Low-Temperature Alteration in Tuffs from Yucca Mountain, Nevada

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Abstract: The structure, chemistry and distribution of hydrothermal alteration and weathering products of feldspars and glass in 3 samples of Yucca Mountain tuffs (GSW G4 borehole at a depth of 1531 ft (464 m) and USW GU3 borehole at 1406 ft (426 m) from the Calico Hills Formation and USW G4 at a depth of 272 ft (82.4 m) from the Topobah Springs Member) were examined by high-resolution transmission electron microscopy (HRTEM) and analytical electron microscopy (AEM). Alteration products are of interest because they may influence the form and distribution of contaminants released from the proposed high-level nuclear waste repository. Samples from the Calico Hills Formation contain alkali-bearing aluminosilicate glass and its alteration products. Zeolites appear to have formed from compositionally similar glass by recrystallization, probably under hydrothermal conditions. Crystals are fibrous and frequently no more than a few tens of nanometers in diameter. Porous aggregates of few-nanometer-diameter, poorly crystalline silica spheres (probably opal C-T) develop adjacent to corroded glass surfaces and zeolite crystals. Finely crystalline Fe-rich smectites coat etched glass surfaces, zeolites and feldspar crystals and occur within opal-like silica aggregates. Microstructures in the clay-dominated coatings and details of smectite-glass interfaces suggest that clays grow in orientations controlled by heterogeneously retreating surfaces and from constituents released at associated glass dissolution sites. The alteration assemblage also includes finely crystalline hematite, goethite, Mn-oxide films and illite formed by alteration of muscovite. The zeolitized sample contains abundant opal-like silica whereas glass in the unzeolitized sample is weathered to smectite-like clays. These differences may be attributed to hydrological and consequent geochemical factors resulting from the higher porosity of zeolitized samples. Exsolved alkali feldspar, which occurs as micron-sized crystals in the Calico Hills Formation and as phenocrysts and in the groundmass of the devitrified Topobah Springs Member, are almost unaltered. Feldspar alteration is confined to cracks and grain boundaries, where minor, poorly crystalline, Fe-bearing aluminosilicate alteration products are developed. In these tuffs, most of the porosity, permeability, high surface area and capacity to affect solution chemistry are associated with products of glass alteration.

Key Words: Alteration • Clays • Coatings • Glass • Silica • Smectite • Tuff • Weathering • Yucca Mountain • Zeolites

Clays and Clay Minerals; February 1998 v. 46; no. 1; p. 27-37; DOI: 10.1346/CCMN.1998.0460104