VOLCANIC AND TECTONIC HAZARD ASSESSMENT FOR NUCLEAR FACILITIES

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.

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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 assesment 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

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.

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