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Mineralogical and chemical characterization of newly formed nano-sized minerals in a fulgurite from Outer Banks, NC

RACHEL LYNN COURTNEY AND **DR. CHIARA ELMI, PHD**

James Madison University

Presenting Author: elmicx@jmu.edu

In Outer Banks, North Carolina, Professor Edwin S. Bair discovered several fulgurite samples. Some are elongated, hollow, tube-like fulgurites, and some porous, spherical fulgurite droplets; both of which formed when a lightning strike made contact with the shorelines' sand. Elevated temperatures above 1000 °C and pressure above 6 GPa (if thermodynamic equilibrium was reached) create the thermodynamic conditions for forming a glass-lined tube with residual, partially melted minerals, and newly formed minerals embedded into the glass matrix. Previous study on the composition of the samples revealed via X-ray powder diffraction (XRPD) the presence of quartz, plagioclase, clinochlore, cordierite, cristobalite, coesite, and dolomite; with stishovite detected exclusively in the tubular sample. In the current study, two thick sections were analyzed: one hollow tube and one droplet sample, with the goal of shedding light on the minerals formed during a high-energy event, such as a lightning strike.

Scanning electron microscopy (SEM) coupled with energy dispersive spectroscopy (EDS) were used to characterize the morphology and chemical composition of the thick section of the fulgurite from Outer Banks, NC. Partially melted quartz crystals and flaky crystals identified as clinochlore were found in the fine-grained to glassy matrix. Newly formed cordierite was identified by XRPD, and newly formed nano-sized pyrite crystals were identified via SEM coupled with EDS. SEM imaging revealed well-crystallized clusters of pyrite (FeS_2), with an average size of < 2μm. These spherical clusters of cubic and octahedral crystals are widespread throughout the sample. Pyrite formation can result in reducing conditions as a byproduct of the sulfidation of ferromagnesian silicates such as clinochlore and cordierite and Fe-Ti oxides in the presence of H_2S fluids derived from decomposed or burned organic matter. Extreme high temperatures from the lightning strike and the H_2S-rich fluids may have facilitated the precipitation of octahedral pyrite inside the bubbles formed during the volatilization of water when the lightning struck.

Through investigating shock-impacted minerals at the nano-metric scale, this study provides a greater understanding of the thermodynamic constraints that can influence mineral formation and phase transition shock impact events, such as a lightning strike or meteor impacts.