**GEOGRAPHICAL DISTRIBUTION OF CRATER DEPTHS ON MARS** T. F. Stepinski, Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058, tom@lpi.usra.edu

**Introduction:** There is a renewed interest in compiling updated global catalogs of impact craters on Mars using crater detection algorithms (CDAs) [1,2]. In particular, the CDA presented in [1] catalogs craters from topographic data instead of images. Using the topography-based CDA yields a catalog of craters that not only lists coordinates and diameters of the craters, but also their estimated depths. Thus, construction of planet-wide geographical distribution of crater depths becomes possible. A global map of crater depth/diameter (d/D) ratio is important for studies that use crater morphology for determining the rate and amount of surface degradation (including a degradation due to the presence of subsurface ice), or to the studies of target strengths. Here we report on the geographical distribution of crater depths derived from an automatic estimate of the depths for 75,919 craters located over the entire surface of Mars. We discuss the implications of the results to location of the Martian cryosphere and we identify and discuss locations of the deepest craters on Mars.

**Methods.** We use the CDA described in [1] to catalog craters over the entire surface of Mars. The input is the 128 pixels/degree MOLA Mission Experiment Gridded Data Record (MEGDR) [3]. Because of the size of the global MEGDR, we needed to subdivide the surface into 356 overlapping tiles. The craters are identified and measured at each tile separately and the results from individual tiles are concatenated into a single catalog from which duplicate detections are eliminated. The output is the catalog of 75,919 craters (ranging in size from 1.36 km to 347 km.) listing coordinates of the center of each crater, its diameter (D) and depth (d). The depth is estimated as the difference between the highest and the lowest elevation within a crater. This is a rather coarse measure of crater depth, but the only one that can be performed by an automated system without a potential for major inconsistencies. In [1] we compared the values of depth estimated by our CDA with manual calculations for 144 craters and have found that our CDA systematically overestimates the value of depth. However, for the purpose of constructing global maps of (d/D) the accuracy of our estimate is sufficient, as the purpose of the map is to provide relative values of (d/D) at different geographical locations and not to give the best absolute estimate of (d/D). Note that the number of craters (75,919), for which we have estimated the depth, is much larger than in any previous studies; for example, in [4] depths were calculated for only 5189 craters located at selected regions of Mars and predominantly at the northern hemisphere.

**Results.** A ``carpet coverage” of Mars surface by 75,919 craters with estimated depths makes possible separate mapping of (d/D) for craters of different sizes. For this purpose we have divided all craters into six size bins, $D < 5$ km (35,738 craters) , 5 km $\leq D <$ 10 km (21,614 craters), 10 km $\leq D <$ 15 km (6594 craters), 15 km $\leq D <$ 20 km (3788 craters), 20 km $\leq D <$ 25km (2180 craters), $D \geq$ 25 km (5971 craters). Using craters from each bin separately raster maps with resolution of 0.5 degree were constructed to show spatial variation of (d/D). The value of (d/D) at each pixel of the map is calculated as an average of the values of d/D for individual craters located within a 2 degree square window centered at that pixel. In cases where there are no craters within a window a “nodata” entry is assigned to a pixel.

Fig.1 shows the (d/D) maps for the six crater size bins as indicated. The maps show different geographical distributions of (d/D) depending on the size of the craters. **(1)** For small craters with D < 10 km (the first two size bins) there is a clear latitudal pattern that indicates an existence of two zones: the equatorial zone ($Zone_E$, predominance of reddish colors on the map) extending from the equator to the latitude of up to ±40°, and the high latitude zone ($Zone_{HL}$, predominance of yellowish colors on the map) extending from to the latitude of ~ ±40° to the poles. In $Zone_E$ the craters are relatively deep, whereas in $Zone_{HL}$ the craters are relatively shallow. **(2)** For craters with D > 25 km (the sixth size bin) there is no obvious spatial pattern; throughout most parts of the surface the carters have the same, low values of relative depths. **(3)** For craters with 10 km < D < 25 km craters (the third to fifth size bins) some limited latitudal dependence is observed and some regional dependence is also noticeable.

The geographical distributions of (d/D) on Fig. 1 can be explained by an existence of the cryosphere with the depth of its upper boundary significantly lowered in the equatorial regions, just as predicted by models based on ice stability concept [5,6,7]. Calculations [8,9] of viscous relaxation indicate that the style of crater modification depends on the depth of the cryosphere relative to the crater size. For a relatively deep cryosphere viscous relaxation leads to significant decrease of crater’s (d/D) value. For a relatively shallow cryosphere there is no significant modification of crater's (d/D) value.

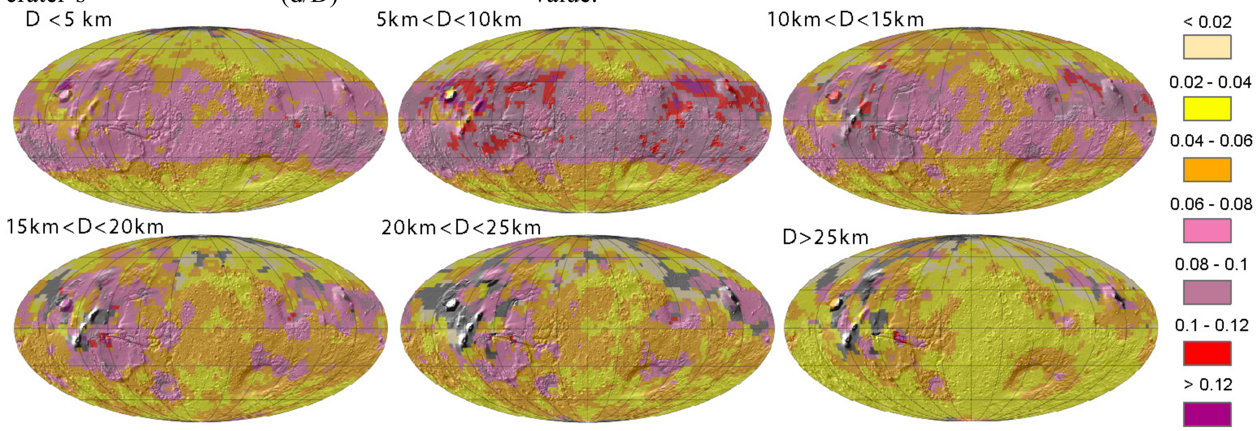


Fig. 1: Geographical distribution of (d/D) on the surface of Mars for six crater size bins.

In $Zone_E$ the high values of (d/D) for D < 10 km craters indicate absence of viscous relaxation and no cryosphere up to the depths of ~ 1 km. In $Zone_{HL}$ the low values of (d/D) for D < 10 km craters indicate presence of viscous relaxation and cryosphere located just below the surface.

Fig.2 shows the location of 652 craters with the value of (d/D) ≥ 0.15; these are the relatively deepest craters on Mars. The average diameter of these craters is 6 km. Several locations including Utopia Planitia, Isidis Planitia, Chryse Planitia, Amazonis Planitia have particularly high concentrations of relatively deep craters. Amongst those deep craters the 133 craters with (d/D) ≥ 0.18 are located mostly in Utopia Planitia and Isidis Planitia. This finding is in agreement with earlier reports [10,11] based on manual examination of only the freshest craters. These authors attributed anomalous depth of craters in Utopia Planitia and Isidis Planitia to unusually strong target material at those locations. However, our global map points out to an existence of additional regions, located in both lowlands and highlands, that are characterized by the presence of deep craters. Further analysis is required to establish whether target strength is responsible for the anomalous crater depths in those additional regions.

**References.** [1] Stepinski, T.F., Mendenhall, M., Bue, B.D., *Icarus, 203*, 77-87, 2009. [2] Salamunićcar, G., Lončarić, S., *Planetary and Space Sci.*, 56, 1992-2008, 2008. [3] Smith D. et al. (2003) NASA Planetary Data System, MSG-M-MOLA-5-MEGDR-L3-V1.0. [4] Boyce, J. M., Garbeil, H., *LPSC XXXVIII,* Abstract #1338, 2007. [5] Clifford S. M. and Hillel D. (1983) *JGR, 88,* 2456-2474. [6] Fanale F. P. et al. (1986) *Icarus, 67,* 1-18. [7] Clifford S. M. (1993) *JGR, 98 E6,* 10,973-11,016., 121-133. [8] Parmentier, E. M. and Head, J. W. (1981) *Icarus, 47,* 100-111. [9] Jankowski, D. G. and Squyers, S. W. (1993) *Icarus, 106*, 365-379. [10] Boyce, J.M. et al., *Geophys. Res. Lett.*, 33, L06202, doi:10.1029/2005GL024462, 2006. [11] Stewart, S.T., Valiant, G.J., *Meteoritics and Plant. Sci.*, 41(10), 1423-1690, 2006.

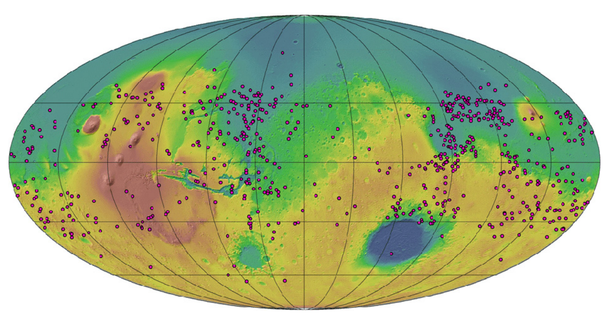

Fig. 2: Locations of deep craters on Mars that having (d/D) ≥ 0.15.