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Thermodynamics in Petrology **Mineral Equilibria in Three Missouri Soils** **Metamorphic Phase Equilibria and Pressure-temperature-time Paths** *Minerals Manual* **Metamorphic Crystallization** **Phase equilibria involving minerals of the system CaSO4-Na2SO4-H2O** *Thermodynamics of Natural Systems* *Rock-Forming Minerals: Orthosilicates, Volume 1A* **Mineral Equilibria in Low-grade Carbonate Bearing Rocks** Chemical Equilibria in the Earth **Uranium Solution-mineral Equilibria at Low Temperatures with Application to Sedimentary Ore Deposits** **Hydrothermal Systems** *Special Issue: Mineral Equilibria in Metamorphic Systems*

Based on Mineral equilibria at low temperature and pressure, by R.M. Garrels, published in 1960. Today large numbers of geoscientists apply thermodynamic theory to solu tions of a variety of problems in earth and planetary sciences. For most problems in chemistry, the application of thermodynamics is direct and rewarding. Geoscientists, however, deal with complex inorganic and organic substances. The complexities in the nature of mineralogical substances arise due to their involved crystal structure and multicomponental character. As a result, thermochemical solutions of many geological-planetological problems should be attempted only with a clear understanding of the crystal-chemical and thermochemical character of each mineral. The subject of physical geochemistry deals with the elucidation and application of physico-chemical principles to geosciences. Thermodynamics of mineral phases and crystalline solutions form an integral part of it. Developments in mineralogic thermody namics in recent years have been very encouraging, but do not easily reach many geoscientists interested mainly in applications. This series is to provide geoscientists and planetary scientists with current information on the develop ments in thermodynamics of mineral systems, and also provide the active researcher in this rapidly

developing field with a forum through which he can popularize the important conclusions of his work. In the first several volumes, we plan to publish original contributions (with an abundant supply of back ground material for the uninitiated reader) and thoughtful reviews from a number of researchers on mineralogic thermodynamics, on the application of thermochemistry to planetary phase equilibria (including meteorites), and on kinetics of geochemical reactions. With contributions by numerous experts Metamorphic Crystallization investigates the upper regions of the crystalline Earth, where countless solid-state chemical changes have taken place during the long history of the planet. The exploration proceeds in five stages. Firstly, a brief reminder of the importance of field, microscopic, and experimental phase-equilibrium results in metamorphic studies is given, followed by a review of classical thermodynamics as applied to minerals. Different kinds of mineral equilibria are defined, and representative natural and experimental examples of each kind are examined. The kinetics of reactions involving crystals (reaction rate, diffusion, nucleation, crystal growth), referring to certain experiments that have provided information on these microprocesses, are reviewed. Finally, the granular microstructure of natural samples (crystal shape, size, spatial distribution) together with chemical data are examined, and an interpretation of these observations in terms of mineral kinetics is pursued. This exploration intends to leave the reader more appreciative of changes which occur within the Earth, and more interested in the application of thermodynamics and kinetics in the study of these changes. Volume 14 of Reviews in Mineralogy covers a short course about the relations among the microscopic structure of minerals and their macroscopic thermodynamic properties. Understanding the micro-to-macro relations provides a rigorous theoretical foundation for formulation of energy relations. With such a foundation, measured parameters can be understood, and extrapolation and prediction of thermodynamic properties

beyond the range of measurement can be done with more confidence than if only empirical relations are used. The purpose of this course is to consider the microscopic factors that influence the free energy of minerals: atomic environments, bonding, and crystal structure. These factors influence the structural energy and the detailed nature of the lattice vibrations which are an important source of entropy and enthalpy at temperatures greater than 0 K. The same factors determine the relative energy of different phases, and thereby; the relative stability of different minerals. Configurational entropy terms arising from disorder also contribute to the energy and entropy. In transition metal compounds there are additional energy and entropy terms arising from the electronic configurations, leading to additional stabilizations, magnetic ordering, and, incidentally, color. Organized by Sue Kieffer and Alex Navrotsky, the course was presented by the ten authors of this book on the campus of Washington College in Chestertown, Maryland. This was the second of MSA's short courses to be given in conjunction with meetings of the American Geophysical Union. A second edition, in two parts, of Volume 1 of this well-known reference series. This volume deals mainly with the olivine and garnet groups and also the humite group, zircon, sphene, vesuvianite, the Al2SiO5 (including mullite), topaz, staurolite and chloritoid. The disilicates and ring-silicates are covered in Volume 1B. In the years since the first edition was published, the quantity and scope of research on the olivines, garnets and the aluminosilicates has grown enormously and has given rise to a wide variety of literature. This book, which has been completely rewritten and considerably expanded, summarizes the important research results and presents them in an organized fashion. Each mineral chapter is divided into sections on structure, chemistry, optical and physical properties, distinguishing features and paragenesis. Each chapter is headed by a tabulation of mineral data and a sketch showing optical orientation, and concludes with full references to the literature. Diagrams

of the crystal structures are presented and are followed by a discussion of the structural features. The chemical sections include a large number of analyses from which structural formulae have been calculated, illustrating the chemical and paragenetical variation exhibited by each mineral; phase equilibria in relevant systems are fully considered. In the sections on optical and physical properties, particular attention is paid to the correlation of these properties with chemical composition. The principal modes of occurrence are described and discussed in the paragenesis sections; here again correlation with chemistry is emphasized. 11 volumes are available in this series. In this book metal deposits, in particular those of non-ferrous and precious metals, are classified and analyzed in terms of their plate tectonic settings. This approach allows a meaningful treatment of metal deposits of different types and provides significant insights into both their genesis and formative environments. The updated 2nd edition incorporates the most significant advances in economic geology of the last 5 years. Particular attention is paid to the geological settings and generative models of gold deposits of all kinds. 30% discount for members of The Mineralogical Society of Britain and Ireland This volume addresses the fundamental factors that underlie our understanding of mineral behaviour and crystal chemistry - a timely topic given current advances in research into the complex behaviour of solids and supercomputing. Thermodynamics deals with energy levels and the transfer of energy between states of matter, and is therefore fundamental to all branches of science. This edition provides a relatively advanced treatment of the subject, specifically tailored for the interests of the Earth sciences. The first four chapters explain all necessary concepts, using a simple graphical approach. Throughout the rest of the book the author emphasizes the use of thermodynamics to construct mathematical simulations of real systems. This helps to make the many abstract concepts acceptable. Many computer programs are mentioned and used throughout the text, especially

SUPCRT92, a widely used source of thermodynamic data. An associated website includes links to useful information sites and computer programs and problem sets. Building on the more elementary material in the first edition, this textbook will be ideal for advanced undergraduate and graduate students in geology, geochemistry, geophysics and environmental science. Considerable progress has been made in our understanding of the physicochemical evolution of natural rocks through systematic analysis of the compositional properties and phase relations of their mineral assemblages. This book brings together concepts of classical thermodynamics, solution models, and atomic ordering and interactions that constitute a major basis of such analysis, with appropiate examples of application to subsolidus petrological problems. This book is written for an audience with a senior undergraduate level background in chemistry. Derivations of fundamental thermodynamic relations which are in need of reemphasis and clarification are presented. This book represents a revision and expansion of an earlier set of diagrams for tempera 0 0 tures from 25 to 300 C along the equilibrium vapor-liquid curve for H 0 (Helgeson, Brown, 2 and Leeper, 1969). The activity diagrams summarized in the following pages were generated over a six year period from 1977 to 1983 in the Laboratory of Theoretical Geochemistry (oth erwise known as Prediction Centra!) at the University of California, Berkeley. They represent the culmination of research efforts to generate a comprehensive and internally consistent set of thermodynamic data and equations for minerals, gases, and aqueous solutions at high pres sures and temperatures. Among the many who contributed to the successful completion of this book, we are especially indebted to David Kirkham, John Walther, and George Flowers, who wrote program SUPCRT, Tom Brown, who created program DIAGRAM, and Eli Mess inger, who generated the Tektronix plot routine to construct the diagrams. Ken Jackson and Terri Bowers both devoted an enormous amount of time and effort over the past six

years to produce the diagrams in the following pages; some of which went through many stages of revision. Consequently, they appear as senior authors of this volume. It should be mentioned in this regard that their equal dedication to the project made it necessary to determine their order of authorship by flipping a coin. Volume 10 of Reviews in Mineralogy reviews the use of a powerful probe into metamorphic process: mineral assemblages and the composition of minerals. Put very simply, this volume attempts to answer the question: "What can we learn about metamorphism through the study of minerals in metamorphic rocks?" It is not an encyclopedic summary of metamorphic mineral assemblages; instead it attempts to present basic research strategies and examples of their application. Moreover, in order to limit and unify the subject matter, it concentrates on the chemical aspects of metamorphism and regrettably ignores other important kinds of studies of metamorphic rocks and minerals conducted by structural geologists, structural petrologists, and geophysicists. 30% discount for members of The Mineralogical Society of Britain and Ireland This volume addresses the fundamental factors that underlie our understanding of mineral behaviour and crystal chemistry - a timely topic given current advances in research into the complex behaviour of solids and supercomputing.

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