AGE ESTIMATE OF MARTIAN DUNES BASED ON POSSIBLE IMPACT FEATURE. S. J. Coleman[1,2], R. K. Hayward[2], N. G. Barlow[2,3], and T. N. Titus[2], [1]Dept. Geology, Northern Arizona Univ., Flagstaff, AZ, 86011-4099, sjc229@nau.edu, [2]US Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ, 86001, rhayward@usgs.gov, [3]Dept. Physics and Astronomy, Northern Arizona Univ., Flagstaff, AZ, 86011-6010, Nadine.Barlow@nau.edu.

Introduction: There are little published data documenting the age of Martian dunes, primarily due to a lack of impact craters on dune surfaces. Reiss et al. (2004) used impact craters to date a field of Transverse Aeolian Ridges (TARs) in Nirgal Vallis [1], but TARs tend to have a higher average albedo and different morphological characteristics when compared to the large, low-albedo dunes that comprise the majority of Martian dune fields [2]. Moreover, TARS are often found with low-albedo dunes overlying them [2]. Therefore, the age of 0.621 Ma obtained by Reiss et al. [1] is likely older than that of the low-albedo dunes. This is supported by the fact that until now, no craters have been found on the nearly 1 million km^2 of dunes found on Mars' surface [3].

Examination of Thermal Emission Imaging System–Visible (THEMIS-VIS) (19m/pixel) and Mars Orbital Camera (MOC) (1.5m/pixel) imagery of a dune field in Thaumasia (MC-25) has uncovered a crater-like feature superimposed on a dune field (fig. 1). Although we do recognize that a single point is insufficient to obtain a precise age, we were able to obtain an approximate age for this particular dune field using the crater. This process was also expanded to obtain a qualitative relative age based on all dune fields exhibiting similar levels of preservation, and, for continuity's sake, obtain an age based on all dune fields on Mars.

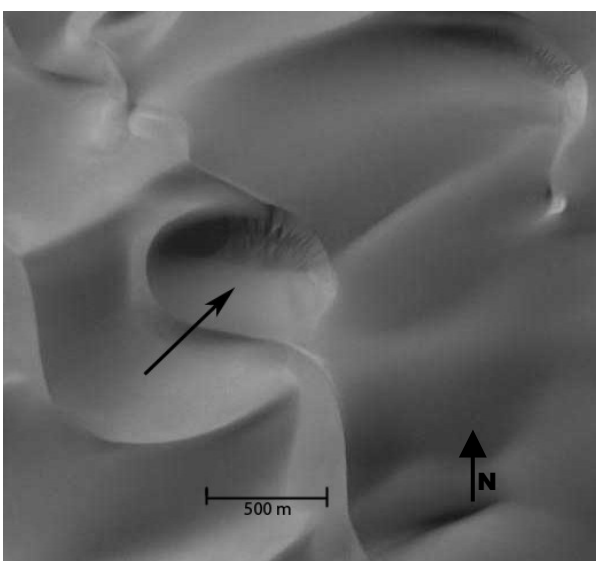

Figure 1 – Crater-like feature in a dune field located at 297.6° E, 41.2° S. MOC image #r0301175.

Study Area: The dune field in question is located at 297.6° E, 41.2° S in an unnamed host crater near Argyre Planitia in Aonia Terra just south of Bosporos Planum and west of Bosporos Rupes. The host crater is degraded and is found in the cratered and desiccated units of the Noachian plateau sequence. The host crater has an area of 2458 km^2, and the dune field has an area of 104 km^2 [4]. The dune field crater measures 500 m by 700 m and has a series of possible gullies on the northern interior. The southern rim has been subdued and the interior partially infilled by continued aeolian processes.

Dating Methods: We used the dating method of Hartmann (2004) to determine ages [5].

Host Crater: The area of the crater was obtained from the Mars Global Digital Dune Database (MGD^3) [4], then an interior crater count was performed using THEMIS-IR (100m/pixel) images. The counted craters were binned and plotted on the Hartmann plot.

Dune Fields: The MGD^3 provided the planetwide total dune field area (996,341 km^2) as well as that of our study site [4]. The categorization of similarly preserved dunes was derived from Fenton and Hayward (2009) [3]. Their class one and class two dune fields – sharp to moderately sharp crests with gullies and partial aprons – were determined to be closest to the preservation exhibited by the dune field in question. Fenton and Hayward's categorization covered the southern hemisphere down to 45° S. We extended their classification north to cover the entire equatorial region, resulting in an area of 59,739 km^2 for the dune fields exhibiting similar preservation.

Results:

Age of Host Crater: The age of the host crater was determined to be late-Hesperian to early-Amazonian, between 3 and 3.5 Ga (fig. 2).

Age of Original Dune Field: Using only the area of the dune field containing the crater, the crater count gave an age of late-Hesperian to early-Amazonian, between 3 and 3.5 Ga (fig. 3).

Age of Dune Fields with Similar Preservation: Using the area of all dune fields exhibiting similar states of preservation to that of the field containing the crater, we determined the age to be Amazonian, between 1 and 10 Ma (fig. 3).

Age of all Dune Fields: Using the area of all dune fields on Mars, we obtained an age of between 100 ka and 1 Ma (fig. 3).

Conclusions: Of the three dune field ages obtained, the second – that for all dunes showing similar levels of preservation – is likely the most accurate. The age of 3.5 Ga obtained using only the area of the dune field containing the crater – which would make the dune field approximately the same age as the host crater – is likely inaccurate because the dune field shows sharp dune crests and little to no dust coverage, indicating recent, if not current, activity.

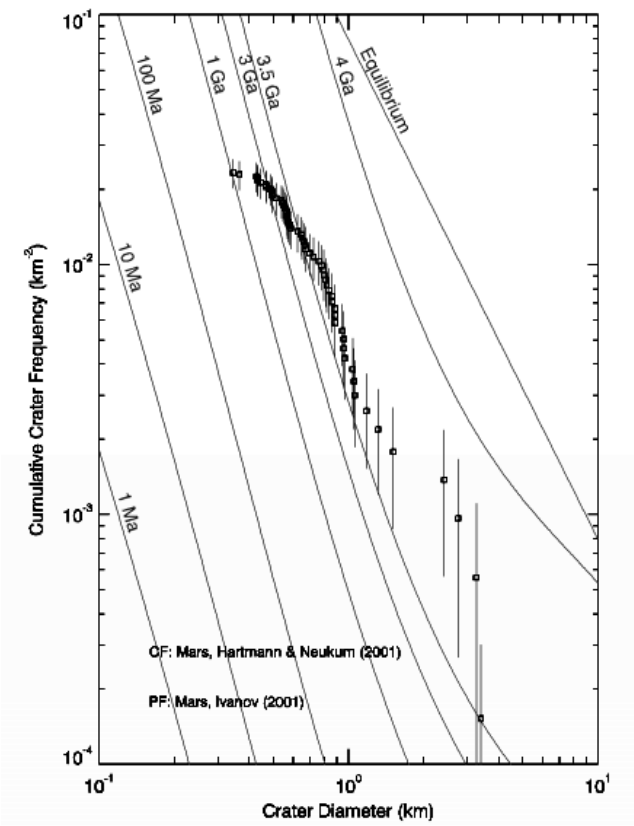

Figure 2 – Hartmann plot for crater data from the floor of the host crater with THEMIS-IR imagery. Plot produced with Neukum's Craterstats tool [6,7].

Likewise, the accuracy of the age obtained from the cumulative dune field area is questionable because a significant majority of the planetary dune field area is found in the north polar region, where the dunes are much more degraded than the dune field where the crater was found.

Future Development: There are multiple opportunities for future development and related research on this subject. Higher resolution imagery from the High Resolution Imaging Science Experiment (HiRISE) will provide a clearer picture of the candidate impact crater possibly enabling a conclusive determination of its nature. HiRISE images would also allow us to examine the erosion and infilling on the north crater wall, and possibly further constrain the age of this feature.

Further study of impacts into sand dunes, through field studies or modeling, is necessary to characterize the resulting impact crater. What would an impact crater and the associated ejecta look like in unconsolidated material? How quickly would the crater be modified? These questions need to be addressed in order to positively identify craters on dunes in the future.

If we gain a better understanding of what impact features look like in unconsolidated dunes, then perhaps more craters on dunes will be found, to help refine the age determined in this study.

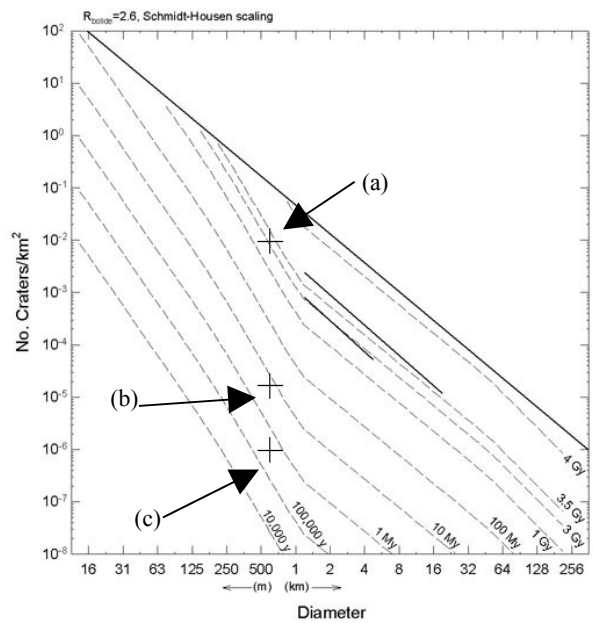

Figure 3 – Hartmann plot of ages obtained from the crater and (a) just the dune field containing the crater, (b) dune fields exhibiting similar levels of preservation as the dune field containing the crater, and (c) all dune fields on Mars.

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References:

[1] Reiss D. et al. (2004) *JGR, 109,* E06007. [2] Wilson S. A. and Zimbelman J. R. (2004) *JGR, 109,* E10003. [3] Fenton L. K. and Hayward R. K. (2009) *Geomorphology,* doi: 10.1016/j.geomorph.2009.11.006. [4] Hayward R.K. et al. (2007) *USGS Open-File Report* 2007-1158. [5] Hartmann W. K. (2004) *LPS XXXV,* Abstract #1374. [6] Michael G. and Neukum G. (2007) *LPS XXXVIII*, Abstract #1825. [7] Neukum G. (2008) http://hrscview.fu-berlin.de/craterstats.html.