Fundamentals of Geophysics
Third Edition

This enduringly popular undergraduate textbook has been thoroughly reworked and updated, and now comprises twelve chapters covering the same breadth of topics as earlier editions, but in a substantially modernized fashion to facilitate classroom teaching.

Covering both theoretical and applied aspects of geophysics, clear explanations of the physical principles are blended with step-by-step derivations of the key equations and over 400 explanatory figures to explain the internal structure and properties of the planet, including its petroleum and mineral resources. New topics include the latest data acquisition technologies, such as satellite geophysics, planetary landers, ocean-bottom seismometers, and fiber optic methods, as well as recent research developments in ambient noise interferometry, seismic hazard analysis, rheology, and numerical modeling – all illustrated with examples from the scientific literature.

Student-friendly features include separate text boxes with auxiliary explanations and advanced topics of interest; reading lists of foundational, alternative, or more detailed resources; end-of-chapter review questions; and an increased number of quantitative exercises. Completely new to this edition is the addition of computational exercises in Python, designed to help students acquire important programming skills and develop a more profound understanding of geophysics.

WILLIAM LOWRIE is Professor Emeritus of Geophysics at the Institute of Geophysics at ETH Zürich, Switzerland, where he taught geophysics and carried out research in rock magnetism and paleomagnetism. He graduated from the University of Edinburgh in 1960 with first class honors in physics, before completing a master's degree in geophysics at the University of Toronto and a doctorate at the University of Pittsburgh. He has been President of the European Union of Geosciences (1987–1989) and Section President and a council member of the American Geophysical Union (2000–2002). He is a fellow of AGU and a member of the Academia Europaea.

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This book is dedicated to Marcia and Carolin

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Preface

Widespread access to powerful computers, advances in instrumentation, and the expansion of remote sensing of properties of the Earth and some other planets from space missions have resulted in considerable advancements in many fields of geophysics in the years since the second edition of this book was published. During this time the continual spread of internet-related education has made online availability of teaching materials increasingly desirable. These developments encouraged us to prepare this third edition of *Fundamentals of Geophysics*, and to provide interactive involvement for students in solving problems online in the form of Jupyter Notebooks.

For this edition, William Lowrie, the author of the earlier editions, has been joined by Andreas Fichtner. Both authors are professors of geophysics at the Swiss Federal Institute of Technology (ETH Zürich), with different fields of specialization. The collaboration adds expertise and a fresher approach to the different disciplines covered in the book.

Geophysics is often taught as two topics, with titles like "general" and "applied." In fact these are two sides of the same coin, and they often benefit from advances in instrumentation and analysis developed in each other's domain. As in the earlier editions, we therefore continue to describe the principal methods in both fields.

It is not possible to explain briefly every recent advancement in an introductory textbook, but we have included some of the most striking. These include the geophysical results from space missions to other bodies in the solar system (e.g., Mercury, Mars, Jupiter, and Pluto). There has been great progress in remotely sensing the gravitational and magnetic fields of our own planet from orbiting satellites. A new section is added to deal with space geodesy, in which we explain some of the developments that have revolutionized research in geodesy and gravity. New seismic methods for understanding the Earth's internal structure are described, for example by analyzing ambient noise. The danger presented by earthquakes can be estimated by probabilistic seismic hazard. Advancements in seismic tomography and the numerical modeling of geophysical processes (e.g., mantle dynamics) have illuminated – and posed new questions about – our understanding of the Earth's interior. Text boxes are used to handle some topics in greater detail than is needed in the body of the text, which, as in the earlier editions, emphasizes fundamental principles in the individual disciplines.

The new structure of the book divides the field of geophysics into 12 chapters, with a little overlap between some of them. In order to keep the price to students as low as possible, the authors decided to continue to use black-and-white figures, avoiding the use of more expensive color. However, as the book's title claims, its emphasis is on teaching the fundamental principles and these (mostly) do not change. If necessary, the teacher is in a position to enlarge upon the illustrations with colored examples, of which there is abundant choice in the professional literature. The website provides the solutions to the exercises at the end of each chapter for teachers who want to use them.

In preparing this edition we have received contributed figures, voluntary reviews, and constructive suggestions from a large number of colleagues. We are very grateful for their generous support. If we have not accepted suggestions, it was usually not because we disagreed, but rather because of our personal preferences. In particular we wish to thank Michael Afanasiev, Peter Annan, Nienke Blom, Jim Channell, Rob Coe, Laurentiu Danciu, Rhodri Davies, Sjoerd de Ridder, Jordi Diaz, Laura Ermert, Chris Finlay, Alexandre Fournier, Domenico Giardini, Alan Green, James Harris, Ann Hirt, Ian Jackson, Dennis Kent, Paula Koelemeijer, Maria Koroni, Kostas Lentas, Guust Nolet, Markku Poutanen, and Andrew Schaeffer.

In addition, the book has benefited from the suggestions of anonymous reviewers of each chapter. We appreciate the time and effort they made to improve our book, surely at the expense of their involvement in other research or academic work, and thank them sincerely for their help.

Finally, we thank our wives, Marcia Lowrie and Carolin Fichtner, for their understanding and encouragement. This book is dedicated to them.