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The mineralogical, microstructural, chemical characteristics of Recently Formed Fulgurite in Kinmen, Taiwan

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Lightning is a common high-energy phenomenon. In particular, cloud-to-ground lightning (CG lightning) generates shock wave and electrical discharge on the ground and forms the associated geological evidence including melting and shock lamella on rocks, termed fulgurites. Because lightning strikes on different protolith (cohesive or non-cohesive rocks), Pasek et al. (2012) divided the fulgurites into four types: (I) sand fulgurites, (ii) soil/clay fulgurites, (iii) calcic-soil fulgurites, and (iv) rock fulgurites. Compared with the reported fulgurites derived from non-cohesive rocks, the recognition of rock fulgurites was rare and remains unclear. Here we report the detailed characterization of rock fulgurites formed in a very recent CG lightning event with microanalytical methods including optical microscope, Field-Emission Scanning Electron Microscope (FESEM), Transmission Electron Microscope (TEM), regular and synchrotron X-ray Powder Diffraction (XRD), and Raman spectroscope. We also provide a CG lightning energy dissipation model constrained by the observed current values. The CG lightning event (the current value is ~ 162 kA) took place on granitic gneiss in Kimen county, Taiwan, on May. 7th, 2018. Our results show that the rock fulgurites were characterized with a black-to-brown thin (~10 μm in thickness) glassy crust with some vesicles covering on the host rock. Hydrous sulfates, including jarosites and gypsums, were recognized to locally deposit on fulgurites, likely suggesting the presence of hydrothermal condition in near-surface exposures after the cessation of the CG lightning. Planer deformation features derived from high pressures (up to several GPa) were found in k-feldspar located beneath the glassy crust, suggesting the presence of shock waves also on the surface. In addition, the estimated melting energy for the observed fulgurite (~20 m^2 in area with the thickness of 100 μm) is much less than one one-hundredth of the observed CG lightning. It supports the previous studies that documented most of the electrical discharge was dissipated into ground. Our study establishes a reference rock fulgurites data originated from CG lighting on granitic rocks set for future on-site drilling and presents an application of these data for studies of ancient rock fulgurite relicts.