Electron Microscopy Study of Volcanic Tuff Alteration to Illite-Smectite under Hydrothermal Conditions

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Abstract: Experimental alteration of volcanic tuff from Almería, southeastern Spain, was performed in solutions with different Na/K ratios (0.01, 1, 10, and 100), different total salt concentrations (0.01, 0.1, 0.2, 0.33, and 1 M), and in deionized water, at 60, 80, 120, and 160 ° C, for periods of 60, 90, 180, and 360 d. Two particle size fractions of volcanic tuff were used: 10 – 200 and 20 – 60 μm. Alteration products were examined by X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), laser-particle size analysis, scanning electron microscopy equipped with an energy dispersive X-ray spectrometer (SEM-EDS), image computer analysis, and transmission electron microscopy with microanalysis (TEM-AEM). XRD detected neoformed phases only in the products from experiments of 180 – 360 d at high temperatures (120 – 160 ° C) and with Na/K ratios above unity and in deionized water. The synthesized phase is a random mixed-layer illite-smectite (I-S) with 75% smectite. The quantity of newly formed I-S, determined by FTIR, ranged between 3 – 30%. There was no apparent change in grain size and shape of the grains after the experiments as compared to before.

SEM-EDS and TEM-AEM revealed the following alteration sequence: 1) intense etching on glass-grain surfaces; 2) formation of hemispherical morphologies on grain surfaces; 3) precipitation of very thin, individual flakes of illite-smectite on glass-grain surfaces; 4) development of I-S at the edges of glass grains; and 5) development of I-S honeycomb structures either covering large areas of the glass grains or resulting from the complete alteration of glass grains. A direct transformation of glass to I-S seems to be the major reaction mechanism, although there also is evidence of glass dissolution and subsequent I-S precipitation.

Key Words: Hydrothermal Alteration • Illite-Smectite • SEM-EDS • TEM-AEM • Volcanic Tuff

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