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Can hypervelocity impacts onto olivine generate serpentine and thus methane?

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Abstract

A possible source for martian methane is the serpentinisation of olivine. It could be possible for this conversion to occur as a result of impacts. A series of experiments are being carried using the light gas gun at the University of Kent to determine the likelihood of this occurring, and to quantify the percentage of serpentine produced relative to the projectile's volume.

To date the results show no detectable evidence of serpentinisation at impact velocities of 5 km s^{-1} are lower indicating: i) higher speeds may be required to produce serpentine, ii) the degree of serpentinisation is very small or, iii) this process does not occur as a result of impacts.

1. Introduction

There have been a number of publications [1-3] that have reported the detection of methane in the Martian atmosphere, using either data from spacecraft orbiting Mars or terrestrial based ground telescopes. The existence of methane in the atmosphere of Mars indicates a the presence of an active process releasing the gas, as methane only has a lifetime of 300 - 340 years in the planet's atmosphere [1,4].

One possible abiogenic source for Martian methane is via the process of serpentinisation [5] via the following reactions:

$$(Mg_{80\text{-}95}, Fe)_2\, SiO_4 + H_2O + CO_2 \longrightarrow (Mg, Fe)_3Si_2\, O_5\, (OH)_4 + Fe_3O_4 + Mg(OH)_2 + CH_4$$

$$(Mg_{75}, Fe)_2\, SiO_4 + H_2O + CO_2 \longrightarrow (Mg, Fe)_3Si_2\, O_5\, (OH)_4 + Fe_3O_4 + CH_4$$

$$(Mg_{70}, Fe)_2\, SiO_4 + H_2O + CO_2 \longrightarrow (Mg, Fe)_3Si_2\, O_5\, (OH)_4 + Fe_3O_4 + (Mg, Fe)_2Si_2O_6 + CH_4$$

On Earth serpentinisation dominantly occurs at fore-arc wedges and spreading centers. However, a recent study [6] has found serpentines on the surface of Mars in three distinctive geological units, one of which were in association with craters in the southern highlands.

This investigation examines whether or not impacts can create the conditions for an almost instantaneous conversion of olivine to serpentine, and thus be a possible source of atmospheric methane.

2. Method

The light gas gun at the University of Kent [7] is being used to simulate impacts. Targets are made from a mixture of olivine grains, CO_2 and H_2O ice with a weight ratio of 1:2:2; at speeds of 3.90 and 4.97 km s^{-1} by a 2 mm diameter stainless steel sphere. An ejecta capture system (ECS) is used to collect impacted material with different energies, depending on its distance from the target container (Figure 1).

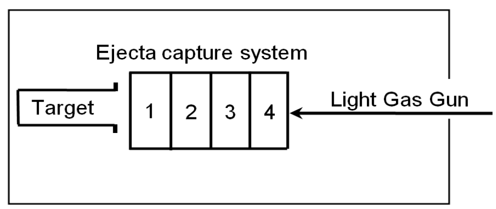

Figure 1: Schematic of the experimental setup for impacts and capture of impacted grains.

3. Analysis and Results

Impacted grains were separated from the ice mixture, by immediately placing the recovered material on a filter paper in a funnel to ensure grains are not in solution for a long period of time. The grains were then dried overnight in a fume cupboard to make certain the grains are completely dry before analysis.

Analysis of shocked grains was carried out using a LabRam-HR Raman spectrometer to determine if any hydration had occurred as a result of impacts. The hydration of grains, were determined by the presence of the hydroxyl (OH) vibration feature between 3629-3710 cm^{-1} Raman shift, (Figure 2).

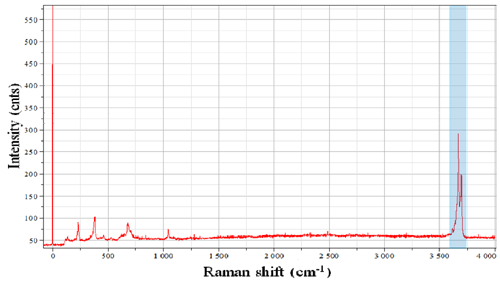

Figure 2 Raman spectra of serpentine. The blue shaded area highlights the region of the Raman shift for the samples hydration.

50 Raman spectra of impacted grains from each section of the ECS was obtained to determine if there was a statistical difference in the amount of hydration (if any) of the olivine grains in each of the ECS sections.

Raman spectra of olivine grains taken before impact show a spectrum indicative of high Mg forsterite, with doublet peaks at 823 and 856 cm^{-1}. Preshocked grains also show no sign of the hydration feature in the 3629 - 3710 cm^{-1} region.

A number of grains did show a strong and sharp peak at 3673 cm^{-1}, which is within the range for serpentine. However, closer examination showed these occurrences to be a combination of olivine and actinolite or talc, which were present in the olivine grains as small inclusions before impact.

Overall the impacted olivine grains at both speeds showed no conclusive evidence of impact induced hydration.

4. Conclusions

Impact speeds of 3.90 km s^{-1} and 4.97 km s^{-1} have not (detectably) been able to generate the conditions required for sepentinisation. This indicates that either the amount of serpentine generated by impacts is very small, higher speeds are required for impact induced serpentinisation, or serpentinisation does not occur instantaneously.

Further experiments are planned with impact speed of 6 and 7 km s-1 to produce higher shock pressures and temperatures and the final results being presented later in the year.

Acknowledgements

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References

[1] Mumma, J. M., Villanueva, G. L., Novak, R. E., Hewagama, T., Bonev, B. P., DiSanti, M. A., Mandell, A. V., Smith, M. D., 2009, Strong Release of Methane on Mars in Northern Summer 2003. *Science*, 323, 1041 – 1045.

[2] Formisano, V., Atreya, S., Encrenaz, T., Ignatiev, N., Giuranna, M., 2004, Detection of Methane in the Atmosphere of Mars. *Science*, 306, 1758-1761.

[3] Geminale, A., Formisano, V., Giuranna, M., 2008, Methane in Martian atmosphere: Average spatial, diurnal, and seasonal behavior. *Planetary and Space Science*, 56, 1194-1203.

[4] Kransopolsky, V.A., Maillard., J. P., Owen., T. C., 2004, Detection of methane in the martian atmosphere: evidence for life? I*carus*, 172, 537-547

[5] Oze, C., and Sharma, M., 2005, Have olivine, will gas: Serpentinization and the abiogenic production of methane on Mars. *Geophysical Research Letters*, 32, L10203.

[6] Ehlmann, B., L., Mustard,J., F., Swayze, G., A., Clark, R., N., Bishop, J., L., Poulet, F., Des Marais, D., J., Roach, L., H., 2009, Identification of hydrated silicate minerals on Mars using MRO-CRISM: Geologic context near Nili Fossae and implications for aqueous alteration. *Journal Of Geophysical Research,* 114.

[7] Burchell, M. J., Cole, M. J., McDonnell. J. A. M., and Zarnecki, J. C., 1999, Hypervelocity impact studies using the 2MV van de Graaff accelerator and two-stage light gas gun of the University of Kent at Canterbury. *Measurement. Science and Technology*, vol 10, pg 41 -50.