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Structural and Chemical Features of Experimentally-generated Silicate Fulgurites

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Fulgurite is a naturally occurring glass generated by cloud-to-ground and volcanic lightning discharges in soil, sand and/or rock substrates. Here we investigate silicate fulgurites by a simulated lightning discharge with the aid of a DC-source trigger setup on natural silicate rocks, tholeiite from Krafla Fire, Iceland and ankaramite from Azores volcanic complex, Portugal. We have chosen these powdered rock samples, <63 µm, (as a starting material) in similar compositions but exhibit a different vesicularity as well as different degree of crystallinity to better understand the effect on structural and chemical features of fulgurite formation.

The silica contents of natural tholeiite and ankaramite are 49.3 wt% and 47.5 wt%, respectively. They are mainly composed of pyroxene, plagioclase and olivine. Petrographic features of both show concentric zoning and complex twinning in plagioclase and plagioclase inclusions in augite. The structure of the tholeiite is hemicrystalline, whereas the ankaramite is holocrystalline. The tholeiite exhibits a higher vesicularity than the ankaramite.

Tholeiitic and ankaramitic fulgurites were generated under similar experimental conditions of 500 ms duration. The products exhibit the typical channel-like structure of natural fulgurites with a central void, ca. 15 mm and 10 mm in diameter, respectively. The inner wall of these fulgurites is fully glassy. In contrast, the outer surface of both fulgurites preserves a remainder of the original material state. The structure of the original material adhering to the outer wall of the fulgurites varies between the two fulgurites. The original particles on the outer wall of tholeiite are rounded, whereas the original particles on ankaramite preserve their original morphology. Geochemical investigation (XRD, EPMA and SEM) of experimentally-generated tholeiite and ankaramite fulgurites indicate that they generally preserve their original compositions. Partially melted and unmelted phenocrysts from the original materials remain dispersed in the outer edge of the fulgurites and exhibit solely textural changes (no chemical changes). These results lay the basis for further investigations of potential signatures of fulguritic alteration of volcanic rocks via manipulation under measured lightning discharges and should eventually contribute to indicators for ancient atmospheric chemistry based on fulgurites.