The Barker Index of Crystals, 1951-1964

The Barker Index of Crystals, vol. 3, *Crystals of the Anorthic System*, in two separately bound parts, pt. 1, Introduction and Tables; pt. 2, Crystal Descriptions A.1 to A.831 [and] Atlas of Configurations (Heffer, Cambridge, England, 1964. Unpaged, £12), edited by M. W. Porter and L. W. Codd, is referred to by one of the contributors as "this final anorthic volume" and brings to a conclusion the publication of *The Barker Index of Crystals*. Other reviewers in discussing the initial volume called it a "monumental work," and such it is. The first volume, in two parts, was published in 1951 and was reviewed in *Science* [**116**, 21 (1952]. Unfortunately the reviewer did not understand the scope or nature of the work for he stated that volume 1 covered "cubic, orthorhombic, tetragonal, hexagonal and trigonal" crystals. The aim of the index is to provide a scheme for the identification of crystals from their morphology by means of so-called "classification angles," characteristic for each substance, which are either measured or calculated from measured interfacial angles. For "cubic" crystals there can be no such characteristic angles, so these are necessarily excluded from the index. The second volume, in three separately bound parts, covering monoclinic crystals, was published in 1956.

The delay in the publication of this last volume arose largely from the difficulty in devising a scheme for obtaining the necessary classification angles for an anorthic (triclinic) crystal. This problem occupied crystallographers in Britain (Oxford) and the Netherlands (Groningen) for decades after T. V. Barker in his little book, *Systematic Crystallography* (1930), had proposed the task that led to the development of the index named after him. A single classification angle suffices for tetragonal, hexagonal, and trigonal crystals, whereas three are given for each orthorhombic crystal, five for monoclinic, and six for anorthic crystals. However, the "setting and orientation rules" that must be applied to obtain the classification angles require but half a page for statement for each of the tetragonal, hexagonal, and trigonal, or orthorhombic systems, a full page for the monoclinic system, and six and a half pages for the anorthic system. Moreover, the rules for the anorthic system are so complex and unwieldy that two further guides for the steps that are needed to find the Barker setting and orientation are provided—a "Table of Configurations," occupying 94 pages, and an "Atlas of Configurations," which shows "the 764 projectively distinct zonograms for crystals that are not overdeveloped." "Overdeveloped" is used in a special sense, as is "underdeveloped," and the definitions are such that "a crystal can thus be both underdeveloped and over-developed at the same time."

Part 1 of the present volume contains "An introduction to the application of the Barker method to anorthic crystals" (35 pp.) by M. H. Hey, of the British Museum of Natural History, who also contributed the "Introduction to the Barker index" in the first volume; "Notes on the use of the Bond matrix for calculating crystal angles" (5 pp.) by L. W. Codd who had contributed "An elementary explanation of the Barker index for non-crystallographers" to the first volume; and a 4-page account, "The Barker work in Groningen," by W. G. Perdok, which has great historical interest. In the rest of this part the familiar and very useful multiple tangent tables of Barker are reprinted; these are followed by a table entitled "Classification Angles of Anorthic Crystals" and the usual separate tables for refractive indices, densities, and melting points. A new feature is a table that gives the Bond matrices and their inverse matrices for all those substances for which complete axial elements are available. Matrices of this type were introduced nearly 20 years ago, by W. L. Bond, to facilitate the calculation of interfacial angles in crystals of low symmetry. This is the first example of their extended use, and with Codd's lucid explanation, it may be that they will become standard tools of the morphological crystallographer. Part 1 closes with the "Tables of Configurations" and three lists of chemical names. Part 2 contains the crystal descriptions, similar to those in earlier volumes, and the "Atlas of Configurations."

In his concluding paragraph, Perdok states that the aim of all of the collaborators has been "to get the Barker Index ready for practical use." In view of the difficulty of applying Barker's concepts to anorthic crystals, it is questionable whether the index is fully "practical" even now that the final volume has been published. However, there is another and far more serious hindrance to its usefulness as an aid in the identification of crystalline materials. *The Barker Index* covers 7394 substances. The second (1963) edition of Donnay's *Crystal Data* covers about 13,000 materials, and the X-Ray Powder Data File of the American Society for Testing and Materials covers an even larger number. Obviously the probability of finding a substance in *The Barker Index*, even if the scheme works perfectly, is far less than the probability of finding it in the other compilations.

The Barker Index is essentially a reworking of data compiled by Groth in his *Chemische Krystallographie*, completed in 1919. The first volume of the index included data for 137 substances (4.6 percent of its coverage) postdating Groth, mostly due to the inclusion of data for tetragonal substances collected by Donnay and Melon in 1934. The second volume included data for 125 substances (3.5 percent of its coverage) postdating Groth, mostly data for crystals that had been published by Mary W. Porter, the principal editor of the index. The present volume contains only seven references to the original literature. All other references are to Groth or other secondary sources, and data for only one substance postdate Groth.

This lack of coverage after Groth

might suggest that the publication of morphological data on new crystalline materials practically ceased after 1919. To be sure, it is no longer as common as it once was. However, a check of volumes 55 to 60 of the *Zeitschrift für Kristallographie*, covering the first 5 years after the completion of Groth's compilation, reveals 19 reports of axial elements for newly described anorthic crystals and hundreds of reports for other crystals, several contributed by such distinguished crystallographers as Jaeger, Zambonini, and Machatschki. A test of the coverage of *The Barker Index* was made by selecting a dozen synthetic crystalline materials with published descriptions, half organic and half inorganic, distributed among all of the systems other than the isometric. Of these only three are included in *The Barker Index*. They are described on the basis of data from 1838, 1862, and 1900, as quoted by Groth, although the data for one of these substances were shown to be faulty in 1934.

The preface includes this surprising statement: "It has not been possible to include some 20 anorthic minerals. It is hoped that there may be a mineral supplement to include these as well as new anorthic minerals and new minerals belonging to other crystal systems." Mineralogists are the only group that includes any substantial number of morphological crystallographers.

In the course of preparing previously published volumes of *The Barker Index*, many errors in axial elements or calculated interfacial angles in Groth were detected, in some cases determining the exclusion of material from the index. In preparing material for the present volume, computers were used extensively; this was essential for completion of the very tedious calculations for anorthic crystals. However, because original sources were not used and some of the data are very old, it is to be feared that much effort may have been spent on reworking inferior data. The purely routine procedures used to detect errors in computed angles or axial elements will not detect errors in experimental data.

C. W. Wolfe [*Am. Mineralogist* **37**, 875 (1952)] and J. D. H. Donnay [*Nature* **169**, 851 (1952)] in their thoughtful reviews of volume 1 of *The Barker Index* praised it highly. Wolfe wrote that "This work must go a long way toward convincing the chemical profession and others that crystallography is a tool without which they cannot afford to continue," and Donnay wrote that "As an authoritative source of crystal data it will soon become indispensable." It is with great regret that I must dissent from these opinions. Barker's system was intended to be an improvement of the scheme for identifying crystals from morphological measurements published in Russia by the great Fedorov in *Das Krystallreich* (1920), almost simultaneously with the completion of Groth's compilation. It has taken 45 years to carry out this improvement. Only a minute part of the data accumulated in the meantime have been included in *The Barker Index*. Improved techniques in microscopy and entirely new techniques in x-ray diffraction together with modern compilations of optical and x-ray data have become the bases of widely used methods for the identification of crystalline materials. *The Barker Index* might have become the important tool that Wolfe and Donnay hoped it would be, if it had appeared at least 50 years ago. Even at the time that it was being planned, the beginnings of the methods that were bound to supercede it should have been evident to discerning crystallographers. It is a crowning irony that only the use of modern computers has permitted the completion of this anachronistic and monumental work.

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Astrophysics: Summary and Discussion

Sunspots. R. J. Bray and R. E. Loughhead. Wiley, New York, 1965. xvi + 303 pp. Illus. $13.75.

Although the science of astrophysics may be said to have begun in 1611 with the first telescopic observations of sunspots by Galileo and others, our understanding of sunspots today is certainly not one of the proudest achievements of this discipline. Indeed, so poorly are they understood that, although they receive descriptive treatment in almost all texts on astrophysics, this new book by Bray and Loughhead is the first modern text devoted entirely to sunspots. It is a formidable task to bring some sense of order to a topic that, despite a wealth of observational data, lacks an established coherent theory. However, in my opinion, these authors have succeeded admirably in setting out the current state of the subject in a logical and ordered fashion.

After a historical introduction, they give an account of high resolution methods of observation. A detailed discussion of the morphology of individual sunspots precedes an assessment of the physical conditions in sunspots derived from optical observations. Observations of magnetic fields in sunspots are discussed in detail, and magnetohydrodynamic theories of sunspots and the solar cycle are treated in the concluding chapter. Although they recognize the prime importance of the magnetic field, the authors give little weight to some of the elaborate magnetic models of sunspots put forward by various authors on the basis of slight observational evidence and weighty physical assumptions. Indeed, the great merit of this treatment is the disciplined relation of the degree of detail in a mathematical theory to the accuracy of the observations on which they are based. Various highly speculative theories of the solar magnetic fields are given adequate discussion, without being invested with a spurious mathematical respectability.

The book is well set out and generously illustrated with a selection of some of the best observational material available, much of which has been obtained by the authors themselves. Although it will undoubtedly "date" more rapidly than texts on well-understood topics, the dating process will be hastened by the book's own achievement in stating the current situation clearly and concisely and by pointing the way to future development. Active workers in the field will find it invaluable, while the more general reader, who will undoubtedly skip the technical discussions, will find a very readable account of this fascinating subject.

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