SHOCKED QUARTZ IN A FULGURITE

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Fulgurites are glasses formed by cloud-to-ground lightning. Recently fulgurites have been suggested to parallel impact glasses in terms of geochemical changes [1]. The formation of a fulgurite occurs during the rapid transfer of lightning energy, equivalent to several 10s of MJ, to a narrow channel in the ground. In the most rapid lightning strikes, the rate of energy deposition is similar to that in a meteorite impact, and lightning strikes may generate shockwaves and cause shock effects in fulgurites.

Here we report the results of a series of shock models of a lightning strike, and show the occurrence of shocked quartz in a type II [2] fulgurite from Greensboro, NC, USA. The effect of channel diameter, total energy and current duration on the radial distribution of peak pressure and temperature was modeled using the iSALE shock physics code [3]. In high-energy lightning, with short current duration and narrow current channel, energy deposition causes a shockwave to propagate away from the lightning channel with maximum shock pressures up to 20 GPa. The shockwave attenuates rapidly and hence maximum shock pressures are strongly related to radial location.

In the Greensboro (GNC) fulgurite the least shocked material shows development of a series of planar fractures similar to those reported in impactites. Inward of this material is a variety of "toasted" quartz [4] which has a reduced index of refraction, increased crystal lattice volume, and exhibits a shift in a number of Raman bands sensitive to pressure changes[5]. The "toasted" quartz is estimated to have experienced shock pressures between 22-30 GPa. Closer to the central void of the fulgurite is a glassy material identified as diaplectic glass based on its index of refraction (n between 1.46 and 1.47).

The shocked quartz in the GNC fulgurite lacks planar deformation features and no high pressure SiO_2 polymorphs like coesite or stishovite were found by Raman spectroscopy. In this respect, the shock metamorphism occurring in the GNC fulgurite is distinctive from hypervelocity impact shock metamorphism. However, the presence of shocked quartz in this fulgurite suggests other effects of shock may be found in fulgurites forming in different materials. Furthermore, shock metamorphism by lightning may provide an explanation for occurrences of shocked quartz in isolated glasses found throughout the geologic record.

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