

A natural analogue of nuclear waste glass in compacted bentonite

Gento Kamei [1], Yasuhisa Yusa [2]

[1] JNC, [2] Tono Geosci. Center, JNC

A marine based argillaceous rock containing volcanic glass (1 Ma) was investigated to infer the long-term durability of vitrified nuclear waste in compacted bentonite. Neither glass matrix dissolution nor precipitation on the surface was seen and little leaching of any element was recognized. The ambient physical and chemical conditions surrounding the glass (temperature and water chemistry) were also investigated.

Because of the equilibrium between aqueous silica and SiO₂ amorphous, the volcanic glass did not dissolve during the burial. Based on the results of this study and literature concerning the radiation damage on nuclear waste glass, it is concluded that the nuclear waste glass sealed in compacted bentonite could survive under a condition of silica-saturating saline water.

A marine based argillaceous rock containing volcanic glass shards has been investigated to infer the long-term durability of vitrified nuclear waste in compacted bentonite, which is a candidate of buffer material constituting the engineered barrier system for nuclear waste disposal. Fission track ages indicate that the volcanic glass shards, andesitic scoria, have been buried in the argillaceous rock for about 1 million years. Neither glass matrix dissolution nor precipitation on the surface was seen under an optical microscope. Little leaching of any element has been recognized by analyses using an electron microprobe analyzer. Secondary ion mass spectrometry analysis, however, indicates hydration which may dominantly be a permeation of molecular water.

As an indicator of durability of glass against groundwater a normalized mass loss of Si (NLSi) has been evaluated for the volcanic glass based on free energy for hydration. The difference between estimated NLSi of the volcanic glass and that of a simulated waste glass is within one order so that the volcanic glass may be analogous to a waste glass with respect to durability to water. The argillaceous rock is analogous to the compacted bentonite with respect to physical properties such as dry-density, unconfined compression strength, porosity, and hydraulic conductivity. The ambient physical and chemical conditions surrounding the volcanic glass has been also investigated: Temperature was in the range from 4 to 30 deg.C due to the burial history of the volcanic glass. Over most of the past 1 million years the volcanic glass has been contact with groundwater originating from seawater. Thermodynamic calculations indicate (1) pH (=7.74~7.94) of the groundwater has mainly been controlled by dissolution of carbonate minerals, (2) the redox potential (Eh=-34 ~-73mV) of the groundwater has dominantly been controlled by decomposition of organic materials to produce CH₄(g), and (3) activity of aqueous silica of the groundwater was in equilibrium with SiO₂ amorphous. Because of the equilibrium between aqueous silica and SiO₂ amorphous, the volcanic glass did not dissolve during the burial.

Based on the results of this study and literature concerning the radiation damage on nuclear waste glass, it is concluded that the nuclear waste glass sealed in compacted bentonite could survive under a condition of silica-saturating saline water.