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Characterization of organics, microorganisms, desert soils and Mars-like soils by thermal volatilization coupled to mass spectrometry and their implications for the search of organics on Mars by Phoenix and future space missions

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A key goal for Astrobiology is the search for evidence of life on Mars. Because liquid water is a fundamental environmental requirement for life, the recent set of missions to Mars has focused on a strategy known as “follow the water”. Since life is made of organic molecules, a logical next step is “followed the organics”. However, organics are expected to be present at very low levels on Mars making their detection challenging. Viking was unable to detect organics at ppb but the effective upper limit could be higher due to the low efficiency of the thermal volatilization (TV) step in releasing organics. Because of simplicity, TV is still the method selected for current and future NASA and ESA missions. Here we show that when organics are present in the soil at levels above 1500 ppm, there are several characteristic organic fragments detected by TV-MS; however when the levels are below < 150 ppm, TV oxidizes them and no organic fragments are released. Instead nitric oxide (NO) is produced and can be used to quantitatively determine the organic content if the C/N ratio is determined. Any atmospheric NO sorbed or mineral nitrogen (e.g., nitrates) present in the soil would release NO by TV at distinctive temperatures regimes that would not overlap with organic nitrogen source. Therefore we suggest that monitoring NO provides the best chance for Phoenix and/or other future Mars missions to detect organics in the soil and/or ice.