and limitations are explained. Counter methods are next discussed, and reference is made to the procedures for correcting intensity data for use in subsequent structure determination. The essential steps in solving a crystal structure are then set out, and the methods of refinement described. The aim throughout is to explain the procedure to be adopted by the practical crystallographer who does not want to be distracted by digressions into full background theory or the more specialized aspects of crystal structure determination. The style is clear and very readable, and one is conscious of being given the experimental 'know how' that can only come from an experienced crystallographer who has herself met all the practical difficulties and overcome them. The usefulness of the book as a crystallographers' 'workshop manual' is reinforced by a final chapter summarizing and assessing the advantages of the various techniques against the effort likely to be expended in applying them and the cost of the necessary equipment. An extension of the very brief one-page section on direct methods would have been an advantage in view of the prominence of these techniques in current research, but this is a minor criticism of what is on the whole a very well-balanced account.

The book can be warmly recommended to undergraduates or graduates who wish to learn quickly the elements of the subject in order to apply them in the course of a project or research. It is well produced, and the diagrams are clear. Comprehensive references are provided for those who wish to read further; and at £5·95 the paperback edition should be within the reach of most students even at the current depressed level of grants.

S. G. FLEET

Kerr (P. F.), *Optical Mineralogy* (fourth edition). New York (McGraw Hill Book Company), 1977. xvi + 492 pp., 427 figs. Price £16·90.

This is the latest edition of a textbook that has always been popular with students because it sets out in a well-arranged way the properties needed to identify minerals in thin section. It is in two parts, the first giving the principles of mineral optics and the second describing each mineral systematically. There are relatively few changes from the preceding edition, but instructors who may be tempted to prescribe the book for class use should be aware that it has many serious deficiencies.

The most obvious shortcomings arise from the failure to revise the new edition to take account of developments in the subject. For example the differences between high- and low-temperature feldspars seem to be only grudgingly recognized, and low-temperature plagioclases continue to be described as 'normal plagioclase'. The determinative curves for plagioclase based on 2V and the angle of the rhombic section are taken from publications of 1931 and 1919 respectively and completely ignore subsequent discoveries on the effects of variation in structural state. Albite is listed as optically positive with a 2V of 77° to 82°, which is only true of the low-temperature variety. Non-metric measurements continue to be used, such as miles per second on p. 55 and pounds per square inch on p. 430, and for monoclinic minerals β is usually quoted as an acute angle. A really bizarre entry is that of iddingsite, which although in reality a poorly characterized mixture is given a most detailed description that includes crystal system, refractive indices, 2V, cleavage directions, and pleochroic scheme. There is no explanation of the real nature of such materials as opal or limonite, even though they are much better understood than when the first edition of the book appeared. Some of the updating that has been done is of dubious value. The electron micrographs and phase diagrams do not contribute much to a handbook on optics, especially when liquidus temperatures are referred to as 'temperatures of formation' (p. 286).

Errors abound. Wrong chemical formulae are given for augite, biotite, chabazite, dumortierite, glauconite, heulandite, illite, phlogopite, staurolite, stilbite, and trona, Chabazite is wrongly described as monoclinic and erionite as orthorhombic, while the refractive indices quoted for the latter are much too high ($\sim$ 1·54 instead of $\sim$ 1·47). There is a general disregard of the principles of crystal chemistry. Formulae of minerals are sometimes quoted as though they were made up of separate molecules, e.g. kaolinite $Al_2O_3.2SiO_2.2H_2O$, while others are presented in a more modern form. The treatment of hydroxyl ions is capricious, and they are shown as (OH) in talc and chlorite, as H in prehnite, serpentines, axinite, chloritoid, stilpnomelane and lawsonite, and as H_2O in kaolinite, chamosite, and several others. In heulandite and stilbite, molecular water is written simply as H. Melilite is grouped with the tectosilicates, but glauconite is not classed either as a mica or a clay mineral. It is suggested that feldspathoids may be considered as 'silica-deficient feldspars'. In places, isomorphous substituents are written without a comma, e.g. $(KNa)AlSi_3O_8$ for microcline on p. 285.

There is a great deal of carelessness in the systematic descriptions, with students being led into pitfalls that should be guarded against. The interference colour of albite is described as 'pale yellow of the first order, about the same as quartz in the same section', with no reminder that this would be the *maximum* interference colour of a number of grains (and then only in a rather thick

section). This is immediately followed by the statement that the maximum extinction angle in albite twins varies from 12° to 19°. This is only true for sections cut perpendicular to (010), exactly the kind of mistake that students make when first using the Michel-Lévy method to determine feldspars. Another very misleading statement is that 'among the members of the tourmaline group schorlite shows the strongest absorption normal to the plane of the polarizer'. There is no explanation of anomalous interference colours.

The standard of production of the book is generally good, with the exception of the photomicrographs, most of which are out of focus and unrecognizable. There are various errors of spelling and indexing, and two figures (4-12 and 4-13a) have had their captions transposed. The interference colour chart is of very poor quality. The most useful part of the book is the short section of determinative tables in which minerals are classified according to their various optical properties.

A. HALL

Anthony (J. W.), Williams (S. A.), and Bideaux (R. A.). *Mineralogy of Arizona.* Tucson, Arizona (Univ. of Arizona Press), 1977. viii + 225 pp., 50 figs., 69 colour photos. Price $22·50 (cloth), $9·75 (paper).

After an introduction, this book opens with a series of all-too-brief verbal sketches on Arizona specialities, pride of place in this copper-mining state being given to minerals of the porphyry copper and related deposits, followed by the Colorado Plateau-type uranium and vanadium deposits. Descriptions of the mineralogy of the Mammoth-St. Anthony mine at Tiger and of the mines at Bisbee are intended to fill a gap in the mineralogical literature. Special reference is also made to the hydrated sulphate minerals formed by a mine fire in 1894 at the United Verde mine and there is a note on Arizona meteorites. But after that clearing of the throat, as it were, the remainder of the book is devoted to an alphabetically arranged catalogue of Arizona minerals—totalling over 600 species, 224 of them recognized since the 1959 edition of *Minerals of Arizona* by Galbraith and Brennan, and including 48 mineral species first described from Arizona. This listing is followed by an extensive bibliography and detailed maps of Arizona mining districts.

In the catalogue, the chemical composition of each mineral is given, together with notes on its paragenesis and a list of localities, but few other details (even colour) are added. Some of the entries are accompanied by morphological drawings and there is a good leavening of generally excellent colour photographs of localized material; unfortunately no scales are given and only by intuition or experience is the reader able to judge that the crystal of wickenburgite reproduced 1 cm across is probably much smaller and that the prismatic crystals of dioptase or of brochantite are really incredibly tiny. Nevertheless this is an attractive and useful work and in the paperback version is surely good value.

R. A. HOWIE

Hill (C. A). *Cave Minerals.* Huntsville (Nat. Speleological Soc.), 1976. 136 pp., 108 figs., 9 colour pls. Available from National Speleological Society, Cave Avenue, Huntsville, Alabama 35810, U.S.A. Price $15·00 (postpaid).

This attractive and liberally illustrated book is one of very few to survey the field of minerals found in caves. Some seventy minerals are listed and described according to the usual groupings of carbonates, sulphates, etc. The author admits to having had some difficulty in defining a 'cave', and thus a cave mineral, and a number of those listed have been found only in large vugs in hydrothermal veins or in weathered zones above ore bodies. Precedence is naturally given to the many varieties of cave calcite and aragonite, and the author draws attention to problems in explaining how some of the bizarre forms grow. Reference is also made to the conflicting evidence as to what causes calcite to precipitate in one cave while aragonite forms in the one next door under apparently the same environmental conditions.

There are some oddities in the book: baryte is separated from the rest of the sulphates and noted among 'ore-associated' minerals. Cristobalite is consistently mis-spelt. Another is the inclusion of 'petromorphs', defined as 'secondary mineral deposits in the bedrock accidentally exposed within a cave': an example is the boxwork of small quartz veins in Wind Cave, South Dakota. Many of the other cave minerals listed could come within this category but they are not so noted.

Formulae are given for most minerals listed, but little is said on crystallography, in contrast to the comparable recent work by W. B. White, which this reviewer edited not so long ago (Chapter 8 in T. D. Ford and C. H. D. Cullingford, 1976. *The Science of Speleology.* Academic Press).

Locality information is deliberately sparse, as the author emphasizes, being largely restricted to tourist and other controlled caves in the United States so as to minimize commercial collecting and other forms of vandalism.

A short chapter at the end reviews matters such as speleothem dating, the role of micro-organisms,