Confident Thickness Estimates for Planetary Surface Deposits from Concealed Crater Populations. T. Platz, G. G. Michael and G. Neukum, Freie Universität Berlin, Institute of Geological Sciences, Malteserstr. 74-100, Building D, 12249 Berlin, Germany (thomas.platz@fu-berlin.de).

Introduction: Thickness determinations of geological/geomorphological units on planetary surfaces are essential for estimating volumes and rates of deposition. In the past, thickness measurements were mainly restricted to volcanic units since their emplacement occurred on short time-scales, often covering larger areas. Early thickness studies focussed on the basalt fills of lunar maria [1-4]. The most commonly used method to determine minimum thicknesses utilises partially or nearly completely flooded craters (see references above). From known crater diameter-to-rim-height relations, unit thicknesses can be calculated. An advancement of this method is the exploitation of crater populations where the crater size-frequency distributions exhibit a characteristic deflection in slope which is used to find thickness values. The new technique introduced in this paper [5] to estimate deposit thicknesses uses characteristic features of crater size-frequency distributions and is applicable to any cratered surface unit regardless of the presence of visible flooded craters

Technique: The new methodology requires the crater size-frequency distributions (CSFD) of two surface units from which the thickness is calculated. In comparison to the method by [4], our method has three further characteristics: firstly, a thickness estimate can be made in the absence of the characteristic deflection in the CSFD; secondly, a lower limit on the thickness of a surface unit can be reliably calculated; and thirdly, a confidence level (2σ) is provided to better constrain and validate the estimate.

The following scenario is chosen to demonstrate the new method. A planetary surface unit continuously records from its time of formation the impact history which is reflected in its CSFD. However, at a later time a resurfacing event, such as a lava flow, can bury low-relief parts of the unit or cover it entirely. The new top surface (ie. the surface of the lava flow) begins to accumulate new impact events, and hence, records a different crater population. The difference is best shown when the CSFDs of both units are plotted: each CSFD follows a different isochron depending on the time of accumulation.

In order to estimate the thickness of the younger unit from CSFD data, the following steps are made: 1) determine the cratering model age of the older, unmodified surface unit, 2) calculate the expected number of craters for each cumulative size bin in the area of the younger unit as if it had the same age as the older portion, i.e. the expected crater population on the underlying surface, 3) determine the crater deficiency in each cumulative bin – the shortfall in the observation compared to expectation – and calculate the probability that such a deficiency could nevertheless correspond to the age of the underlying surface, 4) find the diameter bin where we may be 95% confident that craters have been obliterated by the resurfacing, and 5) derive the flow thickness from the known rim-height of craters of this diameter.

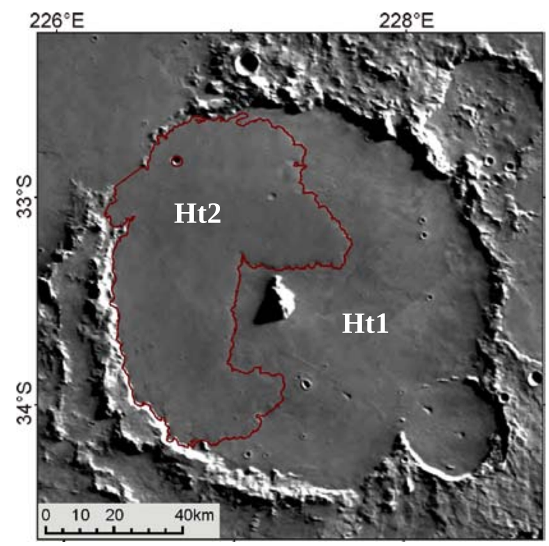

Fig. 1: Pickering crater. Red line marks extent of unit Ht2 used for calculations and crater counting.

Results: Surface units at two locations on Mars which differ in age, spatial extent, thickness, and covering volume were studied to validate this approach: Pickering crater (southern Daedalia Planum) and Lunae Planum. Pickering crater (D≈110 km) is filled by lava flows with two units exposed at the surface, the older Ht1 and the partially overlying Ht2 (Fig. 1, [6]). Four methods to determine the thickness of Ht2 within Pickering were applied to test against our new technique using: 1) single MOLA PEDR tracks, 2) HRSC-DTM, and the standard methods of [1] and [4].

With our technique, we first determined the surface age of Ht1 to be 3.63 Ga (Fig. 2). The expected cumulative number of craters in each bin for Ht2 relative to 3.63 Ga was determined and the probabilities of the observed crater deficiencies calculated. The 2σ confidence level (0.95) occurs at bin size 1.3 km, i.e., in that bin we expect to see 6.12 craters but observe only 2: thus, at least 4 craters are missing. This bin size was used to calculate the overall thickness of unit Ht2 to be 80.2 m [7]. This thickness value was corrected for crater obliteration over >2.7 Gyrs, the time lapse between the deposition of Ht1 and Ht2. The corrected thickness value of 41.8 m for Ht2 compares well to 39.1 m obtained from method 2).

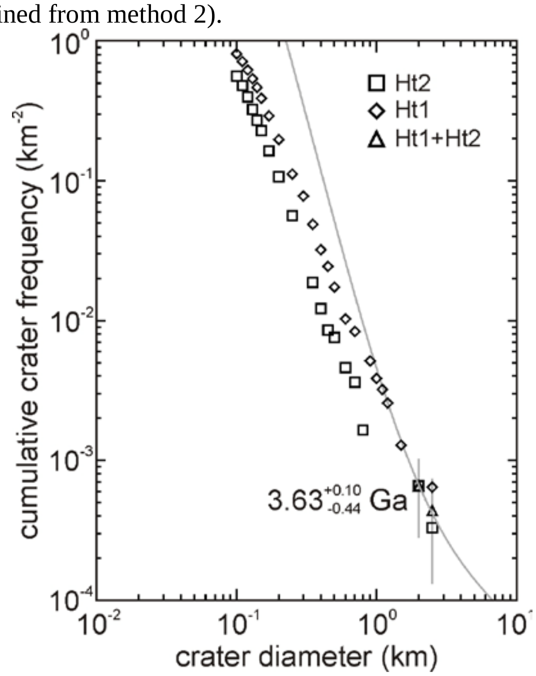

Fig. 2: Crater size-frequency distributions of units within Pickering crater.

Lunae Planum is a vast plain composed of ridged material, Hr [6]. Because its underlying unit is not exposed, a reference surface needs to be defined which is thought to be representative of the surface below the ridged plains material. A reference site to the area east of Maja Valles (part of Xanthe Terra) was chosen which consists of Noachian-aged surface units. Using our approach, we predict a minimum thickness value of ≥840m and a minimum volume of 9.76×10^5 km^3 for the studied Lunae Planum unit Hr (Fig. 3).

Discussion: The new methodology introduced to determine confident thickness values for planetary surface units has several advantages with respect to previous techniques. First, and most importantly, the new technique can be applied for thickness estimates of surface units even if there are no visible flooded craters. Second, the new method can be carried out on any cratered surface within a reasonable amount of time. Only crater counting of the entire unit or a representative portion of it as well as the underlying unit need to be performed. Measuring individually flooded craters, if present, is therefore not necessary. Third, probabilistic measures of crater deficiencies are used to exclude statistical effects, providing thickness estimates of quantified reliability. As a result, better thickness and volume estimates result which are essential for further interpretation, for example, to infer rates of deposition.

However, care must be taken to apply the new technique correctly. One major issue has already been highlighted: currently, crater rim height to floor relationships are based on fresh crater morphologies, and as a result, deposit thickness estimates are overestimated by a factor of up to 2 [cf. 8,9] if a considerable hiatus exists between the formation of the unit and its underlying surface. Therefore, rates of crater degradation and obliteration over the geological history of the planet need to be considered, and ideally, to be quantified.

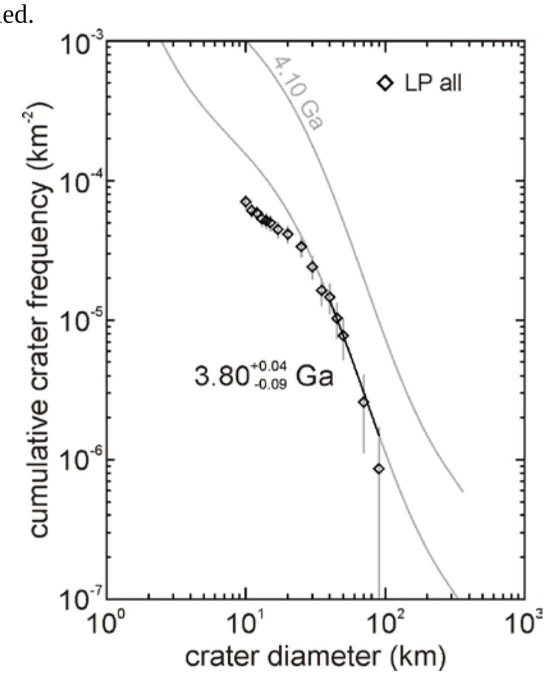

Fig. 3: Crater size-frequency distribution of unit Hr, Lunae Planum. 4.1 Ga refers to the age of the reference site.

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References: [1] De Hon, R. A. (1974) *5th Proc. Lunar Planet. Sci. Conf.*, 2553-2561. [2] Neukum, G. and Horn, P. (1976) *The Moon*, 15, 205-222. [3] Head, J. W. and Wilson, L. (1992) *Geochim. Cosmochim. Acta*, 56, 2155-2175. [4] Hiesinger, H. et al. (2002) *Geophys. Res. Lett.*, 29, 1248. [5] Platz, T. et al. *EPSL*, in review. [6] Scott, D. H. and Tanaka, K. L. (1986) *U.S. Geol. Surv. Misc. Invest. Series*, Map I-1802-A. [7] Garvin, J. B. et al. (2002) *LPS XXXIII*, abstract #1255. [8] Hörz, F. (1978) *Proc. Lunar Planet. Sci. Conf. IX*, 3311-3331. [9] Barlow, N. G. (1995) *J. Geophys. Res.*, 100, E11, 23307-23316.