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BOOK REVIEWS

NATURAL ZEOLITES. By G. Gottardi and E. Galli. Springer-Verlag, New York, 1985, 409 pages. $59.00 (U.S.).

The book entitled "Natural Zeolites" is the 18th volume in the Springer-Verlag series on Minerals and Rocks. It is a good overview of the study of natural zeolites from the 1800s to the 1980s, with almost 1000 references. In this alone, it is a notable volume because the literature on zeolites is widely dispersed among both mineralogy and chemistry journals. Furthermore, much of the detailed crystallographic study of zeolites has been published in other than English journals. This book contains 250 references to such literature which might be otherwise missed by the casual reader of zeolite literature.

The first chapter, numbered zero, contains general chemical and historical information on zeolites. It introduces a partially new classification scheme for the mineral group based on framework topology. Numerous illustrations clarify the zeolite structures. Each subsequent chapter is devoted to one of the six topological classes, with a seventh chapter covering zeolites of unknown structure. Within each chapter, the mineral members of the respective topological class are treated under the following subheadings: 1) history and nomenclature; 2) crystallography; 3) chemistry and synthesis; 4) optical and other physical properties; 5) thermal and other physicochemical properties; 6) occurrences and genesis; 7) uses and applications.

This structuring lends itself to the book's emphasis on crystallography and reflects the authors' research interests. It is, however, not as satisfactory for their discussion of petrological studies and mineral genesis, for which mineral assemblages may be more significant than individual minerals. A general section on zeolite paragenesis might be preferable to a distribution of the discussion over sections on individual minerals. However, as the authors state in their preface, it is difficult to meet every requirement when covering as interdisciplinary a subject as mineralogy. The book admirably faces this problem by at least highlighting the diverse aspects of mineralogy and thereby serves as a useful guide to the zeolite literature.

Scanning electron photomicrographs are used effectively to illustrate crystal habits and augment the accompanying block diagrams.

There are two appendices. The first contains a convenient collection (42) of X-ray powder patterns, some of which represent new data from the authors. The second appendix contains 8 infrared-absorption spectra for the fibrous zeolites that the authors have found useful for their identification.

There are only a few books on natural zeolites with which to compare this volume and, as stated in the preface, this is one of the reasons it was written. It definitely fills a niche in that other publications on natural zeolites are predominantly collections of papers by various authors presented as short-course notes or as proceedings of the international zeolite conferences. Many other books on zeolites are written by industrial chemists and do not specifically treat natural zeolites.

This book would make a worthwhile addition to a specialist's library or to that of anyone interested in zeolites. It is most comprehensive in its coverage of zeolite crystallography, but also provides a well-referenced overview of other aspects of a fascinating group of minerals.

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RING COMPLEX GRANITES AND ANOROGENIC MAGMATISM. By Bernard Bonin, Elsevier, New York, 1986. 188 pages, $46.00 (U.S.).

Bernard Bonin has studied the ring complexes of Corsica for the past 15 years. This volume summarizes this extensive work, and briefly compares Corsican examples to a selection of anorogenic complexes from other parts of the world. The treatment is divided into five chapters as follows: (1) an interesting, but somewhat dated account of the structure and mode of emplacement of ring complexes, (2) mineral compositions and textures, (3) geochemical data bearing on magmatic evolution and postmagmatic processes, (4) a discussion of the origin and evolution of anorogenic alkaline magmatism, (5) a brief review of conclusions. As a summary of the beautifully exposed Corsican complexes, this book has value, but as a general study of anorogenic granites it suffers from serious drawbacks. Only one small (5 × 10 cm) map of Corsica is given, which is totally inadequate, and does not show the many place names used in the text. Line drawings of the individual occurrences are not very useful. Outside of Corsica the scope of complexes treated is erratic, and by no means complete. Passing mention is made of the Gardar province, which in the reviewer's opinion belongs to a different kindred altogether. The terminology will make even the hardened members of the alkaline rock clan reach for their glossaries (malgachite, llanite, lindinosite, for example), and there is not even a ritual nod to the IUGS–Streckeisen terminology. No full chemical analyses are given, either whole rock or mineral, and some of the conventions used in deriving chemical diagrams are unusual (for example, amphiboles are said to be reduced to $Y+Z=13$, but data for grunerite, which cannot be reduced on this scheme, are plotted). There is little discussion of trace-element data (only Ba, Sr and Rb), and most readers will find the treatment of experimental data simplistic. I found some of the arguments difficult to follow because the data had not been drawn together. Prof. Bonin has not been well served by his interpreter. English problems range from minor (hyperalkaline instead of peralkaline), to annoying (precocious instead of early) to outright blunders (heavy positive anomaly instead of strong positive anomaly). The time required to translate doubtless explains the rather dated bibliography, which only goes up to about 1980. (The book originally appeared in French in 1982 as a bulletin of the BRGM, a more appropriate format than the present one.)

Despite these criticisms the book is of interest because of Bonin's strong advocacy of fractional crystallization and direct mantle derivation for anorogenic complexes. The journal literature at present tends to emphasize crustal involvement and mixing processes. Petrologists and others interested in granite genesis will find much to reflect on. Whether 188 pages of indifferently translated French is worth $46 U.S. is a question each potential reader will have to answer for himself.

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International Tables for Crystallography, Brief Teaching Edition of Volume A, Space-Group Symmetry (Theo Hahn, ed.), D. Reidel Co., Dordrecht, Boston, Lancaster, 1985. 120 pages, 9 by 12 inches, flexible cover. $8.50 (US).

We owe the book under review to the labors of the Editorial Committee of the IUCr (International Union of Crystallography) who, under the chairmanship of Theo Hahn, produced the large volume A of IT'83 [reviewed by J.T. Szymański, *Can. Mineral.* 22, 517-519, 1984]. The aim of the Brief Teaching Edition (BTE) is to help the student familiarize himself with the layout and contents of the larger one.

The first 57 pages are reproduced from Part I of IT'83; left out are Bertaut's 20 pages of synoptic tables of space-group symbols and the 17 plane groups, as are also all 138 pages of Part II. (Seven tantalizing titles on Symmetry are listed on p. vi.) [The title of BTE might have specified "Volume A, Part I, *pro parte*."] Twenty-four space groups out of the 230 have been selected for inclusion, and their descriptions on twenty-four double pages, with their exquisite line-drawings, have been faithfully reprinted. [The Editor's claim that they are the most frequently observed ones has been checked against an old statistical survey (Nowacki 1967); it proved to be essentially correct. $I2_13$, whose reported frequency was 3, may have slipped in by mistake instead of $P2_13$, frequency 71 (out of 8789). Five groups that were rare in 1967 may have gained ground since then. The sample is certainly representative].

The chief value of the book lies in its analytical presentation of the space groups, which remains as impressive today as it was in 1922, in Wyckoff's prototype of all ITs. Such a "teaching edition", however, is not a textbook; judged as such, it leaves much to be desired. Yet it should prove definitely useful to students. On the material side the standards of bookmaking are high, just like those of Volume A, and the price has been kept refreshingly low.

Many changes have rejuvenated the familiar IT'52 and its forerunner IT'35. Here is how the double-page description of a space group has been modified (mostly added to). Just below the top line, the space group of the Patterson function is added. Below the drawings, the asymmetric unit is described. The symmetry operations of the general Wyckoff position are numbered, and the numbers are repeated at the sites of the general position in the list of symmetry operations (left page). For example, in $P\bar{3}1m$: (7)$\bar{1}$ 0,0,0, (10)m x,x,z. On the right page, under 12 l 1 (7) $\bar{x},\bar{y},\bar{z}$, (10) y,x,z. (Inversion in centre (7) takes x,y,z to $\bar{x},\bar{y},\bar{z}$; reflection in mirror (10) takes x,y,z to y,x,z.) Line drawings have been redone in all systems, except *h* and *r*. A clever drawing, seen in $C2/c$, relates the lattice-mode orientations (*C*, *A*, *I*) to one another.

In the low-symmetry systems, the picture is shown in plan-and-two-elevations [made by someone who wanted to introduce the $a<b<c$ setting convention, now in conflict with the more usual $c<a<b$ (no great damage done: the two are related by a cylic permutation)]. Cubic drawings re-appear, after an absence of half a century, original in that the sphere is projected, not stereographically, but orthogonally. This novelty is shown in $Fm\bar{3}m$ and $Fd\bar{3}m$. On the right page, in the list of site co-ordinates, site symmetries are oriented with respect to the space-group symbol. In $P6_3/mmc$, for example, both sites *j* and *k* have symmetry *m*, oriented *m*.. and .*m* ., respectively.

Finally most of us will have a chance to learn more group theory in a novel addition to every group, *viz.* its maximal subgroups, either isomorphic of lowest index or nonisomorphic, *and* its minimal nonisomorphic supergroups. All have been calculated and tabulated in IT'83. [No mean feat!] In the preface the Editor divulges how to derive, from the first subgroup so listed in $I2_13$, all the sites of the general position in $I2_12_12_1$. He also hopefully encourages such "'playing' with space groups."

Any adverse criticisms that can be leveled at BTE will (in view of the unorthodox, if original, method of publication) also apply to volume A of IT'83. [As my name appears, on p. iii, as that of a member of the IUCr Commission on IT'83, and inasmuch as not all of my suggestions were adopted, I welcome the invitation to write this review, which can thus serve as a minority report. J.D.H.D.]

The Editor (BTE, p.10) explains that the present volume is an "extension and complete revision . . . of the two previous editions . . ." IT'35 and IT'52. He then proceeds (p. 10, top of col. 2) to justify his retaining the (so-called) "trigonal system" on the only ground that it was used in IT'52: "In this volume, as well as in IT'52, . . ." [A feeble argument!] Fortunately the next paragraph, a model of fair play, states the physical basis on which crystal systems *should* rest, *viz. the point symmetry of the lattice, e.g.,* $m\bar{3}m$ (c), $6/mmm$ (h), $\bar{3}m$ (r). This ". . . different subdivision . . . that is in use" goes back to Bravais (1850-51); it is in line with all the other crystal systems, where the holosymmetric point-group expresses the symmetry of the lattice. As there exists no trigonal lattice, there can be no trigonal system. See Metzger (1918) on Bravais's seven crystal systems.

Now consider the purely formal nature of the IT'52 definitions of the trigonal and hexagonal systems (BTE, p.10, col. 2): they are based on the nature of the principal axis, "3 or $\bar{3}$" = trigonal; "6 or $\bar{6}$" = hexagonal. Simplicity itself, eh? Yes, but . . . Before 1952, rotatory-reflection axis $\tilde{3} = 3/m$ was used instead of rotary-inversion axis $\bar{6}$, so that the two point groups $\bar{6}$ and $\bar{6}m2$, disguised as $3/m$ and $3/m\ m\ 2$, brought up to 7 the number of point groups in the trigonal system [see the 1955 edition of Encyclopaedia Britannica under CRYSTALLOGRAPHY, if you don't believe me; the article is signed L.J. Spencer, a prestigious name in mineralogy.] Schoenflies, one of the greatest mathematical crystallographers of all times, a few years before he correctly enumerated the 230 space groups, was led astray by the "trigonal system" and the use of rotoflection. Like Spencer, Schoenflies has $\bar{6}$ and $\bar{6}m2$ in *his* trigonal system, and he also places $\bar{3}$ and $\bar{3}\ 2/m$ in his hexagonal system (as $\tilde{6}$ and $\tilde{6}\ 2/m$). Forty years after Bravais and Delafosse clarified the concept of merohedry (*alias* merosymmetry), he ignores the relation between the point-group symmetry of a crystal and that of its lattice (Schoenflies visualizes seven crystal systems and eight holohedries, the eighth P_2 one being $\tilde{6}m2$, which he calls "trigonal holohedry"). He recognizes 3 as rhombohedral tetartohedry (in modern parlance, subgroup of index 4), but does not say that 3 is also the hexagonal ogdohedry. [In Hermann–Mauguin notation, the two cases are distinguished as "31 and 311", an illuminating distinction, which cannot be made in the 32 "crystal classes" and which the Brief Teaching Edition does not teach.]

The next item on which the student may stumble is Table 2.1.1 (BTE, p. 10), in which the 32 traditional point-groups of crystallography are listed in the order of increasing symmetry, from *a* (anorthic = triclinic) to *c* (cubic), and divided into six "families" (a word coined in IT'83 for the benefit of those who wish to retain the "trigonal system"). The "hexagonal family", which includes both hexagonal and rhombohedral systems of Bravais, is here subdivided into other "systems": "hexagonal" (7 point groups) and "trigonal" (5 point groups). [The latter comprises 18 space groups with an hexagonal lattice and 7 with a rhombohedral lattice.] Note symbol *hR* (row $\bar{3}$ of Table 2.1.1), applied to a lattice described by an *r* cell and parameters *a* and α. [Correct lattice symbol *rP* is taboo to IT'83.] This type of subdivision on the basis of the lattice does not appeal to IT'83, which attempts to split the "trigonal system" on the basis of the co-ordinate system. Two axial crosses are available; they are referred to as "hexagonal" and "rhombohedral" axes. Either set is permissible in every point group, and such a splitting, therefore, cannot work.

Most students who read BTE will already be familiar with *hR* = *rP,* though perhaps not with the corresponding *rH* = *hP.* [The explanation is given in section 4.3.5, which was left out of BTE: hence this remedial note.] Just as *a rhombohedral primitive lattice is described by an hexagonal triple cell* (extra nodes at ⅔, ⅓, ⅓ and ⅓, ⅔, ⅔), *an hexagonal primitive lattice can be described by a rhombohedral triple cell* (extra nodes at ⅓, ⅓, ⅓, and ⅔, ⅔, ⅔). It is obvious, therefore, that the choice of axes does not determine whether the lattice is *h* or *r* ; the lattice must be obtained by X-ray diffraction or by morphological inspection. The letter *H* in *rH* is used to designate the thirding of the body diagonal [111]of the rhombohedral cell. [IT'83 changed the *H* into a *D,* thereby forsaking the mnemonic symmetry of the two related equalities.] Another *H* thirding is that in *hH* = *hP*; the extra nodes are at ⅔, ⅓, 0 and ⅓ ⅔, 0. Only two Bravais lattice modes are involved: *rP* and *hP:* the triple cells do not define new modes.

Although the Editor of IT'83 and BTE is aware of the fact that *hR* is not a mode of the hexagonal lattice, he makes it look like one in Table 2.1.1, especially since the *rP* symbol has not been mentioned, not even as a synonym of *hR*!

The footnote to Table 2.1.1 explains that symbols framed by full lines indicate . . . "lattice point-symmetries". In the "trigonal system", $\bar{3}m$ is so framed: it is indeed *a* holohedry, but not *the* holohedry of the "trigonal system", which by definition cannot have any holohedry. The only system that has this holohedry, in that pigeon hole, is the rhombohedral system of Bravais. [The preceding two remarks reveal a *modus operandi* that smacks of "*leger de main*" as we say in English, or "*le petit coup de pouce*", as we say in French.]

The solution of the trigonal conundrum is simple: write down the point group to which every trigonal

TABLE OF HEXAGONAL AND RHOMBOHEDRAL SPACE GROUPS

Sch	H-M	HEXAGONAL SYSTEM 45 space groups	RHOMBOHEDRAL SYSTEM H-M	7 space groups
D_{6h}	$\mathbf{6/m\ m\ m}$	$^{1}P6/mmm$ $^{2}P6/mcc$ $^{3}P6_3/mcm$ $^{4}P6_3/mmc$		
D_{3h}	$\bar{6}\ 2\ m$	$^{3}P\bar{6}2m$ $^{4}P\bar{6}2c$		
	$\bar{6}\ m\ 2$	$^{1}P\bar{6}m2$ $^{2}P\bar{6}c2$		
C_{6v}	$6\ m\ m$	$^{1}P6mm$ $^{2}P6cc$ $^{3}P6_3cm$ $^{4}P6_3mc$		
D_6	$6\ 2\ 2$	$^{1}P622$ $^{2}P6_122$ $^{3}P6_522$ $^{4}P6_222$ $^{5}P6_422$ $^{6}P6_322$		
C_{6h}	$6/m\ 1\ 1$	$^{1}P6/m$ $^{2}P6_3/m$		
C_{3h}	$\bar{6}\ 1\ 1$	$^{1}P\bar{6}$		
C_6	$6\ 1\ 1$	$^{1}P6$ $^{2}P6_1$ $^{3}P6_5$ $^{4}P6_2$ $^{5}P6_4$ $^{6}P6_3$		
D_{3d}	$\bar{3}\ m\ 1$	$^{3}P\bar{3}m1$ $^{4}P\bar{3}c1$	$\mathbf{\bar{3}\ m}$	$^{5}R\bar{3}m$ $^{6}R\bar{3}c$
	$\bar{3}\ 1\ m$	$^{1}P\bar{3}1m$ $^{2}P\bar{3}1c$		
C_{3v}	$3\ m\ 1$	$^{1}P3m1$ $^{3}P3c1$	$3\ m$	$^{5}R3m$ $^{6}R3c$
	$3\ 1\ m$	$^{2}P31m$ $^{4}P31c$		
D_3	$3\ 2\ 1$	$^{2}P321$ $^{4}P3_121$ $^{6}P3_221$	$3\ 2$	$^{7}R32$
	$3\ 1\ 2$	$^{1}P312$ $^{3}P3_112$ $^{5}P3_212$		
C_{3i}	$\bar{3}\ 1\ 1$	$^{1}P\bar{3}11$	$\bar{3}\ 1$	$^{2}R\bar{3}1$
C_3	$3\ 1\ 1$	$^{1}P311$ $^{2}P3_1$ $^{3}P3_2$	$3\ 1$	$^{4}R31$

The supercript preceding the space-group symbol is the superscript of the Schoenflies symbol. This addition is only a space-saving device for the present table; it is *not* meant to be a permanent appendage to the H-M symbols.

space-group belongs; you find 5 point groups that are subgroups of $\bar{3}m$ (two kinds of symmetry directions) and eight that are subgroups of $6/mmm$ (three kinds of so-called *Blickrichtungen*). The first set of symbols have two items (or digits), down to $\bar{3}1$ and 31; the second set have three, down to $\bar{3}11$ and 311. [So much for the myth that point groups cannot serve to classify space groups!] But BTE considers these dummy ones at the end of a symbol superfluous.

It is deplorable that some people cannot leave "well enough" alone. IT'83 has perverted the neat Hermann-Mauguin symbolism by officially approving monoclinic symbols that violate its spirit. The unorthodox symbol *P*112, for instance, is presented as "the *full* H-M symbol" of *P*2, for monoclinic 2 taken as *c* (p. 14). The two dummy ones are said to indicate "two axial directions that are not symmetry directions of the lattice". [In fact, they should symbolize directions that *are* symmetry directions for the lattice, but not for the crystal, according to the original definition. They are useful as potential twin axes.]. Note that BTE teaches only the "*b* unique" convention. [Bravo!]

The reviewer begs to present the readers of *The Canadian Mineralogist* with an unpublished table that summarizes the facts of the "trigonal controversy" independently of co-ordinate systems. The crystal point-groups are listed according to decreasing symmetry; this sequence enables each system to start with its lattice symmetry (H-M symbol in bold face) [A holosymmetric crystal has the symmetry of its lattice; a merosymmetric one has *less* symmetry; all the merosymmetries are subgroups of the lattice symmetry.] The twelve Schoenflies point-group symbols in the table are shown in Schoenflies notation, next to their H-M symbols. The recognition of the *r* system increases the number of point-group entries from 12 to 17. The orientation splittings further increase it from 17 to 21; each additional entry is connected by a brace to the original symbol.

In H-M symbolism the letter *R* is used, instead of *P*, to designate a primitive lattice, in all the *r* space-group symbols. Historically it was a way of lifting the ambiguity that arose (without dummy ones) when $P\bar{3}$ became the H-M symbol for both C_{3i}^{1} and C_{3i}^{2} (and *P*3, for both C_3^1 and C_3^4). The crux of the matter is that one of them, $P\bar{3}11$, has an *h* lattice, whereas the other, $P\bar{3}1$, has an *r* lattice. (Likewise for *P*311 and *P*31). In the Table the *r* space-group symbols could all have been written with *P* instead of *R*, without any ambiguity. Although it is now too late to advocate reverting to *P*, note that the need for the letter *R* would not have arisen had Hermann and Mauguin chosen, as *Ueberbegriff*, the *seven lattice point-symmetries* rather than the *32 crystal point-symmetries*. Which is the more fundamental concept? The unnecessary substitution of *R* for *P* holds the answer to this very question, which divided the crystallographers, at the turn of the century, in a protracted polemic.

It is incredible that the Editor of IT'83 and BTE would still be trying to uphold the primacy of Hessel's 32 crystal classes of 1830, one hundred thirty-five years after Bravais, and seventy-three years after Laue and the birth of X-ray crystallography. He is perhaps atoning for the scientific sin of his forefathers, who failed to recognize Hessel's great contribution until Sohncke saved it from oblivion in 1891.

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