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Glass from ancient Swedish fort provides knowledge for Hanford cleanup

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A sample of ancient Broborg hillfort glass from Sweden is stored at the Applied Process Engineering Laboratory in Richland. The glass fused together rocks into a hillfort wall. **Sarah Gordon** - Tri-City Herald

BY ANNETTE CARY
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A hilltop Swedish fort built more than 1,000 years ago might help answer questions about how to best immobilize radioactive waste at Hanford.

In the Swedish Iron Age, before the time of the Vikings, the Broborg fort was built on top of a hill north of present-day Stockholm.

The fort's occupants looked down on what then was a major river into inland Sweden, using the fort's position to control trade as boats from the Baltic Sea traveled upriver.

Today a ring of rock remains on the hilltop, all that shows above ground of a fort with an unusual vitrification construction method.

At Broborg and several other sites in Europe, ancient people sometimes used glass to fuse rocks together to build sturdy walls at what archaeologists call hillforts.

About 1,500 years later, the glass at Broborg remains intact, despite harsh winter weather and frost heaving.

"They were clever," said Rolf Sjöblom, an adjunct professor of structural chemistry at Uppsala University. "Don't underestimate ancient people."

Sjöblom was in the Tri-Cities last week after helping the Department of Energy vitrification plant project and Pacific Northwest National Laboratory get samples of Broborg hillfort glass from the collection of a retiring professor.

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> Carolyn Pearce, PNNL scientist

The ancient glass has many of the same metal oxides that will be used in the glass formula to immobilize up to 56 million gallons of Hanford radioactive waste within a glass form for permanent disposal.

At the vitrification plant under construction, radioactive waste left from plutonium production for the nation's nuclear weapons program will be mixed with glass-forming materials in melters and heated to 2,100 degrees. The molten glass and waste mixture then will be poured into stainless steel containers to harden into glass logs for disposal.

The Broborg hillfort's residents likely packed small rocks they knew would melt at lower temperatures between boulders stacked into walls. A fire built atop the rock wall would have melted the fill material, which might have included some other substances, and fused the larger rocks together.

The ancient people were guided in their vitrification work by a relatively sophisticated knowledge of temperatures and materials gained from iron work.

At the Applied Process Engineering Laboratory in Richland, Carolyn Pearce, a PNNL scientist, and Jamie Weaver, who just finished a doctoral internship at PNNL, carefully unwrapped some of the Broborg and other European hillfort vitrification samples stored there on Friday.

“It’s just amazing they thought of this as a way to build forts,” Pearce said.

The pieces have dark streaks of glassified rock infiltrating the cracks of lighter-colored rocks, solidly fusing them together.

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The condition of the ancient glass should help demonstrate to the public that glass can survive for long periods, said Albert Kruger, DOE’s glass scientist at Hanford.

He became interested in hillfort glass after meeting Sjöblom at an environmental conference in France.

Not only did old glass structures that were manmade exist, but they were aged in a natural

environment in Sweden, Sjöblom said. He estimates that the Broborg hillfort was built in 375 to 550 AD, or possibly earlier.

Some of the glass produced at the vitrification plant will be buried in a Hanford landfill, where glass must meet regulatory standards to resist corrosion and deterioration to keep waste out of groundwater for as long as 10,000 years.

Tests used to estimate how long glass will contain waste are conservative, starting with grinding up glass into small particles and exposing it to high temperatures. But vitrified glass holding the waste might be more durable than current testing methods can show.

Kruger is interested in developing a testing method to more accurately reflect how glass ages.

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>
> Albert Kruger, DOE glass scientist

Studying Broborg glass will help scientists develop a recipe to reproduce it to create similar glass for testing. The accuracy of glass aging tests would be validated if new glass subjected to accelerated aging methods matches the condition of ancient glass.

More accurate aging tests could show that more waste could be loaded into the glass without compromising the long-term integrity of the

glass, Kruger said, allowing the vitrification plant to finish waste treatment years sooner.

“As federal employees, we have a fiduciary responsibility to the taxpayer,” he said.

The Swedish glass also might help scientists project how glass would age over periods of up to 10,000 years by studying how glass has aged in an initial 1,000 to 2,000 years.

The study also has the potential to provide additional information about Broborg and other hillforts.

“We want to understand what these samples have been through and why they lasted 1,500 years,” Sjöblom said.

In addition to the DOE vitrification plant project and PNNL, collaborators on the project include the Smithsonian Institution’s Museum Conservation Institute and the Lulea University of Technology in Sweden.

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