Experimental Study on the Formation of Clay Minerals from Obsidian by Interaction with Acid Solution at 150 ° and 200 ° C

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Abstract: Experimental alteration of obsidian with HCl solution was performed to elucidate dissolution mechanism and formation process of clay minerals in acid solution. Reactions were carried out using 0.1, 0.5, and 4.0 g of obsidian to 100 ml of 0.01 N HCl solution at 150 ° and 200 ° C for 1 to 60 days. The reaction products were examined by X-ray powder diffraction, scanning electron microscopy, transmission electron microscopy (TEM), and energy dispersive X-ray analysis. The surface composition of obsidian before and after alteration was investigated by X-ray photoelectron spectroscopy (XPS). TEM showed that boehmite precipitated at early stage and spherical kaolinite appeared subsequently by 200 ° C reactions. However, spherical halloysite occurred predominantly with small amounts of allophane, boehmite, and kaolinite by 150 ° C reaction in which formation process of the halloysite from allophane passing through an intermediate phase of small size rounded aggregate that consists of fine particles of allophane was observed. A boehmite exhibiting hexagonal platy habit with higher degree of crystallinity was formed by 200 ° C reaction as a stable phase in solution containing lower Si concentration at which the solution composition coincides with the stability field of boehmite on activity diagram for the system Na_2O-Al_2O_3-SiO_2-H_2O. The fibrous boehmite having lower crystallinity appeared with increasing Si concentration, considered as a metastable phase in the stability field of kaolinite. XPS indicated that dissolution of obsidian in acid solution proceeded initially by cation exchange between Na ions and hydronium ions in solution and subsequently by preferential release of Al ions relative to Si from the Na depleted surface.

Key Words: Acid solution • Allophane • Boehmite • Experimental alteration • Halloysite • Obsidian • Spherical kaolinite

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