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Micro- and nano-CT textural analysis of an experimental volcanic fulgurite.

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Fulgurites are natural glasses formed by cloud to ground lightning discharges causing rapid heating into rocks or unconsolidated sediments. Volcanic lightning can determine the re-melting and even ablation of newly formed or just deposited volcanic tephra during explosive eruptions. In this case the pristine material is already constituted by glass that can be further modified by the discharge. Although volcanic lightning discharges are generally less energetic than those produced by thunderclouds, the high temperatures reached by the lightning channel are well in excess of the low melting temperature of glass material. Here we have experimentally reproduced a fulgurite by single impulse voltage discharges (134 kV, 331 A, 10.5 J) on a target glass material. We have chosen borosilicate glass fibers (180 microns nominal length) as starting material to better account for the structural and chemical modification of the single particles after discharge-melting. The structure of the small fulgurite is best resolved through X-ray micro- and nano-computed tomography. Micro-CT analysis was carried out on a phoenix nanotom m with a voxelsize of 1 μm3. Additionally a 3D reconstruction with a voxel size of 150 nm3 has been analyzed at the new nano-analysis beamline ID16B at the ESRF. 3D analysis was carried out using Avizo 9.2 software, which allows non-destructive analysis of the fragile structure of the sample.
The sample shows the channel-like structure typical for natural fulgurites with an inner void channel and internal wall constituted by the melted fibers. About 33% of the total solid volume of the fulgurite is melted to form the inner wall. The inner wall is characterized by nano- to micro-metric vesicles determined by volatile exsolution (mainly H_2O) during the instantaneous heating and trapped in the low viscosity melt by the subsequent rapid quenching. Progressively outward the fulgurite shows the intricate delicate structure of the pristine glass fibers. Our results demonstrate that structural and chemical alteration of low viscosity glass material is possible by small impulse discharges with relatively low currents, thus reproducing a plausible scenario for electrical discharges during volcanic eruptions. Our experiment opens the opportunity for systematic constrained experimental investigation of the modification induced by volcanic lightning on tephra.