DUST STORM ELECTRIFICATION IN A MARS CHAMBER - FIRST RESULTS.

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Introduction: The composition of the martian atmosphere and the abundance of methane and hydrogen peroxide are affected by different processes, such as interaction with solar UV and surface-atmosphere interaction. The generation of atmospheric electricity via contact electrification of dust and soil, or “triboelectricity”, is a process at work on Earth and can play an important role on Mars as well. Laboratory studies, numerical simulations, and desert field tests indicate that terrestrial aeolian dust transport can generate large electric fields through this mechanism. Analogue studies and numerical simulations suggest that in martian dust devils and larger dusty convective storms a similar process is taking place, which generates and maintains large-scale electric fields.

Dust and electrochemistry in the atmosphere: In Earth’s atmosphere, anhydrous electrical currents are generated in dust devils and dust storms [1],[2],[3]. In terrestrial dust devils, dust particles generate and transfer electric charge through collisions with each other and with the surface [3].[4].[5]. In this process smaller particles get charged negatively and are eddied up in dust storms, whereas larger grains become positively charged and stay close to the surface [3],[5],[6],[7],[8]. This displacement in grain charge types creates a dust storm-sized electric dipole moment, resulting in the development of coherently varying electric fields that extend well outside the dust storm. Field strengths near 500 V/m at a distance of many 10’s of meters from the features have been measured [1].[2]. In desert tests that combined electrical, magnetic, and meteorological measurements electric fields were found to be coherent, large-scale, and exceeding 20 kV/m [9],[10],[11].

Unsaturated electric fields near 120 kV/m were measured from dust devils in the Mojave desert [12] and simple saltating grains were found to generate electric fields exceeding 160 kV/m [13]. These coherent electric fields from dust devils are not impulsive “discharge fields” or lightning, but long-lasting electrostatic fields associated with the build-up of vertical, well-separated charge centers in the feature. Discharges occur when these electrostatic fields become anomalously large creating “breakdown” conditions, leading to increased impulsive electron flow.

Using Earth as an analogy, it is anticipated that martian dust storms will also be electrical in nature, as long as (1) vertical winds exist to mass stratify grains and (2) the lifted grains possesses a variation in size and composition (required for efficient grain-grain charge generation [14]. Both required conditions exist with the easily lifted iron mineral/basalt grain mix on Mars. Modeling of these electrical processes in dust storms suggests that the macroscopic electrostatic fields within a martian dust cloud could reach breakdown levels of ~20 kV/m [7]. Comparison of the development of a terrestrial and martian dust storm of similar size by [5] showed that both would ultimately develop comparable electric field strengths (> 20 kV/m), with the martian storm’s temporal development about 15 % slower due to current leakage into the more conductive martian atmosphere.

It has already been suggested that dust devil electricity could alter the local atmospheric chemistry on Mars to produce reactive species [15], such as hydrogen peroxide, and breakdown species, including methane [16].

Dust circulation chamber: Preliminary experiments with a static discharge chamber have shown that electric discharge in a static dust-free CO_2 atmosphere is effective in ionizing CO_2 (Fig. 1).

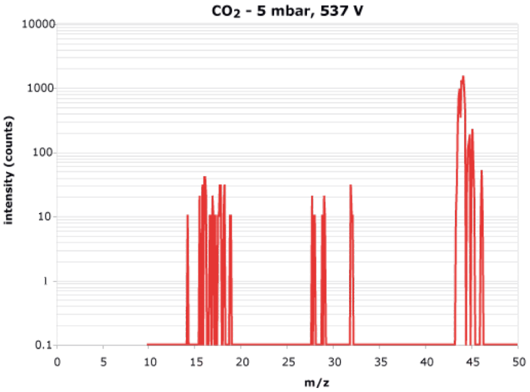

Figure 1. A mass spectrum of CO_2 ionized by the electric field, during a continuous discharge event at a voltage difference of 537 V. The 44, 28 and 16 peaks are CO_2, other peaks include water (16, 17, 18, 19), oxygen (32, 16), and nitrogen (28, 14), from some residual air present in the chamber.

Based on these results a dust circulation facility is developed in which electric currents are generated from direct dust interaction. This chamber (Fig. 2) The chamber consists of a 3 liter, 6” stainless steel cross, with 3 gooseneck-shaped tubes and a fan integrated in the bottom. An electrometer, as used in field measurements in terrestrial dust devils [12], is inserted inside the dust chamber to directly measure the electric field in the dust storm. Furthermore, a high pressure mass spectrometer (QMS100 high pressure gas analyzer, Stanford Research Systems) is attached to the system, to analyze the composition of the atmosphere in the chamber during the dust interaction. For the experiments the most commonly used martian soil analogue JSC-1 ([17]) is used.

Figure 2. The experimental dust circulation chamber, with the dust inlet on the top. The electrometer is attached to the back. Gas is pulsed in through the bottom.

Experimental approach: Cleaned and baked dust is inserted into the chamber, which is at 10 Torr, from the top, while the fan is turning. This way the dust is kept in circulation. In order to lift dust that accumulates at the bottom of the chamber, CO_2 is pulsed onto the soil through the goosenecks and resuspended in the atmosphere. Preliminary results show that an electric field is built up in this process. Experiments are underway that focus on the relation between the measured electric field and the composition of the atmosphere.

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