

## TOO HOT TO TOUCH: THE PROBLEM OF HIGH-LEVEL NUCLEAR WASTE<sup>2</sup>

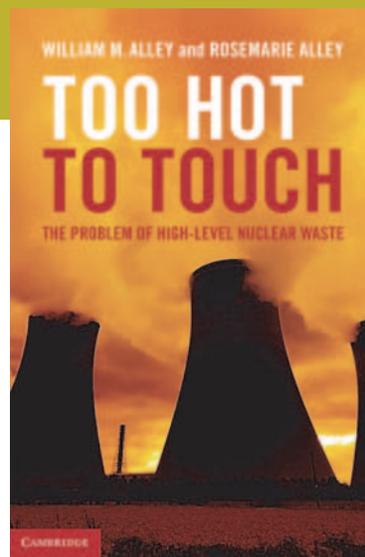
In 2010, after more than 25 years of study and a \$10-billion investment, the Yucca Mountain site in Nevada was shelved by the Obama Administration as a potential repository for high-level nuclear waste. This leaves the United States with no plan for the disposal of its high-level radioactive waste—derived from power plants and weapons manufacturing—currently scattered across 121 sites in 39 states. This story is put into its political, social, and scientific context by William M. Alley and Rosemarie Alley, a husband-and-wife team. William Alley watched the story unfold at close quarters, as he was chief of the Office of Groundwater at the USGS and oversaw the Yucca Mountain project from 2002 to 2010. Rosemarie Alley is a literary specialist who used her talents to make sure the book delivers what it promises: “an engaging and authoritative account of the controversies and possibilities surrounding disposal of nuclear waste in the US.” The focus of the book is on the United States, but examples from other countries are woven throughout. In 2012 there were 440 nuclear power plants in 31 countries, and no country had an operating high-level waste disposal facility.

As in so many matters, historical perspectives illuminate the issue at hand. In order to put the Yucca Mountain decision in context, in the first half of the book, Alley and Alley trace the history of nuclear development in the United States, starting with the Manhattan Project, which was mostly carried out at 3 secret locations: the Oak Ridge Reservation, where uranium was enriched, the Hanford Reservation, where plutonium was created, and the Los Alamos National Laboratory, where weapons were manufactured. Electricity from nuclear power was first generated in Idaho in 1951 (this is also where the first meltdown of a nuclear reactor occurred), and construction of the first nuclear plant in the US started in 1954 in Shippingport, Pennsylvania. During the Cold War, the Savannah River site in South Carolina produced plutonium and tritium for nuclear weapons. At the end of the Cold War, 30,000 nuclear warheads were dismantled. The 100 tons of plutonium contained in these weapons are now nuclear waste that has to be dealt with.

Robert Oppenheimer, scientific director of the Manhattan Project and a fervent believer in the peaceful use of the atom, dismissed the waste problem as “unimportant.” He was not alone in thinking this way. Most researchers and politicians involved in the early years were confident that the problem of waste disposal would be an easy fix. In 1949, the chair of the Atomic Energy Commission stated that dealing with waste was just a matter of “learning to live with radioactivity.” The authors review in several chapters how thinking about dealing with waste has evolved: from dumping it in the ocean to more esoteric solutions, like ice-sheet disposal and disposal in space. There is now a worldwide consensus that a geologic repository is the best way to deal with waste, and Alley and Alley examine the main geological environments that have been considered as potential repositories, including salt beds and domes, which were studied extensively, and the thick unsaturated zone in a desert environment. The Yucca Mountain site belongs to the latter.

The second half of the book is devoted to Yucca Mountain: how Yucca Mountain became the sole candidate for a repository in 1985, the obstacles that were encountered, and the enormous amount of science that was done to characterize the site. In June 2008, in spite of many setbacks, the Department of Energy (DOE) submitted a license application to construct a nuclear waste repository at Yucca Mountain to the Nuclear Regulatory Commission (NRC) for review. The application weighed 50 kg, totaled 8600 pages, and included the results of hundreds of studies. The application was under review by the NRC when the Obama Administration decided to cancel the project.

2 Alley WM, Alley R (2013) *Too Hot to Touch: The Problem of High-Level Nuclear Waste*. Cambridge University Press, New York, xiv + 370 pp, ISBN 978-1-107-03011-4, hard cover, US\$29.99



The terms *NIMS* and *NIMBY* figure prominently throughout the book: “Not in my state” and “Not in my back yard” pretty much summarize the main stumbling blocks. Nobody wants a repository of high-level nuclear waste in his backyard. In the instances where groups or locales were interested, the states used all their legal powers to stop the projects. The authors point out that it is perhaps not accidental that the two countries most advanced in developing a repository—Sweden and Finland—are countries with

only a central government and no state or provincial governments. The coup de grâce, however, was the requirement to demonstrate that Yucca Mountain could be safe for 1 million years. The authors look back at the last million years of the geological record to demonstrate how impossible a task this was.

In the wake of shelving the Yucca Mountain site, the Obama Administration created a Blue Ribbon Commission in 2010 to advise on the path forward. Members of the commission submitted their final report in January 2012 (<http://energy.gov/ne/downloads/blue-ribbon-commission-americas-nuclear-future-report-secretary-energy>).

Alley and Alley stress that even if the world were to stop using nuclear energy tomorrow morning, we would still have to deal with the waste accumulated since 1945. Moreover, nuclear energy is one of the proposed solutions to address global warming. A realistic starting point to move forward is to acknowledge that any course chosen will be an imperfect solution: the problem is too big and too complex. The authors acknowledge that “the technical characteristics of nuclear waste make the disposal problem difficult, but it is the human factors that have made it intractable.” Taking the human elements into account is key to avoid past failings.

I encourage anyone remotely interested in the topic to buy a copy. At US\$29.95, this is a very affordable book. The authors have done a remarkable job of making the scientific information accessible to lay persons. I certainly learned much about national laboratories, the role of the DOE, the National Academy of Sciences, and the amazing and complex ramifications of politics. Woven in are biographies of scientists and lots of side science stories, from ocean currents to the origin of Monte Carlo simulations. Treatment is fair: you get the sense that the authors tried hard to present the facts and all sides of the story. This book would be ideal for using in a seminar class. Overall a fascinating read!

In the “100 mineralogical questions” exercise, which was summarized in the previous issue of *Elements*, two questions deal with radioactive waste:

- 82. What are the dissolution reactions that lead to the breakdown of nuclear waste materials in deep geological disposal facilities, and what might be the long-term impact of nuclear waste dissolution?
- 83. What is the long-term fate of man-made actinides, mainly plutonium, in the environment?

After reading this book, I would argue that they are the two most urgent and pressing problems to attend to.

**Pierrette Tremblay**, Managing Editor  
*Elements* magazine