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Alteration evolution of lightning fossils: Insights from natural fulgurite scars and hydrothermal experiments

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Abstract

Rock fulgurite is a high-temperature, high-pressure metamorphic rock that contains glass and is attributed to transient extreme deformation events caused by lightning strikes. Their glassy nature and susceptibility to weathering on Earth's surface present significant challenges to their preservation and recognition in the field, and the associated alteration processes are poorly constrained. Based on a well-exposed outcrop containing both ancient and fresh rock fulgurite, this study aims to investigate the evolution of rock fulgurite through alteration, integrating both natural observations and alteration experiments. The latter were conducted on fresh fulgurite with simulated rainwater and deionized water at temperatures ranging from room temperature to 300 °C and durations from 10 min to 117 days. The altered rock was investigated by microanalytical methods, with results showing matrix dissolution, element depletion, and the formation of hydrated minerals within the glassy layers. Chemical analysis of the alteration solutions suggests that the glassy layers will completely dissolve on a thousand-year scale. By integrating experimental results with field observations, this study establishes the evolution of rock fulgurite under geological and temporal constraints and provides insights into the alteration processes of rock fulgurite exposed at the surface. Our findings also offer applications for recognizing rock fulgurite and the relevant remnants and, by extension, other rock-exposed regions with incomplete lightning catalogs.

Keywords: Lightning fossil, rock fulgurite, alteration, hydrothermal experiment