Geoscientists worldwide are developing and applying methodologies to estimate geologic hazards associated with the siting of nuclear facilities, including nuclear power plants and underground repositories for long-lived radioactive wastes. Understanding such hazards, particularly in the context of the long functional lifetimes of many nuclear facilities, is a challenging task. This book documents the current state of the art in volcanic and tectonic hazard assessment for proposed nuclear facilities, which must be located in areas where the risks associated with geologic processes can be quantified and are demonstrably low.

Specific topics include overviews of volcanic and tectonic processes, the history of development of hazard assessment methodologies, description of current techniques for characterizing hazards, and development of probabilistic methods for estimating risks and uncertainties. Examples of hazard assessments are drawn from around the world, including the United States, Great Britain, Sweden, Switzerland and Japan.

This volume will promote much interest and debate about this important topic among research scientists and graduate students actively developing methods in geologic hazard assessment, geologists and engineers charged with assessing the safety of nuclear facilities and those with regulatory responsibility to evaluate such assessments.

Charles B. Connor is Professor and Chairman of the Geology Department at the University of South Florida. He has worked on assessment of volcanic hazards at nuclear facilities since 1992, in association with the US Nuclear Regulatory Commission, the International Atomic Energy Agency and the Nuclear Waste Organization of Japan. These professional activities have included developing the US Nuclear Regulatory scientific program for assessment of volcanic hazards at Yucca Mountain, Nevada, chairing of the committee to develop IAEA safety guidance for nuclear power plants and developing safety guidelines for nuclear installations in Japan. In addition, he served on the US National Research Council commission to review the US Geological Survey volcanic hazards program for the National Academy of Sciences.

Neil A. Chapman is Chairman of the ITC School of Underground Waste Storage and Disposal, Switzerland; Research Professor of Environmental Geology, Department of Engineering Materials, University of Sheffield, UK; Programme Director, Arius Association, Switzerland; an independent consultant. He has worked for more than 30 years on the scientific and strategic issues of the nuclear industry and radioactive wastes, for industrial, governmental and international organizations and agencies worldwide. This has involved participation in many national and international advisory committees, in the management of internationally funded projects and as a visiting expert. He is currently chairman of the INSITE site investigation overview group for the Swedish regulatory authority, SSM, and was recently a member of the International Technical Advisory Committee (ITAC) of the Japanese radioactive waste management organization (NUMO).

Laura J. Connor is a computational scientist and research associate in the Department of Geology at the University of South Florida. Her work has focused on computational methods in geologic hazard assessment and geophysical research, which have highlighted new methods for optimization of volcanic hazard models, uncertainty assessment for volcanic hazard models and applications in real-time monitoring of geophysical processes. She has authored numerous codes, including the probabilistic volcanic hazard assessment codes currently in use by the US Nuclear Regulatory Commission and the Nuclear Waste Organization of Japan. She is co-editor of Statistics in Volcanology, recently published by the Geological Society of London.
VOLCANIC AND TECTONIC HAZARD ASSESSMENT FOR NUCLEAR FACILITIES

Edited by

C. B. CONNOR,¹ N. A. CHAPMAN,² L. J. CONNOR¹

¹ Department of Geology, University of South Florida
² MCM Consulting, Switzerland
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Contributors

W. R. Alexander  Bedrock Geosciences, Veltheimerstrasse 18, CH-5105 Auenstein, Switzerland.


W. P. Aspinall  Aspinall & Associates, 5 Woodside Close, Beaconsfield HP9 1JQ, UK.

K. Berryman  GNS Science – Te Pu Ao, 1 Fairway Drive, Avalon, Lower Hutt 5010, New Zealand.

J. Beavan  GNS Science – Te Pu Ao, 1 Fairway Drive, Avalon, Lower Hutt 5010, New Zealand.

C. Bonadonna  Section des Sciences de la Terre, Université de Genève, 13, rue des Maraîchers, CH-1205 Genève, Switzerland.

M. L. Caplinger  Department of Geology, University of South Florida, 4202 E. Fowler Ave, Tampa FL, 33620, USA.

N. A. Chapman  MCM Consulting, Täfernstrasse 11, CH 5405 Baden-Dättwil, Switzerland.

M. Cloos  Department of Geological Sciences, Jackson School of Geosciences, University of Texas at Austin, Austin TX, 78712, USA.

C. B. Connor  Department of Geology, University of South Florida, 4202 E. Fowler Ave, Tampa FL, 33620, USA.

L. J. Connor  Department of Geology, University of South Florida, 4202 E. Fowler Ave, Tampa FL, 33620, USA.

K. J. Coppersmith  Coppersmith Consulting, Inc., 2121 North California Blvd, Suite 290, Walnut Creek CA, 94596, USA.

M. Díez  Department of Geology, University of South Florida, 4202 E. Fowler Ave, Tampa FL, 33620, USA.

G. Downes  GNS Science – Te Pu Ao, 1 Fairway Drive, Avalon, Lower Hutt 5010, New Zealand.
List of contributors

S. J. Fowler Department of Earth Science, University of California, Santa Barbara CA, 93106, USA.

A. R. Godoy ESS/NSNI, P.O. Box 100, Wagramer Strasse 5, A-1400 Vienna, Austria.


A. Hasegawa Research Center for Prediction of Earthquakes and Volcanic Eruptions, Tohoku University, Sendai 980-8578, Japan.

B. E. Hill US Nuclear Regulatory Commission, NMSS/HLWRS, EBB 2-02, Washington DC, 20555-0001, USA.

S. S. Hughes Department of Geosciences, Idaho State University, 921 S. 8th Avenue – Stop 8072, Pocatello ID, 83209-8072, USA.

D. Inoue Central Research Institute of Electric Power Industry, 1646 Abiko, Abiko-shi, Chiba-ken 270-1194, Japan.

O. Jaquet In2Earth Modelling Ltd., c/o Wirtschafts-Treuhand AG, Arnold Böcklin-Strasse 25, CH-4051 Basel, Switzerland.

K. E. Jenni Insight Decisions, LLC, 1616 Seventeenth St., Suite 268, Denver CO, 80202, USA.


J.-C. Komorowski Institut de Physique du Globe de Paris (IPGP) – CNRS (UMR 7154), Equipe de Géologie des Systèmes Volcaniques, 4, Place Jussieu, B 89, 75252 Paris cedex 05, France.

H. Kondo Nuclear Fuel Cycle Backend Research Center, Central Research Institute of Electric Power Industry, 1646 Abiko, Abiko-shi, Chiba-ken 270-1194, Japan.


A. -M. Lejeune Laboratoire de Pétrologie, Modélisation des Matériaux et Processus, Universite, Pierre et Marie Curie, Case 110 - 4 place Jussieu, 75252 Paris cedex 05, France.

N. Litchfield GNS Science – Te Pu Ao, 1 Fairway Drive, Avalon, Lower Hutt 5010, New Zealand.

B. Lund Department of Earth Sciences, Uppsala University, Villavägen 16, 752 36 Uppsala, Sweden.
List of contributors

S. H. Mahony Department of Earth Sciences, University of Bristol, Wills Memorial Building, Queen’s Road, Bristol BS8 1RJ, UK.

R. McCaffrey GNS Science – Te Pu Ao, 1 Fairway Drive, Avalon, Lower Hutt 5010, New Zealand.

T. McEwen McEwen Consulting, Cobblestones, Main Street, Hickling, Melton Mowbray LE14 3AJ, UK.

I. G. McKinley McKinley Consulting, Tafernstrasse 11, CH-5405 Baden/Dättwil, Switzerland.

T. Menand Centre for Environmental and Geophysical Flows, Department of Earth Sciences, University of Bristol, Queens Road, Bristol BS8 1RJ, UK.

D. Merritts Department of Geosciences, Franklin and Marshall College, Lancaster PA, 17603-3003, USA.

S. Miura Research Center for Prediction of Earthquakes and Volcanic Eruptions, Tohoku University, Sendai 980-8578, Japan.

S. Nakada Earthquake Research Institute, University of Tokyo, Yayoi 1-1-1, Bunkyo-ku, Tokyo 113-0032, Japan.

J. Nakajima Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, Sendai, 980-8578, Japan.


Y. Ota Yokohama National University, Tokyo, 145-0063, Japan.

S. C. P. Pearson Department of Geology, University of South Florida, 4202 E. Fowler Ave, Tampa FL, 33620, USA.

R. C. Perman AMEC Geomatrix, Inc., 2101 Webster St., 12th Floor, Oakland CA, 94612, USA.

F. V. Perry Earth and Environmental Sciences Division, Los Alamos National Laboratory, Los Alamos NM, 87545, USA.

J. C. Phillips Centre for Environmental and Geophysical Flows, Department of Earth Sciences, University of Bristol, Queens Road, Bristol BS8 1RJ, UK.

W. Power GNS Science – Te Pu Ao, 1 Fairway Drive, Avalon, Lower Hutt 5010, New Zealand.

L. Reiter Consultant, 1960 Dundee Road, Rockville MD, 20850, USA.

W. D. Smith GNS Science – Te Pu Ao, 1 Fairway Drive, Avalon, Lower Hutt 5010, New Zealand.
List of contributors

R. S. J. Sparks Centre for Environmental and Geophysical Flows, Department of Earth Sciences, University of Bristol, Queens Road, Bristol BS8 1RJ, UK.

F. J. Spera Department of Earth Science, University of California, Santa Barbara CA, 93106, USA.

M. Stirling GNS Science – Te Pu Ao, 1 Fairway Drive, Avalon, Lower Hutt 5010, New Zealand.


G. A. Valentine Department of Geology, University at Buffalo, 876 Natural Sciences Complex, Buffalo NY, 14260-3050, USA.

A. C. M. Volentik Department of Geology, University of South Florida, 4202 E. Fowler Ave, Tampa FL, 33620, USA.

L. M. Wallace GNS Science – Te Pu Ao, 1 Fairway Drive, Avalon, Lower Hutt 5010, New Zealand.

P. H. Wetmore Department of Geology, University of South Florida, 4202 E. Fowler Ave, Tampa FL, 33620, USA.

A. W. Woods BP Institute, Cambridge University, Madingley Rise, Madingley Road, Cambridge CB3 OEZ, UK.

R. R. Youngs AMEC Geomatrix, Inc., 2101 Webster St., 12th Floor, Oakland CA, 94612, USA.
Preface

Worldwide, geoscientists are exploring and developing methodologies to estimate volcanic and tectonic hazards associated with the siting of nuclear facilities, including nuclear power plants and proposed long-lived geological repositories of radioactive wastes. Understanding such geological hazards, particularly in the context of long-lived nuclear facilities, is a challenging task. This book presents the current state of the art in volcanic and tectonic hazard assessment for nuclear facilities, with the goal of promoting interest and debate in this important topic.

Nuclear energy has been a source of power for a little over fifty years. Today, 30 countries utilize nuclear power plants to generate 16% of the world’s electricity. By 2015, world energy demand is set to double from its 1980 figure. Nevertheless, in the early years of this century it would not have been possible to forecast the renewed worldwide interest in nuclear energy that is now evident. Low carbon emission requirements and need for security of energy supply have caused many countries to take steps to renew or increase their existing nuclear power capacity. Other countries may soon embark upon nuclear power programs for the first time. It is not inconceivable that within the next twenty years a dozen additional countries will have nuclear power plants or associated nuclear fuel cycle facilities.

One reason for the slow development of nuclear power during the last two decades has been concern, and sometimes controversy, about the safety of nuclear installations. Although much of this concern revolves around the safe management and operation of nuclear power plants, the possibility that natural events could jeopardize facilities has attained increasing significance among those charged with regulating safety. Many current and potential future nuclear power countries lie in regions that are tectonically active. These regions will inevitably experience volcanic eruption, earthquake and tsunami in the future. Site assessment and hazard analysis are essential in order to understand and account for potential natural hazards in the siting, design and operation of nuclear facilities.

Sites hosting operational, surface-based nuclear facilities can today be envisaged to have operational lifetimes of the order of one hundred years. Underground repositories for the disposal of radioactive wastes have to provide isolation and containment for thousands of years. That any such facility might be vulnerable to the forces of nature was appreciated from the earliest days of nuclear power. During the course of writing this book, two very significant events occurred that highlight the importance of the issues we address. The
world’s largest nuclear power generating complex, the Kashiwazaki–Kariwa nuclear power plant in Japan, was struck by a major earthquake in 2007. Although its safety systems were not compromised, it remains closed for extensive checks, at tremendous economic cost. Several chapters in this book address lessons learned in Japan and elsewhere from experience in seismic hazard assessment for nuclear facilities. In 2008, a license application was finally submitted for the proposed United States’ geological disposal facility for spent fuel and high-level waste, Yucca Mountain, after decades of research and discussion. The susceptibility of the Yucca Mountain site to future volcanism will be a central issue for the regulatory appraisal that will take place over coming years. Several chapters address specific issues in tectonic and volcanic hazard assessment of the proposed Yucca Mountain repository.

In this book, we begin by looking at the nature of tectonic and volcanic hazards with respect to nuclear facilities. Chapters 1–3 provide essential background on the nature of hazard assessment for nuclear facilities and progress in understanding volcanic and tectonic processes. In Chapters 4–8, the reader will find rich details about the physical conditions that give rise to natural hazards, the rates of tectonic and volcanic processes, and the geological and geophysical observations that make it possible to understand them. Translating observations into hazard models is a complex area of research, and the focus of Chapters 9–18. Techniques of probabilistic seismic hazard analysis have been available for many years and, indeed, owe much to the requirement for seismic analysis of the early generations of nuclear power stations. They are, however, only recently being adapted and applied to volcanic hazard and the reader will see that we have concentrated many of our examples on the latter, as this is an emerging area. Tsunami hazard is also highlighted in this section, as the area of probabilistic tsunami hazard assessment is only now receiving the attention it deserves, following the 2004 Great Sumatran earthquake and resulting global disaster. All hazard models must be based on good understanding of geological processes, basic observations and scientific deduction. The practical aspects of sifting alternative models of causal mechanisms must not be overlooked. Chapters 19–26 address the development of risk-informed approaches to site hazard assessment and the nature of regulation in light of our improving, and increasingly complex, understanding of natural phenomena.

The concept for this book arose from a long-running project initiated by the Nuclear Waste Management Organization of Japan (NUMO). The tectonically active nature of the Japanese islands means that NUMO is naturally concerned with evaluating possible risks to the isolation of potential geological repository sites that emerge from its voluntarist siting process. With the likelihood of future volcanic and rock deformation impacts varying widely from location to location across Japan, NUMO brought together a small team of experts from Japan and around the world to devise techniques for assessing the nature and probability of volcanic and tectonic hazards. Some chapters in this volume describe the initial results of this ongoing project, which has furthered development of hazard models for nuclear facilities generally. This illustrates not only the central nature of tectonic risk assessment in Japan, but also the far-sighted approach that is being adopted in that country to the progressive development and testing of hazard assessment techniques. Similarly, several
Preface

Chapters in this volume reflect the efforts of the International Atomic Energy Agency to foster methods in seismic and volcanic hazard assessment.

We would like to acknowledge the support of NUMO — not only in encouraging us to produce this book and thereby, we hope, promoting interest in this important topic — but also for their financial assistance in producing the color illustrations. Through their active encouragement, the authors have begun to dig more deeply into the subject than has ever been done before. Numerous individuals have helped bring this work to fruition. We thank Hideki Kawamura, Akira Chigama, Raymond Munier, Peter LaFemina, Ivan Savov, Gordan Woo, Diana Roman and Chris Newhall for their efforts. Special thanks go to Susan Francis and colleagues at Cambridge University Press for their guidance and enthusiasm.

Chuck Connor and Laura Connor, Tampa, USA
Neil Chapman, Remigen, Switzerland
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