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Laboratory Simulated Volcanic Lightning and Prebiotic Synthesis

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Introduction: Analyses of archived aliquots from one of Stanley Miller's classic 1953 experiments that utilized an apparatus configuration wherein a jet of steam was directly injected into an electric discharge (see ***Figure*** below) suggested the potential importance of the synthesis of prebiotic compounds by lightning often associated with volcanic eruptions [**1**]. In 2014, the Munich-based authors above published a paper on the experimental generation of volcanic lightning [**2**], which suggested that the results from Miller's "volcanic" experiment might be directly testable. Contact was rapidly established between San Diego and Munich about doing such a prebiotic synthesis experiment with laboratory simulated volcanic lightning (see ***Figure*** below). In Munich a dedicated fragmentation facility has been built for experimentation involving gas mixtures. Here we report here the preliminary results from experiments using this new facility.

Experimental Conditions and Results: We selected mixtures of gases such as NH_3, N_2, CH_4 and CO_2 to be used in the apparatus and the Munich group collected volcanic ash from Sakurajima volcano (Japan), known for frequent explosive eruptions, which are very often accompanied by volcanic lightning. After using a combination of gases and ash in the laboratory volcanic lightning apparatus, we analyzed the ash for interesting prebiotic compounds. The ash was extracted using water heated over night at 40°C.

Analyses indicated that with NH_3 (in some cases associated with its presence in the gas mixture), as well as simple amino acids such as glycine (electrospray mass spectrometry of OPA/NAC-derivatized amino acids was used for analysis) were synthesized in the experiments as long as there was a reduced gas (either ammonia or methane) present. We hypothesize that in the discharges observed in the experiment, one of the components synthesized was hydrogen cyanide (HCN). It has been know for over a half-century that HCN can react to form HCN polymers that upon hydrolysis yield glycine and lesser amounts of other amino acids [**3, 4, 5**]. We are now carrying out a systematic series of analyses to determine whether essential prebiotic reagents such as hydrogen cyanide, aldehydes/ketones, etc. are made during the laboratory volcanic lightning.

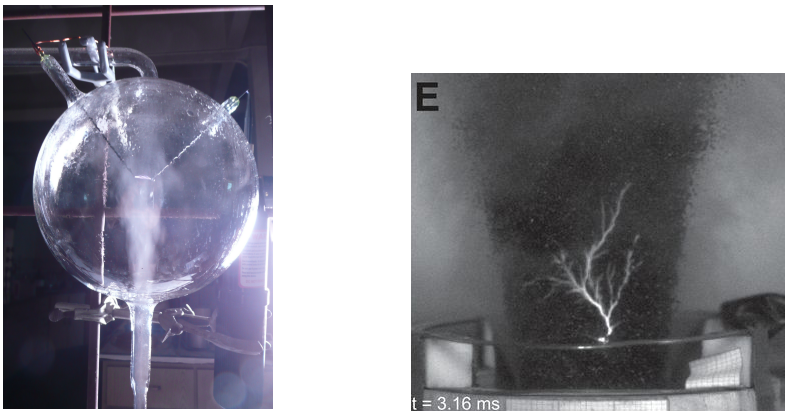

***Figure*: Left, Miller Volcanic Apparatus; Right, Experimental Laboratory Simulated Volcanic Lightning**

References: [**1**] Cimarelli, C., et al. (2014), *Geology* 42: 79-82. [**2**] Johnson, A. P., et al.(2008), *Science* 322: 404. [**3**] Abelson, P. H. (1966) *Proc. Natl. Acad. Sci.* 55: 1365-1372. [**4**] Levy, M, et al. (2000), *Icarus* 145: 609-613. [**5**] Yuasa, S., et al. (1984), *J. Mole. Evol.* 20: 52-58.