Mineralogical study on performance assessment of nuclear waste glasses with reference to natural analogue

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Glass is an important material used for high-level nuclear waste (HLW) management, accommodates and immobilizes several constituents. The heat generated due to decay of stored radionuclide rises temperature of the glass matrix that results in the release of radionuclide into the surrounding medium. To predict possible mineralogical phases owing to water-glass interaction, sodium and barium borosilicate glasses and natural analogue (Deccan Traps associated obsidian from Osham hill, Gujarat, India) specimens were treated in the deionized water from 1-256 hours at 100-300 ^{0}C temperatures under hydrothermal-like conditions. As a result, smectite, halloysite (grains spheroidal in shape), illite chlorite and saponite were formed in sodium borosilicate glass ((Fig: 1 a). Silica concentration below saturation to amorphous silica was noticed in the aqueous solutions obtained after experiments. It has been found that the solutions were in equilibrium with the smectite minerals. The saponite is more persistent as a secondary phase which represents high Ti, Fe and Mn values. Silica enrichment in solution with the incremental time of alteration favours transformation of saponite into hydrotalcite. Barium borosilicate glass represents Fe-rich montmorillonite and nontronite-like smectite (Fig: 1 b) whereas, alteration products of natural analogue showed appearance of altered surfaces, clustered to form massive aggregates and platy-flakes alongwith series of channels and cusps similar to that observed in case of smectite ((Fig: 1 c). These minerals and clays yielded after experiments largely correspond to the minerals which are commonly found in the residual soil profile developed over fresh obsidian outcrops, formed as a result of weathering in the natural environment. There are formless Si particles, whose number increases with the increase in the temperature. The smectite Fe content varies with the time - early formed alteration products in alkaline conditions contain high Fe values and it increases as the alteration progresses in the system. It is concluded that the nucleation of secondary mineral phases initiated not only from the solution, but by the re-arrangement of micro-domains within the glass network. The precursors for the clay minerals formation occurred in a glass region, where, humps and secondary layers have undergone process of hydration and hydrolysis.

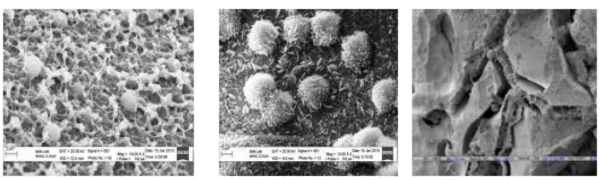

Fig 1: Back scattered SEM image of sodium and barium borosilicate glass and obsidian treated in hydrothermal-like conditions.