Prebiotic synthesis in volcanic discharges: lightning, porous ash and volcanic gas atmospheres

C. Springsklee[1*], T. Steiner[2], T. Geisberger[2], B. Scheu[1], C. Huber[2], W. Eisenreich[2], C. Cimarelli[1] and D.B. Dingwell[1]

[*]christina.springsklee@min.uni-muenchen.de

1) Department for Earth and Environmental Sciences, University of Munich, 80333 Munich, Germany

2) Department of Biochemistry, Technical University of Munich, 80333 Munich, Germany

Introduction

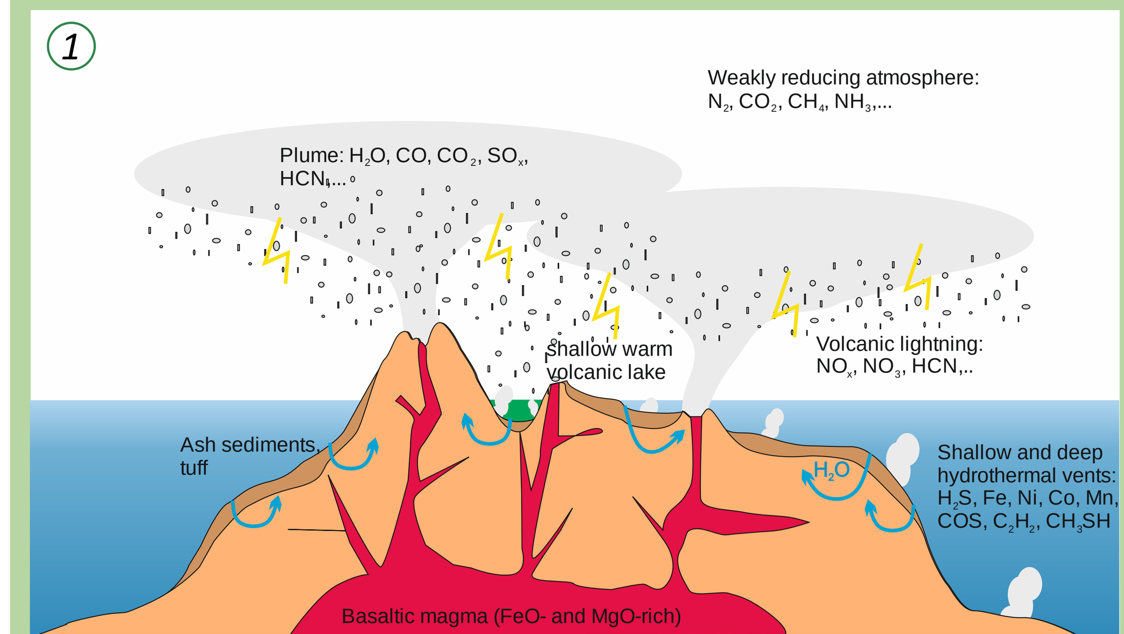


Figure 1: Schematic drawing of a potential environment for volcanic lightning at Early Earth conditions.

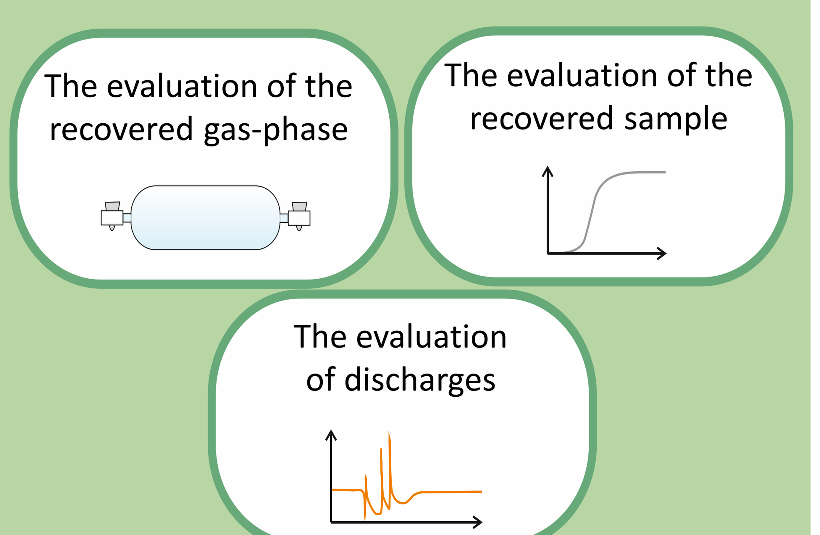
Over the last 60 years our understanding of early Earth conditions significantly advanced and a variety of origin of life hypotheses has been developed.

This project aims at quantifying the role of geomaterials (e.g. volcanic ashes as catalyst and compartment provider) in some of these settings and scenarios considered to contribute to the origin of metabolism and life. The project focuses on the creation and accumulation of organic compounds, in particular on molecules which are the product of the discharge-induced interaction of ash and atmosphere.

Specifically we will analyze volcanic ashes, experimentally erupted into various atmospheres, for their productivity and yield of primordial organic components. In addition, these ashes will be brought into aqueous solutions mimicking hydrothermal vents.

Outlook

Experiments will be performed under reducing atmosphere conditions to investigate the yield of organic molecules on the surface of the recovered samples. Additionally, the gas-phase will be recovered and analyzed and the measured discharge behaviour evaluated.



Method

The experimental setup is a modified mobile and gastight version of that described in Alidibirov and Dingwell (1996) which has been further developed (e.g. Kueppers et al., 2006; Scheu et al., 2008; Alatorre-Ibargüengoitia et al., 2010). As in Gaudin and Cimarelli (2019) the large low pressure tank and associated parts are modified to work as a Faraday cage. Our modifications allow studying electrical discharges in volcanic jets in variable atmospheric conditions. The sample is inserted into an autoclave and pressurized applying argon gas to the desired eruptive condition. The eruption is triggered by a controlled failure of two diaphragms. The grounding of the autoclave and the attachment of an additional resistor between the Faraday cage and the ground allows to measure the voltage of the discharges across the resistor what allows to compute the electric current.

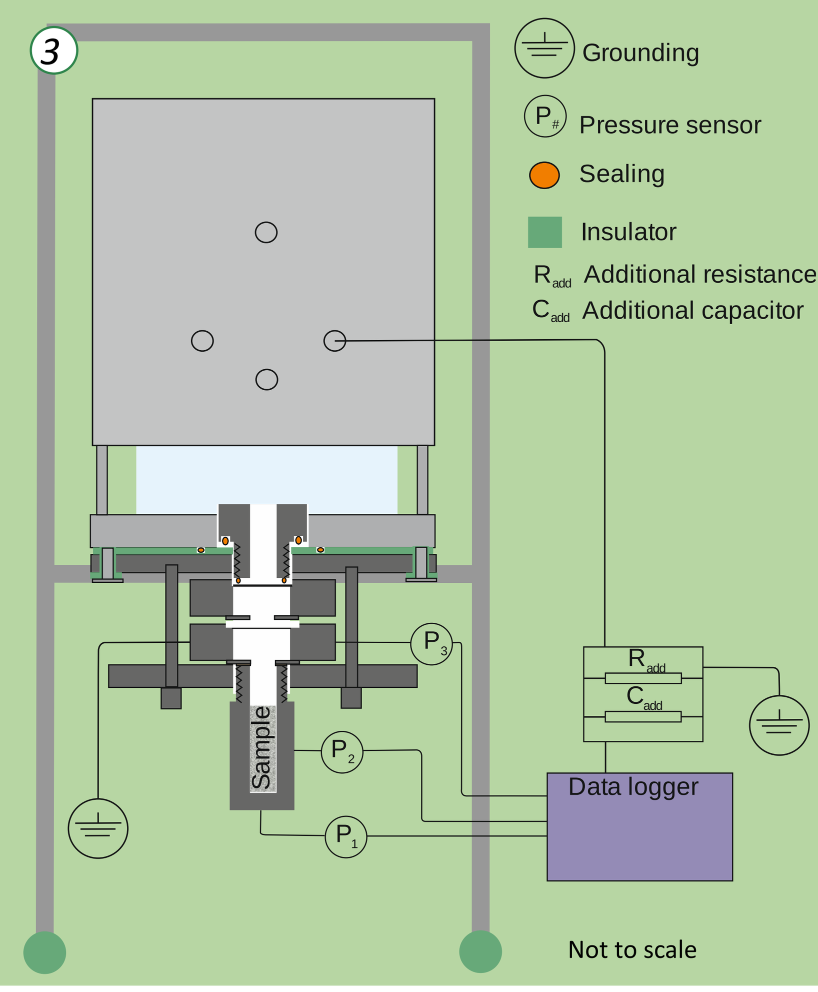
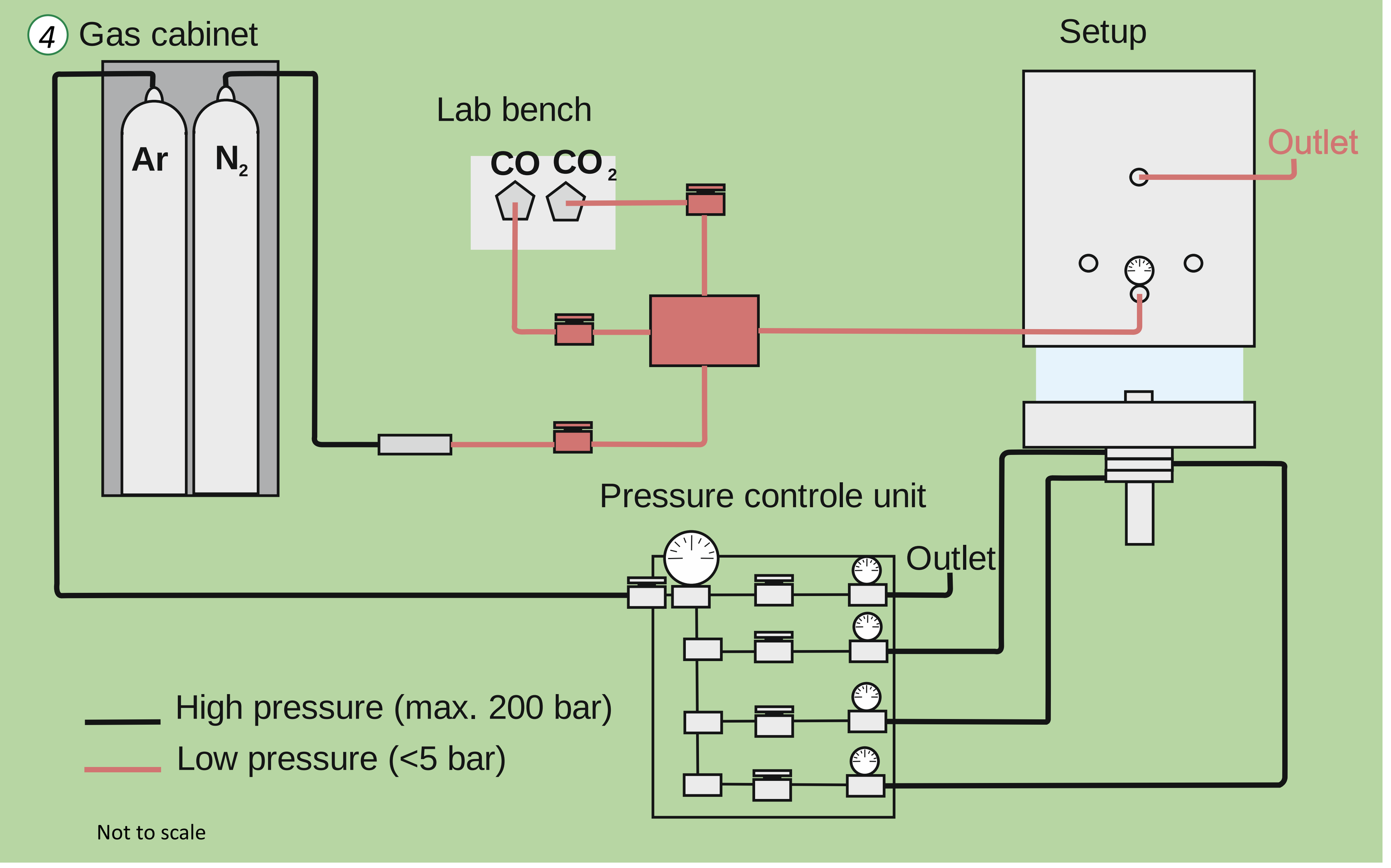


Figure 2: Photography of the experimental setup.

Figure 3: Schematic drawing of the experimental setup. The upper part of the setup is a Faraday cage (FC).

Figure 4: Schematic plan of the installation of the experimental setup. The sample is pressurized by argon gas and ejected into different atmosphere compositions.



Results

The discharges are observed by a high-speed camera (V711-Phantom) and the recordings from the Faraday cage. The mass of ejected ash, the initial pressure in the autoclave and the proportion of fine ash particles (fraction <63 µm) play a crucial role in the number and magnitude of the discharges during the ejection of the particle-laden flow.

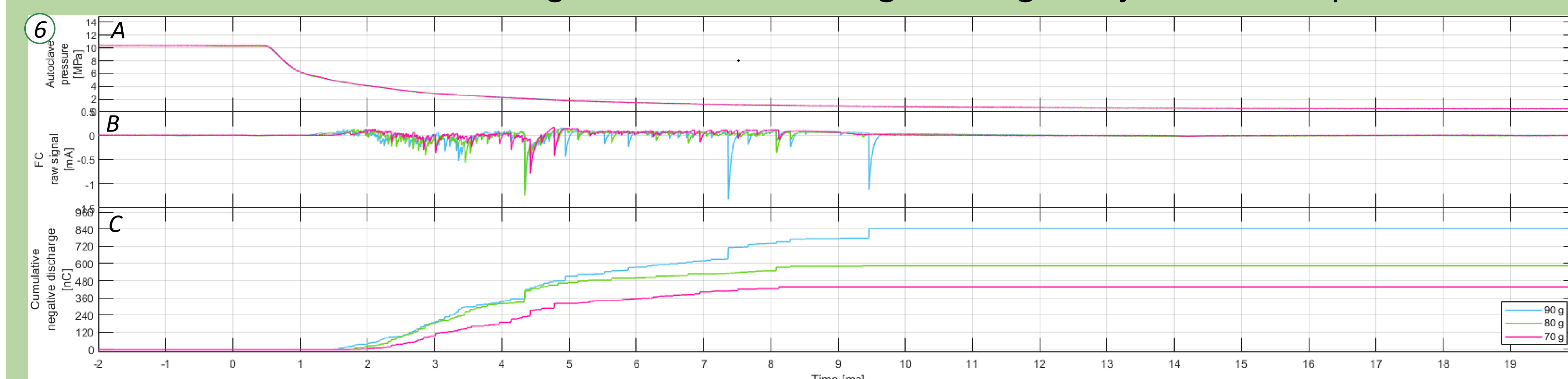


Figure 6: Example of signals from three experiments. The samples (grainsize 180 – 250 µm) were erupted with 10 MPa autoclave pressure and contained 5 wt% of fines (< 63 µm), only the amount of sample was changed .6-A) Static pressure at the top of the autoclave; 6-B) Faraday cage current. Individual spikes mark discharges; 6-C) Total magnitude of the negative discharges. The figure shows the significance of the mass in the generation of discharges.

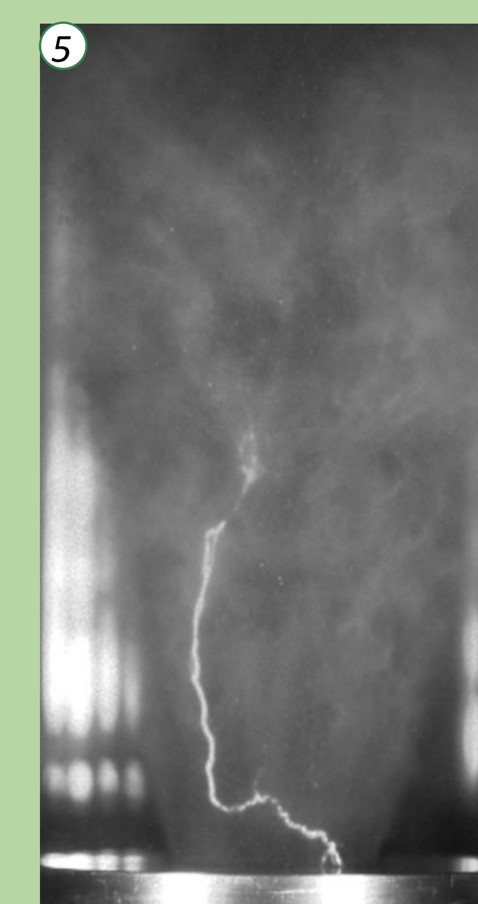


Figure 5: High-speed photography of a discharge in ambient air. The tholeiitic sample (grainsize 180 -250 µm) containing 15 wt% fines (< 63 µm) was erupted at 12 MPa.

Literature:

Alatorre-Ibargüengoitia, M.A., Scheu, B., Dingwell, D.B., Delgado-Granados, H., Taddeucci, J., 2010. Energy consumption by magmatic fragmentation and pyroclast ejection during Vulcanian eruptions. Earth Planet. Sci. Lett.291, 60–69.

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