

istry and phase equilibria of amphiboles hitherto, but improved techniques have led to a great increase in this kind of work in recent years.

The present volume deals in separate chapters with experimentally and theoretically derived phase relationships of the main amphibole sub-groups, and puts these in an appropriate setting by discussing in earlier chapters the crystal structures and chemical variability of amphiboles, and also by giving, for each sub-group, an account of the natural modes of occurrence of the minerals, the kinds of rock in which they occur, and the common mineral associations.

The crystal structures of the amphibole minerals are very effectively summarized, but perhaps undue weight is given to conclusions from single-projection structure determinations as compared with more recently completed full three-dimensional solutions. Unfortunately, a number of the latter are known to have been completed within the last few years but have so far only been published as abstracts of conference proceedings. Discussion of the ordering of cations (Fe, Mg, Al) in nearly equivalent sites is not as clear or as detailed as it might be. It is given in terms of ionic sizes only, and important crystal field effects are not mentioned at all.

The treatment of phase equilibrium relationships is extremely helpful to the reader. A good deal of the experimental work on amphiboles has in fact been done by Ernst and his co-workers within the last decade. Ernst discusses the way in which experimental results bear relation to natural occurrences of amphiboles in terms of temperature, pressure, oxidation potential, ranges of solid solution, and abundances of elements in different geological environments. He is perhaps unduly gloomy therefore in stating in the last paragraph of the book that 'because of the complex and subtle relationships between bulk compositions of the host rocks and amphibole compositions, very little can be said regarding amphibole parageneses in igneous and metamorphic rocks, in spite of painstaking studies by numerous investigators'.

This book and others in the series will undoubtedly be useful, as intended, to students and research workers who are interested in rocks and minerals, but the intention stated in the foreword '... to publish, at reasonable prices...', must be said to have been forgotten, ignored or revised. It is not uncommon for reviewers to feel that prices of books are high, but this one is unusually so. The price is not explained by an exceptionally lavish production; many of the figures, for example, are direct copies of varying quality from papers in journals.

A feature of this volume, which may not be typical of the series, is that in spite of a long reference list (comprehensive until early 1967), a rather high proportion of its content is available in a relatively small number of recently published papers.

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Hydrogen bonding in solids. By WALTER C. HAMILTON and JAMES A. IBERS. Pp. xv + 284. New York: Benjamin, 1968. Price \$ 13.95.

Every year it becomes more difficult to write a good scientific book. The crazy tempo of the accumulation of experi-

mental data, the continuous birth of new investigational methods, the rapid change in theoretical points of view and – perhaps the main thing – the unavoidable growth of several kinds of hybrid scientific topics – all this makes the problem of the successful selection of material and the scope and logical sequence of its exposition a matter of high scientific skill.

Surely there are subjects which do not require the author to make a choice between a lot of possible sections in a multidimensional space of science. This is so in the case of books about crystal symmetry, or the dynamics of material points, but such is not the case for a book dealing with hydrogen bonds.

Why hydrogen bonding in solids? Are the bonds in solids different in principle from bonds in the melt or in solution? Surely not. But the authors ingeniously give their book a secondary title – 'Methods of Molecular Structure Determination'. It is written with small letters but this is a mere formality since it is not customary to give a book such a long title. If we want to understand the principle of construction of the book, however, we must read the two titles together.

Our previous question – why in solids – was quite legitimate if one bears in mind the *nature* of bonding, but we agree with the authors that the methods of investigation of hydrogen bonding in solids are multifarious and there is some specificity which deserves attention and knowledge.

The second title is surely very important because the methods topic plays the First Fiddle in the book. The title reflecting most truly the book content is the following: 'The methods of determining the structure of solids which are appropriate to the investigation of hydrogen bonds and exposition of some results of these investigations'.

My opinion that the authors are more interested in methods than in results is based on the fact that there are very few pages in the book dedicated to the crystallography of hydrogen bonding. The results are given as an aggregate of abstracts. We find practically no attempt to give any classifications of bonds, based on their very interesting geometry. (The brief and naive discussion on pages 18–21 does not count.) Physical, not chemical, classification of the crystallographic data is badly needed, but unfortunately is lacking in the book. The anisotropy of physical properties caused by hydrogen bonding is also outside the scope of the book. All things which are done with love and with enjoyment are done well, therefore I find the first 160 pages of the book much more interesting than the last 100 pages, where the description of hydrogen bonds in organic substances is given.

I think that the first chapters, *i.e.* Chap. 2, 'Diffraction Methods'; Chap. 3, 'Spectroscopic and Diffraction Studies'; Chap. 4, 'Rotation Motion in Solids and Neutron Spectroscopy', make the Hamilton-Ibers book a very valuable contribution to the literature of physical methods of investigation of the structure of matter. These chapters are written with a perfect and deep understanding of a very important thing – the interrelation of different methods. The whale cannot be caught with a fishing rod and nobody goes trout fishing with a harpoon. We have very few books, if any, discussing the possibilities of different structure methods in the same book and with the same high competence.

Therefore the book is interesting not only to the scientist interested in hydrogen bonding but extremely useful to every member of the crystallographic family.

In Chapter 2 all concepts of diffraction methods are vividly and concisely described: the Bragg equation, the reciprocal lattice, the structure amplitude, the scattering density and the principles of structure determination. The next step is to discuss the scattering amplitudes in all three usable diffraction methods – X-ray, neutron and electron. After that the peculiarities of each diffraction method branch are treated briefly but all important things are stated clearly.

In this short exposition very valuable remarks are spread here and there about the physical meaningfulness of different techniques so often used somewhat blindly in different structure investigations.

Systematic errors in structure determinations are fully discussed in a special section. Perhaps a half page is lacking to warn the reader of unexpected trouble with which he can be faced if the crystal contains a comparatively small per cent of impurities. I cannot help repeating my opinion that the inner consistency of the structural result is sometimes more important than the R index. The 'clever' structure with R equalling say 0.11 is better than a 'silly' structure with $R=0.10$. The importance of introducing structural reasoning as an element of structure determination is, from my point of view, not claimed with sufficient firmness.

Chapter 3 introduces us to optical vibration spectroscopy. Perhaps it would be worth giving a little more place to the Urey–Bradley field. Spectroscopic manifestations of hydrogen bonding are described briefly and I think this is right bearing in mind the book of Pimentel & McClellan.

The sections dedicated to neutron magnetic resonance methods are to be highly welcomed. At the moment no one method (I ask the optical spectroscopists not to be angry with me) has a comparable value as a partner of the diffraction methods. The n.m.r. method, as is clearly shown in a special section of the book, is well suited to the determination of proton–proton (or F–F *etc.*) distances. In the next chapter it is shown that without n.m.r. techniques we have no means of investigating the reorientation movements of molecules and this is especially valuable as in many cases even we did not suspect the presence of such movements.

But let us return to Chapter 3. Here we get acquainted with potential functions used for describing hydrogen bonding. It is shown quite clearly that the potentials can be checked with different diffraction and spectroscopic experiments. Some examples of using both techniques are given at the end of Chapter 3. But the importance of the n.m.r. method is insufficiently stressed. One of the n.m.r. applications is buried in a section on diffraction and optical spectroscopy. The other (reorientation problem) is dealt with in the neutron spectroscopy section *en passant*.

So Chapter 4 is in the first instance an exposition of neutron inelastic scattering. I should be happier if this chapter occupied another 5–10 pages, at the expense of the last part of the book if necessary.

In Chapter 5 we find information about hydrogen-bonded organic and biological molecules; in Chapter 6 are discussed the hydrogen bonds in hydrates and other inorganic crystals. (Why 'other'? There are plenty of organic hydrates.) Chapter 7 is dedicated to the hydrogen bonded ferroelectrics. The last chapter (two pages) has a title – 'Outlook for the future'.

Summing up I can say that the Hamilton–Ibers book is certainly a happy occurrence. The reading of the method-

ical parts is surely stimulating. The pages where hydrogen-bonded structures are described give the reader a lot of useful information.

The book is illustrated with stereoscopic drawings. It is amusing and instructive to search for a three-dimensional view of the structure.

The references are voluminous. So, from all points of view the book is a good introduction not only to the hydrogen-bond problem but to the methods of crystal structure investigation.

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The physics of large deformation of crystalline solids. Springer tracts in natural philosophy Vol. 14. By J. F. BELL. Pp.viii+253. Berlin, Heidelberg, New York: Springer Verlag, 1968. Price DM 48, \$ 12.00.

From its title, crystallographers might expect this book to deal with crystal lattices and their imperfections; in fact, these are scarcely mentioned. It is actually a review of 'nearly 2000 individual uniaxial stress experiments in 19 crystalline elements and several binary combinations. The experiments include many different force-time histories and metallurgical states'. From these data a generalized large deformation behaviour is demonstrated.

It is shown that all of the nominal stress-strain curves have an equation of the form

$$\sigma^2 = \beta^2(\varepsilon - \varepsilon_b)$$

where σ and ε are respectively the stress and strain, and ε_b is the intercept of the parabola on the strain axis. β is given by the equation

$$\beta = (\frac{2}{3})^r \mu(0) B_0 (1 - T/T_m),$$

where $\mu(0)$ is the shear modulus of the isotropic material at absolute zero, T the absolute temperature of the experiment, T_m the melting point, and B_0 a universal constant. r is always an integer. Different segments of a given stress-strain curve will have different values of r and ε_b , but the strains at which the transitions between segments occur, form a series which is the same for all elements. It is further demonstrated that the value of $\mu(0)$ is always one of the series of values given by

$$\mu(0) = (\frac{2}{3})^{s/2} (\frac{2}{3})^{p/4} A$$

where s and p are integers and A is a universal constant. Changes in s and r are shown to be equivalent.

A research monograph of this type should meet two requirements: it should be understandable by the student with only a general background knowledge of the subject, without reference to the numerous papers which it should supersede, and it should convince the reader that it is more than curve fitting.

I feel the book does not fully meet the first requirement since the student would, in several places, be forced to consult the original papers. It is unfortunate that there is an annoying mixture of units, stresses being given some-