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CHAPTER 1 Introduction and Acknowledgments

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Notes

❧ CHAPTER 1 ❧

Introduction and Acknowledgments

This book deals with the exploration of the Earth's crust and uppermost mantle using the method of controlled-source seismology. It presents the historical development of controlled-source seismology from its very beginning at around 1850 until 2005. We summarize the main scientific and technical achievements that have led to an increase in our knowledge of the structure of the Earth's crust and uppermost mantle, as obtained by seismic controlled-source methods.

It is the intention of the book to present a comprehensive history of controlled-source seismic studies of the Earth. As far as they were accessible in literature, we have compiled the results from all major field projects, on land and at sea, that have used man-made seismic energy sources with the aim to explore the Earth's crust, the crust-mantle boundary, and details of the uppermost mantle to depths of ~100 km.

We have not reinterpreted the seismic data to obtain new scientific results. Rather, we summarize published interpretations and show how controlled-source seismology developed gradually over the years, in particular how the amount and quality of data grew hand-in-hand with the development of better technology, as well as enhanced seismic theory and computational methods.

We have subdivided the history and results of controlled-source seismology into decades. For each decade we discuss the outstanding achievements of that time period, including which major field experiments were carried out and their main scientific results. For each decade from 1940 onwards, the reader will find short summaries of all the continental and marine seismic reflection and refraction campaigns that we could access. Within each decade, we have followed consistent geographic order.

Marine projects in continental shelf areas are discussed in the "Oceans" chapters, as long as they are pure offshore marine surveys. As soon as a major onshore component is involved, we have placed the project under the corresponding continent and country. Also, all British BIRPS and French ECORS marine seismic reflection surveys are discussed as continental projects, as well as all projects located in the North and Baltic Seas, in the Mediterranean, and in the Red Sea.

This book has been prepared with several purposes in mind. First, for each major project, we present location information, some technical details of the data acquisition, and then the scientific results, in many cases as velocity-depth cross sections and/or contour maps of crustal thickness. In seismic reflection surveys, authors tend to give depths in s TWT (two-way traveltime). We have not converted such depths into km, if the authors did not do it themselves. We provide a list of basic references for the reader who seeks further information. In addition, for many major

projects we have compiled copies of the original seismic data in the form of record sections and present these in the Appendix on a DVD. We do not, however, attempt to summarize all details of the seismic interpretations, nor the implications in terms of geodynamic or tectonic interpretations. These implications can be found in the original papers.

A second purpose of this book is to provide some background information regarding scientists whose efforts drove major projects to be realized, or on experimental details, many of which have changed over the decades. The intention is to document the special efforts needed to carry out the major projects reported here, and to highlight the very individual and personal input of scientists, students, technicians and others. In particular, we mention many of those people who have promoted controlled-source seismic experiments in theory and practice. Often these personalities contributed greatly to the success of the most logistically challenging and adventurous projects, e.g., those located in such places as arid deserts, in high mountains, at sea, or on ice. Our observation is that, in each country with major projects in controlled-source seismology, there have been strong personalities acting as driving forces behind the scientific vitality.

A third purpose is to present a project that is as complete as possible. We have tried to mention nearly all major projects, together with experimental details and the most important results. With a composite work such as the present one, it is, however, impossible to ensure a precise balance between the various projects. Some individual projects have been described in greater detail, whereby we often use the original phrasing of the corresponding authors, whereas in other cases the published sources have not been detailed enough to describe a major project with full details.

A fourth purpose is to present a summary of the whole earth that is as complete as possible. But, according to our own professional experience, we are most familiar with results from North America and central Europe, but have less familiarity with the former USSR and, in general, marine projects. Considering the large quantity of controlled-source seismic experiments carried out around the world since World War II and the enormous number of relevant publications being widely spread throughout the international literature, we are aware that we may have missed the one or other larger project and we apologize for such omissions.

A fifth purpose is to highlight the most important developments within each decade, be it interpretational procedures, experimental innovations, or landmark publications that summarized the state-of-the art at that point in time. Any use of trade product or firm names is for descriptive purpose only and does not imply endorsement by the German or U.S. governments.

We have prepared the text such that the individual field projects are described in the decade when the experiment was actually carried out, and not when results were published. While in most cases experiments and subsequent interpretations described in the individual chapters were accomplished in the same decade, in some cases the corresponding publications followed many years later. Examples are the special publications of Giese et al. (1976) or Prodehl (1979), published in the mid-to-late 1970s, but describing work essentially accomplished in the 1960s, or the PNE (Peaceful Nuclear Explosions) experiments in Russia, carried out in the 1970s and early 1980s but published only after 1990.

Some large and/or colored figures reprinted in this historic overview of explosion seismology may be difficult to read because we have avoided using foldouts. To enable the reader to view the figures in full, we have reproduced all figures of the printed version as jpg files in Appendix A1-1. In the figure captions, we have furthermore added the corresponding book or journal details where the original figure was published.

The data collected were usually compiled as record sections aligned either in linear profiles or fans. In our text, the description of the individual projects will not always contain data examples. But, as far as it was available to us, a significant amount of seismic data can be viewed on the accompanying DVD in Appendices A2–A10, arranged according to the relevant decade. The DVD contains collections of record sections in a reduced and compressed scale for various projects, with or without correlations, that were easily available from personal collections and open-file reports or from publications. For several projects of the U.S. Geological Survey in the 1980s and early 1990s, data reports were available in PDF that we have included in this data collection part. Most data presented in the Appendix on the DVD come from projects in which one of the authors or his institution was actively involved. It would be beyond the scope of this book, however, to reproduce complete sets of digital data for any project which people might be able to reprocess at later times. In the Appendix, we have also included PDF files of a few publications of historical interest that cannot easily be found in libraries.

This compilation would not have been possible without the input of many colleagues with whom the authors have cooperated in numerous field projects, meetings, conferences and personal discussions. The authors are also indebted to the numerous colleagues who helped enlarge the personal databases for further use without formalities by exchanging the data from the many joint national and international cooperative research projects in which they had been involved.

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For review, the manuscript was divided so that some reviews dealt with general aspects while others specialized in particular regions. The constructive criticism and manifold suggestions were extremely valuable and of great importance in improving the manuscript. All reviewers added valuable information and additional references. We want to thank in particular Ron Clowes

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Most of the data from western Europe (Scandinavia, British Isles, France, Germany, Alpine countries, and Mediterranean) and from the United States shown as record sections on jpg-files in the Appendix are from the personal data archives of either one of the authors. In most cases they had been collected prior to publication of the corresponding projects. Due to the complexity and costs of large-scale seismic projects, a major number of research institutions always cooperated, both on national and international basis. However, it was impossible to include in the authors' lists of those publications the members of all institutions which had directly or indirectly been involved in the realization of the fieldworks. Therefore, in practice, mostly only a few actively interpreting scientists appeared as authors. In Germany, for example, the organization of manpower and instrumentation (widely distributed in small numbers amongst all seismically active institutions) for seismic-refraction experiments was enabled by ASFA (working group for seismic field measurements and interpretation), in which all university and state institutions with seismic instrumentation cooperated and which was headed by one of the authors from 1970 to 2001. Similar organizations existed in Great Britain, Italy, and Spain. It was by mutual agreement that scientists of the participating institutions were permitted to reuse freely the data for reinterpretations and republications without further formalities, after the first report on the corresponding project had been published.

The history and results of controlled-source seismology would not be complete without the inclusion of many of the original figures. Numerous publishing companies and institutions have provided permission for their figures to be reprinted here. We greatly acknowledge the friendly cooperation of all. These are in particular:

American Association of Petroleum Geologists (*AAPG Bulletin*)
 American Association for the Advancement of Science, Washington, D.C., USA (*Science*)
 American Geophysical Union (*Eos, Journal of Geophysical Research, Geophysical Research Letters*, American Geophysical Union Monographs)

Annual Reviews, Palo Alto, California, USA (*Annual Reviews*)
 Australian Geological Survey Organisation (AGSO) (*BMR Journal of Australian Geology and Geophysics*)
 Australian National University (ANU, Research School of Earth Sciences)
 Bergakademie Freiberg, Germany (*Freiberger Forschungshefte*)
 Birkhäuser Verlag AG, Basel, Switzerland (*PAGEOPH*)
 Cambridge University Press, New York, USA (books)
 Canadian Society of Petroleum Geologists (*Bulletin of Canadian Petroleum Geology*)
 Carnegie Institution for Science, Washington, D.C. (a.k.a. Carnegie Institution of Washington)
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 Edition Technip (Paris, France)
 Elsevier, Amsterdam, Netherlands (books, *Earth and Planetary Science Letters, Journal of South American Earth Science, Physics of the Earth and Planetary Interiors, Tectonophysics*, books—Academic Press)
 Eötvös Loránd Geophysical Institute of Hungary, Budapest (*Geophysical Transactions*, special editions)
 ETH Zürich, Institute of Geophysics, Department of Earth Sciences, Switzerland
 European Association of Geoscientists and Engineers (EAGE) (*First Break*)
 European Science Foundation, Strasbourg, France
 Freie Universität Berlin, Germany (*Berliner Geowissenschaftliche Abhandlungen*)
 Geological Society of America (*Geology, Geological Society of America Bulletin*, Special Papers, Memoirs)
 Geological Society, London, UK (Special Publications, Memoirs, *Petroleum Geology, Journal of the Geological Society*)
 Geological Society of Australia (*Australian Journal of Earth Sciences*)
 Geological Society of India (Memoirs)
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 International Union of Geological Sciences (*Episodes*)
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 John Wiley and Sons (*Geophysical Journal of the Royal Astronomical Society, Geophysical Journal International, First Break, Terra Nova*)
 Komitet Badań Polarnych (*Polish Polar Research*)
 LITHOPROBE, Canada
 National Research Council, Canada
 Nature Publishing Group
 NRC Research Press (*Canadian Journal of Earth Science*)

- Polish Academy of Sciences (Publications of the Institute of Geophysics, Polish Academy of Sciences, *Acta Geophysica Polonica*)
- Royal Astronomical Society, London, UK
- Russian Academy of Sciences, Schmidt United Institute of Physics of the Earth, Russian Academy of Sciences (books, Nauka Moscow)
- Schweizerbart'sche Verlagsbuchhandlung OHG (Naegele u. Obermiller, Stuttgart, Germany) (books)
- Schweizerische Geologische Gesellschaft (*Eclogae Geologicae Helveticae*)
- Seismological Society of America (*Bulletin of the Seismological Society of America*)
- Seismological Society of Japan (*Earth, Planets and Space*, a continuation of *Journal of Physics of the Earth*)
- Servicio Nacional de Geología y Minería, Chile (*Revista de Chile/Andean Geology*)
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- Swedish Research Council
- TOTAL-CSTJF (Centre Scientifique et Technique Jean Feger), Pau, France (*Bulletin Centre Recherche Pau-SNPA*)
- U.S. Geological Survey
- University of Bergen (Norway, Prof. Sellevoll)
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