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BOOK REVIEWS

CRYSTALS AND X-RAYS. By H. S. Lipson. Springer–Verlag, New York, 1970. 197 pp. $4.80.

The stated aim of the Wykeham Science Series, which includes this little monograph, is to provide the advanced high school student or beginning undergraduate with an authoritative, but not overwhelming, view of the present–day state of selected fields of science. Professor Lipson and Schoolmaster R. M. Lee have assembled thirteen short chapters which lead the student from the optical microscope, the symmetry of crystals, production and diffraction of X–rays, through the rudiments of crystal–structure determination. Fourier methods are emphasized here. The final chapters consider electron and neutron diffraction and some industrial—mostly metallurgical—applications of X-ray diffraction.

The treatment is of necessity brief but without being either terse or bland. Professor Lipson has chosen to give a somewhat chronological account of the more important developments in X–ray crystallography, including some on–the–scene insights into the nature of the progress of science. Indeed, it is the numerous anecdotes and historically interesting sidelights which should most contribute to the enjoyment of the book for more advanced readers. Equations are minimal but not avoided where needed. The line drawings are generally good, some of the photographic reproductions are not.

A minor criticism of the style is that, although Professor Lipson intends the book to "excite some of the younger minds," there seems to be an overall lack of optimism. The impression is left that the field has arrived at the "useful tool" stage and future investigators can only look forward to working out still more crystal structures. And even these will present a challenge and degree of difficulty less than that already met and solved.

Because of its brevity and lack of references to further reading it is doubtful that this paperback will compete with the more complete textbooks recently published in the general field of X–ray diffraction by crystals. It is, however, one of the lowest cost introductions to the field presently available.

As is often the case, the paperback binding is not very strong and in the reviewed copy one of the signatures (p. 99 through 114) was not bound in.

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CHEMICAL EQUILIBRIA IN THE EARTH. By Wallace S. Broecker and Virginia M. Oversby. McGraw-Hill Book Company, New York, New York, 1971. 318 pages. $16.50.

This is an excellent book for those undergraduate and graduate geology students, fresh from a good course in physical chemistry and an introduction to differential equations, who desire relevancy and stimulation from courses showing immediate geological applications. The authors intend the book as an introduction to the thermodynamics and kinetics of geological systems to be used as a supplement rather than as a substitute for more complete thermodynamic training.

The book is well organized and edited. Syntax is clear and adequate use is made of illustrations. An excellent up–to–date bibliography is provided and problems at the end of each chapter are sufficient. However, it would be most

desirable to have some, if not all, of the answers to the problems in the appendix.

The first five chapters provide a good introduction to the fundamental concepts of thermodynamics and include an excellent discussion of randomness and entropy. It is difficult to find in one chapter of any other book such a concise and clearly written treatment of entropy and statistical thermodynamics. The discussion of entropy begins with a graphic description of the number of complexions available to atoms and progresses to a rigorous development of partition functions. A desirable addition to the problem sets at the end of chapter four would be a problem in which the student would be required to calculate the entropy of a mineral at a given temperature from raw heat capacity data as a function of temperature. Chapter five is unique in that it treats not only equilibrium but also the kinetics involved in the attainment of equilibrium. A brief introduction to diffusion is also presented with explicitly derived equations.

Chapters six through twelve deal with the application of concepts developed in earlier chapters to important geologic problems. For example, chapter six has a more than adequate treatment of the reactions in natural gases. However, some discussion of the experimental determination of *PVT* data for gases might be helpful. References to sources of *PVT* data should be included in the supplementary reading. The problems included at the end of this chapter emphasize the calculation of fugacity. I would suggest the inclusion of a problem requiring the calculation of free energy changes using fugacity data.

Some subjects are treated with almost exhaustive thoroughness and these may be considered the *tour de force* of the book. Notable among these are discussions of distribution of trace isotopes between coexisting phases, solid solution phenomena à la Waldbaum, and reactions in natural waters à la Garrels and Helgeson. However, other subjects are treated lightly, completely ignored, or are unnecessary. For example, their discussion of the theoretical background to the Rayleigh distillation is explicit but the example chosen for the application of this principle is without substance. Perhaps Gast's application of the Rayleigh distillation to trace element distribution between coexisting phases should be added as an example [*Geochim. Cosmochim. Acta*, **32**, p. 1057, (1968)]. Consequently, the authors' treatment of the subject should be taken out of the chapter dealing with trace isotope distribution between coexising phases and included in the chapter on trace element distribution. Another inadequacy is their discussion of the perturbation of phase boundaries in chapter nine on solid-state mineral transformations. This discussion is detailed, but it is extremely tedious and possibly irrelevant for many students. Its obvious use is in reference to the Moho which most consider to be a compositional boundary. I believe this discussion could be deleted completely from the book without any loss.

The authors have not intended to present an exhaustive treatment of the subject, which may be an almost impossible task because of recent developments. They admit that their coverage is limited and strongly recommend reference to a standard thermodynamic textbook. However, their aim was to design the book to be used for a one-semester course which, I think, they have achieved. The book will make an excellent textbook for most graduate or senior geochemistry courses. In my opinion, it is the best book of its kind currently available.

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CONTRIBUTION À L'ÉTUDE GÉOLOGIQUE DES SÉRIES CRISTALLOPHYLLIENNES INVERSES DU MASSIF CENTRAL FRANÇAIS: LA SÉRIE DE LA SIOULE (PUY-DE-DÔME, ALLIER). By Jacques Grolier. Bureau de Recherches Géologiques et Minières, Paris, Mémoire No. 64, 1971, 163 pages.

This memoir of the French geological survey is a doctor's thesis supervised by Professor M. Roques of the École des Mines in Saint-Étienne. It is written in French, and there are no summaries in other languages. The study deals with a medium-grade metamorphic and granitic terrain of roughly 25 by 50 km, situated on the northern edge of the Massif Central in south-central France. The study deals particularly with the possibly inverted position of zones of metamorphism in the metasedimentary series.

The metamorphic series, which is locally known as the Série cristallophyllienne de la Sioule, is discussed in Chapter II. Along the lines laid down by Jung and Roques in 1936 and 1952 the following regional-metamorphic zones in order of increasing grade are recognized: (1) a zone of muscovite-biotite schists, locally containing staurolite and garnet, (2) a zone of muscovite-biotite gneisses, locally containing sillimanite. (3) a zone of biotite-sillimanite gneisses, locally containing garnet and cordierite, and including garnet-rich rocks ("grenatites") containing kyanite, and (4) migmatites, which are subdivided in those with and those without cordierite.

The structure of the area is discussed in Chapter VII. The metamorphic series occurs in two antiforms and two synforms consisting of isoclinal folds. The foliation is considered to be an axial-plane foliation. A recrystallization foliation (S_1), corresponding to metamorphic zoning, is superimposed on axial-plane foliation (S_2) and lithologic layering (S_3).

Chapter VIII gives a synthesis of the regional geology. The Sioule Series is considered an Upper-Precambrian sediment, which became isoclinally folded and metamorphosed during the Cadomian orogeny. Metamorphism ceased during the Caledonian orogeny, at which time also thrusting, cross-folding, and granite intrusion took place. Other granites intruded, and rhyolitic tuffs were deposited, during the Hercynian orogeny. Most of the relative ages are tentative since no absolute ages are apparently known from this area.

The last chapter (IX) discusses the problem of inversion of metamorphic zoning. Proof for inversion is apparently based upon the assumption that isograd surfaces are expressed by the recrystallization foliation (S_1) which are considered to parallel the axial-plane foliation (S_2) in the area. No sketch maps or sections are given to demonstrate the inversion of metamorphic zones.

The work suffers from the limitations of Jung and Roques' system of metamorphic zoning (micaschistes supérieurs, micaschistes inférieurs, gneiss supérieurs, gneiss inférieurs, etc.). The geologic map shows such zones instead of isograds based on index minerals as is customary outside France. The text presents general rock descriptions, but no chemical or modal analyses are given, no mineral compositions and mineral assemblages are listed, no ACF or similar diagrams are shown, and no facies analysis based on Eskola's system has been attempted. M. Grolier missed an excellent opportunity, having a relatively small area in which there are rocks with and without muscovite, and with occurrences of staurolite, garnet, cordierite, sillimanite, kyanite, and sillimanite.

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