PHASE RELATIONS AND MICROSTRUCTURES IN A FULGURITE FORMED IN A COARSE SOIL OF WEATHERED GRANITE

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Fulgurites are mostly "branch-like" cylindrically or conically shaped glassy structures that form, when a cloud-to-ground lightning strikes a target material, which is usually soil, sand or rock. The energy dissipated during the fulgurite forming electrical discharge event is between 1 and 30 MJ/m, which is transferred to the target material within several 10s of µs leading to a peak power output of about 10^{13} W, heating rates of 10^3 K/s, and peak temperatures on the order of 10^5 K (e.g. PASEK et al., 2012). The conditions prevailing during fulgurite formation are extreme, comparable only to other short-lived high-energy geological events such as hypervelocity impact and induced impact metamorphism as well as frictional heating during seismic slip. Accordingly, the phase content and the microstructures that are observed in fulgurites are peculiar. We present new mineralogical and petrographical data from a fulgurite from the Inyo County, E-California (USA), which was formed in a coarse soil (gravel) of weathered granite as target material.

Several fragments of a fulgurite tube including side branches are available. The largest sample represents a segment of a hollow cylinder with a wall thickness of 1.8 centimeters and an inner fulgurite tube diameter of about 4 centimeters. The fulgurite can be subdivided into five concentric zones. The innermost zone is dominated by a colourless, translucent glass with grey schlieren. In addition, lechatelierite (amorphous SiO_2) and cristobalite are present. Moreover, spherical aggregates of metallic Fe and of polyphase of Fe-Si-P alloys with eutectic internal microstructure occur. In the next zone, cristobalite embedded in a translucent glass matrix is the main mineral phase. Further out, cristobalite forms rims around cores of quartz. The next zone contains many relic quartz grains floating in a glassy matrix. The outermost zone contains abundant grains of quartz, feldspar, and opaque phases, whereby magnetite and hematite dominate. In addition, a variety of dendritically grown phases including spinel, Fe-rich olivine, and clinopyroxene occur.

The presence of lechatelierite indicates peak temperatures in excess of 1700 °C at the inner fulgurite wall at extremely reducing conditions as indicated by the presence of Fe-Si-P alloys. A significant outwards decrease of the peak temperatures is indicated by the fact that quartz grains are preserved at the outer fulgurite wall. In addition, the conditions have been far less reducing in the outermost portions of the fulgurite as indicated by the presence of magnetite and hematite. Finally, the flash heating was followed by fast cooling as indicated by the presence of dendritically grown phases, which are considered as evidence for crystallization under the conditions of large undercooling.

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