American Mineralogist, Volume 99, page 250, 2014

BOOK REVIEW

MANTLE CONVECTION FOR GEOLOGISTS by Geoffrey F. Davies (2011) Cambridge University Press, U.K., 232 p. $64.00 ISBN 978-0-521-19800-4 (Hardback; e-formats available).

Since the plate tectonics model was advanced in the 1960s, mantle convection has been recognized to be at the heart of various activities of the solid Earth like volcanism, continental drift, mountain building, and earthquakes. Yet, mantle convection is often vaguely understood as "something mysterious that happens down there" according to the author, a leading authority of mantle dynamics. There are even wide-spread misconceptions concerning mantle convection. *Mantle Convection for Geologists* is written for non-specialists of mantle dynamics to clear the haze and misconcepts that surround mantle convection. The book is kept concise, and mathematics that may be intimidating for non-specialists are avoided. This is a welcome textbook.

The book consists of 11 chapters and three appendices. Following the introduction and a brief description of the internal structure of the Earth in Chapters 1 and 2, Chapter 3 accounts for how the basic concepts that constitute plate tectonics model like plates, transform fault, and hot spot have emerged in the course of studies of the Earth's tectonics. Chapter 4 provides an introduction to rheology, i.e., the mechanical properties of mantle materials, with an emphasis on its strong temperature-dependence, while Chapter 5 covers the fluid dynamics of thermal convection. Here, a semi-quantitative discussion includes buoyancy, viscous resistance, and thermal diffusion in convecting fluid. Chapters 3 to 5 constitute the starting point of the discussions on thermal convection in the Earth's mantle presented in Chapters 6 to 8. Plate mode and plume mode of mantle convection are explained separately in Chapters 6 and 7, respectively. In particular, Chapter 6 emphasizes that tectonic plates are integral parts of mantle convection that move by their own buoyancy independently from the underlying mantle. In Chapter 8, the plate mode and the plume mode are discussed as two interacting, but separate, modes of mantle convection. Through the discussion from Chapters 5 to 8, the author points out several misconceptions that are commonly observed in earlier discussions of mantle dynamics. Then, the author proceeds to discussing the evolution of the Earth's mantle based on his own view in Chapters 9 and 10. Chapter 9 covers the tectonic evolution of the Earth with emphasis on two subjects that still remain open questions: One is the thermal budget of the mantle. Geochemically estimated internal heating rate of the mantle appears to be too low to explain the low cooling rate of the mantle inferred from petrologic studies. Another is the compositional buoyancy of subducted oceanic crusts. Crustal buoyancy may impede subduction of oceanic plates and flow of subducting slabs through the 660 km phase boundary and may also affect the distribution of subducted oceanic crusts in the mantle. It is suggested that subducted oceanic crust is distributed over the entire mantle to make it compositionally heterogeneous on all spatial scales from global to kilometer scale or even smaller. This view constitutes the basis of the model on the compositional evolution of the mantle presented in Chapter 10. Here, isotopic ratio of rare-earth elements and other geochemical signatures of magma derived from such a heterogeneous mantle are examined. Then, the geochemical signatures of Oceanic Island Basalts and Mid Oceanic Ridge Basalts are interpreted in the context of mantle evolution developed in Chapter 9. In Chapter 11, the author emphasizes the importance of including mantle convection in the routine study of earth sciences.

In terms of writing style, the basic concepts of mantle convection are clearly and concisely presented. Some patience may be necessary to digest the author's view on mantle evolution presented in Chapters 9 and 10. Given our still incomplete understanding of mantle evolution, however, this seems to be unavoidable.

To keep the price of the book low, the figures that are presented in color in original papers are shown in grayscale here, and much information is lost. It would be helpful for readers if color versions of these figures were presented somewhere (e.g., as supplemental material for download?). The grayscale of figures may be the reason why only a limited space is spared for the review of seismic tomography. However, seismic tomography has been a major driving force of geophysical research on mantle dynamics for the last two decades; it deserves a full account.

Readers may not necessarily agree to the author's view on mantle evolution that is presented in Chapters 9 and 10. However, readers can still learn a great deal about mantle evolution obtained from various fields of Earth science by following the discussion presented in this book. More importantly, the discussion on mantle dynamics and evolution presented here is physically sound and comprehensive. Overall, this is a highly recommendable textbook for non-specialists, and also is a good complement to earlier standard and more mathematics-oriented textbooks for students of geodynamics.

MASAKI OGAWA
Department of Earth Sciences and Astronomy
University of Tokyo at Komaba
Tokyo, 153-8902, Japan

0003-004X/14/0001–250$05.00/DOI: http://dx.doi.org/10.2138/am.2014.621