REINTERPRETING THE IMPACT CRATERS OF THE NORTH POLAR LAYERED DEPOSITS, MARS.

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Introduction: The North Polar Layered Deposits (NPLD) on Mars record the recent climate history of the planet. The NPLD preserves a series of stratigraphic layers, and dating these layers holds significant promise for understanding recent Martian climate change. However, age estimates for the surface of the NPLD range widely. Herkenhoff and Plaut [1] assigned an age of less than 120Kyr based on the lack of any visible craters within Viking images. Tanaka [2] derived an age of 8.7Kyr based on two superposed craters. Banks et al. [3] searched CTX and HiRISE data and recorded a population of ~100 craters on an area that they determined had recently accumulated. Using the crater production function of Hartmann [4], they inferred that the current craters were an equilibrium population, with crater lifetime proportional to crater size, and that all of the current craters likely accumulated within the last 10-20Kyr.

Not only is the age of the whole deposit not well constrained, there are also open questions about the current mass balance of the NPLD. The stratigraphic layers show that the NPLD has accumulated over a period of time where alternation occurred between dust and ice deposition. Models suggest that the NPLD should currently be accumulating at the expense of mid-latitude ground ice [5]. However, sizes of ice grains on the NPLD surface in late summer suggest that old ice is currently being exposed, so there is net annual ablation in progress [6]. This situation cannot have persisted long, as those same data show that the old ice surface has not accumulated any significant amount of dust. Examining the cratering record will put further constraints on how quickly the NPLD could be accumulating or ablating, as well as the minimum age of the deposit.

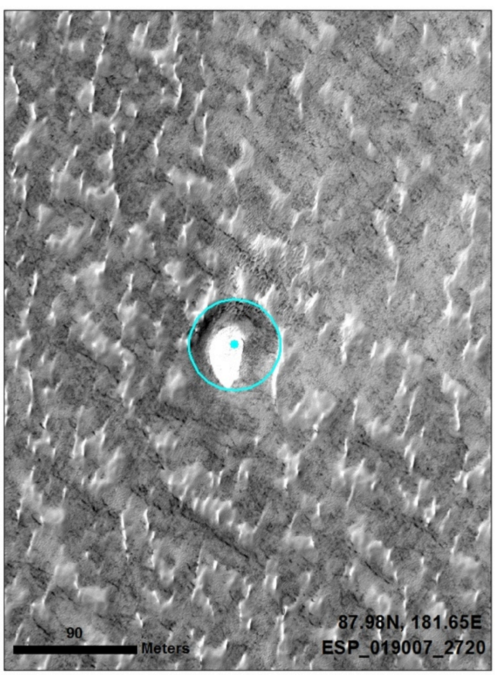

Figure 1-HiRISE image of small NPLD crater originally identified in CTX imagery [3]. The rim (D~70m) is outlined in light blue, and ice is present at the bottom of the crater. Image: NASA/JPL/ University of Arizona.

Here, we revisit the NPLD crater population, described in [3], with an important new piece of information. Recently, Daubar et al. [7] has measured the production of small craters on Mars directly, and this new production function yields different conclusions for north polar history. We have also acquired more HiRISE images of these craters since the Banks et al. [3] study. Several craters were originally measured with CTX data alone and now these diameter measurements can be refined.

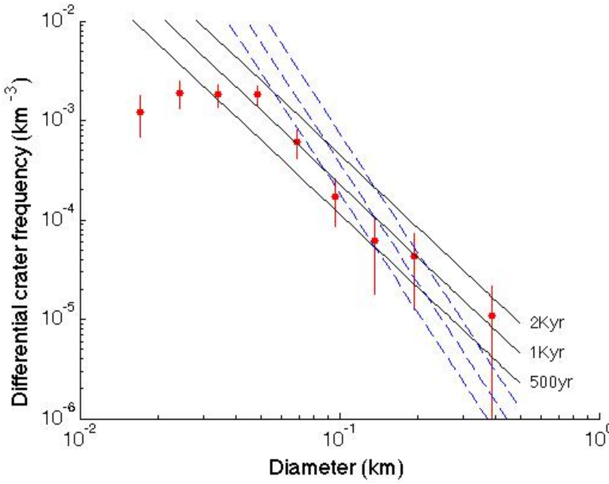

Figure 2-Differential size-frequency distribution of NPLD crater population is plotted in red. The Daubar et al. [7] isochrons for 0.5, 1 and 2 Kyr are shown in solid black while the Hartmann [4] isochrons for 5, 10 and 20 Kyr are shown in dashed blue.

Methodology: Crater diameters were measured using the ArcMap Crater Helper Tools, available from the United States Geological Survey. Where crater clusters were present, the effective diameter was calculated according to the formula $(\Sigma D^3)^{(1/3)}$ [3,7]. Where multiple images existed for a site, the diameters were measured and averaged.

Following [3], we took crater counts above a diameter of 44m to be statistically complete. There are 38 craters fitting this criterion (e.g. Figure 1), eight of which have since had their diameter measurements refined through newly acquired HiRISE data. The updated diameter data was on average 2±5m smaller than the diameters reported in [3]. This translated to a most a 10% difference between updated diameters from the diameters reported in [3].

Results: Figure 2 shows the differential size-frequency distribution of the impact craters in this study, plotted in red, against several isochrons based on the current production function given in [7]. The size-frequency distribution of the impact craters on the NPLD is close to the 1Kyr isochron. Error bars shown are the usual counting errors. There is also error associated with the production function determination in [7]. Overall, ages determined are accurate within a factor of 2 for this population.

Discussion: The closeness of the data to a model age of ~1Kyr presents two possible scenarios. First, a resurfacing event 1Kyr ago could have reset the surface and all visible craters formed afterwards. Second, this may be an equilibrium population with both small and large craters having the same lifetime (~1Kyr) on the surface. For shallower craters to persist as long as deeper ones, the accumulation rate within smaller craters must be lower than within the large craters. Modeling accumulation rates of the NPLD surface would distinguish between these two scenarios.

These conclusions stand in stark contrast to those of Banks et al. [3], which relied on the Hartmann [4] isochron system (Figure 2). They concluded that these craters were best explained as an equilibrium population where crater lifetime is roughly proportional to diameter. Therefore, infill rates are roughly the same for large and small craters. The Hartmann isochron system also indicates that the current crater population accumulated over the past 10-15 Kyr, as small craters have been preferentially infilled.

The choice of crater production function affects the interpretation of the NPLD crater population in a first order way. The Hartmann [4] system is based on extrapolations from craters whose sizes differ from the NPLD population by at least an order of magnitude, while the Daubar et al. [7] system overlaps with the smallest, non-statistically significant size bins of the NPLD population. Uncertainties in the efficacy of atmospheric screening and how it changes with bolide size affect both crater production functions. The Hartmann system is an average over timescales orders of magnitude longer than those relevant to this population, while the Daubar et al. [7] system is a snapshot of crater production over timescales orders of magnitude shorter than those relevant to this population.

The varying preservation of the NPLD craters mean they are unlikely to secondary craters from a single impact and their young age rules out secondaries from several large, distant impacts. They are also isolated and crater clusters are easily identifiable. This makes the production functions of Daubar et al. [7] more appropriate as it does not include distant secondaries, as the Hartmann [4] production function does, and calculates the effective diameter of clusters in the same way as we have. An additional feature of Daubar et al. [7] production function is that it is developed from currently observed small Martian impact craters, and so can be updated further using additional impact crater measurements.

We will discuss this reinterpretation of the NPLD craters and its implication for recent NPLD history.

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