

Cambridge University Press

0521675510 - An Introduction to Seismological Research: History and Development

Benjamin F. Howell

Frontmatter

[More information](#)

---

*An introduction to  
seismological research*

Cambridge University Press

0521675510 - An Introduction to Seismological Research: History and Development

Benjamin F. Howell

Frontmatter

[More information](#)

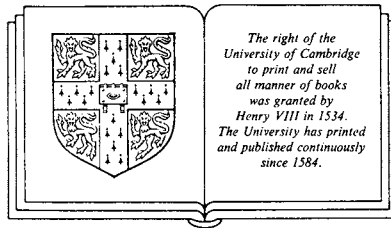
# An introduction to seismological research

---

*History and development*

BENJAMIN F. HOWELL, JR.

*The Pennsylvania State University*



CAMBRIDGE UNIVERSITY PRESS

*Cambridge*

*New York Port Chester Melbourne Sydney*

Cambridge University Press

0521675510 - An Introduction to Seismological Research: History and Development

Benjamin F. Howell

Frontmatter

[More information](#)

CAMBRIDGE UNIVERSITY PRESS

Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo

Cambridge University Press

The Edinburgh Building, Cambridge CB2 2RU, UK

Published in the United States of America by Cambridge University Press, New York

[www.cambridge.org](http://www.cambridge.org)Information on this title: [www.cambridge.org/9780521385718](http://www.cambridge.org/9780521385718)

© Cambridge University Press 1990

This book is in copyright. Subject to statutory exception  
and to the provisions of relevant collective licensing agreements,  
no reproduction of any part may take place without  
the written permission of Cambridge University Press.

First published 1990

This digitally printed first paperback version 2005

Chapter 2 was first published in modified form by  
the American Geophysical Union in 1986 in *Eos*, v.67, pp. 1323–6.  
Chapter 4 is revised from “Seismic Instrumentation: History” from  
*The Encyclopedia of Solid Earth Geophysics*, edited by David E.  
James. Copyright © 1989 by Van Nostrand-Reinhold.

*A catalogue record for this publication is available from the British Library**Library of Congress Cataloguing in Publication data*

Howell, Benjamin F. (Benjamin Franklin), 1917–

An introduction to seismological research : history and  
development / Benjamin F. Howell, Jr.

p. cm.

Includes bibliographical references.

ISBN 0-521-38571-7

1. Seismology – Research. I. Title.

QE534.2.H68 1990

551.2'2 – dc20

90-1551

CIP

ISBN-13 978-0-521-38571-8 hardback

ISBN-10 0-521-38571-7 hardback

ISBN-13 978-0-521-67551-2 paperback

ISBN-10 0-521-67551-0 paperback

Cambridge University Press

0521675510 - An Introduction to Seismological Research: History and Development

Benjamin F. Howell

Frontmatter

[More information](#)


---

## CONTENTS

---

*Preface* vii

1. INTRODUCTION	page 1
2. CAUSE OF EARTHQUAKES	5
2.1 Mythology	5
2.2 Recognition of the role of rock fracture	6
2.3 The problem of deep earthquakes	11
2.4 Early focal mechanism studies	13
2.5 A possible mechanism of failure	16
2.6 Source characteristics from recorded pulses	18
3. SEISMICITY AND PREDICTION OF EARTHQUAKES	25
3.1 Direct observation	25
3.2 The beginning of cooperative data gathering	29
3.3 Plate tectonics as an explanation for seismicity	36
3.4 Estimation of recurrence rates	45
3.5 Induced seismicity	50
3.6 Maps of seismic risk	50
3.7 Prediction of earthquakes	53
4. INSTRUMENTS	57
4.1 Seismoscopes	57
4.2 Inertial seismographs	59
4.3 Modern seismograph systems	65
4.4 Strain seismographs	69
4.5 Strong-motion seismographs	71

Cambridge University Press

0521675510 - An Introduction to Seismological Research: History and Development

Benjamin F. Howell

Frontmatter

[More information](#)

vi

*Contents*

5. SEISMIC PULSES AND THE INTERNAL STRUCTURE OF THE EARTH	73
5.1 Identification of different seismic pulses	73
5.2 Structure of the crust	77
5.3 Structure of the mantle	79
5.4 The core of the earth	85
5.5 Density in the earth's interior	90
5.6 Free oscillations of the earth	95
6. QUANTIFICATION OF EARTHQUAKE SIZE	97
6.1 Introduction	97
6.2 Intensity scales	97
6.3 Magnitude	102
6.4 Moment	109
6.5 Energy	112
7. ATTENUATION	119
7.1 Introduction	119
7.2 Geometric spreading	120
7.3 Dispersion	121
7.4 Scatter	123
7.5 Absorption	124
8. MICROSEISMS	131
9. TSUNAMIS	137
9.1 Introduction	137
9.2 Cause	138
9.3 Transmission	141
9.4 Tsunami warning systems	145
<i>Appendix. Some important dates in the history of seismology</i>	149
<i>References</i>	153
<i>Index</i>	185

Cambridge University Press

0521675510 - An Introduction to Seismological Research: History and Development  
Benjamin F. Howell

Frontmatter

[More information](#)

---

## PREFACE

---

This book has several purposes. First, I wrote it for my own reeducation. After spending 14 years as an assistant and associate dean, I knew I had failed to keep up with new ideas in seismology. On retirement, I set out to remedy this. Writing a history of seismology appeared to be a logical and useful way to give direction and organization to my reading. The science is progressing so rapidly that I may never catch up.

My main goal in writing this history is to provide a basis from which a seismologist can start to research a new topic. In reporting research, it is often helpful to begin with references to the classic, basic papers on the subject. I have tried to reference a wide spectrum of such papers here. When a source is not stated, it will often be found in Charles Davison's (1927) *The Founders of Seismology* or in Beno Gutenberg's (1941) article in the Geological Society of America's *Geology, 1880–1938*. As one of Gutenberg's former students, I find that his careful style of referencing has greatly influenced me (see, e.g., Gutenberg, 1951, 1959).

Another goal in writing this book has been to show how new ideas came into being, that is, how the understanding of earthquakes has grown from the earliest simplest ideas to modern concepts. It has become obvious in doing this that ideas grow from simple early inspiration to later full-blown understanding as a result of extensive observational and experimental researches. It is often a person who is well along in the development of a concept who so clearly expounds an idea that he or she is remembered as its originator. It is the ability to convince others of the rightness of a concept that leads to being remembered. A good example is that Harry Fielding Reid (1910) is remembered as the originator of the elastic-rebound theory rather than J. F. Hayford and A. L. Baldwin (1908), who made the measurements on which Reid's theory is based, or G. K. Gilbert (1884), who said essentially the same thing more than two decades earlier. Similarly,

Cambridge University Press

0521675510 - An Introduction to Seismological Research: History and Development

Benjamin F. Howell

Frontmatter

[More information](#)

viii

*Preface*

H. H. Hess (1962) and R. S. Dietz (1961) are generally considered to be the originators of the plate-tectonics theory whereas one rarely hears of the earlier work of Osmond Fisher (1882, 1891).

This history focuses on the development of scientific ideas rather than on the people who developed them. I make no apology for this even though it may disappoint some historians. The objective here has been to trace the evolution of ideas to assist in understanding seismology as it is practiced today, not to examine the culture in which these ideas developed. Seismology is a relatively new science, with most current ideas having roots going back no further than the last half of the nineteenth century. Also, I have depended almost entirely on the published literature. It is clear that 100 years ago the published literature followed verbal discussion by one or more years even as it does today. A study based on published material cannot show how ideas evolved through informal communications among the people who were working in the field at the time. An historian might emphasize this other aspect of the history of seismology; I can only pass on my own limited view of how ideas developed.

No attempt has been made to cover the history of exploration geophysics or of nuclear-blast identification. Excellent books are available on both these topics: Sweet (1978) for exploration geophysics and Bates, Gaskell, and Rice (1982) for nuclear-blast identification. It seemed wisest to concentrate on those aspects of seismology in which I have the greatest interest and on which I can speak with some authority.

Readers will note that the discoveries reported here are largely by Americans and western Europeans. This is in part due to my inability to read many languages, but it also results from modern seismology being developed largely from two early centers of interest: one in Germany, represented by the work of Emil Wiechert and his colleagues at Göttingen University, and the other in Great Britain, beginning with Robert Mallet and John Milne and those whom they interested in seismology. Milne was also the founder of research in seismology in Japan. The basis was much wider in America but did not flower until after the 1906 San Francisco earthquake.

Finally, I would like to thank the many colleagues and friends who have read all or parts of this book and have helped to make the coverage as complete as it is. The following have been particularly helpful: Keiiti Aki, Don L. Anderson, William Glen, Roy J. Greenfield, Charles A. Langston, Peter M. Lavin, and Jack Oliver. The support and encouragement of the Department of Geosciences at The Pennsylvania State University, especially its head, Shelton S. Alexander, is gratefully acknowledged.

*University Park, Pennsylvania*

Benjamin F. Howell, Jr.