

## Crater Size-Frequency Distribution of the South Polar Layered Deposits, Mars: Preliminary Results. M.E.

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**Introduction:** The South Polar Layered Deposits (SPLD), like the North PLD, is made up alternating layers of dusty ice that are widely believed to contain a climate signal. However, model ages from craters identified in Viking [1], MOLA [2], and THEMIS [3] data suggests that the surface age of the SPLD is 10s of Myr old, several orders of magnitude older than the ~10-20kyr [4] to as young as ~1.5kyr [5] surface age estimates for the NPLD, depending on crater production function used. Viscous relaxation also plays a key role in the morphology of large craters on the SPLD [6] while viscous relaxation of small craters on the NPLD has not been observed [4, 5] nor is expected [7]. Also, unlike the NPLD surface, the SPLD surface can be divided into two geologic units [8] that have previously been combined for crater statistics.

Three major advances have occurred that merit revisiting the SPLD crater catalog and statistics. First, Mars Reconnaissance Orbiter's Context Camera (CTX) [9] has imaged most of the SPLD (Figure 1) at an improved 6 m/pixel or better resolution. Second, significant updates to the martian crater production functions have occurred [10, 11]. Third, the discovery and characterization of radar reflection free zones (RFZs) [12] suggest that pockets of CO<sub>2</sub> ice, containing at least the equivalent of the current martian atmosphere, are present beneath the surface. Refining the age estimates of the SPLD surface with CTX images will place limits on how recently the RFZs (several of which lie under the SPLD [12, 13]) could have formed.

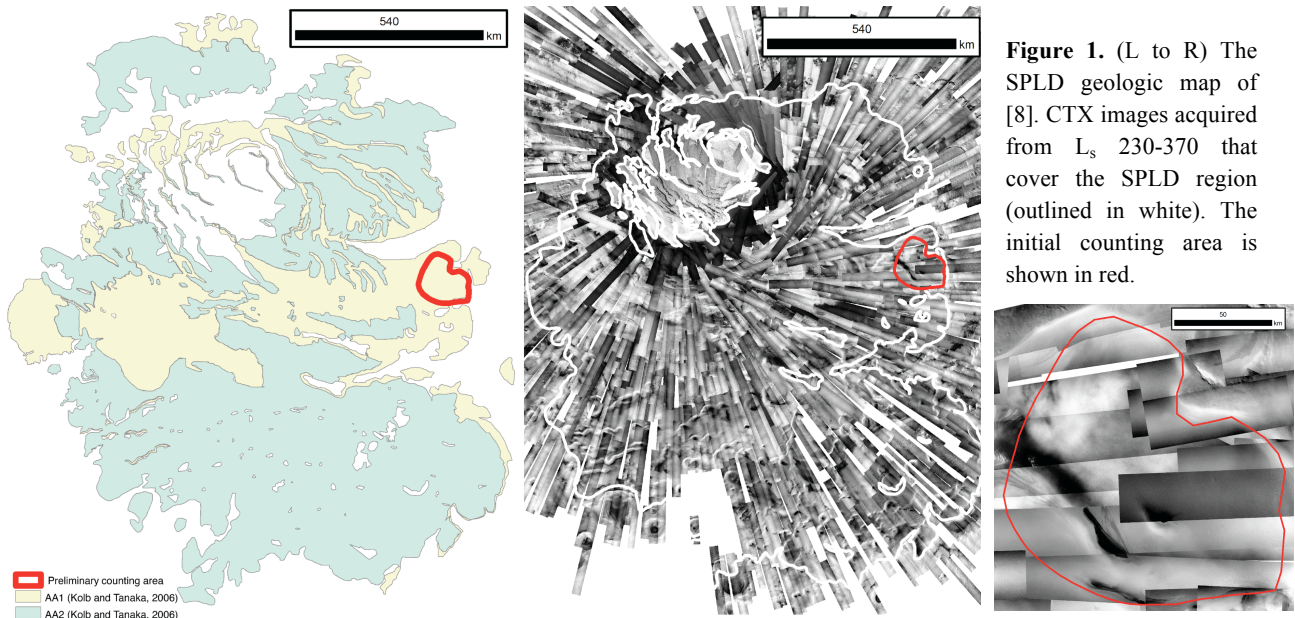
This abstract presents the methodology and initial crater size-frequency distribution (CSFD) from one subset of the SPLD that overlies an RFZ. This is part of a larger effort to produce a CTX-image-based catalog of the craters on the SPLD to determine the surface age using higher-resolution image data, determine if there is an age difference between the two surface geologic units described by [8], and to place a lower age limit constraint on the formation of the RFZs.

### Initial Mapping Area and Crater Cataloging:

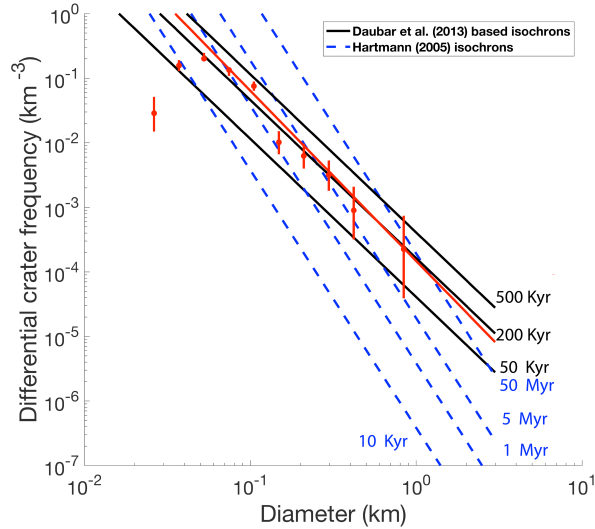
Figure 1 shows the CTX image coverage over the SPLD, from solar longitude (L<sub>s</sub>) 230-370. The initial counting area is outlined in red, on the AA1 unit and overlying an RFZ [8, 13]. This area is also distant from the two documented secondary crater fields on the SPLD [14]. The craters and overall terrain in this area are similar to the nearby non-RFZ-covering AA1 unit. While there are some gaps, the CTX image coverage is sufficient to yield statistically significant numbers of craters for the initial region of interest (ROI) as well as the entire SPLD (Figure 1).

An image mosaic of the SPLD was generated from the >3000 CTX images that cover that area, with a fixed resolution of 6 m/pixel. Craters were counted using the CraterHelper extension (available from the USGS) in ArcMap<sup>®</sup>.

**Crater Statistics and Model Ages:** Initial results over the region outlined in red in Figure 1 are shown in Figure 2. The 210 impact craters in this area range in diameter from 26 m to 7 km.



■ Preliminary counting area  
■ AA1 (Kolb and Tanaka, 2006)  
■ AA2 (Kolb and Tanaka, 2006)



**Figure 2.** Differential crater size-frequency distribution plot for the counting area outlined in red in Figure 1.

Most craters in this region have diameters <400m, and the median diameter is ~70 m. The largest crater ( $D \sim 7$ km) shows clear signs of degradation and significant viscous relaxation. Due to this crater being the only one in its diameter bin, as well as its highly degraded appearance and possibly significant viscous relaxation, we do not include it in the population of craters used to date the SPLD's surface.

The differential plot (for comparison with the NPLD surface ages given in [4, 5]) is shown in Figure 2. Statistical roll off occurs around 50-60 m diameter range due to incomplete crater detection at smaller diameters. This is due in part to image resolution (6 m/pixel resolution would give a minimum reliable detection diameter of ~60 m, though [4] argue that their identifications in CTX images were complete to ~35 m) and to surface circular pitting and patterning common the PLDs [e.g. 4, 5]. We do not take into account the effects of material strength, and the reported model ages derived here are therefore overestimates [5].

We utilize the Hartmann [10] and Daubar et al. [11]-based isochrons. The SPLD craters presented here are more numerous and larger in diameter than the entire crater population of the NPLD (<100 craters, largest crater diameter of ~360 m), and thus indicate an older SPLD surface age. [5] argues that the Daubar et al. [11] isochrons are more appropriate for the small craters on the NPLD surface, both in terms of crater size and crater formation time-scale. The model surface ages for the initial SPLD ROI are much older (on the order of 100s of kyrs to 50 Myrs-old, depending on the isochron used) and future work will explore additional isochrons [e.g. 15] that may be more appropriate for this impact crater diameter range.

Preliminary results suggest that the crater SFD cuts across multiple Hartmann [2005] isochrons and therefore a maximum age of ~50 Myr can be determined. The slope of the best-fit line to the crater SFD is similar to that of the Daubar et al. [2013] isochrons, and follows closely the 200 Kyr isochron. While these model ages are preliminary and represent only the outlined area in Figure 1, these ages are younger than previous model ages previously derived from older data [1-3].

This younger age determination could be due to several factors. [1-3] did not distinguish between the AA1 and AA2 units, thus giving an average age. There could also be field secondaries in the counting area, which are not included in the Daubar et al. [11] isochrons. This may lead to an underestimation of surface age, but may not outweigh the advantages of using observed new impacts argued in [5].

The hypothesis that SPLD surface is orders of magnitude older than the NPLD surface is supported by this new data. Future work will expand the crater catalog to encompass all of the RFZs identified by [12,13] as well as both AA1 and AA2 geologic units.

**References:** [1] Herkenhoff and Plaut (2000). *Icarus* doi:10.1006/icar.1999.6287 [2] Koutnik et al. (2002). *JGR: Planets*. doi:10.1029/2001JE001805 [3] Plaut (2005). LPSC 36, #2319 [4] Banks et al. (2010). *JGR*, doi:10.1029/2009JE003523 [5] Landis et al. (2016). *GRL*, doi:10.1002/2016GL068434. [6] Pathare et al., (2005). *Icarus*. doi:10.1016/j.icarus.2004.10.031 [7] Sori et al., (2016). *GRL*, 10.1002/2015GL067298 [8] Kolb and Tanaka (2006). *Mars* doi:10.1555/mars.2006.0001 [9] Malin et al. (2007). *JGR: Planets* doi:10.1029/2006JE002808 [10] Hartmann (2005). *Icarus* 174(2), pp.294-320. [11] Daubar et al. (2013). *Icarus* 225(1):506-16, doi:10.1016/j.icarus.2013.04.009 [12] Phillips et al. (2011). *Science* doi:10.1126/science.1203091 [13] Whitten and Campbell, (2017). *AGU 2017 Fall Meeting* [14] Schaller et al. (2005). *JGR: Planets*, doi: 10.1029/2004JE002334 [15] Hartmann and Daubar (2017). *MAPS*. doi:10.1111/maps.12807

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