Palaeoseismology: Historical and Prehistorical Records of Earthquake Ground Effects for Seismic Hazard Assessment
The Society makes every effort to ensure that the scientific and production quality of its books matches that of its journals. Since 1997, all book proposals have been refereed by specialist reviewers as well as by the Society’s Books Editorial Committee. If the referees identify weaknesses in the proposal, these must be addressed before the proposal is accepted.

Once the book is accepted, the Society Book Editors ensure that the volume editors follow strict guidelines on refereeing and quality control. We insist that individual papers can only be accepted after satisfactory review by two independent referees. The questions on the review forms are similar to those for Journal of the Geological Society. The referees’ forms and comments must be available to the Society’s Book Editors on request.

Although many of the books result from meetings, the editors are expected to commission papers that were not presented at the meeting to ensure that the book provides a balanced coverage of the subject. Being accepted for presentation at the meeting does not guarantee inclusion in the book.

More information about submitting a proposal and producing a book for the Society can be found on its web site: www.geolsoc.org.uk.

It is recommended that reference to all or part of this book should be made in one of the following ways:


Palaeoseismology: Historical and Prehistorical Records of Earthquake Ground Effects for Seismic Hazard Assessment

EDITED BY

K. REICHERTER
RWTH Aachen University, Germany

A. M. MICHETTI
Università dell’Insubria, Italy

AND

P. G. SILVA
Universidad de Salamanca, Spain

2009
Published by
The Geological Society
London
THE GEOLOGICAL SOCIETY

The Geological Society of London (GSL) was founded in 1807. It is the oldest national geological society in the world and the largest in Europe. It was incorporated under Royal Charter in 1825 and is Registered Charity 210161.

The Society is the UK national learned and professional society for geology with a worldwide Fellowship (FGS) of over 9000. The Society has the power to confer Chartered status on suitably qualified Fellows, and about 2000 of the Fellowship carry the title (CGeol). Chartered Geologists may also obtain the equivalent European title, European Geologist (EurGeol). One fifth of the Society’s fellowship resides outside the UK. To find out more about the Society, log on to www.geolsoc.org.uk.

The Geological Society Publishing House (Bath, UK) produces the Society’s international journals and books, and acts as European distributor for selected publications of the American Association of Petroleum Geologists (AAPG), the Indonesian Petroleum Association (IPA), the Geological Society of America (GSA), the Society for Sedimentary Geology (SEPM) and the Geologists’ Association (GA). Joint marketing agreements ensure that GSL Fellows may purchase these societies’ publications at a discount. The Society’s online bookshop (accessible from www.geolsoc.org.uk) offers secure book purchasing with your credit or debit card.

To find out about joining the Society and benefiting from substantial discounts on publications of GSL and other societies worldwide, consult www.geolsoc.org.uk, or contact the Fellowship Department at: The Geological Society, Burlington House, Piccadilly, London W1J 0BG: Tel. +44 (0)20 7434 9944; Fax +44 (0)20 7439 8975; E-mail: enquiries@geolsoc.org.uk.

For information about the Society’s meetings, consult Events on www.geolsoc.org.uk. To find out more about the Society’s Corporate Affiliates Scheme, write to enquiries@geolsoc.org.uk.

Published by The Geological Society from:
The Geological Society Publishing House, Unit 7, Brassmill Enterprise Centre, Brassmill Lane, Bath BA1 3JN, UK
(Orders: Tel. +44 (0)1225 445046, Fax +44 (0)1225 442836) Online bookshop: www.geolsoc.org.uk/bookshop

The publishers make no representation, express or implied, with regard to the accuracy of the information contained in this book and cannot accept any legal responsibility for any errors or omissions that may be made.

© The Geological Society of London 2009. All rights reserved. No reproduction, copy or transmission of this publication may be made without written permission. No paragraph of this publication may be reproduced, copied or transmitted save with the provisions of the Copyright Licensing Agency, 90 Tottenham Court Road, London W1P 9HE. Users registered with the Copyright Clearance Center, 27 Congress Street, Salem, MA 01970, USA: the item-fee code for this publication is 0305-8719/09/$15.00.

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library.

Typeset by Techset Composition Ltd., Salisbury, UK
Printed by MPG Books Ltd., Bodmin, UK

Distributors

North America
For trade and institutional orders:
The Geological Society, c/o AIDC, 82 Winter Sport Lane, Williston, VT 05495, USA
Orders: Tel. +1 800-972-9892
Fax +1 802-864-7626
E-mail: gsl.orders@aidcvt.com

For individual and corporate orders:
AAPG Bookstore, PO Box 979, Tulsa, OK 74101-0979, USA
Orders: Tel. +1 918-584-2555
Fax +1 918-560-2652
E-mail: bookstore@aapg.org
Website: http://bookstore.aapg.org

India
Affiliated East-West Press Private Ltd, Marketing Division, G-1/16 Ansari Road, Darya Ganj, New Delhi 110 002, India
Orders: Tel. +91 11 2327-9113/2326-4180
Fax +91 11 2326-0538
E-mail: affiliat@vsnl.com
Earthquakes are one of the greatest natural hazards humans face. During the twentieth century alone, over two million people died during strong ground shaking, attendant fires, tsunamis and landslides. Most recently, in May 2008, about 80 000 people died in an earthquake in Sichuan Province in China and, earlier, on 26 December 2004, more than 200 000 people lost their lives to the tsunami resulting from the great earthquake off the west coast of Sumatra in Indonesia. In December 2003, the ancient city of Bam in Iran was destroyed by an earthquake, with the loss of over 30 000 lives. The worst disaster in modern times occurred in China in July 1976, when an entire city was destroyed and over 240 000 people killed in less than six minutes. Earlier, in 1556, an earthquake in north-central China killed an estimated 800 000 people, one of the worst natural disasters in recorded history.

Given the tremendous toll in human lives and attendant economic losses, it is appropriate that scientists are working hard to better understand earthquakes, with the ultimate aim of forecasting and, ultimately, predicting them. Their research is broadly of three types. First are instrumental studies of earthquakes by seismologists. Most countries have seismic networks, and seismologists use these records to characterize earthquakes in time and space. Their research allows them to continually improve understanding of seismic risk. Second are geodetic studies of contemporary surface deformation. Modern, GPS-based measurements of changes in the position of fixed points on Earth’s surface are providing important insights into crustal stress that can be linked to the instrumental earthquake record. Third are studies of active tectonics and of the geological evidence left by historic and prehistoric earthquakes. These studies provide valuable context for interpreting contemporary seismicity and crustal strain accumulation. They also are the only means of extending the instrumental earthquake record into prehistory, which is particularly important in areas such as western North America where written accounts of earthquakes are limited to the past 150 years.

The papers in this Special Publication fall into the third group mentioned above, a field of research termed ‘palaeoseismology’. Palaeoearthquake research is a broad endeavour, with roots in geology, seismology, tectonics, structural geomorphology, geomorphology, stratigraphy and sedimentology. Its practitioners are interdisciplinary scientists who emphasize field research and typically have strong interests in risk, a topic that lies outside physical science.

This Special Publication is the ‘brain child’ of its three editors, Klaus Reicherter, Alessandro Michetti and Pablo Silva Barroso. It stems from presentations and lively discussions at two recent events sponsored by the INQUA Subcommission on Palaeoseismology: a session at the 2006 EGU in Vienna titled ‘3000 years of earthquake ground effects in Europe’; and an ICTP/IAEA workshop held in 2006 at Trieste on seismic hazard analyses for critical facilities. A key contribution of these meetings was to show how the systematic study of earthquake surface rupture, liquefaction, tsunami deposits, and other ground effects can be integrated with traditional seismological and tectonic information to provide a better understanding of seismic hazards and risk.

Some words about INQUA seem appropriate here, because this organization enabled the scientific meetings and discussions that led to this Special Publication. INQUA (the International Union for Quaternary Research) is a member union of the International Council of Science. Its primary objectives are to encourage the interdisciplinary study of all aspects of the Quaternary Period (the last two million years), and to facilitate and coordinate international cooperation for this study. The Quaternary is a unique period in Earth history – humans appeared at the beginning of the Quaternary, and their evolution was driven by frequent large changes in global climate with environmental conditions very different from those of today. These climatic fluctuations led to major global reorganization of terrestrial geography, ocean circulation and structure, and biotic communities. An important part of INQUA’s remit is fostering research on hazardous Earth processes, including earthquakes, tsunamis, landslides, floods, and severe storms. The research is carried out under the aegis of INQUA’s Commission on Terrestrial Deposits and Processes, of which the Subcommission on Palaeoseismology is part.

In the introduction the editors comment on each of the papers in the volume. Their summary makes it clear that the papers, although diverse in subject and scope, group around several themes. Many of the papers are concerned with the effects of earthquakes on the natural environment, and in particular with the application of the recently introduced ‘INQUA ESI scale’ to large historic earthquakes in different tectonic settings. The ESI scale is based on primary and secondary ground effects of earthquakes rather than traditional effects on
people and infrastructure, and was developed by the Subcommission on Palaeoseismology over the past five years. Another group of papers examines regional earthquake histories in relation to the tectonic environments in which they occur. A third group is concerned with earthquakes and archaeology.

By nature of its subject, this volume can provide only a sample of modern palaeoseismological research. It cannot possibly cover the entire breadth of palaeoseismology, for such a volume would be an encyclopedia not a single volume. Nevertheless, this ‘sampler’ will whet the appetite of readers interested in learning what palaeoearthquake research can bring to the table of earthquake research. To those readers, I say ‘bon appetit’.

JOHN J. CLAGUE
Past-President, INQUA
Director, Centre for Natural Hazard Research,
Simon Fraser University