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Mineralogical and physicochemical characteristics of bentonite layers at shallow depths from the ground surface: Natural analogue study of bentonite buffer

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Bentonite characteristics under various conditions obtained from natural systems can be used to evaluate the long-term safety of bentonite buffer in deep geological repositories (DGRs) for high-level radioactive waste. In this study, the mineralogical and physicochemical properties of bentonite and andesitic lapilli tuff (i.e., parent rock) in the Naah mine in South Korea were investigated for a natural analogue study of bentonite buffer in DGR. Fourteen samples collected from the site (B1 and B2) and one bentonite ore body sample (B0), were analyzed. B1 and B2 group samples were collected at regular intervals from the bentonite layer and andesitic lapilli tuff. The bentonite layer was located at a depth of about 1 m below the ground surface and was potentially exposed to weathering. Each sample was separated into particles < 75 μm (C group) and particles < 2 μm (D group) through grinding and sedimentation processes. The separated subsamples were characterized mineralogically and physiochemically using various analytical techniques. X-ray diffraction, Fourier transform infrared, visible-near infrared spectroscopy and thermal gravimetry differential thermal analyses were performed to characterize the mineral phases and thermal behavior. Whole-rock analysis was performed to determine the chemical composition and structural formula of smectite. In addition, the free swell test, water uptake capacity, and cation exchange capacity measurements were performed to identify the physicochemical characteristics. The B0, B1 and B2 group samples had similar smectite, cristobalite, quartz, and feldspar mineral compositions, but the relative proportions of the minerals in each sample were different. The B0 and B1 group samples were mainly composed of smectite, and the B2 samples were mainly composed of feldspar. The smectites contained in the B0, B1, and B2 group samples were all Al-rich dioctahedral smectites, in particular Ca-montmorillonite. However, some structural differences were identified between the three types of smectites, and there was a slight difference in swelling properties. These results suggest that bentonite was located near the ground surface for a long time and potentially exposed to weathering, but the properties of smectite contained in the bentonite were hardly changed.