, and have omitted many results of observations, &c., which have been published elsewhere.

The correspondence began in January 1802, when Olbers had just succeeded in recovering the lost planet Ceres by means of the elliptic elements calculated by the young mathematician Gauss by a new method devised by himself. The great sensation which Piazzi's discovery had produced was kept up for some years by the discovery of Pallas, Juno and Vesta, the first and last of these minor planets being found by Olbers, and Juno by Harding, so that (as Gauss remarks) of five planets found in the years 1781 to 1807, the four were found by natives of Hanover. The great respect in which the wonderful success of the computations of Gauss with regard to Ceres were held by astronomers, naturally led to his being left to compute orbits and ephemerides of all the four minor planets, and they consequently occupy a very large part of the letters for the first seven or eight years, until Gauss gradually handed over this work to his pupils. Among many interesting matters connected with the minor planets, which are touched on in the letters, we may mention Olbers' well-known hypothesis as to the origin of these bodies, which directly led him to the discovery of Vesta, also the annoyance of Bode at the discovery of a second planet between Mars and Jupiter, whereby his ideas about the harmony in the solar system were upset. That these new bodies were not followed with the same attention outside Germany is evident from the fact that Vidal, of