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New Evidence for Local Dark Aeolian Sediment Sources

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Abstract

We present new evidence for dark mafic sediment layers, exposed at impact crater or pit walls as well as on impact crater floors, to embody local sources for the dark aeolian dunes material on Mars. CTX, HiRISE, HRSC and CRISM data prove that those layers have a wider geographical distribution as previously thought. Age determinations of selected source regions led suggest that the exposure time of the dark layers and the concomitant reactivation of the dark ash material clusters around Early to Late Hesperian times.

1. Introduction

The search for the sources for the dark dune material is currently of high interest among Mars aeolian research. It is likely that the mafic sediments have a volcanic origin due to their distinct mineralogical composition dominated by pyroxenes and olivines [e.g., 1, 2]. Recent analyses show that in some places the dark dune composition does not only vary between mafic minerals (i.e., LCP, HPC and olivines) but also comprises sulphates and weathered glass [3]. A variety of source units has been proposed by different authors, including layers of volcanic ash exposed at impact crater walls and floors [2], general wall strata at the Valles Marineris [4], the Medusae Fossae Formation [5] or the Planum Boreum cavi unit at Ulympia Undae in particular for the north polar erg [6].

Here, we search for more evidence for the ash layer hypothesis suggesting the dark sediments to be volcaniclastic sediments [1, 2, 7] and determine the age of selected surfaces, which provides the maximum time of re-exposure of the dark dune material.

2. Methods and Background

Dark layers of volcanic ash are exposed at the walls of numerous impact craters. The material trickles out of these layers, runs down-wall to the crater's interior, and is deposited as aeolian dunes on the crater floor (Fig. 1, case A). Other places of material exposures are large crater floors that are blotched by numerous smaller craters. The material emerges from these smaller craters that seem to cut the ash layer underneath the larger crater's floor (Fig. 1, case B and C). We analysed various image data from Mars in order to find places of dark material exposure as described above. Spectral analyses of layer and dune material have confirmed their similarity [2, 7, 8].

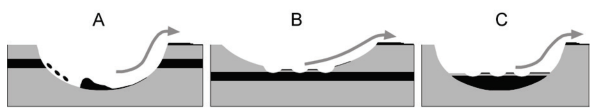

Fig. 1: Types of dark aeolian sediment exposure in impact craters. A: Dark layer is exposed at crater wall; B: Dark layer is located beneath large crater floor and was cut by smaller craters; C: Dark sediments were deposited on a large crater floor, covered by regolith and finally cut by smaller craters [1].

Analysing the material's exposure time can be accomplished by dating the large crater floors that exhibit material exposure (exposure case B and C) or the ejecta of those impact craters showing dark layers at their walls (exposure case A). Absolute age dating was done by means of crater size-frequency distributions [9] whereby all primary craters located on a defined surface were counted using the software *crater tools* by [10] and further analyzed by utilizing a software tool named *craterstats* [11]. Details are described in [12].

3. Results and Discussion

It turns out that the exposure of dark sediment layers can be observed much more globally on Mars as previously stated. One of the primary regions of dark layer exposure is Oxia Palus at western Arabia Terra. Here, predominant are exposure cases B or C on large crater floors. Thus far identified other locations of local dune sand sources are sparsely spread all over Mars, including Noachis Terra, Terra Sirenum and Ophir Planum. Our latest research shows that such exposures can be observed at many other places (Fig. 2), even in very high southern latitudes, where the layers are predominantly exposed at the walls of pits (Fig. 3), such as exposure case A in Figure 1.

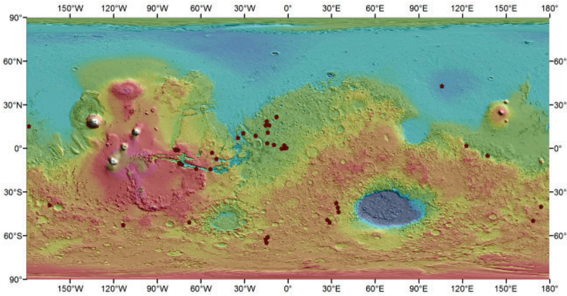

Fig. 2: Current set of 44 confirmed and proposed exposures of dark ash layers on Mars (MOLA topography map).

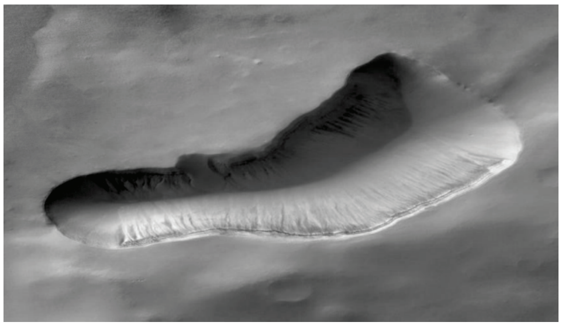

Fig. 3: Gullies at the wall of a pit in Mare Australe. The distinct dark linear structure along the alcoves might be a layer of volcanic ash that represents the local source for nearby dark dunes (CTX P03_002048_1173_XN_62S015W).

More examples were disclosed in Valles Marineris. Previously, [3] has proposed that the local dark dunes might partially be composed of disintegration products of interior layered deposits (ILD) and canyon wall rocks. Additionally, we propose that there might be distinct layers of mafic material incorporated into the ILD layering (see Fig. 4). However, it must be further analyzed if it is plausible that a layer of unaltered mafics can survive into a set of aqueously weathered minerals that built the ILDs.

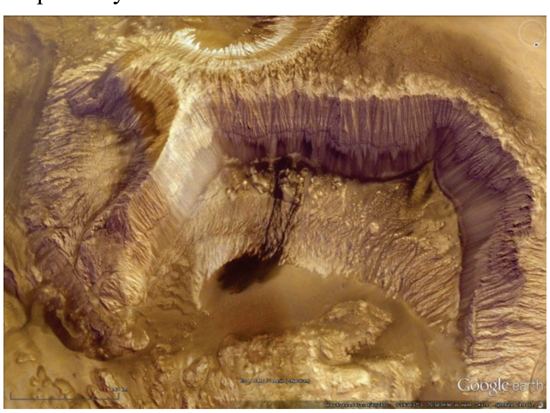

Fig. 4: Distinct dark sediment emergence from Hebes Mensa, an ILD at Hebes Chasma, Valles Marineris (HRSC image mosaic in Google Mars).

Moreover, we found further evidence that the dark layers exposed at depression walls are partially covered by a layer of ice-cemented regolith (see Fig. 5). This strengths the hypothesis of [2] suggesting that insolation effects and local melting of such an ice-cemented layer might be the cause for the predominant sun-facing exposition of dark layers at crater walls and the lack of even more locations of exposure.

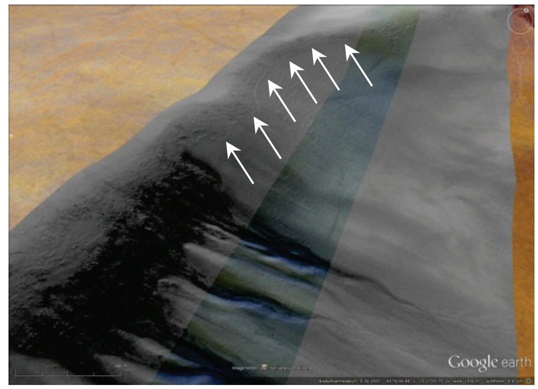

Fig. 5: Gullies at the walls of Sarth Crater are partially covered by an ice-rich mantling deposit (arrows mark the course of the upper boundary). This coverage of dark layers is likely the case for many other places on Mars and might be the reason why we cannot disclose layer exposures at all potential sites (HiRISE red and color image PSP_005595_1150 in Google Mars).

Age dating implies an Early to Late Hesperian time period (between 3.61 and 3.16 Ga at 14 dated surfaces) for the majority of material exposures. All ages signify the earliest possible time of material re-exposure from the subsurface at the given location. Some other dated crater ejecta and crater floors show Early to Middle Amazonian ages (between 754 Ma and 3.04 Ga at 8 dated surfaces) and represent examples of later material exposure.

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