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Volcanic lightning on Venus and early Earth

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Lightning may have been crucial in the development of life, as it enables key chemical reactions to occur. We cannot directly observe early Earth's hot, CO_2-rich, atmosphere; however, similar conditions exist today on Venus, where there may be volcanic and/or meteorological lightning. Recent observations made by ESA's Venus Express satellite have provided evidence for active volcanism [1-3] and lightning discharges [e.g. 4], which may be volcanic in origin.

This study uses laboratory experiments to simulate ash generation and to measure its electrical charging under typical atmospheric conditions for Venus and the early Earth (specifically the Hadean eon, up to 4 billion years ago, and the Archean eon, from 4 billion to 2.5 billion years ago). Ultimately the work will address the following questions: (a) is volcanic activity a feasible mechanism for lightning generation on Venus and early Earth, (b) how would these extreme paleo-environmental conditions affect lightning, (c) can the similarities in atmospheric conditions inform us of planetary evolutionary concepts, (d) could volcanic lightning have been important in the emergence of life on Earth, and (e) what are the wider implications for the likelihood of the emergence of life on other planets?

A 1-litre atmospheric simulation chamber will be used to simulate the high-pressure, high-temperature, CO_2-dominated atmospheres of the surface of early Earth, and Venus at $\sim$10 km altitude ($\sim$5 MPa, 650 K) (where ash plume-forming eruptions on Venus are more likely to occur [5]). The chamber contains temperature/pressure monitoring and logging equipment, a collision apparatus to generate the charged rock fragments, and electrodes for charge measurement with an electrometer [6].

The planned experimental programme will measure the effects of varying temperature, pressure, atmospheric, and sample composition under a range of conditions appropriate to Venus and early Earth. Comparative work with present day Earth conditions will be undertaken in order to explore the independent effects of each variable on ash charging in these environments. By comparing the effects on atmospheric electrical phenomena due to the transition from paleo to current atmospheric conditions, the occurrence of volcanic lightning may be placed in the context of planetary and astrobiological evolution.

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