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Laboratory simulations of volcanic ash charging and conditions for volcanic lightning on Venus

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Lightning may be important in the emergence of life on Earth and elsewhere, as significant chemical reactions occur in the superheated region around the lightning channel. This, combined with the availability of phosphates in volcanic clouds, suggests that volcanic lightning could have been the catalyst for the formation of biological compounds on the early Earth [1]. In addition to meteorological lightning, volcanic activity also generates electrical discharges within charged ash plumes, which can be a significant contributor to atmospheric electricity on geologically active planets. The physical properties of other planetary atmospheres, such as that of Venus, have an effect on the processes that lead to the generation of volcanic lightning. Volcanism is known to have occurred on Venus in the past, and recent observations made by ESA's Venus Express satellite have provided evidence for currently active volcanism [2-4], and lightning discharges [e.g. 5]. Venusian lightning could potentially be volcanic in origin, since no meteorological mechanisms are known to separate charge effectively in its clouds [6]. The hunt for further evidence for lightning at Venus is ongoing, for example by means of the Lightning and Airglow Camera (LAC) [7] on Akatsuki, the current JAXA mission at Venus.

Our laboratory experiments simulate ash generation and measure electrical charging of the ash under typical atmospheric conditions on Earth and Venus. The study uses a 1 litre chamber, which, when pressurised and heated, can simulate the high-pressure, high-temperature, carbon dioxide-dominated atmosphere of Venus at ∼10 km altitude (∼5 MPa, 650 K). A key finding of previous work [8] is that ash plume-forming eruptions are more likely to occur at higher altitudes such as these on Venus. The chamber contains temperature/pressure monitoring and logging equipment, a rock collision apparatus (based on [9]) to generate the charged rock fragments, and charge measurement electrodes connected to a high-precision electrometer. The separate effects of varying the atmospheric composition, temperature, and pressure on the charges attained and the relationship between particle size and charge polarity will be addressed, and the implications discussed.

The key questions considered here are: (a) is volcanic activity a feasible mechanism for lightning generation on Venus, (b) how do the extreme environmental conditions on Venus affect the mechanisms required to generate lightning, (c) what are the implications for volcanic lightning's role in the emergence of life on other planets?

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