NANOPHASE CARBONATES ON MARS: IMPLICATIONS FOR CARBONATE FORMATION AND HABITABILITY

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Despite having an atmosphere composed primarily of CO_2 and evidence for abundant water in the past, carbonate minerals have only been discovered in small amounts in martian dust [1], in outcrops of very limited extent [2, 3], in soils in the Northern Plains (the landing site of the 2007 Phoenix Mars Scout Mission) [4] and may have recently been detected in aeolian material and drilled and powdered sedimentary rock in Gale Crater (the Mars Science Laboratory [MSL] landing site) [5]. Thermal analysis of martian soils by instruments on Phoenix and MSL has demonstrated a release of CO_2 at temperatures as low as 250-300 °C, much lower than the traditional decomposition temperatures of calcium or magnesium carbonates. Thermal decomposition temperature can depend on a number of factors such as instrument pressure and ramp rate, and sample particle size [6]. However, if the CO_2 released at low temperatures is from carbonates, small particle size is the only effect that could have such a large impact on decomposition temperature, implying the presence of extremely fine-grained (i.e., “nanophase” or clay-sized) carbonates.

We hypothesize that this lower temperature release is the signature of small particle-sized (clay-sized) carbonates formed by the weathering of primary minerals in dust or soils through interactions with atmospheric water and carbon dioxide and that this process may persist under current martian conditions. Preliminary work has shown that clay-sized carbonate grains can decompose at much lower temperatures than previously thought. The first work took carbonate, decomposed it to CaO, then flowed CO_2 over these samples held at temperatures >100 °C to reform carbonates. Thermal analysis confirmed that carbonates were indeed formed and transmission electron microsopy was used to determine crystal sized were on the order of 10 nm. The next step used minerals such as diopside and wollastonite that were sealed in a glass tube with a CO_2 and H_2O source. After reacting these materials for a number of hours, thermal analysis demonstrated the formations of carbonates that decomposed at temperatures as low as 500 °C [7].

Further work is underway to carry out the weathering process under more Mars-like conditions (low pressure and low temperature) to determine if the carbonate decomposition temperature can be shifted to even lower temperatures, consistent with what has been detected by thermal analysis instruments on Mars.

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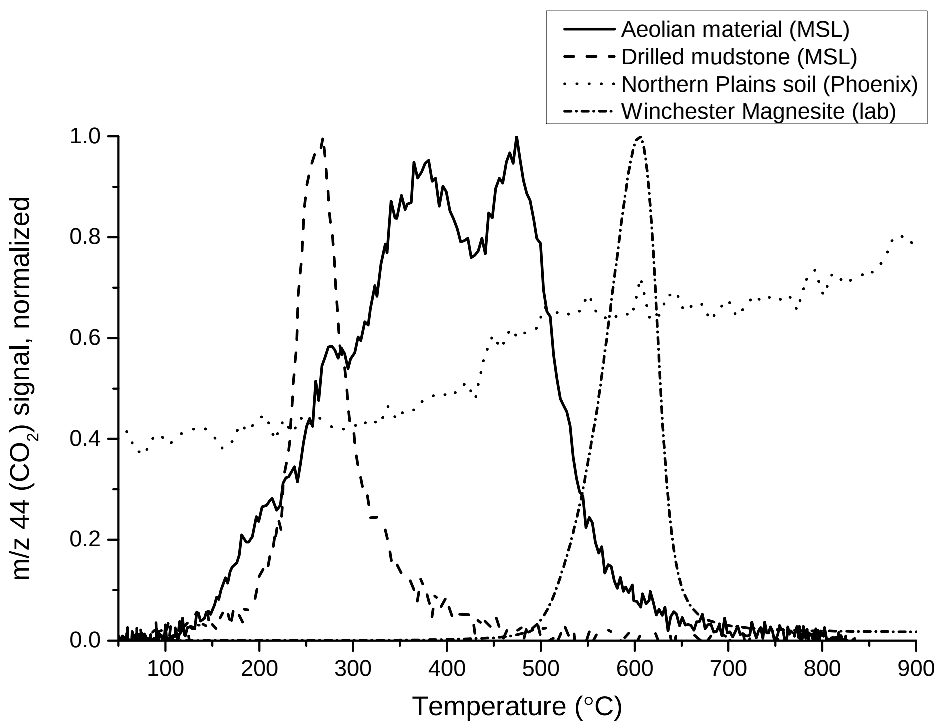

Figure 1. Evolved Gas Analysis (EGA) data, m/z 44 (CO_2) in particular, for samples analyzed on Mars and in terrestrial labs. The laboratory sample of a Winchester magnesite with particle size <150 µm, analyzed under conditions similar to the martian samples, has a peak decomposition temperature of ~600 °C. Martian samples of an aeolian material, a drilled mudstone, and soil from the martian Northern Plains have peak decomposition temperatures of 250 to 550 °C (the northern plains sample has a second peak >1000 °C not shown in this plot). The lower decomposition temperatures of martian samples could be due to the presence of nanophase carbonates, formed at low temperatures from the interaction of CO_2 and water vapor in the martian atmosphere with surface materials.