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Formation of the grooves of Phobos, in the light of new evidence from Mars Express images

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Abstract

Each of the proposed hypotheses on the origin of Phobos' grooves is re-examined in the light of the evidence from HRSC Mars Express images. This new data allows us to decide on the origin of these grooves beyond any reasonable doubt.

Introduction

Many hypotheses have been put forward to explain these curious features, but there is as yet no general consensus on their origin. These hypotheses fall into two groups: that they are caused by secondary impact, or that they are fractures. The secondary impact ideas include proposals that they are secondary crater chains either from Stickney, at 10 km the largest impact crater on Phobos, or from impacts on Mars, or that they are the tracks of rolling boulders ejected from Stickney. The fracture hypotheses suggest that they are fractures caused by the Stickney impact, or by tidal forces, or by drag forces during capture, or by re-opening of drag force fractures caused by the Stickney event.

New map of Phobos' grooves

A new map of the grooves on Phobos (fig. 1), mainly based on recent images from Mars Express, has clearly shown that the lineaments observed on the surface of Phobos are different in several respects from all other lineaments on planets, satellites and other solid solar system bodies [1]. There are several different families of grooves, each family consisting of parallel lineaments that fall on planes intersecting Phobos' surface, but covering one hemisphere only (fig. 2). Each family is centred at a different location on the leading hemisphere of Phobos, with the result that an area about 12 km wide around the trailing apex of Phobos is completely devoid of grooves.

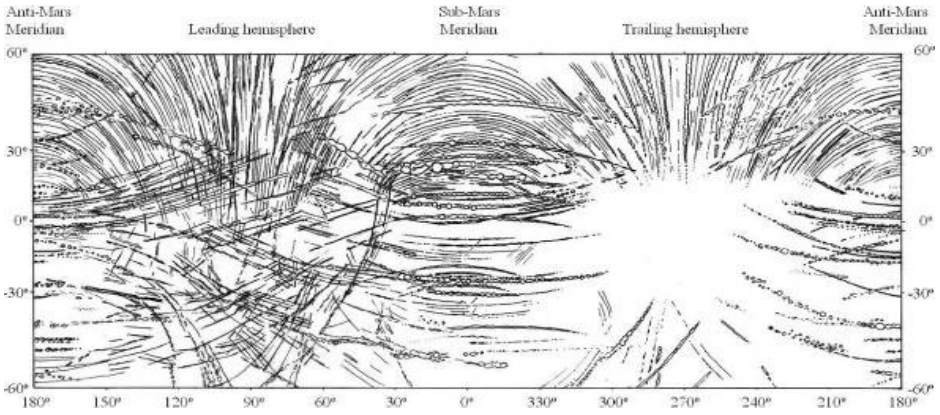

Fig. 1: Map of Phobos' grooves.

Discussion & Conclusions

Each of the theories of groove origin is examined in the light of the new evidence. The geographical distribution and orientation of the grooves, and their ages and cross-cutting relationships allow us to discount the fracture hypotheses altogether. The tiny gravitational field, the difference in age between the grooves and Stickney, the geographical distribution and the topography of Phobos are similarly at odds with the Stickney secondary cratering and rolling boulder theories. Only the idea that they are secondary impact crater chains from primary impacts on Mars fits all the observations.

The implications of this idea, in the form of information on Phobos' regolith, interior, and its formation and past orbital history are presented, as well as details of the impact process in relation to the ejection of material from large impact events early in crater excavation.

References

[1] Murray, J.B. & Iliffe, J.C. 2011. Morphological and geographical evidence for the origin of Phobos' grooves from HRSC Mars Express images. *In* Balme, M.R., Bargery, A.S., Gallagher, C.J., & Gupta, S. (eds.) *Martian Geomorphology,* Geological Society, London, Special Publications, Vol. 356, pages 21-41.

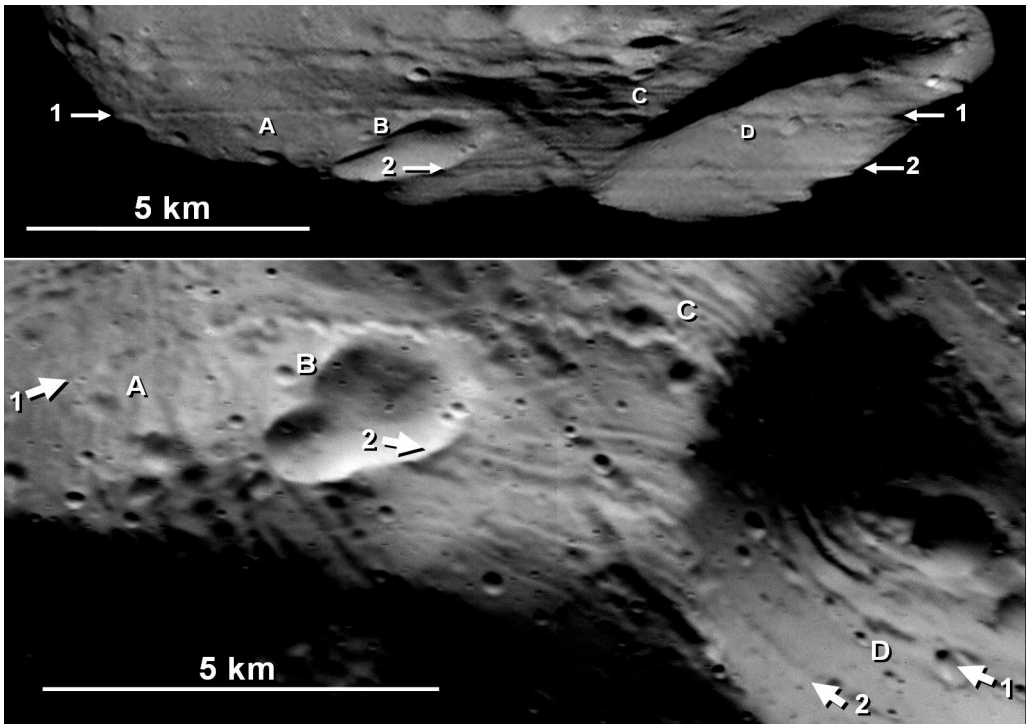

Fig.2: The same grooves viewed from different viewing points. The grooves 1 and 2 (arrowed) appear as straight and regular troughs exactly parallel to each other in the top image, where the viewing angle to the local surface is about 30° from the horizontal. In the lower image, the surface is seen from a viewing direction closer to the vertical. Despite the surface illumination being similar, the grooves appear as wavy, disjointed segments of roughly-aligned groups of craters of different diameters, as at C and D, and above A and B. The craters A,B,C & D are the same in each image, labelled to aid identification of the groove traces in the lower image. Note the clear raised rim to the crater chain between C and B in the lower image. (ESA *Mars Express* HRSC images, orbits 7478 & 4307.)