Breaking Good: Study examines durability of glass with ties to nuclear waste storage

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(PhysOrg.com) -- In a first-of-its-kind study, scientists at Pacific Northwest National Laboratory determined how durable four-component glass is when aluminum atoms are replaced by boron atoms and vice versa. By determining the effect of these elements, scientists can better predict how water interacts with minerals and glass. Water-glass interactions matter to people working to glassify liquid and sludge-like waste from nuclear weapons into a safer, solid form. Water-mineral interactions are also of interest to geochemist and agricultural scientists who want to know how minerals weather.

As with any power source, the safety of workers, the environment, and nearby populations must be considered. In nuclear power, this means trapping or immobilizing certain radioactive elements in the waste. In addition, nuclear waste from decades-old weapons sites must be permanently and safely stored. This research supports continuing efforts to manufacture a vitrified form that safely encapsulates the waste.

Using several spectrometers including EMSL's 900-MHz nuclear magnetic resonance spectrometer, five glass samples with different ratios of boron and aluminum were studied. These samples were four-component glass. These glasses are so named because it contains four major nonradioactive parts of vitrified atomic waste: alumina, boron oxide, sodium oxide, and silica. These four components play a significant role in the determining the chemical durability of glass.

The spectrometry results were combined with flow-through dissolution experiments. The flow-through experiments allowed the scientists to evaluate the relationship between the atomic structure and the rate of glass dissolution.

The scientists found that water determines how fast the glass dissolves. Water breaks apart bonds between aluminum and oxygen as well as silicon and oxygen under certain conditions (noted in previous studies). Determining how substituting other elements weakens or strengthens water's desire to break apart the bonds is critical in understanding the processes that control water's interactions with minerals and glass.

This research is part of ongoing work at Pacific Northwest National Laboratory and elsewhere to answer the questions about chemically durable waste forms.

More information: Pierce EM, LR Reed, WJ Shaw, BP McGrail, JP Icenhower, CF Windisch Jr, EA Cordova, and J Broady. 2010.

"Experimental Determination of the Effect of the Ratio of B/Al on Glass Dissolution along the Nepheline (NaAlSiO4) -- Malinkoite (NaBSiO4) Join." Geochimica et Cosmochimica Acta 74(9):2634-2654. DOI:10.1016/j.gca.2009.09.006