

USE OF GEOLOGIC MEDIA FOR DISPOSAL OF HIGH-LEVEL NUCLEAR WASTE

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ABSTRACT

Radioactive waste exists now and it will continue to be produced in the future. In nuclear countries, it results mainly from the nuclear power industries and in some cases from military programs. In the future, in these countries, it will also come increasingly from the decommissioning of facilities that have reached the end of their life, or have become redundant. In non-nuclear countries, radioactive wastes come from medical. Industrial and research uses of radioactive materials. Radioactive waste can be short- or long-lived depending on its intrinsic rate of decay. The concept of geologic disposal for spent nuclear fuel and high-level radioactive waste, both which are long-lived, involves deep underground repositories that ensure security, i.e. isolation of the waste from malicious or accidental disturbance, and containment of the waste over very long times. Although several other disposal strategies have been considered in the past, and re-evaluated up through present time, waste management experts continue to favor the concept of geologic disposal of long-lived radioactive waste. The Yucca Mountain site in Nevada, the potential location for a nuclear waste repository in the United States, has been under investigation by the U.S. Department of Energy (DOE) for more than a decade. This poster outlines the technical geological characterization activities performed at the Yucca Mountain site.

INTRODUCTION

During the first half of the 20th century, scientists began experimenting with nuclear materials. By the 1950s plans were well underway for the wide-spread use of large nuclear reactors for electric power generation. A number of scientists realized that a plan was needed for the disposal of spent nuclear fuel and high-level wastes that would be generated by both commercial reactors and nuclear weapons development and manufacture. Scientific bodies in several countries evaluated options for nuclear waste disposal. These options included reprocessing, separation and accelerator transmutation, deep seabed disposal, deep liquid injection, space disposal, and disposal in geologic formations. Every scientific evaluation reached the same conclusion: only one option would maximize public health and safety, use currently available scientific and engineering technology, and minimize risk and cost. This is the disposal of nuclear waste in engineered repositories in deep geologic media. The possibility of other management options is still, however, sometimes raised in discussion. The options most often suggested in the recent past, being extended storage of the waste and partitioning and transmutation of long-lived radionuclides within the wastes. Although both options may be

WM'00 Conference, February 27 – March 2, 2000, Tucson, AZ

components of an overall waste management strategy, neither option avoids the need for a final disposal system, such as a geologic repository. This realization has led to extensive research programs in various countries, aiming to identify, characterize, and finally construct geologic repositories in rocks appropriate for the safe disposal of waste. In the United States the Department of Energy (DOE) has previously examined geologic disposal in basalts, salt domes and bedded salt formations, and has also evaluated disposal in crystalline rocks (granite) and sedimentary formations. DOE is presently evaluating a single site, Yucca Mountain in southern Nevada, for the disposal of high-level nuclear waste in welded and non-welded silicic volcanic tuffs.

YUCCA MOUNTAIN

The Yucca Mountain site in Nevada, the potential location for a nuclear waste repository in the United States, has been under investigation by the DOE for more than a decade. Yucca Mountain is located approximately 160 kilometers (100 miles) northwest of Las Vegas, Nevada in the desert southwest of the United States on land owned by the U.S. government. The potential repository location is bordered on the east side by the Nevada Test Site where several above-ground and below-ground nuclear tests were conducted by the DOE from the 1950's until the recent test ban, on the north by the Nellis Air Force bombing range, and on the west and south by public lands. Yucca Mountain is basically a block faulted ridge of layered volcanic welded and nonwelded tuffs which were formed by a series of volcanic eruptions some 32 kilometers (20 miles) to the north of the site. The ridge top peaks at just under 1,830 meters (5,000 feet) above sea level, sloping off to the east at 5 to 10 degrees and sloping sharply to the west along the ridge forming normal fault.

The primary geologic formations found at Yucca Mountain, beginning from the land surface, include the Tiva Canyon, Yucca Mountain, Pah Canyon and the Topopah Spring Tuffs of the Paintbrush Group. Underlying these are the Calico Hills Formation, and the Prow Pass, Bullfrog, and Tram Tuffs of the Crater Flat Group (1). The geologic formations have been divided into hydrogeologic units primarily based on their degree of welding. Syndepositional processes such as welding, fracturing and the formation of lithophysal cavities, along with post-depositional activity such as faulting, additional fracturing and fracture coating formation, control the flow behavior in the unsaturated zone.

The potential repository at Yucca Mountain would be located approximately 300 meters (1000 feet) below the land surface and 240-370 meters (800-1200 feet) above the local water table in the unsaturated zone. Yucca Mountain is the only potential geologic repository site worldwide that is located in unsaturated rocks. An understanding of the rates and pathways of water movement at the potential repository site is crucial in assessing its probable performance in isolating the waste from the accessible environment. Of major concern is the amount of water migrating through the mountain (percolation) and entering the repository (seepage) potentially corroding the waste containers and carrying the waste degradation products to the water table, and eventually to areas accessible to human contact. Hydrogeologic studies at Yucca Mountain, in both the unsaturated zone and the saturated zone, in the immediate site area and on a regional scale, have been carried out to address this concern. In conjunction with this, multiple

refinements have been applied to adapt the engineered barrier design such that a high level of long-term containment can be expected from the combination of physical and chemical controls.

OTHER PROGRAMS

Nations around the world have extensive programs involving detailed characterization using surface testing and underground research laboratories to examine and evaluate a variety of geologic media for disposal of high-level and long-lived nuclear wastes. These countries include Belgium, Canada, Finland, France, Germany, Sweden, Switzerland, and the UK. At present, Belgium is exclusively studying disposal in a clay formation. Canada, Finland, and Sweden have developed concepts and tested techniques for disposal in granites of stable crystalline shield areas. France, Japan, Spain, and Switzerland are examining both crystalline rocks and clay formations for geologic disposal. Germany spent a number of years evaluating and testing a salt dome for disposal of high-level waste, however, recent political changes may re-open site selection to include a variety of geologic media. Other national programs, e.g. Korea, Hungary, and the Czech Republic are in the early stages of development or have entered a political limbo (such as the United Kingdom).

The progress that has been made in the scientific and technical aspects of geological disposal over the past decade has made the necessary technology for implementation of disposal programs available today. Although a geologic facility for the disposal of spent nuclear fuel, has not been implemented, underground facilities for the disposal of wastes with lower radioactive content have been commissioned in several countries. In Germany, low-level radioactive waste was disposed underground in the Asse salt mine, as a demonstration project, and a deep repository for low- and medium-level waste has operated in a salt dome at Morsleben between 1981 and 1998. In Finland, a facility for the disposal of low- and medium-level waste was opened in 1992 at the Olkiluoto nuclear site and in 1998 at the Loviisa site, both which are in granitic bedrock approximately 100 meters below the ground surface. In Sweden, a repository for the disposal of low- and medium-level waste has been operating at the Forsmark nuclear site since 1988, located in granitic bedrock caverns about 60 meters below the Baltic Sea, and accessed by a tunnel from land. In Norway, the Himdalen facility for low- and medium-level waste disposal started operations in 1999, fifty meters below the land surface. And most notable, the Waste Isolation Pilot Plant (WIPP) in south-eastern New Mexico began the disposal of U.S. defense programs waste in 1999 in a bedded salt formation 650 meters below the ground (2). The waste to be disposed of at WIPP contains significant long-lived radionuclides and can be considered a combination of low-, medium, and high-level waste although heat-generating wastes are excluded. WIPP is the first purpose-built, deep geologic repository for long-lived radionuclide waste in the world.

SUMMARY

Safe disposal of long-life and high-level radioactive wastes is a major problem facing many countries worldwide. Geologic disposal in underground repositories has been the disposal method preferred after considerable thought, research, and debate, by waste management professionals for the past forty years. Although political and societal concerns have recently reopened debates on disposal options, waste management developers, regulators, and policy

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makers almost unanimously agree that geologic disposal is the most appropriate means for long-term waste management. Through years of detailed scientific and technical studies at locations throughout the world, the technology for constructing and operating waste repositories has been developed and this has resulted in several low- and medium-level repositories presently being in operation in several countries. This technology and expertise is also available, and has been developed, for the implementation of deep geologic disposal for high-level, long-lived radioactive wastes. Several countries throughout the world are addressing the issue of geologic disposal of high-level wastes, with the United States and the Scandinavia programs being the most advanced. The U. S. has performed comprehensive site characterization at Yucca Mountain, Nevada, and is expected to make a site recommendation in 2001, and if recommended as the national repository site, a license application could be made in 2002. In Finland, a local community has offered to host a national repository, and a siting decision could be made in the year 2000. And in Sweden the plan is to start investigations at two sites in the next few years.

REFERENCES

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