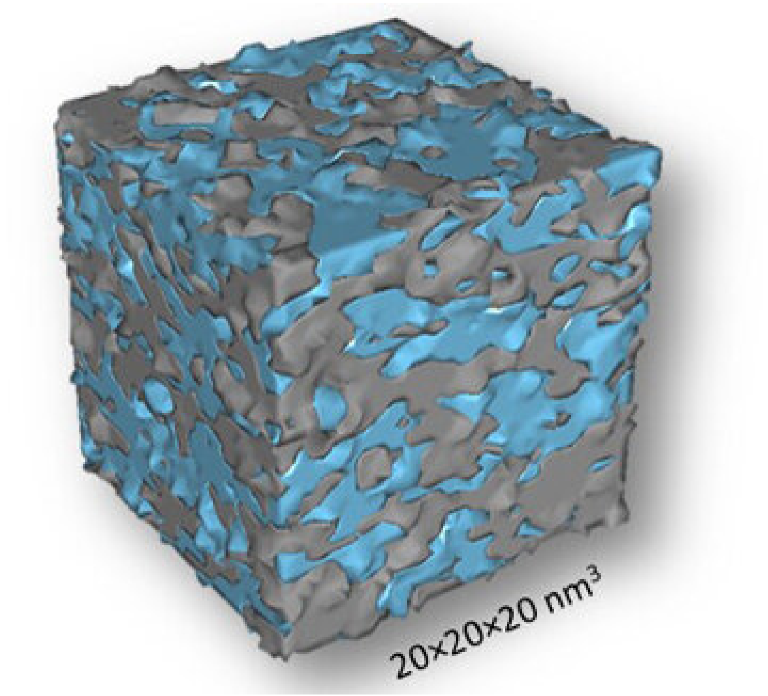
Synergy for storage: Containing nuclear waste for thousands of years

March 28 2019



Researchers determined the structures that sometimes form where water (blue) and glass (gray) meet. These water-filled cavities can cause the glass to corrode suddenly. Credit: US Department of Energy

Browsing the Gilcrease Museum's collection of pre-Columbian American art and tools in Tulsa, OK, one keeps coming back to the obsidian knives, arrowheads (or "projectile points," to anthropologists), and even ear ornaments—glossy black, smooth, and glassy. For tens of thousands of years, indigenous peoples fashioned these items out of cooled lava, beautiful but also able to hold a keen edge for millennia. The same museum collection also features metal knives, some only a few centuries old, already pitted and rusted, and a range of ceramic items in varying stages of deterioration from surprisingly pristine to faded and cracked. Clearly, these different materials—glassy obsidian, earthy ceramic, and metallic—have properties that influence how they stand the test of time.

"There are difficult issues in understanding how materials corrode over really long time spans," said Gerald Frankel, director of the Center for Performance and Design of Nuclear Waste Forms and Containers (WastePD). "These are scientific issues," he continued. "That's why we need fundamental science."

Frankel, an Ohio State University professor, focuses that scientific lens on glass, ceramics, and metals used to trap Cold War leftovers, including ~90 million gallons of radioactive liquid and sludge (like wet beach sand). Solidifying the waste as glass or ceramics keeps it from leaking into soil and groundwater. The solid form holds the waste in for thousands of years, giving the radioactive matter time to decay to safer levels.

To solidify the waste, it's prepared and mixed into the recipes for glass or ceramics. The solidified waste, a.k.a. waste form, is then set in specially designed metal canisters and stored. Defense-related waste in South Carolina is already being glassified. Another such plant is under construction in Washington State.

Although glass, ceramics, and metal forms have been around for ages, researchers don't yet know key details about how materials crumble, dissolve, or otherwise come undone. "Right now, we don't understand waste form corrosion enough to come up with a good model," said

Frankel.

You can't just go off and do your thing alone. To develop the underlying science necessary to model waste form corrosion, Frankel brought together materials scientists, engineers, computer modelers, and theorists as WastePD, an Energy Frontier Research Center funded by the Department of Energy's (DOE's) Office of Science.

The different perspectives give the team a broad view of scientific questions. Even better, they offer more techniques, tools, and know-how to get answers. But collaborating, especially across nine time zones, has its challenges. "We spend a lot of time interacting," said Frankel. "You can't just go off and do your thing alone."

An early win for the team was solving a particularly vexing problem involving water on glass waste forms.

Time and tide wait for no waste. Researchers assume that during the thousands of years that the waste rests in storage, rainwater or groundwater will get in.

When glass is covered in water, either a protective or an unstable layer forms. The unstable film speeds glass corrosion, causing the glass to crumble far faster than if it had a protecting film.

"To determine what drives the formation, we have to look at it in detail," said John Vienna, who leads WastePD's glass thrust area and works at DOE's Pacific Northwest National Laboratory.

But the reactions occur underwater. While you could see the surface easily, conventional techniques aren't designed to get accurate data on an underwater surface. "It's been a Holy Grail of chemistry," said Vienna.

The team found a way by collaborating. Each team member brought in ideas and applied them. It's like bringing together a dozen internationally renowned chefs and asking them to cook a fish, and then combining all that knowledge and techniques to do something nobody's seen before.

They started by flash freezing pristine water on glass. It's like a frozen, frosted chocolate sheet cake with glass as the cake and water as the icing. They sliced a thin piece, like cutting a tiny serving, and analyzed it. They repeated the experiment every few seconds as the water caused an unstable porous layer to form on the glass, essentially creating a sophisticated flipbook.

The troubling layer formed by the water and glass reacting scoops out tiny bits of glass from the surface and lets water get in, just as it could at a storage site. The film's structure—how many pores form, how deep, and how far apart—determines how fast the glass crumbles.

"Our collaboration was something of a shotgun wedding at the start," said Vienna. The study of the glass corrosion in water is just one example of how bringing together different people, different instruments, and different ideas can lead a solution. "Now, we're making real progress by using techniques that were only used in one area and ways of looking at the problems."

Provided by US Department of Energy

Citation: Synergy for storage: Containing nuclear waste for thousands of years (2019, March 28) retrieved 16 August 2024 from https://phys.org/news/2019-03-synergy-storage-nuclear-thousands-years.html