NUCLEAR WASTE COULD FIND HOME IN SHALE

ACS MEETING NEWS: Scrambling for an answer to scuttled Yucca Mountain storage facility, scientists eye clay

IN 1987, the U.S. government was hopeful it had found a solution for the problem of long-term nuclear waste storage in the newly proposed Yucca Mountain Nuclear Waste Repository in Nevada. But over the years, political and environmental issues have essentially halted plans for the facility.

The U.S.'s only underground nuclear waste storage facility, the Waste Isolation Pilot Plant near Carlsbad, N.M., stores its nuclear waste in salt beds. But salt's tendency to slowly flow over time could eventually prevent access to the buried waste. (The facility was shuttered on Feb. 17, after a ventilation leak exposed workers to small amounts of radiation.)

With more than 70,000 metric tons of spent nuclear fuel sitting aboveground at production facilities, the U.S. still has no alternative plans for storing its nuclear waste.

In their search for a solution, some scientists are taking their cue from countries such as France, Belgium, and Switzerland and revisiting a previously considered possibility: shale. They are studying the rock as a medium capable of safely storing radioactive waste for up to a million years.

Shale, a fine-grained sedimentary rock, is ubiquitous and can be found in many seismically stable areas. Most important, its microscopic structure may be compact enough to prevent contaminants from leaching into groundwater.

As early as the 1970s, U.S. geologists had floated the idea of using shale. But scientists were concerned about the possibility of fracturing and the possible effects of heat from the waste. In the intervening years, though, research has shown that these concerns might be less important than previously thought. Shale has been in recent headlines as a controversial source of natural gas released by fracking. But the rock's potential as a nuclear waste storage medium was the focus of a symposium sponsored by the Division of Geochemistry at the American Chemical Society national meeting in Dallas last month.

Christopher E. Neuzil, a hydrologist with the U.S. Geological Survey, noted that a number of European countries—particularly France, where 80% of power generated is nuclear—have been seriously considering shale for a number of years. The Canadian Nuclear Waste Management Organization is also planning an underground storage facility that would be capped by shale.

"We think maybe it should be on the radar in this country as well," Neuzil said.

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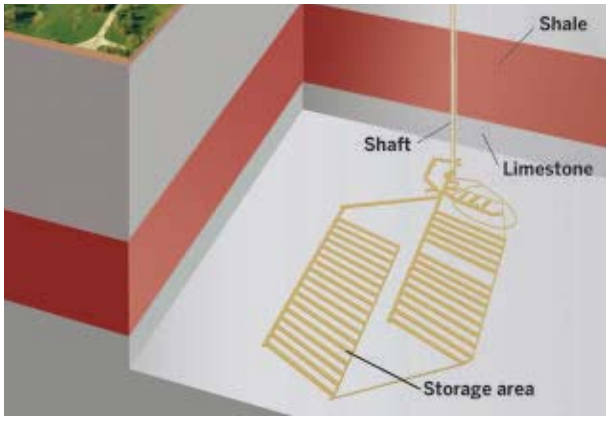

LONG-TERM At the Canadian Nuclear Waste Management Organization's proposed repository, waste would be stored 2,230 feet underground, capped by shale.

IF SHALE were deemed suitable, a storage facility could exist perhaps half a kilometer to a kilometer below Earth's surface. It would consist of tunnel galleries, excavated outward from an access shelf, like veins in a leaf. Containers filled with waste could be stored there for hundreds of millennia.

But first, scientists need to make sure shale's properties hold up under scientific scrutiny. The biggest concern with an underground storage facility is the possibility that radioactive material could leak and filter into a water supply and reach living things at the surface.

"The long-term performance of a deep geologic repository relies heavily on our ability to predict groundwater movement and the related chemical transport around the repository," said Yifeng Wang, a geochemist at Sandia National Laboratories and coorganizer of the ACS symposium. "The knowledge about these processes in shale, to a large extent, is still lacking."

Shale has some promising features, at the outset. Neuzil noted that all shales contain clays, which are very sorptive. "It's hard to move nasty stuff through them." They also act as filters, he said, slowing down ionic species carried in water.

But quantifying this behavior is difficult, Neuzil said. A lab-sized shale sample simply can't be extrapolated to large-scale sections of shale, Neuzil said. So he and his colleagues have turned to "natural experiments," looking at regional water movement in shale formations and studying pressure patterns in rocks. So far, he said, the evidence suggests that almost no water flows through many of these formations.

Scientists also need to fully understand the chemical interactions that go on between radioactive material and nanopores in shale, noted Louise J. Criscenti, a geochemist at Sandia National Labs and coorganizer of the symposium.

Andrey G. Kalinichev, who directs a radiochemical research lab at École des Mines de Nantes, in France, hopes computational chemistry will help provide insights into the chemical behavior of fluids and radioactive nuclides in a shale environment.

At the symposium, he described molecular dynamics simulations his lab has performed that complement experiments on the chemical interactions of radioactive materials with clay minerals.

Nanoscopic phenomena can have significant effects on macroscopic properties. For example, Kalinichev said, edges of clay nanoparticles in shale are typically where most of the chemistry happens. "In terms of absorption and retention, those edges may be very important."

To explore this, Kalinichev's group is zooming its computational lens in even further and developing ab initio models of how radionuclides interact with clay surfaces and their edges.

"This kind of knowledge can be incorporated into larger-scale models for the prediction of longer-term behavior of radioactive waste repositories in shales," Kalinichev said.—ELIZABETH WILSON