Shale could be long-term home for problematic nuclear waste

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Shale, the source of the United States' current natural gas boom, could help solve another energy problem: what to do with radioactive waste from nuclear power plants. The unique properties of the sedimentary rock and related clay-rich rocks make it ideal for storing the potentially dangerous spent fuel for millennia, according to a geologist studying possible storage sites who made a presentation here today.

The talk was one of more than 10,000 presentations at the 247th National Meeting & Exposition of the American Chemical Society (ACS).

About 77,000 tons of spent nuclear fuel currently sit in temporary above-ground storage facilities, said Chris Neuzil, Ph.D., who led the research, and it will remain dangerous for tens or hundreds of thousands of years or longer.

"Surface storage for that length of time requires maintenance and security," he said. "Hoping for stable societies that can continue to provide those things for millennia is not a good idea." He also pointed out that natural disasters can threaten surface facilities, as in 2011 when a tsunami knocked cooling pumps in storage pools offline at the Fukushima Daiichi nuclear power plant in Japan.

Since the U.S. government abandoned plans to develop a long-term nuclear-waste storage site at Yucca Mountain in Nevada in 2009, Neuzil said finding new long-term storage sites must be a priority. It is crucial because nuclear fuel continues to produce heat and harmful radiation after its useful lifetime. In a nuclear power plant, the heat generated by uranium, plutonium and other radioactive elements as they decay is used to make steam and generate electricity by spinning turbines. In temporary pool storage, water absorbs heat and radiation. After spent fuel has been cooled in a pool for several years, it can be moved to dry storage in a sealed metal cask, where steel and concrete block radiation. This also is a temporary measure.

But shale deep under the Earth's surface could be a solution. France, Switzerland and Belgium already have plans to use shale repositories to store nuclear waste long-term. Neuzil proposes that the U.S. also explore the possibility of storing spent nuclear fuel hundreds of yards underground in layers of shale and other clay-rich rock. He is with the U.S. Geological Survey and is currently investigating a site in Ontario with the Canadian Nuclear Waste Management Organization.

Neuzil explained that these rock formations may be uniquely suited for nuclear waste storage because they are nearly impermeable—barely any water flows through them. Experts consider water contamination by nuclear waste one of the biggest risks of long-term storage. Unlike shale that one might see where a road cuts into a hillside, the rocks where Neuzil is looking are much more watertight. "Years ago, I probably would have told you shales below the surface were also fractured," he said. "But we're seeing that that's not necessarily true." Experiments show that water moves extremely slowly through these rocks, if at all.

Various circumstances have conspired to create unusual pressure systems in these formations that result from minimal water flow. In one well-known example, retreating glaciers in Wellenberg, Switzerland, squeezed the water from subsurface shale. When they retreated, the shale sprung back to its original shape faster than water could seep back in, creating a low-pressure pocket. That means that groundwater now only flows extremely slowly into the formation rather than through it. Similar examples are also found in North America, Neuzil said.

Neuzil added that future glaciation probably doesn't pose a serious threat to storage sites, as most of the shale formations he's looking at have gone through several glaciations unchanged. "Damage to waste containers, which will be surrounded by a filler material, is also not seen as a concern," he said.

He noted that one critical criterion for a good site must be a lack of oil or natural gas that could attract future interest.

More information: Emerging role of shales as hosts for nuclear waste:

Abstract
Research findings from underground laboratories and instrumented boreholes in shales (here including claystones, argillites and other clay-rich rocks) is showing that such formations might effectively isolate spent nuclear fuel (SNF) and high-level waste (HLW). These results have led a number of nations to consider or actively plan repositories for SNF and HLW in shales and other clay-rich rocks. The investigations have made it increasingly clear that many shales effectively restrict pore fluid flow over extremely long spans of time. The fact that shales are also widespread, voluminous, and often in tectonically stable settings, has made them increasingly attractive candidates for repositories. Before the 1990s few reliable data existed on fluid transport properties and pore fluid movement in shales, but it is now apparent that many have extremely low permeability at spatial scales large enough to accommodate repositories. This is possible because shales frequently host natural pore fluid pressure anomalies and patterns of pore water constituents that can be analyzed as if they are large-scale, long-term permeability and tracer tests. This permits estimation of transport

properties over areas of several km2 and million year time spans. In many clay-rich formations there is essentially no transport of dissolved constituents by advection, and even diffusion is slowed because they are more or less efficient membranes. A potential difficulty with shale host rocks is effects of thermal loading by the waste. Other concerns, namely limiting excavation damage to the formation and effectively sealing the repository, are common to all types of subsurface disposal.

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