

# The Solid Earth



Geophysics is a broad subject that encompasses not only the physics of the Earth but also that of the atmosphere and oceans. The heart of geophysics, however, is the theory of the solid Earth. This acclaimed textbook provides a general introduction to the study of modern physics of the solid Earth, including the workings of both the Earth's surface and its deep interior.

The book begins with a brief historical introduction to developments in geophysics. The next chapter discusses the important theory of plate tectonics and is followed logically by a chapter on geomagnetism and palaeomagnetism. Subsequent chapters deal with the subjects of seismology, gravity, radioactivity and the age of the Earth, and heat flow in the Earth. The book concludes with chapters on the mantle and core, and on the oceanic and continental lithospheres.

The emphasis throughout the discussion is on basic physical principles rather than instrumentation or data handling. Many helpful worked examples are given in the text and, in addition, there are exercises of various degrees of complexity at the end of each chapter. Solutions to many of the exercises are available to tutors by emailing [solutions@cambridge.org](mailto:solutions@cambridge.org). The book also contains an extensive glossary of geological and physical terms, as well as appendices that develop the more advanced mathematical aspects of seismology.

*The Solid Earth* is a textbook for undergraduate students enrolled in introductory geophysics courses who have a general background in the physical sciences, including introductory calculus. It can also be used as a reference book for graduate students and other researchers in the geological and geophysical sciences. This second edition has been revised to bring the content fully up to date and to reflect the most recent advances in geophysical research.

Praise for the first edition of *The Solid Earth*

'This fine new geophysics textbook will now be added to the top of my list of recommendations, as it promises to be excellent both for teachers and for those seeking a review of these processes from a geophysical point of view.'

*Nature*

'... deserves to be acclaimed. It is a carefully balanced introduction to the physics of the Earth, and is likely to become quickly the textbook used in most classrooms. The main asset of this book is the good balance between geological applications and geophysical methods.'

*Geophysics*

'... a superb, clearly laid out text. It covers a broad range of applied geophysics, from bulk Earth structure to the calculation of thermal histories in sedimentary basins.'

*New Scientist*

'... this book is an excellent text for a general introductory geophysics class focused on applications to the Earth rather than a rigorous presentation of techniques. I have enjoyed using this book in my beginning physics course with graduate and senior undergraduate students. It is also a useful reference book to have on the shelf.'

*Eos*

'... a first-rate, comprehensive text for teaching an audience of earth science students about the multidisciplinary approach that plate tectonics now demands.'

*Episodes*

Cover illustration: Indian Ocean Triple Junction, courtesy of N. J. Mitchell

Cover designed by Zoe Naylor

**CAMBRIDGE**  
UNIVERSITY PRESS  
[www.cambridge.org](http://www.cambridge.org)

ISBN 978-0-521-89307-





# Contents

Preface to the first edition	page xi
Preface to the second edition	xv
Acknowledgements to the first edition	xvi
Acknowledgements to the second edition	xviii
<b>Introduction</b>	<b>1</b>
References and bibliography	3
<b>Tectonics on a sphere: the geometry of plate tectonics</b>	<b>5</b>
Plate tectonics	5
A flat Earth	11
Rotation vectors and rotation poles	14
Present-day plate motions	15
Plate boundaries can change with time	24
Triple junctions	26
Absolute plate motions	32
Problems	37
References and bibliography	40
<b>Past plate motions</b>	<b>43</b>
The role of the Earth's magnetic field	43
Dating the oceanic plates	54
Reconstruction of past plate motions	67
Problems	93
References and bibliography	94
<b>Seismology Measuring the interior</b>	<b>100</b>
Waves through the Earth	100
Earthquake seismology	111
Refraction seismology	140
Reflection seismology	157
Problems	178
References and bibliography	186

<b>Gravity</b>	<b>193</b>
Introduction	193
Gravitational potential and acceleration	193
Gravity of the Earth	196
The shape of the Earth	198
Gravity anomalies	202
Observed gravity and geoid anomalies	213
Flexure of the lithosphere and the viscosity of the mantle	218
Problems	228
References and bibliography	230
<b>Geochronology</b>	<b>233</b>
Introduction	233
General theory	234
Rubidium–strontium	244
Uranium–lead	247
Thorium–lead	249
Potassium–argon	251
Argon–argon	252
Samarium–neodymium	254
Fission-track dating	258
The age of the Earth	262
Problems	265
References and bibliography	267
<b>Heat</b>	<b>269</b>
Introduction	269
Conductive heat flow	270
Calculation of simple geotherms	275
Worldwide heat flow: total heat loss from the Earth	285
Oceanic heat flow	288
Continental heat flow	298
The adiabat and melting in the mantle	303
Metamorphism: geotherms in the continental crust	308
Problems	321
References and bibliography	323
<b>The deep interior of the Earth</b>	<b>326</b>
The internal structure of the Earth	326
Convection in the mantle	353
The core	371
References and bibliography	381



<b>The oceanic lithosphere: ridges, transforms, trenches and oceanic islands</b>	<b>391</b>
Introduction	391
The oceanic lithosphere	397
The deep structure of mid-ocean ridges	409
The shallow structure of mid-ocean ridges	417
Transform faults	440
Subduction zones	458
Oceanic islands	487
Problems	492
References and bibliography	494
<b>The continental lithosphere</b>	<b>509</b>
Introduction	509
The growth of continents	517
Sedimentary basins and continental margins	557
Continental rift zones	584
The Archaean	595
Problems	601
References and bibliography	602
Appendix 1 Scalars, vectors and differential operators	615
Appendix 2 Theory of elasticity and elastic waves	620
Appendix 3 Geometry of ray paths and inversion of earthquake body-wave time–distance curves	630
Appendix 4 The least-squares method	636
Appendix 5 The error function	638
Appendix 6 Units and symbols	640
Appendix 7 Numerical data	648
Appendix 8 The IASP91 Earth model	650
Appendix 9 The Preliminary Reference Earth Model, isotropic version – PREM	651
Appendix 10 The Modified Mercalli Intensity Scale (abridged version)	654
Glossary	655
Index	666

The colour plates are situated between pages 390 and 391.