EPSC Abstracts,
Vol. 4, EPSC2009-595, 2009
European Planetary Science Congress,

Malea Planum and Utopia Planitia, Mars: Absolute model ages of latitude-dependent mantle deposits

M. Willmes, H. Hiesinger, D. Reiss, M. Zanetti

Institut für Planetologie, Westfälische Wilhelms-Universität Münster, D-48149 Münster, Germany
(malte.willmes@uni-muenster.de)

Introduction

The middle and high latitudes (±30-60°) of Mars are partially covered by an ice-rich smooth mantle [1, 2]. These latitude-dependent deposits are usually independent of local geology, topography and elevation, and are presumably related to changes in the obliquity of Mars, which have led to major shifts in the Martian climate and repeated global episodes of deposition [3]. We determined absolute model ages for the mantled surface units in Utopia Planitia (northern hemisphere) and Malea Planum (southern hemisphere) using crater statistics [4]. In both study regions, a specific type of mantle degradation called scalloped terrain is observed, and thus the crater retention ages determined by this study reveal the time since the last resurfacing. Images from the High Resolution Imaging Science Experiment (HiRISE) (25-50 cm/pixel spatial resolution) were analyzed for both study regions. For Malea Planum additional images from the Context Camera (CTX) (~5m/pixel spatial resolution) were used for the crater counts. The mantle in Utopia Planitia appears heavily modified by polygonal fractures and scalloped depressions [5]. Scalloped depressions are also found in Malea Planum, but the mantle appears much smoother and less modified by periglacial processes [5, 6].

Methods

We mapped continuous areas of smooth mantle and counted all fresh, unmodified primary impact craters within specific count areas. The study areas in HiRISE images totalled 722 km^2 in Utopia Planitia, and 296 km^2 in Malea Planum. The CTX study area for Malea Planum has a size of 11,859 km^2. In Utopia Planitia CTX images were not used for crater counts because at CTX resolution, the reliable identification of impact craters is hindered by the occurrence of polygonal terrain that results in crater-like depressions at the joints of polygonal fractures. Using HiRISE images, we performed crater counts of slightly modified craters to find an upper limit for our age estimates. This differentiation of crater types was not possible when using CTX Images due to the lower resolution.

Results

Absolute model ages for the Malea Planum and Utopia Planitia regions were determined by applying the chronology of Hartmann and Neukum [4] and the production function of Ivanov [7] to our crater statistics (Figure 1). The model ages derived from HiRISE images show that the mantle unit in Utopia Planitia is 0.65 (+0.35/-0.41) to 2.9 (+0.69/-0.75) Ma old and the mantle in Malea Planum is 3.0 (+1.5/-1.7) to 4.5 +1.3/-1.4) Ma old. On the basis of both HiRISE and CTX images of Malea Planum, we found that the mantle unit has a model age of 3.19 (+0.55/-0.57) Ma old.

Discussion

Our ages indicate that the mantle units in both study regions represent very recent Amazonian terrain. Independently derived model ages from HiRISE and CTX images of Malea Planum are basically identical despite the different spatial resolutions. It should also be noted that even the youngest craters in both regions do not show an ejecta blanket. This points towards recent resurfacing events and is in agreement with the repeated periods of global deposition of the ice-rich smooth mantle as described by Head et al. [2]. This means that the degradation features found in both regions [e.g. 5, 6, 8] formed during recent phases of ice instability after the emplacement of the mantle [2, 5].

EPSC Abstracts,
Vol. 4, EPSC2009-595, 2009
European Planetary Science Congress,

We acknowledge that the relatively small size of the study region in Utopia Planitia and also the possible contributions of small secondary impact craters can influence our crater statistics. However, Hartmann [9] argued that treating secondary craters as background does not reflect their spatially and temporally highly clustered appearance. Thus regions showing clear signs of being dominated by secondary impact craters were excluded from our counts, minimizing the effect of the secondary craters on the derived age.

Besides secondary craters, erosion of impact craters on the volatile-rich mantle could potentially influence our crater counts. After the impact, subsequent periglacial degradation of the surface could possibly erode craters to the point they are not recognizable. This would result in fewer counted craters, and consequently an underestimation of the age. This is especially problematic in Utopia Planitia, where the mantle is severely degraded by polygons and pits. For this reason, we decided not to use lower resolution CTX images for our crater counts in Utopia Planitia. Based on visual inspection, the mantle material on Malea Planum appears much smoother and fresher than that in Utopia Planitia, which might suggest that less modification has taken place, and thus less time since resurfacing. However, our model ages indicate that Utopia Planitia is younger. Nevertheless, both the results from Malea Planum and Utopia Planitia suggest that the mantle deposits in those areas are very young and probably related to recent climate changes on Mars. For example, Head et al. [2], using models from Laskar et al. [10], concluded that mantle deposition and degradation are connected to obliquity-driven glacial and interglacial stages, with the most recent depositional phase between 0.4-2 Ma ago. Levrard et al. [11] also suggested that the formation of the uppermost part of the mantle is connected to obliquity changes, probably within the last 3-5 Ma. Hence, our results are consistent with earlier work that suggested a very recent formation of the latitude-dependent mantle [2].

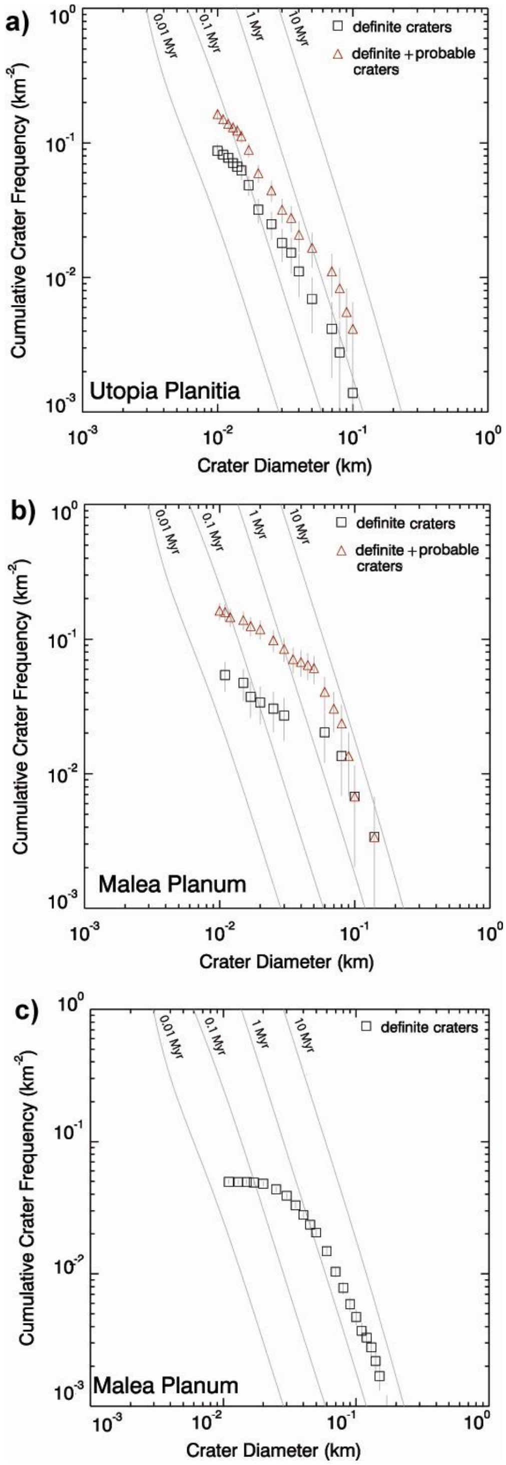

Figure 1. Crater size-frequency distributions determined using HiRISE images for Utopia Planitia (a), and HiRISE and CTX images for Malea Planum (b and c, respectively).

EPSC Abstracts,
Vol. 4, EPSC2009-595, 2009
European Planetary Science Congress,

Conclusions

On the basis of our investigation we conclude that (1) The derived ages place the mantled terrain in both hemispheres into the very late Amazonian period, which is in agreement with the observed morphologies; (2) Our crater statistics agree with the deposition of eolian mantles connected to obliquity-driven ice ages and with model predictions from [2,10,11]; (3) The model ages determined for the mantled terrain in Malea Planum are more reliable, while the model ages for Utopia Planitia might underestimate the actual age due to the loss of impact craters by polygon formation; (4) Further analysis is needed to quantify the effect that the formation of the polygonal terrain has on the crater population in Utopia Planitia.

References

[1] Mustard et al. (2001) *Nature* 412; [2] Head et al. (2003) *Nature* 426; [3] Milliken and Mustard (2003) *Sixth Int. Conf. on Mars*, #3240; [4] Hartmann and Neukum (2001) *Space Science Reviews* 96; [5] Lefort et al. (2007) *LPSC* 40, #1796; [6] Zanetti et al. (2009) *submitted to Icarus*; [7] Ivanov (2001) *Space Sci. Rev*, 96; [8] Morgenstern et al. (2007) *J. Geophys. Res.* 112; [9] Hartman (2004) *Icarus* 174; [10] Laskar et al. (2004) *Icarus* 170; [11] Levrard et al. (2004) *Nature* 431.