Martian Atmosphere-Regolith Interaction: ^{13}C Exchange

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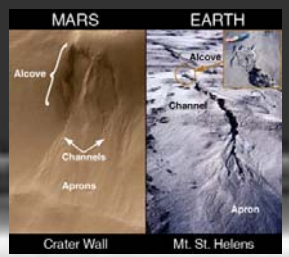
Background

The study of interactions between the Martian regolith and atmosphere is very important in revealing the conditions which prevailed on Mars in the possible presence of liquid water on or near the surface in the era when Mars is believed to have been much warmer and wetter. In the late Noachian period, a strong solar wind combined with the loss of Mars' protective magnetic field resulted in the stripping of much of the Martian atmosphere. During this process, lighter isotopes of most elements, including carbon, were stripped most readily, leaving the remaining tenuous Martian atmosphere with high heavy:light isotope ratios compared to the rest of the solar system. The ^{13}C enrichment of carbonates (thought to have been formed on Mars in the presence of liquid groundwater) found in SNC meteorites is believed to be a result of the relative abundance of ^{13}C in the Martian atmosphere, but a better understanding of the formation rates and conditions of these ^{13}C rich carbonates is needed.

FIG. 1 Calcium Carbonates in Martian meteorite ALH 84001

FIG. 2 Geological features caused by liquid water on Earth vs. Mars



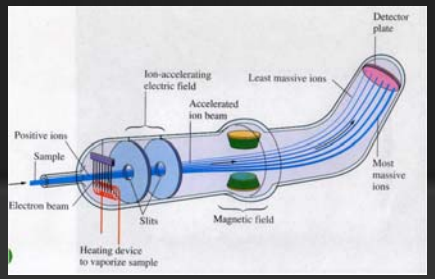
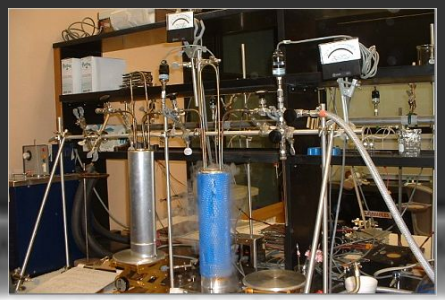


FIG. 4 Diagram of a Mass Spectrometer
FIG. 5 (left) Sample funnel.
FIG. 6 (above) Gas treatment line (purifies CO_2 for testing)
FIG. 7 (right) Flame sealing CO_2 sample for analysis



Proposed Study

This experiment will study the transfer of ^{13}C from a Martian analog CO_2 atmosphere to a Martian soil simulant wetted with carbonated water and comparably from a CO_2 atmosphere to a soil/ordinary distilled water mixture. If the soil/water combinations and atmosphere react as theory suggests, then we should see an enriched $^{13}C/^{12}C$ ratio in the soil as carbonates are formed, which will also manifest itself in a decreased $^{13}C/^{12}C$ in the CO_2 in the headspace as ^{13}C is preferentially absorbed by the soil as a result of Carbon isotope fractionation factors (see Fig. 4). The CO_2 will be injected into the University of Arkansas Biology Department's Mass Spectrometer to obtain a value for the $^{13}C/^{12}C$ isotope ratio.

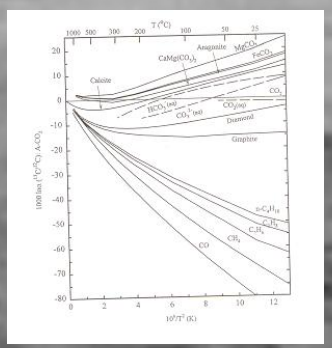


FIG. 4 Plot of Carbon isotope fractionation between various geologic materials and gaseous CO_2. At low temperatures, such as those under which the carbonates in SNC meteorites are believed to have been formed, ^{13}C is absorbed more readily than ^{12}C during carbonate formation (see Calcite and Magnesite curves in Fig. 4). This holds true for all three of the temperatures at which the experiment will be conducted. Very little experimentation has been done to test this, so the curves in the figure are based primarily on theory.

Experimental Setup

The experiment will utilize 30 seperatory funnels (24 experimental, 6 control). The 24 experimental funnels will be separated into two groups containing the same soil/water/CO_2 ratios, but with ordinary distilled water in one group and carbonated water in the other (which should expedite the carbonate formation process). For each of these groups of twelve, four of the funnels will be kept at room temperature (approximately 23C), four will be placed in a freezer and maintained at a temperature of -20C And four will be placed in an oven and maintained at a temperature of 60C. One of the funnels from each of these three locations will be removed on one week intervals and evaluated for changes in the 12C/13C isotope ratios, giving four data points at 1, 2, 3 weeks and 1 month.

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