

therefore come as a surprise to some readers to find that the majority of methods given are still of the classical or conventional type, but the methods now described are in a refined and modified form, incorporating the newer techniques where experience has shown them to be reliable. There are detailed sections on sampling and sample preparation, precision and accuracy, and on the facilities and equipment of the laboratory. The various methods of analysis are discussed element by element in the order in which they are usually determined in the course of an analysis and this is followed by fully detailed descriptions of selected procedures, both for silicates and for carbonates. In addition to the routine methods of analysis equal prominence is given to selected procedures coping with such situations as the gravimetric determination of SiO_2 in the presence of boron, the need to retain any appreciable fluorine when determining water by the Penfield method, and the difficulties of decomposing refractory minerals. Additional chapters deal with X-ray spectrographic analysis and with atomic absorption spectroscopy for Mg, Li, and Zn. The treatment of these techniques is necessarily rather brief but the rapid development of the latter method is perhaps reflected in the statement that atomic absorption spectroscopy has not yet been successfully applied to the routine determination of aluminium in silicates: it has in fact been so used in the reviewer's laboratory for three years. Appendices present outline schemes for conventional silicate rock analysis ($F < 2\%$), for rapid chemical analysis of silicate rocks, and for the combined XRF-chemical rapid analysis of silicate rocks, and the book ends with a usefully detailed 26-page subject index.

The author gives a clear exposition of how the skilful application of the so-called classical methods in their present refined and modified form is still the best means of providing the accurate reference standards by which relative compositional readings are converted into meaningful compositional values. But it is also realised that many laboratories do not have access to the necessary instrumentation required for newer methods, and here we are given an expert appraisal of the recent refinements available for the classical methods. The detailed procedures described for silicate analysis will be welcomed—the reviewer even looks forward to the return of his now dog-eared copy of Washington's *The Chemical Analysis of Rocks* used by successive generations of students. This book should find a place in all analytical and geochemical laboratories as well as in departmental and personal libraries.

R. A. HOWIE

DALRYMPLE (G. B.) and LANPHERE (M. A.). *Potassium-Argon Dating*. San Francisco (W. H. Freeman and Company), 1969. xiv+258 pp., 98 figs. Price 70s.

This book gives an extremely detailed account of the history, principles, techniques, and some of the applications of the K/Ar method of dating. According to the authors, it is the first book to present a convenient summary rather than a comprehensive review about K/Ar dating.

After general introductions to such basic topics as atoms, elements, isotopes, radioactivity, the generalized age equation, the principles of the K/Ar 'clock', etc., the book goes on to describe in detail the principal methods used for radiogenic argon extraction and measurement, namely high-vacuum fusion followed by mass-

spectrometric isotope dilution. Different types of mass spectrometers are discussed. Very brief mention is also made of neutron activation analysis for argon, including the interesting and promising $^{40}\text{Ar}/^{39}\text{Ar}$ variant of the K/Ar method, although it is unfortunate that the authors attribute its invention to the wrong scientist and date. The chapter on measurement of potassium is rather brief, because so much on this topic has been written elsewhere. Full references are quoted in the long list at the end of the book. A very useful chapter is that on the definition and significance of accuracy and precision in age measurements, topics often treated in a confused and secretive manner by geochronologists. Further chapters deal at length with the problems of post-formational argon loss and the resulting low ages, and with extraneous ('excess') argon, which yields anomalously high ages in some minerals. The authors then go on to discuss the most suitable rocks and minerals for use in K/Ar dating, as well as quantity, purity, and size fraction required, particularly in relation to the actual age and composition of the sample. The final chapter describes some case histories in which the K/Ar method has shed light on the age of fossil man, the age of mineralization in Utah, the succession of geomagnetic polarity epochs, the study of provenance areas by dating sedimentary detritus, the age of emplacement of the Sierra Nevada batholith, the Phanerozoic time-scale, the age of the Precambrian of Arizona.

The book is well written, profusely and imaginatively illustrated, and it will clearly be of particular use to everyone who is embarking upon any aspect of K/Ar dating work, or who is collaborating geologically with laboratory-bound geochronologists.

Now for some scientific criticisms. Over and over again in the book it appears to be taken for granted that argon loss in rocks and minerals (weathering, alteration, physical damage, etc., excluded) is restricted solely to post-formational heating events, so that discordant age patterns are always due to 'overprinting' of a later thermal event upon an earlier one. Thus the impression is given that biotite gives low ages in metamorphic terrains only because it is a sensitive indicator of post-formational heating events. Furthermore, the authors appear to regard as 'incorrect' any date that does not yield the true age of crystallization. This is all rather old-fashioned in that it gives only one side of the story. It has been demonstrated beyond any reasonable doubt in the past six or seven years that discordant K/Ar mineral dates are often found in deep-seated, high-grade metamorphic-orogenic belts which have *not* undergone renewed metamorphism, simply as the result of slow uplift and cooling. The dates given by different minerals in such a situation reflect stages in the uplift and cooling history of the rocks, and this can be a valuable aid in structural and tectonic studies. Such ages are not 'incorrect'—they just do not happen to refer to the time of crystallization. Cooling and uplift dates may post-date crystallization dates by an interval greatly in excess of the analytical error of a measurement and it is quite wrong of the authors to state categorically that 'in a metamorphic rock, the age roughly represents the time that the mineral formed in its stability field' (p. 46). This may be true in some cases, but certainly not in others. It is quite astonishing, for example, that no reference is made in the book to the well-known work of Emilie Jäger and colleagues in the central Alps, which helped, as much other work has done, to demonstrate the validity of the

uplift-cooling interpretation in a number of cases. In addition, the authors nowhere mention that a good approximation to age of crystallization *can* often be obtained by dating whole-rock specimens of low-grade metamorphic rocks such as slates and phyllites. A little time and space surely ought to have been spared for a brief comparative evaluation of the principal age methods. The K/Ar method has both advantages and severe limitations as compared with the other methods. One-method geochronology can be very one-sided!

This is in many ways a very useful book, although the body of the subject is perhaps more adequately catered for than its soul.

S. MOORBATH

CORRENS (C. W.). *Introduction to Mineralogy, Crystallography, and Petrology*, 2nd ed. in co-operation with Josef Zemmann (Part One) and Sigmund Koritnig (Mineral Tables). Translated by William D. Johns. London (Allen & Unwin), 1969. xi+484 pp., 391 figs., 1 pl. Price £5. 5s.

The short title of this book, *Introduction to Mineralogy*, is misleading. In fact, Correns pulls on his seven-leagued boots and leads us far and wide across the field of mineralogy and petrology, like a monarch exhibiting his well-loved kingdom. Few regions escape his observation and remark; but some provinces receive only a brief glance, and even in the main centres of its commerce the pace is often bewildering, and we are left a little breathless. As is indicated in the acknowledgement of collaborators, his own personal imprint is most marked in the section on Petrology.

The sections are: Part I, Crystallography (178 pp.); Part II, Petrology (158 pp.); and Part III, Appendix (124 pp.) including crystallographic tables, a tabular summary of the properties of common minerals, petrological tables, and selected literature.

Naturally, this coverage has only been achieved by intense compression of the material, and while this has been done with masterly skill, it makes dense reading, unsuitable for the student and scarcely in keeping with an Introduction. For example, it is doubtful whether the 80-odd lines given to the stereographic projection would really enable a student to master this descriptive aid. Nevertheless many individual sections abound in interest and many topics neglected in other texts are sharply illuminated.

In Part I the opening section on Crystal Mathematics is unattractive. That on Crystal Optics is notable for the uncompromising introduction of elliptical polarization in explaining the passage of light through the polarizing microscope, instead of the usual (and easier) resolution of vibrations on to the plane of the analyser. But no advantage is taken of this in the account of the reflected light microscope, which is disappointingly brief. The account of X-ray Optics is a good conspectus, but too condensed to be a practical guide. Chapter IV on Crystal Growth and Dissolution deals interestingly with a topic often neglected in textbooks.

Part II, Petrology, begins with a brief treatment of phase equilibrium diagrams. Approximately equal space (33 to 41 pp.) is then devoted to each of igneous, sedimentary, and metamorphic rocks, with short chapters on weathering and soil formation, and geochemistry. On igneous rocks, to treat differentiation before description