

BOOK REVIEWS

Thermodynamics in Geology, edited by D. G. Fraser. Reidel, 1976. 410 pp., \$38.00.

IN THIS BOOK are the proceedings of a NATO Advanced Study Institute held in Oxford, England in 1976. It is written in 19 chapters by leading geological thermodynamicists. In the preface the editor indicates that the book is intended to aid application of thermodynamics to geological problems involving complex phases and implies that it is intended for use as a teaching text. However, as is usually the case with proceedings volumes, this collection of articles suffers from erratic editing, duplicated or incomplete coverage as well as from inclusion of articles somewhat inappropriate to the title.

In the first chapter, Navrotsky has provided a needed literature survey on reaction calorimetry of minerals. This is followed by two chapters on thermodynamics of garnets and pyroxenes, one by Wood and one by Newton. Powell and Grover each contribute a chapter on the theory of non-ideal solid solutions. Chatterjee evaluates the calculations of dehydration equilibria and extraction of thermodynamic data from experimentally determined curves, while Anderson evaluates errors in such calculations. Holloway and Eugster each write on fugacity calculations of high P - T fluids. The thermodynamics of silicate melts are dealt with by Fraser and Nicholls in two separate chapters. This curious repetition of topics by successive authors is at once the strength and weakness of the book, providing some duplication but giving alternative and excellent treatments of the same general subject. Other chapters are: a summary of the determination of atomic occupancies by Whittaker, fluid inclusions in metamorphic rocks by Touret, the stability of phlogopite by Wones and Dodge, opaque minerals in lunar basalts by El Goresy and Woermann, thermodynamics of molten salts by Kleppa, trace element thermodynamics by O'Nions and Powell, calcite in seawater by Broecker and Takahashi, and finally non-equilibrium thermodynamics in metamorphism by Fisher.

Navrotsky should have provided a general treatment of calorimetric measurements including differential scanning, adiabatic and drop calorimetric techniques. The editor should be admonished for accepting this annotated bibliography from Navrotsky, who has written excellent reviews on the subject elsewhere. In evaluating experiments on the upper stability of brucite, pyrophyllite and muscovite, Anderson and Chatterjee do not consider other experiments in disagreement with the data chosen. Indeed the importance and use of experiments is hardly mentioned in this volume and the reader may wonder why hundreds of geologists have bothered with them. The book could have been improved by a chapter on the critical evaluation of experiments perhaps written by Wones instead of his

rather specific article. Chatterjee and Anderson each consider muscovite reactions, one choosing thermodynamic data for ordered muscovite and the other adjusting it for the disordered form. Chatterjee discusses calculations with both ordered and disordered muscovite, but appears to use only fully ordered K-feldspar in his calculations although most writers believe that K-feldspar is totally disordered above 600°C. Consultation with Whittaker about site occupancies might have clarified this point; it certainly would have avoided inconsistencies from chapter to chapter. Holloway's modelling of gas fugacities at high pressure is interesting but needs to be tested against tight experimental reversals extended up to 40 kbar. El Goresy and Woermann report the use of opaque minerals in determining f_{O_2} and T in lunar basalts, but their article should have been extended to cover terrestrial magmas as well. They consider several experimental systems—sometimes with unreadable figures—without using any thermodynamics at all on the natural impure phases. The adjustment of their end-member reactions (with proper consideration of cation ordering) using calculations given elsewhere in the book would have strengthened their article considerably and could have integrated their article into the theme of the book. Broecker and Takahashi spend much of their article embroiled in a dispute between Berner and Ingle, time far better to be spent on a general treatment of aqueous equilibria in sea-water systems. This book could have been considerably improved by a strong editorial policy towards the individual authors insisting on generality of coverage, and most of the chapters could have benefited by presenting better applications to geological problems.

The editor and publisher have not been completely successful in their tasks. The titles of articles have irritatingly been left out of references so that a reader is generally obliged to seek the article to judge its content. This pernicious practice, instituted in some journals to conserve space, saves no space here and is particularly inappropriate in a review and teaching volume. The subject index is good but there is no author index which would aid in using the individual bibliographies at the end of each chapter. The cost of this book is high for the mediocre quality of the off-set printing. The reviewer does not believe that the goals given in the preface and at the beginning of this review were attained by this book. Nevertheless, it will be useful for specialists and belongs in any good geology library.

Department of Geology and Mineralogy ERIC J. ESSENE
The University of Michigan
Ann Arbor
MI 48109
U.S.A.