Uncertainty Underground

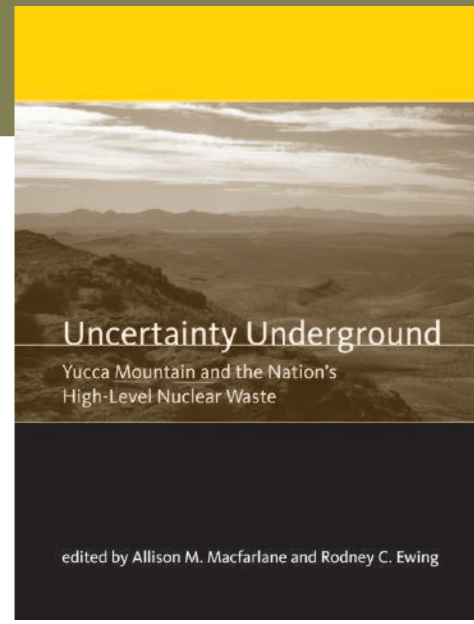
YUCCA MOUNTAIN AND THE NATION'S HIGH-LEVEL NUCLEAR WASTE*

Two decades ago the United States Congress determined that only Yucca Mountain, Nevada, should be further evaluated as a potential site for a geologic repository for high-level nuclear waste. If there is eventually a repository in Yucca Mountain, it will likely be the only repository located in the unsaturated zone, above the groundwater table, where the waste will reside in oxidizing conditions. Spent nuclear fuel is the primary waste form awaiting disposal in Yucca Mountain, and it is chemically unstable in an oxidizing environment. After about seven billion dollars worth of characterization and research, Yucca Mountain has not been licensed to receive waste, and no repository has been built. A quagmire exists at the intersection of policy, science, engineering, and politics.

To understand how the progression of political decisions and scientific research (and how they interrelate) resulted in the current improbable situation in the United States concerning nuclear waste disposal, you need to read *Uncertainty Underground: Yucca Mountain and the Nation's High-Level Nuclear Waste*. As the title implies, much of the focus of the 24 contributed chapters in this volume is on the sources of uncertainty pertaining to the performance of the proposed repository at Yucca Mountain. An impressive list of authorities examine critical questions and uncertainties associated with the Yucca Mountain project. Most chapters are highly informative and readable even for the novice in nuclear waste management. Most authors took their charges seriously and probed the sources of uncertainty concerning repository performance. Some chapters would have benefited from recent revision, but chapter 1, an introduction by the editors, brings the reader up to date concerning recent findings and policy shifts of importance. Read the introduction before other sections of the book.

Uncertainty Underground is divided into three sections: Part I, "Policy;" Part II, "Science and Technology;" and Part III, "Coping with Uncertainty." Part I contains five chapters that probe the details of the evolution of policy concerning nuclear waste disposal in the U.S.A., and Yucca Mountain specifically. This section is a tremendously useful contribution to the book, as it is an unparalleled summary of the many decisions and events that led to the current situation. The authors provide a largely unbiased and factually correct history of nuclear waste policy development in the United States. Events leading to the triumph of engineering over science in the debate concerning the evaluation of repository sites are made clear, and the outcome—performance assessment modeling—is discussed using the fitting analogy of a mechanical duck. Alternative strategies for repository performance assessment are suggested and discussed.

Part II, "Science and Technology," constitutes the bulk of the book and is partitioned into five sections: Earth Science, Hydrology, Thermohydrology, Waste Package Behavior, and Waste Forms. The first of these focuses on the geology of Yucca Mountain, including emphasis on both the assets and the liabilities of the geological setting relative to placing nuclear waste in the mountain. The chapter concerning climate change is particularly interesting in its illuminating discussion of uncertainty. Here, discussion of possible climate change at Yucca Mountain is underpinned by the geologic record of past climate change. The section concerning hydrology contains five chapters. Moving water will eventually transport radionuclides from the repository, yet the movement of water through fractured rocks at Yucca Mountain is complex and difficult to model. In the first chapter, fluid inclusion data reveal the timing of hot-water infusions in the tuff forming the mountain. The next chapter focuses on the many assumptions used to model water movement at Yucca Mountain, and reveals significant uncertainties. Transport of insoluble radionuclides as colloids is probed, and uncertainties concerning the structures, compositions, and stabilities of radiocolloids are discussed. The impact of mineralogy on radionuclide transport, mostly through sorption and ion-exchange reactions, is examined. The final chapter discusses contaminant transport in the saturated zone, a topic that is wrought with uncertainty, as detailed in the chapter. The section concerning thermohydrology probes what happens to water movement in the mountain when heat is added by the decay of radioactive waste. Considerable debate continues to focus on the merits of a hot repository, which may keep the waste packages dry longer, as opposed to maintaining a lower repository temperature to slow reaction rates and simplify modeling. The first of the two chapters in this section bases discussion of uncertainties on heating tests conducted in the actual mountain, as well as on a large block of tuff that was heated and then dissected. The second chapter focuses on the many uncertainties produced by coupling of processes in the near field of the repository. Complicating factors include the time and space scales, and the tremendous heterogeneities that will exist on all



scales in the repository. Waste package behavior is examined in two chapters focusing on waste package corrosion and engineered aspects of the repository such as drip shields and backfill. There is an interesting interplay here between performance uncertainty and design criteria. Are the engineered portions of the repository intended to improve performance or to reduce uncertainty in modeling? The final section concerning waste forms contains four chapters that examine cladding, as well as spent fuel, glass, and ceramics as waste forms.

Part III, "Coping with Uncertainty," contains two chapters that provide thought-provoking examinations of the future of nuclear waste disposal. Given the likely worldwide growth in nuclear energy and the vast and complex wastes that may result, this section is timely and interesting.

In conclusion, *Uncertainty Underground* is a unique and timely treatment of nuclear waste disposal at Yucca Mountain. Researchers, graduate students, and the layperson interested in any of nuclear waste disposal, geochemistry, mineralogy, hydrology, and science policy will find much of substance in this volume.

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