

Martian Atmosphere-Regolith Interaction: ^{13}C Exchange. Katherine Brutlag, D. W. G. Sears, and Mikhail Kareev. Arkansas-Oklahoma Center for Space and Planetary Sciences and Dept. Chemistry, Univ. Arkansas, Fayetteville, Arkansas 72701.

Introduction: The study of interactions between the Martian regolith and atmosphere is very important in revealing the conditions which prevailed on Mars in an era when it was much warmer and wetter. If there was at one time liquid water on the surface, as indeed there may still be today under certain conditions, then carbonate formation undoubtedly took place in the Martian regolith, and these carbonates will be products of the conditions under which they were formed, in particular the temperature and isotopic composition of the atmosphere.

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 the highest heavy:light isotope ratios in the solar system. The ^{13}C enrichment of carbonates (thought to have been formed on Mars in the presence of liquid groundwater) in SNC meteorites is believed to be a result of the relative abundance of ^{13}C in the Martian atmosphere. Indeed, these high isotope ratios are one of the main arguments for the Martian origin of SNC meteorites. Still, a better understanding of the formation rates and conditions of these ^{13}C rich carbonates is needed, as the nature of ^{13}C enrichment in a Martian environment is a phenomenon that is still little understood.

Preliminary Experimentation: This summer a preliminary one-month experiment was conducted using facilities of the Chemistry and Biology departments at the University of Arkansas through the Research Experience for Undergraduates summer internship program at the Arkansas-Oklahoma Center for Space and Planetary Science. The experiment was designed to investigate the detectability of changes in the $^{13}\text{C}/^{12}\text{C}$ ratio of CO_2 gas when it was left to interact with a soil/water combination under three separate temperature conditions. These changes

were furthermore tested under all three experimental temperature ranges using both carbon enriched and ordinary distilled water, to test whether enriching the water with carbon preliminarily would speed the process of carbonate formation. Carbonate formation was expected to manifest itself in a decrease in the $^{13}\text{C}/^{12}\text{C}$ ratio in the CO_2 in the headspace as ^{13}C was preferentially absorbed by the soil as a result of Carbon isotope fractionation factors. The CO_2 samples were injected into the University of Arkansas Biology Department's Mass Spectrometer to obtain a value for the $^{13}\text{C}/^{12}\text{C}$ isotope ratios.

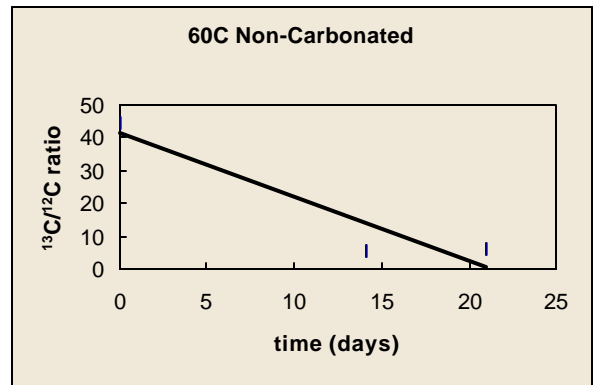
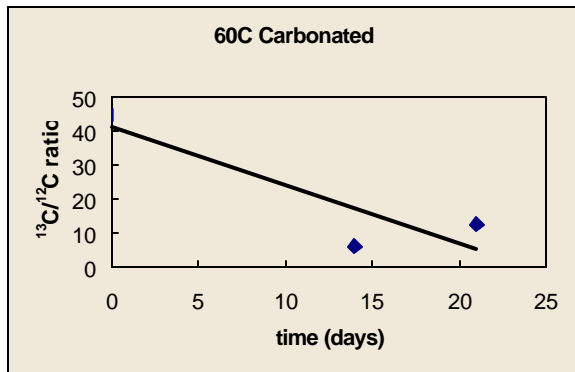
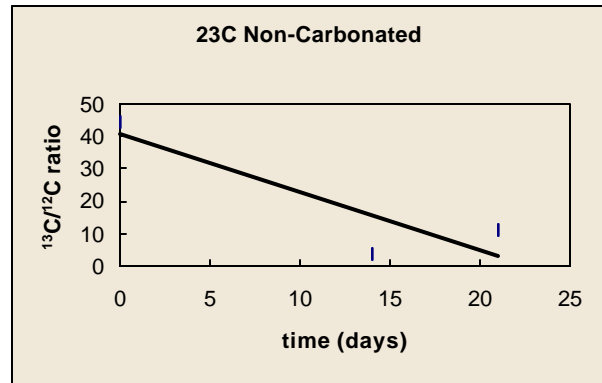
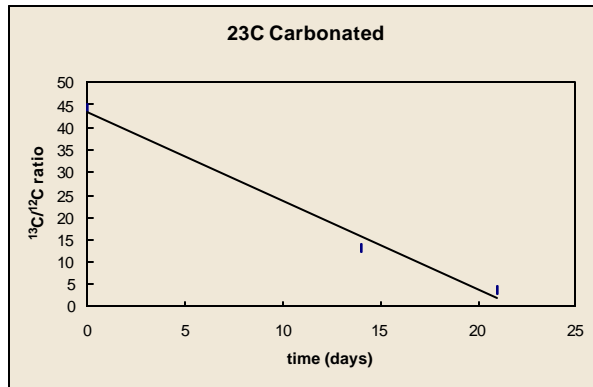
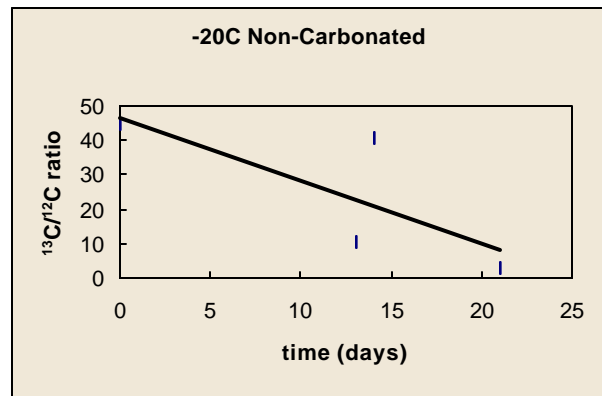
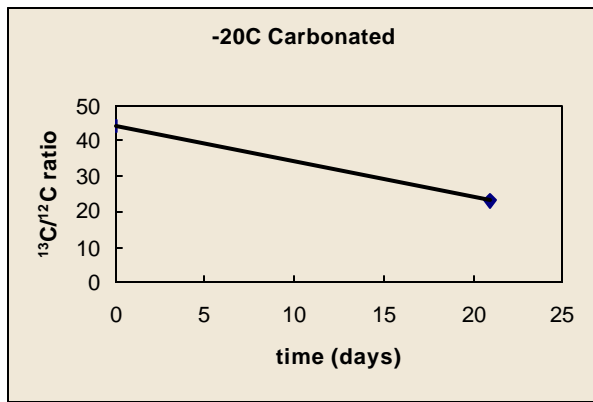
In all, 18 test samples and 6 control were analyzed. The samples were kept in 250 mL separatory funnels containing 80mL of Martian soil synthesis and 20mL of water each, and the headspace of each funnel was filled with CO_2 at atmospheric pressure. The samples were maintained at either -20C , 23C (room temperature) or 60C for the duration of the experiment and two samples from each of these three groups (one containing carbon enriched water and the other distilled) were removed after 2, 3 and 4 weeks and analyzed. The samples were cleansed in a gas treatment line to eliminate trace amounts of water vapor and nitrogen gas.

Results

All of the samples showed a measurable decrease in the amount of ^{13}C over the timescale of several weeks. Given the preliminary nature of the experiment, no conclusions can be made as to the rate of carbonate formation, however it seems clear that a significant amount is taking place.

Future Work

Now that this method has been shown to yield measurable results, more in-depth experimentation can be done. An x-ray diffraction analysis of changes in the composition of the soil would be a good



and it would be advisable to conduct such an experiment with a greater number of repetitive samples to eliminate error, as the process for cleansing the samples is rather involved. Furthermore, rather than measuring the decrease in the amount of CO_2 in the headspace, it would eventually be prudent to study the isotope ratios of the carbonates in the soil directly. Future experimentation would also do well to utilize the University of Arkansas' Andromeda Planetary Environmental Chamber in order to maintain the samples under more accurate Martian pressure and temperature conditions.

References

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