Characterization of Aqueous Martian Surface Deposits

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Introduction

There is substantial evidence that liquid water has existed in the past and may presently still exist on and directly below the martian surface. This evidence comes from geological features seen on the surface of the planet and in martian meteorites, as well as geochemical analyses.[1]

Surface features observed in the recent Mars Global Surveyor and Odyssey missions have given great insight into the possibility of liquid water being present on Mars' throughout the planet's history as well as the possibility that near surface liquid water may still exist today. Channels on the surface have provided compelling evidence to scientists since the days of Percival Lowell of the existence of liquid water existing on Mars. The recent discovery of gullies on Mars has reinvigorated the theory that not only has liquid water existed on Mars throughout the planet's history, but is currently present today. These gullies are identical in size, shape, and appearance to gullies on Earth carved by liquid water.[4]

Martian meteorites contain weathering products, produced when liquid water was present, filling cracks and voids in the rock. These include carbonate deposits at levels of several per cent in ALH84001 as well as trace amounts of carbonates and the mineral iddingsite in several other meteorites.[1-3] Detailed microstratigraphy shows that these deposits were present in the rocks while on the martian surface, providing direct evidence that liquid water circulated through the martian crust.[1,2]

Indirect geochemical evidence for liquid water in the crust comes from measurements of various isotope ratios within these weathering products. They contain enhanced D/H, $^{13}C/^{12}C$, $^{15}N/^{14}N$, and $^{38}Ar/^{36}Ar$ ratios.[2] Enhancement of each of these ratios is best explained as having resulted from atmospheric processes involving preferential escape of lighter isotopes into space. This requires that these gases once resided in the atmosphere, were left behind as a residue of those lost to space, and were subsequently incorporated into the martian crust. Circulation of groundwater between the surface and the crust provides the best means for exchanging of these gases, once again suggesting the presence of liquid water throughout the history of Mars.[2,6,7]

The possibility of the presence of water on Mars has given the scientific world a renewed interest in the possibility of life on the planet. Organic life as we know it cannot exist without the presence of water. Mars, once considered a cold desert, now seems to contain the liquid water that would make life existing on the planet possible. This has once again sparked a renewed interest in the research of Mars. The search for clues to the presence of water continues today, as several NASA missions designed to search for water are scheduled for the very near future.

Experimental Setup

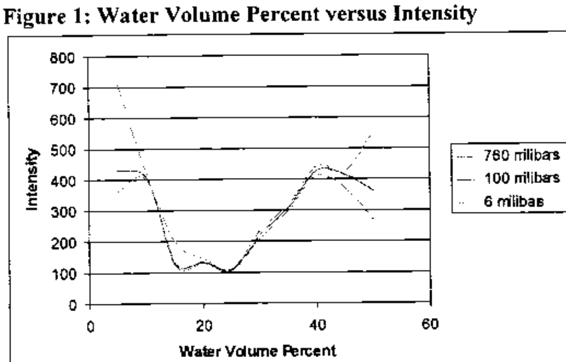
The test bed for the experiments conducted was the Andromeda Chamber, a planetary simulation chamber donated to the University of Arkansas by the Jet Propulsion Laboratory. The experiments were designed to determine the behavior of various water volume fractions in a martian soil simulant under martian conditions.

Experiments were conducted using JSC-1 Martian soil simulant, previously baked in an oven at a temperature of 110° for 24 hours to remove any excess water, mixed with distilled water in volume fractions of 5%-50% water content, in intervals of 5%. Each of these mixtures was then placed in the Andromeda Chamber, which was equipped with a solar simulator with UV filter attached, a spectrometer, and a wireless camera system.

The Andromeda Chamber was then vacuumed down to a pressure of 6millibars (martian pressure) at a nonlinear rate. As the chamber was in the vacuum process spectra at pressures of 760 milibars, 100 milibars, and 6 milibars was recorded. The mixtures inside the Andromeda Chamber were kept at a constant pressure of 6 milibars for a time of 60 minutes. The behavior of these mixtures was recorded through a wireless camera system throughout experimentation. The end state of the mixtures was then recorded by use of a digital camera.

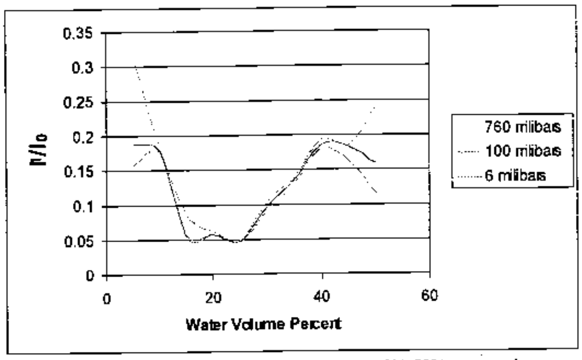
Results

Figure 1: Water Volume Percent versus Intensity



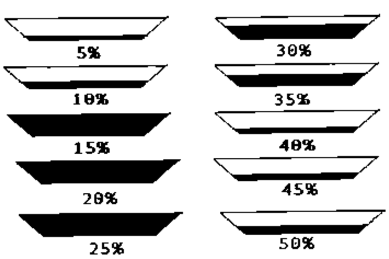
Intensity measurements at 5%-50% water volume percentages as pressure is decreased from atmospheric pressure to martian pressure. Intensity values at wavelength of 625nm.

Figure 2: Water Volume Percent versus I_1/I_0



Intensity vs. light source intensity measurements at 5%-50% water volume percentages as pressure is decreased from atmospheric pressure to martian pressure. Intensity values at wavelength of 625nm.

Figure 3: Surface Feature Formation



Surface feature formation intensity at 5%-50% water volume percentages after exposure to martian pressure. The greatest effects were seen at 15%-25%, followed by 30%-35%, and least at 5%-10% and 40%-50%.

Discussion

Analysis of the experiments conducted consisted of two parts: spectroscopy and visual analysis.

Spectroscopy of each of the mixtures yielded some expected results but was not without some interesting outcomes. As expected, intensity increased as the chamber was placed under vacuum and the pressure decreased. However there is a distinct pattern in the intensity of water volume percent mixture variations. The intensity became the lowest between 15%-35%, but seemed to rise as the percentage of water volume in the mixture under analysis rose above 35% and continued to increase until the water volume percentage reached 50%, at which level it is believed that the mixture became too chaotic to gain a proper intensity measurement.

Visual analysis yielded the observation that the most prominent and abundant surface features were formed between the water volume percentages of 15%-25%. Features were also formed in mixtures with a water volume percentage of 30% and 35%. Although, these features were not as prominent as the features seen between 15%-25%. It was observed that mixtures with either a very small amount of water, 5% and 10%, or a large amount, 40%-50%, did not produce any observable surface features.

Conclusions

The observed results are apparent in relation. The spectra of each of the mixtures that exhibited the most observable surface features also produced the lowest intensities. This is apparently due to the size separation of the sediments in each of these mixtures during the processes that formed the resulting surface features.

The spectra of each of the mixtures that exhibited the least observable surface features produced the greatest intensities, due to the lack of size separation of the sediments in these mixtures and subsequent lack of formation of observable surface features.

Each of the mixtures exhibited a strong relationship between their spectra and observable surface feature formation. Mixtures that exhibited the most observable surface features exhibited the lowest intensity measurements in their spectra. Mixtures that exhibited the least observable surface features exhibited the greatest intensity measurements in their spectra.

Acknowledgements

I would like to thank the entire faculty at the Arkansas-Oklahoma Center for Space and Planetary Sciences for the opportunity to participate in the summer REU program. Also the National Science Foundation for making this program possible. Also, I would like to extend further gratitude to Derek Sears, Paul Benoit, and Mikhail Kareev for their personal help in this project.

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