THE POTENTIAL OF CRATER SIZE FREQUENCY DISTRIBUTIONS FOR DERIVING EROSION HISTORIES: A CASE STUDY ON MARS. G. Wulf[1], S. Hergarten[1] and T. Kenkmann[1], [1]Institut für Geo- und Umweltnaturwissenschaften–Geologie, Albert-Ludwigs-Universität Freiburg, Freiburg, Germany; gerwin.wulf @geologie.uni-freiburg.de.

Introduction: The size frequency distribution (SFD) of impact craters has long been used to determine absolute ages for planetary surfaces [1, 2]. In the process, the observed SFD of a given surface unit is fitted to a crater production function, and the crater frequency for certain crater sizes is used together with a chronology function to obtain an absolute age [3]. On planetary bodies with active atmospheric and surface processes, the craters are affected by obliteration processes such as weathering and erosion or subsequent deposition. Therefore, the measured age does not necessarily show the formation age of the unit but the so-called crater retention age (CRA), defined as the average time interval during which craters of diameter D are preserved on a given surface [4]. The preservation time of craters depends on its diameter/depth, leading to faster obliteration of smaller craters, so that the measured CRA for small craters might deviate from the CRA for larger craters. Thus, the crater inventory of a given region and the derived size frequency distribution does not only contain information about the formation age but also about possible periods of erosion and/or coverage. Here we present a new approach to reconstruct the geological history of cratered planetary surfaces.

Methods: A software tool is developed that creates a theoretical SFD of a surface area on the base of the crater production function and a user-defined history of erosion and deposition. The parameters can be adjusted iteratively to get a best possible fit between the actually measured SFD of a given surface and the created theoretical SFD. In this way, it is possible to simulate and validate a variety of possible geological scenarios for a specific region. In order to verify the functionality of the developed software tool a test region was selected that combines a long geological history with high grades of erosion and accumulation. The Medusae Fossae Formation (MFF) on Mars is an intensely eroded deposit of unknown origin near the northern edge of the cratered highlands, between 130-230°E and 15°S-15°N [5-7]. It is usually considered to be fine-grained, friable deposits of volcanic ash fall, ignimbrites or wind-deposited aeolian loess [8-10]. The surface is dominated by aeolian features such as yardangs with frequent shifts in orientation [7,11,12]. The formation of the MFF is often cited as Amazonian-aged [13], but there is evidence that at least the western part of the deposits are may be older (Hesperian) [14,15]. The chosen case study area is located in the northwestern Eumenides Dorsum area as part of the MFF and shows miscellaneous so called pedestal craters. This is a subclass of impact craters on Mars [16] characterized by a crater perched near the center of a pedestal (mesa or plateau) that is surrounded by an often circular, outward-facing scarp standing tens to over 100 m above the surrounding plains [17]. It is believed that pedestal craters build an erosion-resistant layer, shielding the underlying rocks from erosion [17-19], so that areas around the crater are deflated but the crater bowl and pedestal remain at their original elevations. The appearance of some pedestal craters points to a complex erosion and deposition history of this area, for example showing covered pedestal parts directly adjacent to uncovered, exposed and eroded parts (Fig.1).

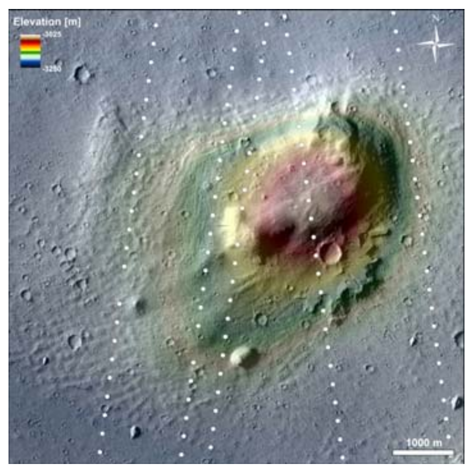

Fig.1: A pedestal crater as an example of a complex deposition and erosion history showing covered pedestal parts directly adjacent to uncovered, exposed and eroded parts (MOLA DTM superposed on CTX imagery).

Results and discussion: In a first step, we measured the SFD of two pedestal craters and the surrounding terrain, using the CraterTool extension for ArcGIS [20] and CTX images, to determine crater ages (Fig. 2). By combining the elevation differences between the two pedestal heights (~54 m), using MOLA DTM data, with the age difference of the two pedestals (~53 Ma) it is possible to make a very rough estimation of an erosion rate of this area (~1.02 m/Ma). In a second step, a simplified geological history of this area is pos-

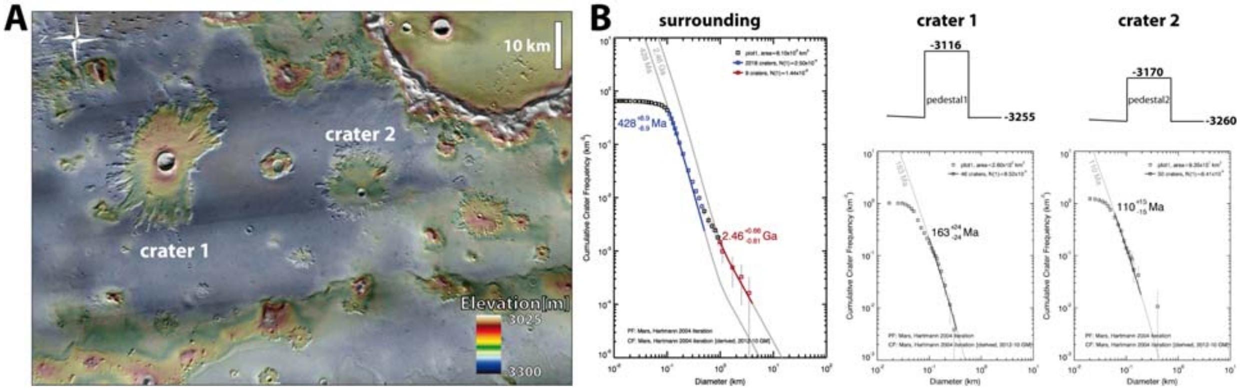

Fig.2: The crater size-frequency distribution of two pedestal craters and the surrounding terrain, in the northwestern Eumenides Dorsum area as part of the MFF, were measured to determine crater retention ages. In addition, pedestal heights were estimated using MOLA DTM data.

tulated and implemented into the developed software tool to get a theoretical SFD that fits the measured SFDs. As an example, assuming an original coverage of 250 m (Hesperian-aged) sediments on top of the today elevation level of the study area, followed by 5 stages of erosion and 4 stages of accumulation, leads to a crater record that displays the actually measured SFDs (Fig. 3). In this case, the erosion rate of the surrounding terrain is 1.25 m/Ma for the last 250 Ma. The erosion rate of the pedestal is 0.5 m/Ma for the same time due to an assumed higher resistance to erosion.

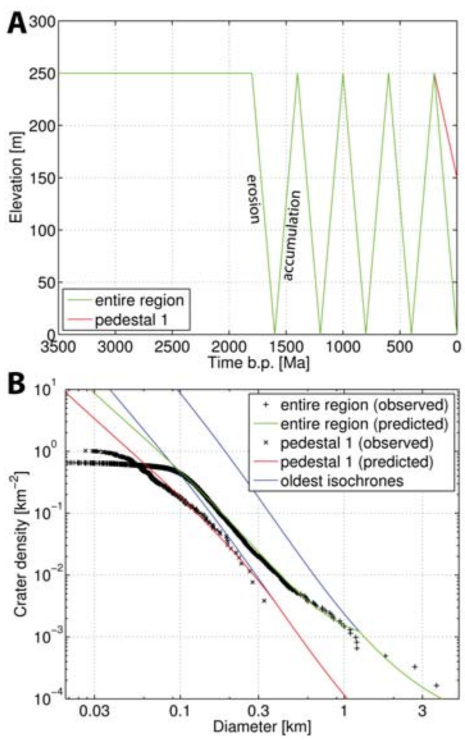

Fig.3: A simplified geological history is postulated and implemented into the developed software tool (A) to get a theoretical SFD that fits the measured SFDs of the pedestal crater and surrounding (B).

The presented approach is a first and promising attempt to reconstruct the geological history of this region, although erosion rates of 1 m/Ma have been reported for the recent past and probably only represent the maximum short-term rate for eolian erosion on Mars [21]. But in future work, the applicability of the software tool will be improved to verify in a fast and efficient way how planetary surfaces with significant erosion have been evolved.

References: [1] Neukum G. et al. (2001) *Space Science Reviews*, 96:55–86. [2] Hartmann W. K. (2005) *Icarus*, 174:294–320 [3] Michael G. G. and Neukum G. (2010) *Earth and Planetary Science Letters*, 294:223-229. [4] Hartmann W. K. (1966) *Icarus* 5:565–576. [5] Scott D. H. and Tanaka K. L. (1986) *USGS Map* I-1802-A, scale 1:15,000,000. [6] Greeley R. and Guest J. E. (1987) *USGS Map* I-1802-B, scale 1:15,000,000. [7] Zimbelman J. R. and Griffin R. J. (2010) *Icarus* 205:198. [8] Scott D. H. and Tanaka K. L. (1982) *JGR* 87:1179-1190. [9] Mandt K. E. et al. (2008) *JGR* 113:E12011. [10] Kerber L. et al. (2011) *Icarus* 219:358-381. [11] Bradley B. A. and Sakimoto S. E. H. (2002) *JGR* 107:E8. [12] Ward A. W. (1979) *JGR* B14:8147-8166 [13] Tanaka K. L. et al. (2005) *USGS map* 2888. [14] Kerber L. and Head J. (2010) *Icarus* 206:669. [15] Zimbelman J. and Scheidt S. (2012) *Science* 336:1683. [16] Barlow N. G. et al. (2000) *J. Geophys. Res.* 105(E11):26733-26738. [17] Kadish S. J. et al. (2009) *J. Geophys. Res.* 114:E10001. [18] Wrobel K. E. et al. (2006) *MAPS* 41:1539–1550. [19] Barlow N. G. (2006) *MAPS* 41:1425–1436. [20] Kneissl T. et al. (2011) *Planetary and Space Science* 59:1243–1254. [21] Golombek M. P. et al. (2014) *J. Geophys. Res. Planets* 119:2522–2547.