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TEM-EDX study of weathered layers on the surface of volcanic glass, bytownite, and hypersthene in volcanic ash from Sakurajima volcano, Japan

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ABSTRACT

Transmission electron microscopy (TEM) and energy dispersive X-ray (EDX) analysis were used to characterize naturally weathered layers on the surface of volcanic glass, bytownite, hypersthene, and secondary precipitates in volcanic ash erupted from the Sakurajima volcano, Japan. TEM analysis of the volcanic ash revealed sharply, bounded, leached layers on the surface of the volcanic glass and bytownite that were thin structureless coatings mostly ≤0.1 μm thick. EDX analysis showed that the leached layer on the volcanic glass surface is preferentially depleted in Si and enriched in Al relative to its parent matrix, whereas the leached layer on the bytownite surface is extremely depleted in Al and enriched in Si relative to the original bytownite matrix. These chemical characteristics of the weathered layers indicate that incipient dissolution of volcanic glass and bytownite proceeded by preferential leaching of Si and Al, respectively. On the surface of hypersthene, a noncrystalline weathered layer generally <0.01 μm in thickness, which has nearly the same composition as that of the parent matrix, was observed. This weathered layer was produced by precipitation of noncrystalline hydrous ferric oxide with partly developed to poorly crystallized Fe-Si-Mg rich phyllosilicate. The volcanic ash sample contains small amounts of noncrystalline secondary precipitates exhibiting three distinct morphologies: (1) aggregates of very fine fibers, (2) aggregates of fine fibers with crinkled fringes, and (3) spherical forms composed of roughly curled fringes. These noncrystalline precipitates are enriched in Al and Si and contain variable amounts of Fe, depending on their morphology. The Fe content of these materials decreases drastically in the sequence morphology 1 → morphology 2 → morphology 3, which is consistent with the transformation from Al-, Si-, and Fe-rich fine fibers to spherical halloysite by elimination of Fe from the fibers. These alterations of the volcanic ash took place in the crater of the Sakurajima volcano by interaction with near-neutral to weakly acidic solutions under relatively low-temperature conditions.