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Small impact craters in crater counting: Examples from the Harmakhis Vallis channel, Mars.

S. Kukkonen and V.-P. Kostama
Astronomy and Space Physics, P. O. Box 3000, FI-90014 University of Oulu, Finland (soile.kukkonen@oulu.fi).

Abstract

Small impact craters are a useful tool for studying recent, short-time or small-scale geologic processes of the surface. Especially in age determination, the role of small impact craters is significant as they may often be the only way to measure the age of the surface. In this work, we compare our crater count results obtained from the Harmakhis Vallis channel floor of Mars based on the CTX and HiRISE images and discuss the benefits and limitations of small (< 1 km in diameter) craters in age determinations.

1. Introduction

The usability of small (diameter < 500 m) impact craters in crater counting has been under discussion since high-resolution images made it possible to extend the crater size-frequency distributions to smaller craters [1–5]. Originally the established method was, however, to leave out the small impact craters from the crater counts due to the uncertainty of their origin (primary or secondary crater). Afterwards, the new crater production studies (e.g. [1, 4–5]) have also made it possible to utilize small craters in age determination if obvious secondary craters and clusters are excluded and the areas showing signs of recent large impact craters are avoided. This has made it possible to expand the crater counts to the small and young units, too.

In this work we present some results of our crater counts performed on Harmakhis Vallis (see also our previous works [6–8]), one of the large outflow channels on the north-eastern Hellas rim region of Mars, based on MRO's CTX and HiRISE datasets. In addition to the evolution studies of the Harmakhis channel, we compare the crater count results based on the different data and thus reveal information on the benefits and limitations of very high-resolution imagery used in age determinations.

2. Data and methods

The age determinations of the Harmakhis Vallis flow units were performed by using established crater count methods (e.g. [9–12]) and the Mars Reconnaissance Orbiter's CTX and HiRISE datasets. The CTX images cover the entire channel system with a resolution of ~ 5 m/pixel whereas the availability of HiRISE imagery is more limited – on the Harmakhis Vallis channel there are only 14 HiRISE image pairs with a resolution of ~ 0.3 – 0.5 m/pixel and many of them focus on the walls of the channels only.

All the image data were imported onto a GIS environment, where the floor units of the Harmakhis channel were mapped and dated. The crater model ages were measured using the Craterstats software.

3. Results and discussion

Mapping on Harmakhis Vallis shows that the channel is almost entirely covered by the flows, the varying texture of which indicates that they are ice-facilitated (see [8]). Because the craters superposed to the flows are relatively small (i.e. the flows are relatively young) and the areas of the units are relatively small, it is necessary to use very high-resolution images for successful dating. In addition, it is acceptable to use very high-resolution images and small craters for dating on Harmakhis Vallis because if the flow units are relatively young, their formation and modification have to mainly postdate the latest secondary-forming impacts. Thus, the superposed craters on the floor units are mainly primaries.

The crater count results, based on the CTX data, show that the oldest measurable cratering model age of the Harmakhis flow units varies from ~ 0.1 Ga to ~ 1 Ga, which may be, however, the youngest limits for the oldest measurable age due to the possible ice-facilitated nature of the flows. In addition, the CTX images show that all the flow units also have 1–3 resurfacing ages. The results of the HiRISE data

instead indicate that although several channel-scale resurfacing processes may have occurred on the channel, their intensity and duration may have varied locally or at least in the HiRISE scale. Figure 1 shows an example of the crater count results from a flow unit at the beginning of the Harmakhis Vallis main channel. A CTX mosaic (Area A in Fig. 1) gives three ages for the unit; a formation age of 75.8 Ma and resurfacing ages of 17 Ma and 6 Ma. Additionally, the first of the two HiRISE images, which also cover parts of the unit, gives three ages for the unit (Area B, Fig. 1) which correlate well with the CTX results (oldest age of 86.9 Ma and resurfacing ages of 10.6 Ma and 5.82 Ma). However, the second HiRISE image (Area C, Fig. 1) shows only two ages which correlate well with the resurfacing ages: 16.3 Ma and 6.57 Ma. We found several possible reasons for this. First, the flow unit, which seems to be homogenous in the CTX scale, may actually consist of several units in the HiRISE scale. On the other hand, the flow unit may be so thin in places that the largest crater populations of older underlying units can be detected. It is also possible that there have been local differences in resurfacing intensities and durations (in this case mainly erosion by wind or sublimation, or the unit down-slope flowing), which have caused the large crater population to be erased in places (in this case the craters with a diameter > ~ 100 m on Area C, but not on Area A or B). A detailed HiRISE scale mapping, the morphology of the large craters and crater distribution studies reveal that the differences in the intensity and duration of the resurfacing events occurred on the region might be the main reason for the differences in the HiRISE results.

4. Conclusions

Small (< 500 m) impact craters are very useful and often also the only way to study the short-time, small-scale or young geologic processes on surfaces. Although the crater count data of the HiRISE images usually correlate quite well with the data of the lower-resolution CTX images, it is good to be careful when only single HiRISE images are used in age determination of larger units. All the results obtained from a specific counting area always represent primarily the results of that area – not the whole unit. Instead, together with the CTX images, the HiRISE images are a very valuable tool for providing unique information about the local surface processes.

Acknowledgements

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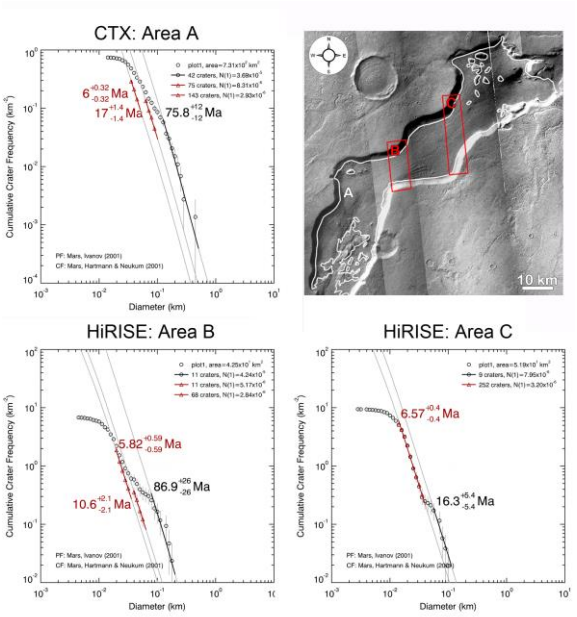

Figure 1: An example of the crater count results of a flow unit from Harmakhis Vallis based on the CTX (area A, outlined by white) and HiRISE images (areas B and C, outlined by red). The crater size-frequency distributions of Area A and B show that the unit has resurfaced twice after the oldest measurable age. The crater size-frequency distribution of Area C, however, shows only these resurfacing ages. The main reason for the lack of a large crater population on Area C might be the differences in the intensity and duration of the resurfacing events compared to the other crater count regions.