Hypervelocity Impacts on Morphologically Distinct Ancient Martian Clays

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Background

Impact craters are a ubiquitous process across the Solar System. Thanks to this constancy, crater counting has provided a means to investigate surface ages of solid planets and moons. Crater counting is limited by the underlying assumption that impact processes are comparable across different rocky bodies and remain consistent across different regions of an individual body. Studying the responses of different planetary analogues to similar impacts in the laboratory provides useful information to validate and improve crater counting methods. [1]

Mars has a higher density of craters detected on the southern hemisphere than on the northern hemisphere. During the Noachian Period of Mars liquid water is theorised to have been present at least in the Northern Plains of Mars. [2] Liquid water may alter the physical and chemical properties of the surface of Mars including the formation of clay. The loss of Mars' oceans revealed the northern plains which were then subjected to impacts. The influence of sediment layering and hydration would affect the impact crater size and, hence, ageing of surfaces on Mars. Any ocean deposited clays would slowly dry out and if the response to impact varies with degree of hydration, then the craters produced by a given sized impactor will vary over time and hence add uncertainty to dating of the surface.

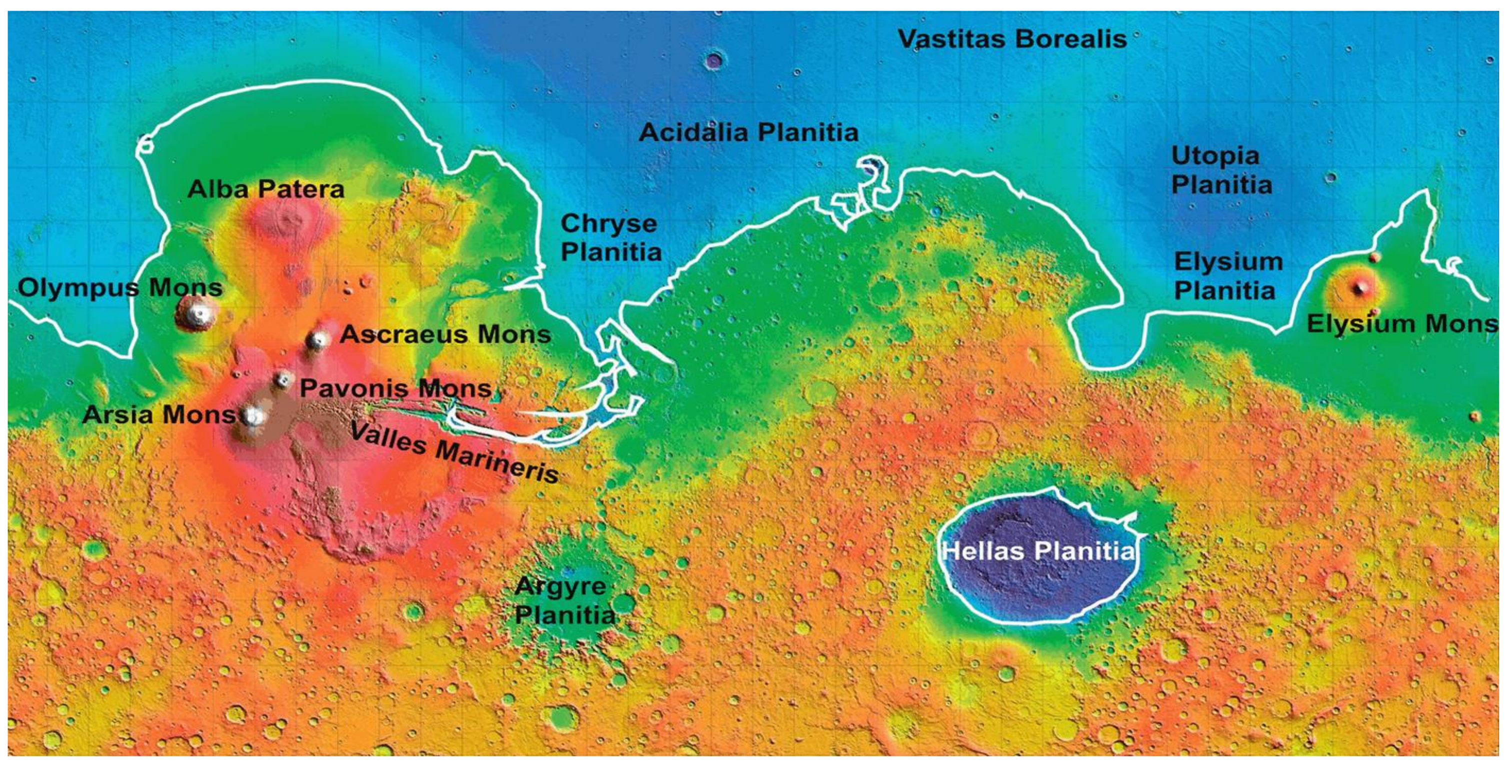


Figure 1: Topographic map of Mars. [3]

This work experimentally investigated the influence of the relative hydration of clay materials on crater diameter and depth during hypervelocity impact events on Mars using the University Kent's Two-Stage Light Gas Gun.

Experimental

Standard potter's clay was chosen to replicate the conditions of a possible transitive Noachian-Hesperian Mars surface. Powdered clay and deionised water were mixed in a 2:1 ratio to form the target material. Iron (III) oxide was also added up to 18 wt%. The water and iron were added stepwise whilst mixing by hand until the correct composition was achieved. Pressure was then applied to the targets to shape them to the desired size. A 1 cm clay layer of different hydration levels were also added (i.e. 10:1 layer is 10 parts clay to 1 part water). , as shown in Figure 2.

(a) (b) (c) (d) (e) (f)

Figure 2: Prepared targets with ratio of 2 parts clay to 1 part water for impact experiments:
(a) No Fe_2O_3, **(b)** 10:1 Layer, **(c)** 10:3 layer, **(d)** 2:1 layer, **(e)** 4:3 layer, and **(f)** 1:1 layer.

Light Gas Gun Experiments

The University of Kent's Two-Stage Light Gas Gun [4] (Figure 3) was used to accelerate 6, 2 mm aluminium spheres onto clay targets at ~ 5 km s^{-1}. Photographs of the resulting craters are shown in Figure 4.

Figure 3: The University of Kent's Two-Stage Light Gas Gun.

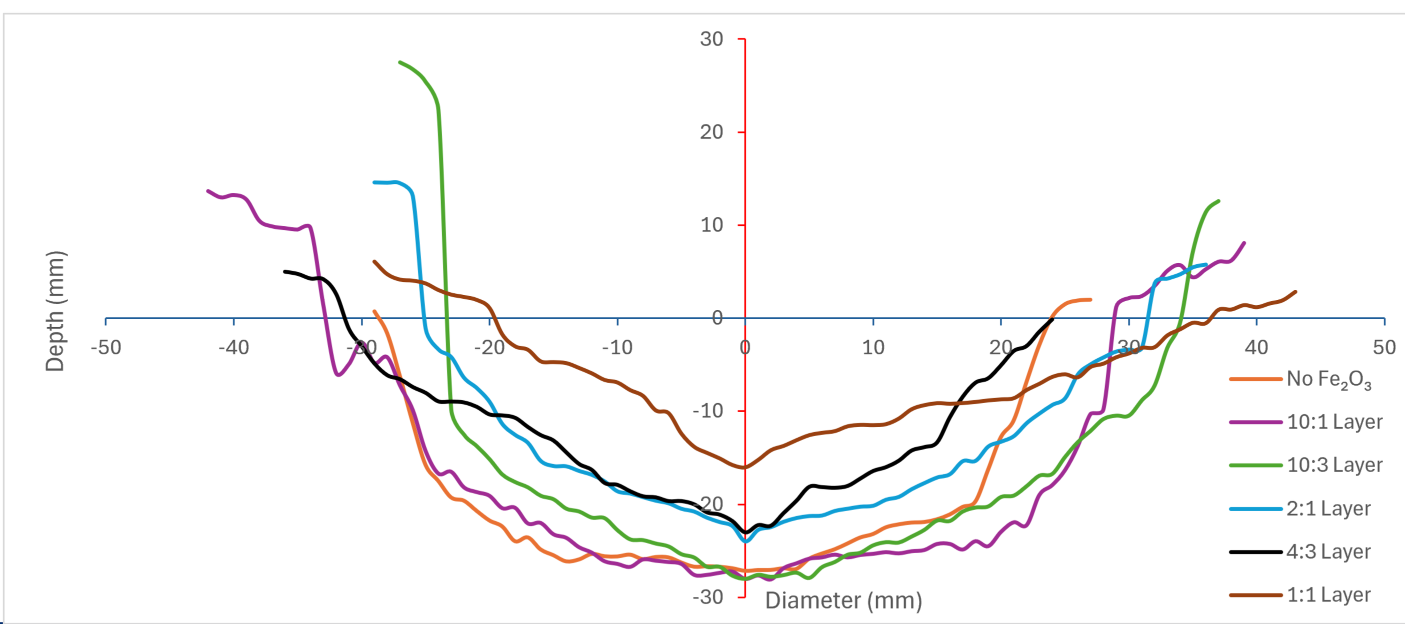
(a) (b) (c) (d) (e) (f)

Figure 4: Shot targets at ~ 5 km s^{-1} with:
(a) No Fe_2O_3, **(b)** 10:1 Layer, **(c)** 10:3 layer, **(d)** 2:1 layer, **(e)** 4:3 layer, and **(f)** 1:1 layer.

Results and Discussion

Measurements of the impact craters (Figure 5) showed that as the top layer becomes more hydrated, the depth reduces and width increases for those targets that are more hydrated. Martian surface ages are calculated by plotting crater size vs frequency, with isochrons derived from lunar samples. [5] Since the isochrons assume a constant crater-impact size relationship, these findings suggest that if clay deposits on the surface of Mars remained partially hydrated over longer periods of time, the size-frequency plots will be skewed towards smaller craters for these regions, resulting in younger ages being derived.

Figure 5: Comparison of crater profiles for 6 clay targets impacted at ~ 5 km s^{-1}.



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