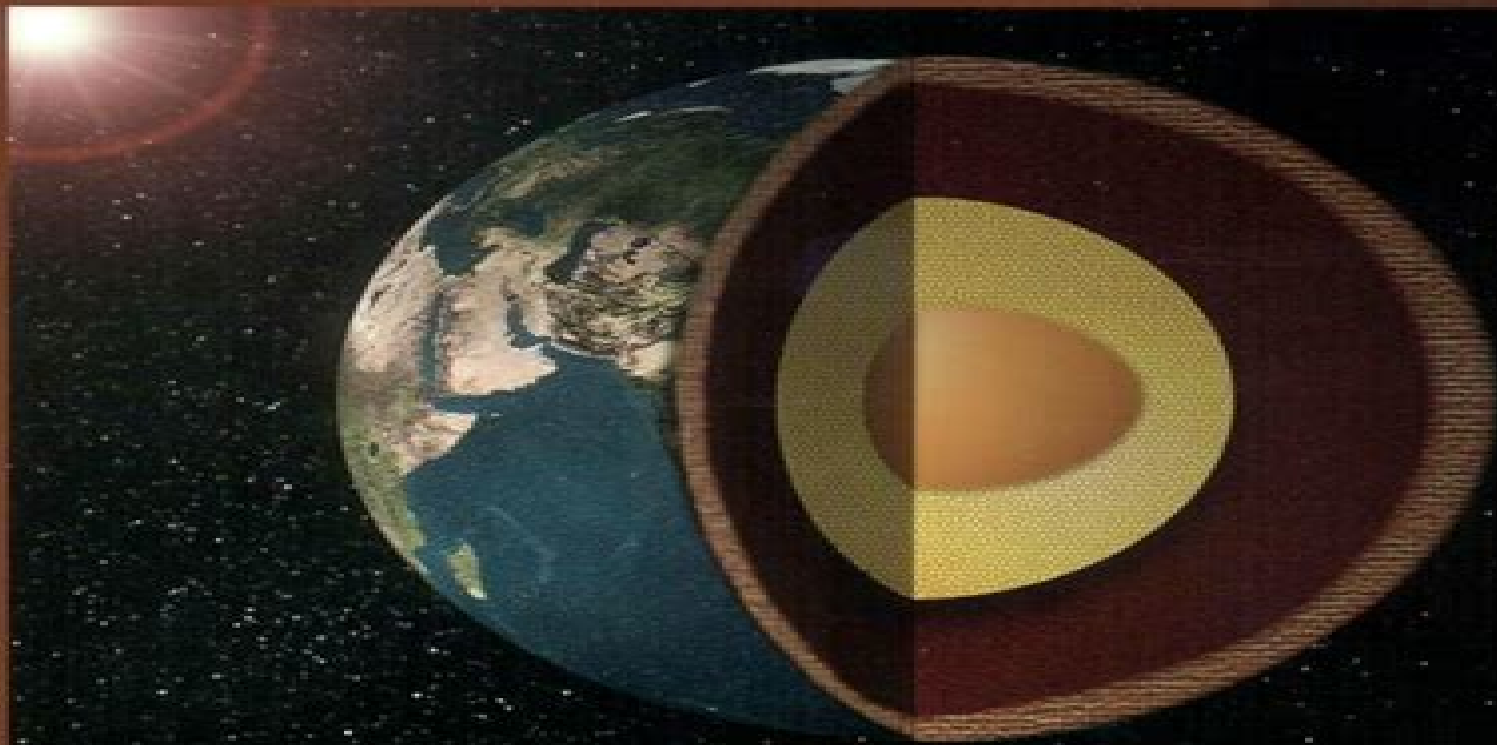


# Earth's Deep Mantle

*Structure, Composition, and Evolution*



Robert D. van der Hilst, Jay D. Bass,  
Jan Matas, and Jeannot Trampert,  
Editors

# Earths Deep Mantle Structure Composition And Evolution Geophysical Monograph Series

**Minjie Lin**



## **Earths Deep Mantle Structure Composition And Evolution Geophysical Monograph Series:**

*Earth's Deep Mantle* Robert D. van der Hilst, 2005-01-14 Published by the American Geophysical Union as part of the Geophysical Monograph Series Volume 160 Understanding the inner workings of our planet and its relationship to processes closer to the surface remains a frontier in the geosciences Manmade probes barely reach 10 km depth and volcanism rarely brings up samples from deeper than 150 km These distances are dwarfed by Earth's dimensions and our knowledge of the deeper realms is pieced together from a range of surface observables meteorite and solar atmosphere analyses experimental and theoretical mineral physics and rock mechanics and computer simulations A major unresolved issue concerns the nature of mantle convection the slow 1.5 cm year solid state stirring that helps cool the planet by transporting radiogenic and primordial heat from Earth's interior to its surface Expanding our knowledge here requires input from a range of geoscience disciplines including seismology geodynamics mineral physics and mantle petrology and chemistry At the same time with better data sets and faster computers seismologists are producing more detailed models of 3-D variations in the propagation speed of different types of seismic waves new instrumentation and access to state of the art community facilities such as synchrotrons have enabled mineral physicists to measure rock and mineral properties at ever larger pressures and temperatures new generations of mass spectrometers are allowing geochemists to quantify minute concentrations of diagnostic isotopes and with supercomputers geodynamicists are making increasingly realistic simulations of dynamic processes at conditions not attainable in analogue experiments But many questions persist What causes the lateral variations in seismic wavespeed that we can image with mounting accuracy How reliable are extrapolations of laboratory measurements on simple materials over many orders of magnitude of pressure and temperature What are the effects of volatiles and minor elements on rock and mineral properties under extreme physical conditions Can ab initio calculations help us understand material behavior in conditions that are still out of reach of laboratory measurement What was the early evolution of our planet and to what extent does it still influence present day dynamics And how well do we know such first order issues as the average bulk composition of Earth

*The Earth's Heterogeneous Mantle* Amir Khan, Frédéric Deschamps, 2015-04-28 This book highlights and discusses recent developments that have contributed to an improved understanding of observed mantle heterogeneities and their relation to the thermochemical state of Earth's mantle which ultimately holds the key to unlocking the secrets of the evolution of our planet This series of topical reviews and original contributions address 4 themes Theme 1 covers topics in geophysics including global and regional seismic tomography electrical conductivity and seismic imaging of mantle discontinuities and heterogeneities in the upper mantle transition zone and lower mantle Theme 2 addresses geochemical views of the mantle including lithospheric evolution from analysis of mantle xenoliths composition of the deep Earth and the effect of water on subduction zone processes Theme 3 discusses geodynamical perspectives on the global thermochemical structure of the deep mantle Theme 4 covers application of

mineral physics data and phase equilibrium computations to infer the regional scale thermo chemical structure of the mantle

**Treatise on Geophysics, Volume 2** G David Price, 2010-04-20 Treatise on Geophysics Mineral Physics Volume 2 provides a comprehensive review of the current state of understanding of mineral physics Each chapter demonstrates the significant progress that has been made in the understanding of the physics and chemistry of minerals and also highlights a number of issues which are still outstanding or that need further work to resolve current contradictions The book first reviews the current status of our understanding of the nature of the deep Earth These include the seismic properties of rocks and minerals problems of the lower mantle and the core mantle boundary and the state of knowledge on mantle chemistry and the nature and evolution of the core The discussions then turn to the theory underlying high pressure high temperature physics and the major experimental methods being developed to probe this parameter space The remaining chapters explain the specific techniques for measuring elastic and acoustic properties electronic and magnetic properties and rheological properties the nature and origin of anisotropy in the Earth the properties of melt and the magnetic and electrical properties of mantle phases Self contained volume starts with an overview of the subject then explores each topic with in depth detail Extensive reference lists and cross references with other volumes to facilitate further research Full color figures and tables support the text and aid in understanding Content suited for both the expert and non expert **Treatise on Geochemistry**

, 2013-10-19 This extensively updated new edition of the widely acclaimed Treatise on Geochemistry has increased its coverage beyond the wide range of geochemical subject areas in the first edition with five new volumes which include the history of the atmosphere geochemistry of mineral deposits archaeology and anthropology organic geochemistry and analytical geochemistry In addition the original Volume 1 on Meteorites Comets and Planets was expanded into two separate volumes dealing with meteorites and planets respectively These additions increased the number of volumes in the Treatise from 9 to 15 with the index appendices volume remaining as the last volume Volume 16 Each of the original volumes was scrutinized by the appropriate volume editors with respect to necessary revisions as well as additions and deletions As a result 27% were republished without major changes 66% were revised and 126 new chapters were added In a many faceted field such as Geochemistry explaining and understanding how one sub field relates to another is key Instructors will find the complete overviews with extensive cross referencing useful additions to their course packs and students will benefit from the contextual organization of the subject matter Six new volumes added and 66% updated from 1st edition The Editors of this work have taken every measure to include the many suggestions received from readers and ensure comprehensiveness of coverage and added value in this 2nd edition The esteemed Board of Volume Editors and Editors in Chief worked cohesively to ensure a uniform and consistent approach to the content which is an amazing accomplishment for a 15 volume work 16 volumes including index volume Treatise on Geophysics, 2015-04-17 Treatise on Geophysics Second Edition is a comprehensive and in depth study of the physics of the Earth beyond what any geophysics text has provided previously

Thoroughly revised and updated it provides fundamental and state of the art discussion of all aspects of geophysics A highlight of the second edition is a new volume on Near Surface Geophysics that discusses the role of geophysics in the exploitation and conservation of natural resources and the assessment of degradation of natural systems by pollution Additional features include new material in the Planets and Moon Mantle Dynamics Core Dynamics Crustal and Lithosphere Dynamics Evolution of the Earth and Geodesy volumes New material is also presented on the uses of Earth gravity measurements This title is essential for professionals researchers professors and advanced undergraduate and graduate students in the fields of Geophysics and Earth system science Comprehensive and detailed coverage of all aspects of geophysics Fundamental and state of the art discussions of all research topics Integration of topics into a coherent whole

*Origin and Evolution of Earth* National Research Council, Division on Earth and Life Studies, Board on Earth Sciences and Resources, Committee on Grand Research Questions in the Solid-Earth Sciences, 2008-09-04 Questions about the origin and nature of Earth and the life on it have long preoccupied human thought and the scientific endeavor Deciphering the planet's history and processes could improve the ability to predict catastrophes like earthquakes and volcanic eruptions to manage Earth's resources and to anticipate changes in climate and geologic processes At the request of the U S Department of Energy National Aeronautics and Space Administration National Science Foundation and U S Geological Survey the National Research Council assembled a committee to propose and explore grand questions in geological and planetary science This book captures in a series of questions the essential scientific challenges that constitute the frontier of Earth science at the start of the 21st century *Spectroscopic Methods in Mineralogy and Material Sciences* Grant Henderson, Daniel Neuville, Robert Downs, 2014-11-21 Spectroscopic Methods in Mineralogy and Material Science covers significant advances in the technological aspects and applications of spectroscopic and microscopic techniques used in the Earth and Materials Sciences The current volume compliments the now classic Volume 18 Spectroscopic Methods in Mineralogy and Geology which became an essential resource to many scientists and educators for the past two decades This volume updates techniques covered in Volume 18 and introduces new techniques available for probing the secrets of Earth materials such as X ray Raman and Brillouin spectroscopy Other important topics including Transmission Electron Microscopy TEM and Atomic Force Microscopy AFM are also covered Water in Nominally Anhydrous Minerals Hans Keppler, Joseph R. Smyth, 2018-12-17 Volume 62 of Reviews in Mineralogy and Geochemistry reviews the recent research in the geochemistry and mineral physics of hydrogen in the principal mineral phases of the Earth's crust and mantle Contents Analytical Methods for Measuring Water in Nominally Anhydrous Minerals The Structure of Hydrated Species in Nominally Anhydrous Minerals Information from Polarized IR Spectroscopy Structural Studies of OH in Nominally Anhydrous Minerals Using NMR Atomistic Models of OH Defects in Nominally Anhydrous Minerals Hydrogen in High Pressure Silicate and Oxide Mineral Structures Water in Nominally Anhydrous Crustal Minerals Speciation Concentration and Geologic Significance Water in Natural Mantle

Minerals I Pyroxenes Water in Natural Mantle Minerals II Olivine Garnet and Accessory Minerals Thermodynamics of Water Solubility and Partitioning The Partitioning of Water Between Nominally Anhydrous Minerals and Silicate Melts The Stability of Hydrous Mantle Phases Hydrous Phases and Water Transport in the Subducting Slab Diffusion of Hydrogen in Minerals Effect of Water on the Equation of State of Nominally Anhydrous Minerals Remote Sensing of Hydrogen in Earth's Mantle

Earthquakes and Multi-hazards Around the Pacific Rim, Vol. II Charles A. Williams, Zhigang Peng, Yongxian Zhang, Eiichi Fukuyama, Thomas Goebel, Mark R. Yoder, 2018-05-16 This is the second of two volumes devoted to earthquakes and multi hazards around the Pacific Rim The circum Pacific seismic belt is home to roughly 80% of the world's largest earthquakes making it the ideal location for investigating earthquakes and related hazards such as tsunamis and landslides Following the Introduction this volume includes 14 papers covering a range of topics related to multi hazards The book is divided into five sections viscoelastic deformation earthquake source models earthquake prediction seismic hazard assessment and tsunami simulation Viscoelastic relaxation can play an important role in subduction zone behavior and this is explored in the first section with specific examples including the Tohoku oki earthquake in Eastern Japan In addition to laboratory rock friction experiments the second section examines earthquake source models for the 2016 MW 6.6 Aketao earthquake in Eastern Pamir and two earthquakes in Eastern Taiwan along with strong ground motion studies of the 2008 MW 7.9 Wenchuan China earthquake The Load Unload Response Ratio LURR Natural Time NT and nowcasting are earthquake prediction techniques that are analyzed in the third section with nowcasting predictions performed for a number of large cities globally Viscoelastic relaxation can play an important role in subduction zone behavior assessment are the focus of the fourth section with specific applications to the Himalayan Tibetan region and the Xianshuihe Fault Zone in Southwest China In the last section a new approach in modeling tsunami height distributions is described Rapid advances are being made in our understanding of multi hazards as well as the range of tools used to investigate them This volume provides a representative cross section of how state of the art knowledge and tools are currently being applied to multi hazards around the Pacific Rim The material here should be of interest to scientists involved in all areas of multi hazards particularly seismic and tsunami hazards In addition it offers a valuable resource for students in the geosciences covering a broad spectrum of topics related to hazard research

*Indian Ocean Biogeochemical Processes and Ecological Variability* Jerry D. Wiggert, Raleigh R. Hood, S. Wajih A. Naqvi, Kenneth H. Brink, Sharon L. Smith, 2013-05-09 Published by the American Geophysical Union as part of the Geophysical Monograph Series Volume 185 Indian Ocean Biogeochemical Processes and Ecological Variability provides a synthesis of current knowledge on Indian Ocean biogeochemistry and ecology and an introduction to new concepts and topical paradigm challenges It also reports on the development of more extensive frequent observational capacity being deployed in the Indian Ocean This represents the first collection of syntheses that emphasize a basin wide perspective and the contributing authors include some of the most esteemed oceanographers and Indian Ocean experts in the world The

volume is derived from invited plenary talks that were presented at the initial Sustained Indian Ocean Biogeochemistry and Ecosystem Research SIBER workshop held at the National Institute of Oceanography NIO in Goa India in October 2006 The volume discusses The overlying physical processes set by monsoonal forcing and how these control biological production and variability Nutrient cycling and limitation Pelagic carbon cycling and air sea exchange Benthic biogeochemistry and ecology The impact of climate and human activities on biogeochemistry and ecosystems The readership for this book will consist of academic and governmental researchers interested in exploring how oceanographic atmospheric and hydrological processes combine to establish the environmental setting that supports and drives the pelagic system and which are especially relevant to understanding the complex biogeochemical and ecological interactions in the Indian Ocean **Carbon Cycling in**

**Northern Peatlands** Andrew J. Baird, Lisa R. Belyea, Belyea, Xavier Comas, A. S. Reeve, Lee D. Slater, 2013-05-03 Published by the American Geophysical Union as part of the Geophysical Monograph Series Volume 184 Carbon Cycling in Northern Peatlands examines the role that northern peatlands play in regulating the atmospheric carbon budget It summarizes current research in four interconnected areas large scale peatland dynamics and carbon cycling plant and microbial dynamics and their effect on carbon fluxes to the atmosphere methane accumulation in and loss from peatlands and water and dissolved carbon fluxes through peatlands The volume highlights include A thorough assessment of the challenges involved in incorporating carbon cycling in northern peatlands into global climate models A conceptual model to examine the partitioning of terminal carbon mineralization into production of CO<sub>2</sub> and CH<sub>4</sub> A comprehensive review of the evidence for the accumulation of methane in deep and shallow peat and A description of the hydrologic changes induced by peat harvesting and associated challenges in restoring altered peatlands to their natural hydrologic regime Carbon Cycling in Northern Peatlands will be of interest to research scientists and graduate and undergraduate students particularly those who wish to know more about the role of peatlands in the global carbon cycle and their role as modifiers of climate

**Superplumes: Beyond Plate Tectonics** David A. Yuen, Shigenori Maruyama, Shun-ichiro Karato, Brian F. Windley, 2007-06-29 This abundantly illustrated book provides a concise overview of our understanding of the entire mantle its evolution since early differentiation and the consequences of superplumes for earth surface processes The book s balanced authorship has produced a state of the science report on the emerging concept of superplumes This presents a new concept to explain catastrophic events on Earth through geologic time *Core-Mantle Co-Evolution* Takashi Nakagawa, Taku Tsuchiya, Madhusoodhan Satish-Kumar, George Helffrich, 2023-05-23 New insights into interactions between the core and mantle The Earth s deep interior is difficult to study directly but recent technological advances have enabled new observations experiments analysis and simulations to better understand deep Earth processes Core Mantle Co Evolution An Interdisciplinary Approach seeks to address some of the major unsolved issues around the core mantle interaction and co evolution It provides the latest insights into dynamics structure and evolution in the core mantle boundary region Volume

highlights include Latest technological advances in high pressure experiments and their application to understanding the mineral physical properties and stability of phases in deep Earth Recent progress in observational seismology geochemical analysis geoneutrino experiments and numerical modeling for understanding the heterogeneity of the lower mantle Theoretical investigations on thermal chemical evolution of Earth's mantle and core Exploring thermal chemical mechanical electromagnetic interactions in the core mantle boundary regions The American Geophysical Union promotes discovery in Earth and space science for the benefit of humanity Its publications disseminate scientific knowledge and provide resources for researchers students and professionals

*Plates, Plumes, and Planetary Processes* Gillian R. Foulger, Donna M. Jurdy, 2007 Presents a collection of papers discussing various hypotheses and models of planetary plumes

*Treatise on Geophysics, Volume 7* David Bercovici, 2010-05-17 *Treatise on Geophysics Mantle Dynamics Volume 7* aims to provide both a classical and state of the art introduction to the methods and science of mantle dynamics as well as survey leading order problems both solved and unsolved and current understanding of how the mantle works It is organized around two themes 1 how is mantle convection studied and 2 what do we understand about mantle dynamics to date The first four chapters are thus concerned with pedagogical reviews of the physics of mantle convection laboratory studies of the fluid dynamics of convection relevant to the mantle theoretical analysis of mantle dynamics and numerical analysis and methods of mantle convection The subsequent chapters concentrate on leading issues of mantle convection itself which include the energy budget of the mantle the upper mantle and lithosphere in and near the spreading center mid ocean ridge environment the dynamics of subducting slabs hot spots melting anomalies and mantle plumes and finally geochemical mantle dynamics and mixing Self contained volume starts with an overview of the subject then explores each topic in detail Extensive reference lists and cross references with other volumes to facilitate further research Full color figures and tables support the text and aid in understanding Content suited for both the expert and non expert

*The Seismic Wavefield: Volume 1, Introduction and Theoretical Development* B. L. N. Kennett, 2001-11-12 This book provides a guide to understanding of seismograms for graduate students researchers professionals in academia and the petroleum industry

*Ocean Modeling in an Eddying Regime* Matthew W. Hecht, Hiroyasu Hasumi, 2013-04-30 Published by the American Geophysical Union as part of the Geophysical Monograph Series Volume 177 This monograph is the first to survey progress in realistic simulation in a strongly eddying regime made possible by recent increases in computational capability Its contributors comprise the leading researchers in this important and constantly evolving field Divided into three parts Oceanographic Processes and Regimes Fundamental Questions Ocean Dynamics and State From Regional to Global Scale and Modeling at the Mesoscale State of the Art and Future Directions The volume details important advances in physical oceanography based on eddy resolving ocean modeling It captures the state of the art and discusses issues that ocean modelers must consider in order to effectively contribute to advancing current knowledge from subtleties of the underlying fluid dynamical equations to meaningful



comparison with oceanographic observations and leading edge model development It summarizes many of the important results which have emerged from ocean modeling in an eddying regime for those interested broadly in the physical science More technical topics are intended to address the concerns of those actively working in the field **Post-Perovskite** Kei Hirose, John Brodholt, Thorne Lay, David Yuen, 2013-04-30 Published by the American Geophysical Union as part of the Geophysical Monograph Series Volume 174 Discovery of the perovskite to post perovskite phase transition in  $\text{MgSiO}_3$  expected to occur for deep mantle conditions was first announced in April 2004 This immediately stimulated numerous studies in experimental and theoretical mineral physics seismology and geodynamics evaluating the implications of a major lower mantle phase change A resulting revolution in our understanding of the D region in the lowermost mantle is well underway This monograph presents the multidisciplinary advances to date ensuing from interpreting deep mantle seismological structures and dynamical processes in the context of the experimentally and theoretically determined properties of the post perovskite phase change the last silicate phase change likely to occur with increasing pressure in lowermost mantle rocks **The Lithosphere** Jarod E. Anderson, 2009 The lithosphere is the outer solid part of the earth including the crust and uppermost mantle The lithosphere is about 100 km thick although its thickness is age dependent older lithosphere is thicker The lithosphere below the crust is brittle enough at some locations to produce earthquakes by faulting such as within a subducted oceanic plate This book presents leading research in the field from around the globe

*Treatise on Geophysics, Volume 9* David Stevenson, 2010-05-18 Evolution of the Earth focuses on the formation of Earth Topics include the differentiation of the core mantle and crust the formation of the ocean basins and continents outgassing and volcanism the initiation of plate tectonics the origin and persistence of Earth's magnetic field the growth of the inner core changes in mantle convection through time and the impact of life on the planet The volume takes an interdisciplinary viewpoint that emphasizes the interplay of geophysics other aspects of earth science and biological evolution Some outstanding questions are identified and debated Self contained volume starts with an overview of the subject then explores each topic with in depth detail Extensive reference lists and cross references with other volumes to facilitate further research Full color figures and tables support the text and aid in understanding Content suited for both the expert and non expert

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