An authors' catalogue and subject index of mineralogical (including petrological and crystallographic) books and papers published in 1901 has been issued as one of the volumes of the International Catalogue of Scientific Literature. With the subject-key in four languages and a list of journals indexed, the volume extends to 208 pages. Owing to the difficulties of organizing the work, the index is very incomplete, there being only two parts of 'Groth's Zeitschrift' included, and none of the 'Centralblatt für Mineralogie, &c.,' or 'Tschermak's Mineralogische Mitteilungen'; on the other hand, German technical journals have been very fully dealt with. Economic literature, indeed, has been indexed much more fully than the scope originally intended for the catalogue would warrant, but this may possibly add to its usefulness. The topographical arrangement of both scientific and economic titles will certainly be found of use.

A complete and fully illustrated treatise on the regular intergrowth of minerals of different species is given by Professor O. Mügge in the 'Neues Jahrbuch für Mineralogie, &c.' (1903, Beil.-Bd. xvi, pp. 335–475, with 82 figs.). The labour of compilation must have been considerable, and have involved an exhaustive search of mineralogical literature, for the facts here brought together are in many cases mentioned only casually in papers. The tabular classification and index now given will greatly facilitate reference to the subject. Seventy-two well-established cases of regular intergrowth are described in detail, while many more receive mention. A general discussion of the subject is appended.

Another paper, covering much the same ground, was published a few months earlier (F. Wallerant, Bull. Soc. franç. Min., 1902, vol. xxv, pp. 180–222, with 26 figs.).

REVIEWS.

Mineralogy: an Introduction to the Scientific Study of Minerals. By Henry A. Miers, D.Sc., M.A., F.R.S. Pp. xviii + 584, with two coloured plates and 716 illustrations in the text. (London: Macmillan & Co., Ltd., 1902. Price 25*s.* net.)

Since the study of minerals must be conducted by means of their chemical, physical, and morphological characters, it follows that it can

only be successfully undertaken by those already tolerably grounded in the elements of chemistry, physics, and crystallography. The recognition of this fact has led to the preparation of numerous treatises possessing the common feature of an elaborate introduction in which the student is provided with all that it is considered necessary for him to know of cognate branches of science. Among the most widely circulated and successful of the attempts made in this direction the 'Text-Book of Mineralogy' by Professor E. S. Dana has taken an honourable place, and English-speaking students are now to be congratulated on the possession of another excellent handbook following much the same lines.

The work before us is divided into two parts of approximately equal length. The first hundred pages of Part I are devoted to the definition of a crystal and to the exposition of the fundamental laws of crystallography, and include a description of the characteristic properties of the thirty-two crystal sub-classes. The next hundred pages deal with the measurement of crystals and with their optical properties. The remaining chapters of Part I are occupied by an account of the chemical principles involved in mineral analysis, and include also a discussion of isomorphism, definitions of the terms, such as hardness, lustre, &c., used in describing minerals, and directions for performing simple chemical tests. Two appendices conclude this part of the book, and contain a synopsis of the thirty-two crystal sub-classes and a very brief outline of the theory of crystal structure.

In an elementary work of this kind no great originality of treatment is to be looked for, nor is indeed possible, when the author is dealing with branches of science in which the main tracks are already so clearly marked out, and when his aim, from the nature of the case, must be chiefly directed to securing as much compression as is consistent with clearness of exposition. Nevertheless, there are several features in this book which claim special attention. In the first place all crystallographers, however little they may be disposed to accept his suggestions, must feel grateful to Professor Miers for his efforts to reduce to order the names of the thirty-two crystal sub-classes. A system of nomenclature elaborated by the author in consultation with Professor Dana cannot fail to claim respect, if indeed it does not carry conviction to all, though doubtless there will be found some to regret the fusion of the rhombohedral with the hexagonal system. Another interesting and novel feature is the application of colour-photography to the delineation of the optical phenomena presented by crystal-sections. A glance at the two plates at the end of the book will cause the reader to regret that con-

siderations of expense prevented the wider application of the process. A third point worthy of attention is the completeness of the work. In it an account will be found, brief it may be, of all the essential properties of crystals. This feature is at once both the strength of the book and also a source of weakness, for it is inevitable that obscurities must occur when subjects which might fitly demand a treatise in themselves are dealt with in the course of a hundred pages. Thus the chapter on optics will be found difficult reading by the elementary student; it seems indeed doubtful if the most attentive perusal will give him accurate ideas as to the polarization produced when light is reflected and refracted by a plate of glass, or as to the cause of the colour-phenomena exhibited by thin crystal-plates viewed in parallel white light between crossed nicols.

While in Part I Professor Miers has achieved all the success that the difficulty of his task permitted, it is in Part II, which deals with descriptive mineralogy, that we find the freshness of treatment which differentiates this book from all others of its class. Too often descriptive mineralogy is treated as a catalogue of the driest facts presented in bewildering number to the eye of the disheartened learner, who is speedily wearied and finally repelled. Professor Miers has chosen a more excellent way. He concentrates the beginner's attention on one or two of the more important and characteristic occurrences of each mineral species, and brings them vividly before his eye, not merely in the shape of the ideal figures of the crystallographer, but also by means of the admirable series of sketches drawn from actual specimens which we owe to the skilful pencil of Miss J. Miers. Where all are so good it is difficult to single out any for special praise, but attention may be called to the drawings of cassiterite and of microcline (pages 361 and 460). A comparison of these pictures with the photographs of calcite, on pages 397 and 398, will speedily convince the most sceptical that there are regions in which the camera cannot compete with the seeing eye and the well-trained hand. No attempt has been made to deal in detail with the rarer minerals, but they are duly inserted in the most valuable tables, last in place but by no means in importance, with which the book concludes. Here we find the minerals arranged according to their chemical composition, and also in order of their refractive indices, birefringences, optic axial angles, and specific gravities. The printer has done his part admirably; there is an excellent index, and the appearance of the book leaves nothing to be desired. It will be found invaluable by teacher and student alike.

The Diamond Mines of South Africa: some account of their rise and development. By Gardner F. Williams, M.A., General Manager of the De Beers Consolidated Mines, Ltd. Pp. xviii + 681. Royal 8vo. (New York: The Macmillan Company; London: Macmillan & Co., Ltd., 1902. Price £2 2*s.* = $10.00 net.)

THIS handsomely got up and profusely illustrated volume contains much that will be of interest to the general public, and being written by the General Manager of the De Beers Consolidated Mines, may be regarded as authoritative when dealing with the operations of this influential Company. Much, however, of the matter contained in the book, though interesting in itself, has little or no direct bearing on the subject indicated in the title. On the other hand, very little is said of those diamond mines of South Africa not directly controlled by the De Beers Company, some indeed being not even mentioned.

The first 119 pages are devoted to a general discourse on the diamond, its mention in ancient writings, the stories associated with famous stones, the discovery and opening up of South Africa, and finally the finding of diamond there in 1867. Then follow graphic accounts of the diggings on the Vaal River and the early workings at Kimberley. A very full and detailed description, based largely on the author's personal observations, is given of the later workings, both open and underground, in the De Beers and Kimberley mines, and of the methods employed in extracting the diamond from its matrix. The book concludes, as it began, with 120 pages or so of more or less irrelevant matter dealing with the cutting of diamond, the opening up of the gold-fields of South Africa, and the siege of Kimberley in the late Boer war.

Practically all the volume contains of special mineralogical interest is confined to the chapter on the formation of the diamond. The author holds the view that the diamond-bearing 'blue-ground' is of aqueous rather than of igneous origin, and was erupted into the pipes by mud volcanoes, a view which is supported by the fact that the shales surrounding the pipes and caught up by the 'blue-ground' have not been in the least altered. As to the origin of the diamond, he favours no particular theory, but raises objections to all that have been brought forward, including that which supposes the diamond to have crystallized from a basic silicate-magma, and which has been proved to be practically possible by the experiments of Friedländer (1898), experiments, however, which receive no mention in the book. The author's chief objection to the view just mentioned seems to be based on Luzi's observation that

crystals of diamond are corroded by molten 'blue-ground.' It might be equally well urged that crystals of salt, being corroded by water, are therefore incapable of separating out from an aqueous solution. It is, however, a notable fact that diamond has never been found enclosed in olivine or in any other mineral, and the intimate association or intergrowth of diamond with other minerals appears to be of extremely rare occurrence. In this connexion a case is here recorded of a diamond enclosing a small octahedron of diamond and some white plates of apophyllite.

The mineralogical information is on the whole unsatisfactory, and contains many minor inaccuracies: for example, the figures of diamond crystals, on p. 534. The technical side relating to the methods of mining and washing might also have been much more complete. The book is popular in style, and its most striking feature is the wealth of illustrations, which include several excellent photogravures. These, however, are not arranged with regard to the accompanying text, and in some cases have no reference to it whatever. Several ancient maps of the African continent are given, and a plan of the De Beers group of mines at Kimberley, but no map to illustrate the distribution of diamond in South Africa.

Mathematical Crystallography and the Theory of Groups of Movements. By Harold Hilton, M.A. Pp. xii + 262, with 188 figures in the text. (Oxford: at the Clarendon Press, 1903. Price 14*s.* net.)

THE British Association Report on 'The Structure of Crystals' (1901) gives a full historical account of the development of the geometrical theory; but such a survey is necessarily lacking in detailed reasoning. The gap is now filled by Mr. Hilton's admirable book. Its scope is perhaps more accurately indicated by the subsidiary than by the main title, since it is almost wholly concerned with the symmetry and structure of crystals. Although in his preface the author modestly disclaims any originality, and points out that in Part II (and to some extent, we may remark, in Part I also) he follows the lines of Schönflies's 'Krystallsysteme und Krystallstructur,' adopting here and there features from the writings of Barlow, Jordan, and Fedorow, the book is by no means a slavish copy of the original. A great improvement is effected by the excellent diagrams of the space-groups, which have been independently drawn on the methods suggested by Fedorow. The absence of such diagrams in Schönflies's book undoubtedly adds greatly to the difficulty of following his reasoning. Mr. Hilton might with advantage have pointed out that underlying each of the 230 groups there is, besides the

lattice, a Sohncke-system. Many readers, who have had no previous acquaintance with the theory of groups, might find this (Barlow's) method the easiest way of approaching the subject.

Part I is mainly occupied with the derivation of the thirty-two point-groups, which obey the law of rational indices and are therefore alone applicable to crystals. It also contains an interesting chapter on the growth of crystals. It seems indeed probable that it is by means of observations on growing crystals that the elusive clue to the problem of the connexion between crystal form and chemical composition will eventually be found. The sequence adopted in Part II is precisely that of Schönflies: after establishing the fourteen lattices, Mr. Hilton discusses the properties of geometrical operations, and proves the fundamental proposition that each space-group is isomorphous with one of the thirty-two point-groups and all the operations of the point-group are symmetry-operations of some space-lattice. The systematic application of this property determines the 230 groups. Towards the end of the book is a discussion of the partitioning of space and of Schönflies's elementary cell. Mr. Hilton has indeed handled with ease and skill a subject which, like all dealing with three dimensions, is with difficulty rendered intelligible. We must not omit a word of commendation to the Delegates of the Press for their enterprise in publishing a book which can appeal only to a limited few, and for the excellent way in which the printing has been executed.

Ueber Harmonie und Complication. Von Dr. Victor Goldschmidt. Pp. iv + 136, with 28 figures in the text. (Berlin: Julius Springer, 1901.)

PERHAPS the most marked feature of recent development of science is the tendency to remove the artificial barriers between the various branches and the merging of the one into the other at their mutual boundaries. Any attempt to co-ordinate the principles underlying the different subjects cannot fail to be of interest, even if not convincing. At first sight it might indeed appear absurd to imagine any possible connexion between subjects so different as crystallography, music, and spectrum analysis; nevertheless a perusal of Professor Goldschmidt's book will convince the careful reader that the co-ordination which he traces is not to be idly dismissed.

Professor Goldschmidt's name is well known to crystallographers. For some years past he has published in the 'Zeits. für Kryst. und Min.' papers dealing with the law of complication, as he interprets Haüy's

crystalline law, in the course of which he shows that the symbols which may be assigned to crystal faces fall into certain groups. This law forms the basis of the present work and is explained in the opening pages. We will quote the following table :—

Primary faces :	A						B	=	Normal row 0.
N_0 =	0						∞		
1 complication :	A			C			B	=	Normal row 1.
N_1 =	0			1			∞		
2 complication :	A		D	C		E	B	=	Normal row 2.
N_2 =	0		$\frac{1}{2}$	1		2	∞		
3 complication :	A	F	D	G	C	H	E I B	=	Normal row 3.
N_3 =	0	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$	1	$\frac{3}{2}$	2 3 ∞		

A, B, C, &c., represent faces lying in the same zone, and the numbers underneath each represent the corresponding indices, which have been arithmetically transformed so as to make the extremes 0 and ∞ instead of, as usual, 0 and 1. Professor Goldschmidt asserts that, if A, B, and C are properly selected, we obtain a series of groups [DE], [FGHI], &c. The faces become rarer as the symbol increases in complexity, and those in each group are likely to appear together. Each of the rows is derived from the preceding in precisely the same way. Thus 0 1 ∞ can be transformed into 0 $\frac{1}{2}$ 1 and 1 2 ∞. The indices of commonly occurring faces rarely exceed those given by the third complication.

Similar series may be obtained from the pitch numbers of the notes constituting a musical scale. Thus in the case of the major scale of C we have :—

c	*d*	*e*	*f*	*g*	*a*	*b*	$\bar{c}$
1	$\frac{9}{8}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{15}{8}$	2
0	$\frac{1}{7}$	$\frac{1}{3}$	$\frac{1}{2}$	1	2	7	∞

where the last row is obtained from the preceding by arithmetical transformation. Two notes, *d* and *b*, have numbers higher than those given by the third complication. These must be excluded because, as the author very plausibly remarks, they really belong to the chord of the dominant, *g*, being respectively the fifth and the third. The third complication gives the following scale :—

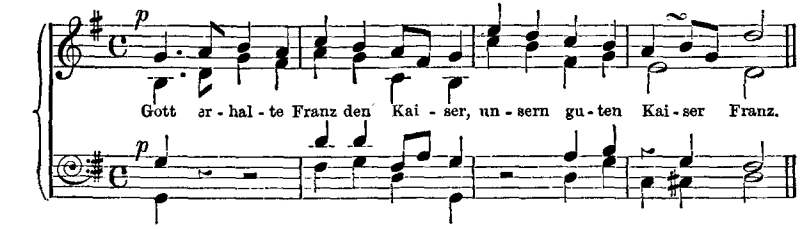
c	*e*	*f*	*f*♯	*g*	*a*♭	*a*	*b*♭	$\bar{c}$
1	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{7}{5}$	$\frac{3}{2}$	$\frac{8}{5}$	$\frac{5}{3}$	$\frac{7}{4}$	2
0	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$	1	$\frac{3}{2}$	2	3	∞

b♭ forms the modulation to the chord of the sub-dominant and is of

great importance in the key of C. The remaining pair are not of such frequent occurrence. The author remarks that often in crystals and in colour phenomena the development lies between two normal rows. It is a remarkable discovery that the minor scale is, so to speak, the reflection of the major; thus we have:—

Rising harmony, major scale:	c	e	f	g	a	$\bar{c}$
	0	$\frac{1}{3}$	$\frac{1}{2}$	1	2	∞
Falling harmony, minor scale:	$\bar{c}$	$a\flat$	g	f	$e\flat$	c
	0	$\frac{\bar{1}}{3}$	$\frac{\bar{1}}{2}$	$\bar{1}$	$\bar{2}$	$\overline{\infty}$

The development from other ground-tones selected from the scale is discussed and the resulting tones are compared with those belonging to the original scale. Equal temperament is touched upon and its justification pointed out. Certain examples of classical music are studied in detail. As an instance of his method, we quote his analysis of Haydn's well-known hymn:—



Gott	er-	hal-	te	Franz	den	Kai	-	ser,	un-sern	gu-ten		Kai -	ser		Franz.
g	a	b	a	c	b	a		$f\sharp$ g	e	d	c	b	a	b	g d
b	d	g	$f\sharp$	a	g	c		c b	c	b	$f\sharp$	g	e	e	e d
g	..	..	..	d	d	$f\sharp$		a g	..	..	a	b	..	g	g $f\sharp$
g	..	..	..	$f\sharp$	g	d		d g	..	..	d	g	c	$c\sharp$	$c\sharp$ d
0 $\frac{1}{3}$	01	0 $\frac{1}{3}$	$\frac{1}{3}$ 1	0 $\frac{1}{3}$ 1 3	0 $\frac{1}{3}$ 1	0 $\frac{1}{3}$ 1 3		0 $\frac{1}{3}$ 1 3 $\frac{1}{3}$	0 $\frac{1}{3}$ $\frac{1}{3}$ 1	0 $\frac{1}{3}$ 1 3	0 $\frac{1}{3}$		0 $\frac{1}{3}$ 2	0 $\frac{1}{3}$ $\frac{2}{3}$ 2	0 $\frac{1}{3}$ $\frac{2}{3}$ 2 0 $\frac{1}{3}$
g	d	g	d	d	g	d		d g	c	g	d	g	c	g	g d
				g	d							g	c	d	
				0	1							0	$\frac{1}{2}$	1	
								g							

Thus it will be seen that no numbers occur exceeding those given by the third complication.

In the next chapter will be found an interesting discussion of the physiological and psychological grounds for the harmony of tones.

Helmholtz was of opinion that Corti's organ renders possible the discrimination of sounds; but, as Professor Goldschmidt points out, it is difficult to account in this way for the almost infinite gradations of tone that are appreciable by an educated ear. He himself thinks that the tympanum plays an important part. The appreciation of musical sounds, as apart from noise, depends on the brain; that there is some connexion is shown by the fact that we can think and dream of tones.

An exceedingly interesting chapter is that dealing with the harmony of colours. The author shows that the wave-lengths of the principal Fraunhofer lines, with the exception of G, agree with the third complication, and that the same is true of the hydrogen lines. The occurrence of the octave in the lines of the spectra of the elements has frequently been observed; the idea that they form an harmonious series is suggestive and worthy of further study. The author discusses fully the various theories of colour vision, especially that of Young and Helmholtz. The exhaustive history of the development of colour vision testifies to his painstaking research. Recent work among the primitive races still existing confirms the correctness of his view, that in early days man possessed little discrimination of colour.

The book closes with a discussion of other evidence of the law in nature, such as is given, for instance, by the characters of organisms, by the systems of numbers, by the monetary systems, and so on. It is however impossible within the limits of a review to enter into these in detail.

Professor Goldschmidt may be congratulated on the production of a thoughtful and philosophical work. Ranging, as it does, over such a diversity of subjects, it is indeed a formidable task to be attempted single-handed. Whether the views expressed are correct or not, it is in the present state of our knowledge perhaps impossible to decide. There can, however, be no doubt as to the value of such a book in calling attention to, and throwing light on, the possibility of the co-ordination of fundamental principles.
