Elements, Oxides, Silicates: High Pressure Phases With Implications for the Earth's Interior


 Reviewed by Thomas J. Ahrens

A vitally important aspect of understanding the composition, structure, and processes acting within the solid Earth is obtaining a complete and possible knowledge of the fields of stability of the Earth's component minerals and their high-pressure polymorphs with respect to pressure and temperature. Liu and Bement's book is the first effort which has focused on bringing together the available phase diagrams for the elements, oxides, and silicates that are relevant to the understanding of Earth's and the other terrestrial planetary interiors. Since the book also covers the isotopes and compounds important to the inelastic region of the mantle of the major planets (e.g., H2, He, Ne, C, O, and N), it is a valuable reference for a wide variety of studies of the Earth's interior.

An initial introductory chapter lays out, in very condensed form, the relations of phase diagrams to thermodynamic properties. Typical chemical principles are summarized, as well as the main features of the techniques and apparatus employed to obtain data summarized in the remainder of the book. Although references to apparatus papers are numerous and well chosen, references to works which relate thermodynamic properties to construction of phase diagrams are lacking.

Part I, a summary of the basic facts of elements in different configurations appears to be the most valuable part of Chapter 1.

Chapters 2, 3, and 4, which describe the phase diagrams of the elements, oxides, and silicates, are at the heart of this book. The pressure range covered varies from 400 to 500 kbar for minerals whose phase diagrams are available with a prism-cylinder apparatus to 3000 kbar for the case of iron which has been made using shock-wave techniques. Similarly, the temperature ranges of the phase diagrams vary from -70°C to 90°C, depending on the range over which the melting point has been explored.

The crystal structures of most of the solid polymeric phases are repeated on the basis of six in six and quadrature X-ray-diffraction measurements conducted in multidial and diamond pressure apparatus during the last 20 years.

In general, the big task of compiling and critically reviewing phase-equilibrium data for hundreds of minerals has been carried out extremely well. Interpreted with phase diagrams are some useful tables and figures providing crystallographic data for groups of compounds and demonstrating the determination of molar volume versus pressure isotherms for related compounds and structures.

A technical flaw in the work, which is easily corrected, is a missing phase diagram for FeO(silica) (p. 143). Unfortunately, the caption is not linking and, as a result, the next 51 phase diagrams have the wrong caption. This problem is not corrected until pp. 178 and 179, where the phase diagrams of K2Cr2O7 are given (see also p. 179) with the correct captions.

In discussing successive phase transformations of the silicates with pressure (after p. 180 in Chapter 4), it would have been helpful to the reader to have provided a detailed series of observed and theoretical seismic velocity versus depth profiles for the transition region of the Earth. The release of shear strain, velocity increases to phase transformation in the 20 to 700-km depth range of the Earth are examined discussed in Chapter 5. Also in Chapter 5, several detailed mantle model compositions are given in a series of tables. Their significance would be easier to compare if the tables specifying these (0.5, 1, 5, 10) had captions. A summary of compositional concepts and the relation of mantle minerals to the observed chemistry of crustal rocks discussed from partial melt processes which have made the last chapter more complete.

A spirit of the mine dedication to the present printing, this monumental work is a highly useful and long-awaited book which will serve solid Earth scientists for many years.

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