INFERRED AGE OF MARE FILL IN TSIOLKOVSKIY CRATER: CONSTRAINTS ON THE PRESERVATION OF EXTERIOR IMPACT MELT DEPOSITS. J-P. Williams[1], N. E. Petro[2], B. Greenhagen[3], and C. Neish[2], [1]UCLA, [2]NASA GSFC, Planetary Geodynamics Laboratory, [3]JPL. (jpierre@mars.ucla.edu)

Introduction: Since it was first imaged, Tsiolkovskiy crater has been an enigmatic feature on the lunar surface. The 180 km diameter crater, partially filled by mare basalt, has a well preserved central peak and is associated with distinct impact melt and ejecta deposits [1-4]. Its mare-covered floor stands in stark contrast to the surrounding highlands and is one of the few exposures of mare basalt on the lunar farside.

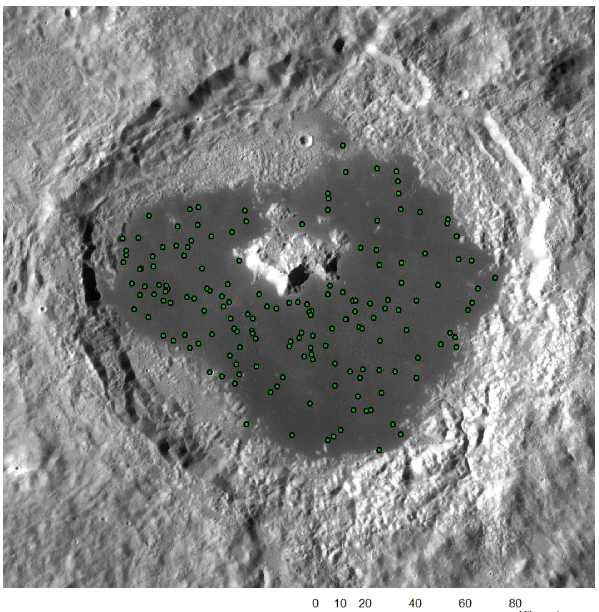

Figure 1. LRO WAC mosaic of Tsiolkovskiy crater. Craters identified (166 > ~500m in diameter) as part of this study are marked in green.

The age of the mare in Tsiolkovsky has previously been dated at 3.51 ± .1 Ga [5] but new observations by the Lunar Reconnaissance Orbiter (LRO) have revealed additional aspects of the crater and its exterior deposits that suggest it may be younger [6, 7]. Here we revisit the age of Tsiolkovskiy using the number of craters larger than ~500m as identified in an LRO Camera Wide Angle Camera (WAC) 100 meter per pixel mosaic (Figure 1). We present a preliminary age estimate for the mare filling Tsiolkovskiy and thus place a lower limit on the age of the crater. Such a constraint limits the exposure age for any of the Tsiolkovskiy impact melts surrounding the crater [6, 7]. We also compare the age of Tsiolkovskiy to other craters of similar sizes and inferred ages that possess distinct melt deposits.

Previous Age Estimates: Given the unique nature of the mare fill in Tsiolkovskiy several authors have used the number of superposed impact craters to estimate its apparent age. Gornitz [8] initially reported an age of 3.2 to 3.6 Ga for the crater and mare infill, but did not specifically differentiate between the two, while Walker and El-Baz [9] place the age of the mare at 3.8 Ga. Subsequent to this Tyrie [5], specifically focusing on the mare fill, assigned an age of 3.51 ±. 1 Ga. In geologic maps [3, 10] the mare fill has been assigned Imbrian ages (specifically Late Imbrian in the case of [10]).

LRO WAC Crater Counts: Using the 100 meter per pixel LRO WAC mosaic of Tsiolkovskiy (Figure 1) craters larger than ~500m were identified across the entire mare. Several clusters of secondary craters in the eastern region of the mare and numerous volcanic craters were avoided. In all 166 craters were identified over an area of 9.19×10^3 km^2 (Figure 1). A cumulative crater frequency plot of these craters (Figure 2) suggests that the mare is, based on the Neukum *et al.* chronology [11] between 3.12 to 3.41 Ga (~3.32 Ga), either in the late Eratosthenian or Late Imbrian [12].

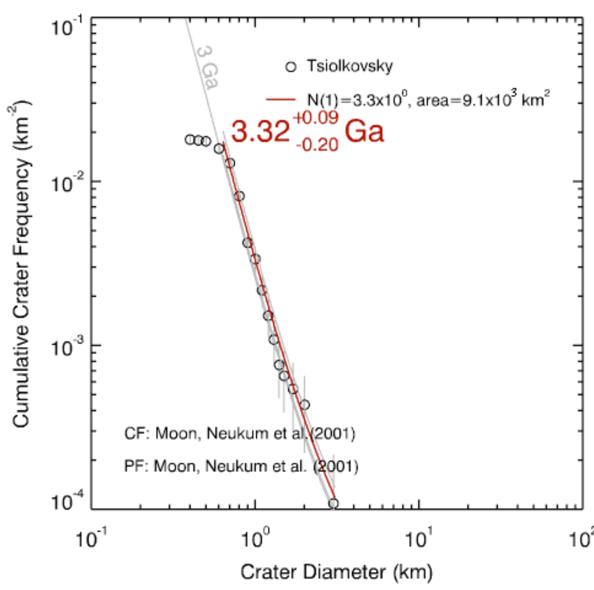

Figure 2. Cumulative crater frequency plot of Tsiolkovskiy mare (Figure 1). Crater plot created using the Craterstats software tool [13].

Comparison to Other Similar Craters: A preliminary comparison between the age of the mare in Tsiolkovskiy and two similar craters, Humboldt and

Langrenus, was completed in order to constrain the ages of craters and the preservation states of their associated impact melt deposits[6, 7]. This comparison utilized only the largest of craters on the floors of each crater, and in the case of Langrenus was only performed on the smooth deposit in the south-southeast region of the floor. These craters were selected as both have previously been identified as containing impact melt deposits [14].

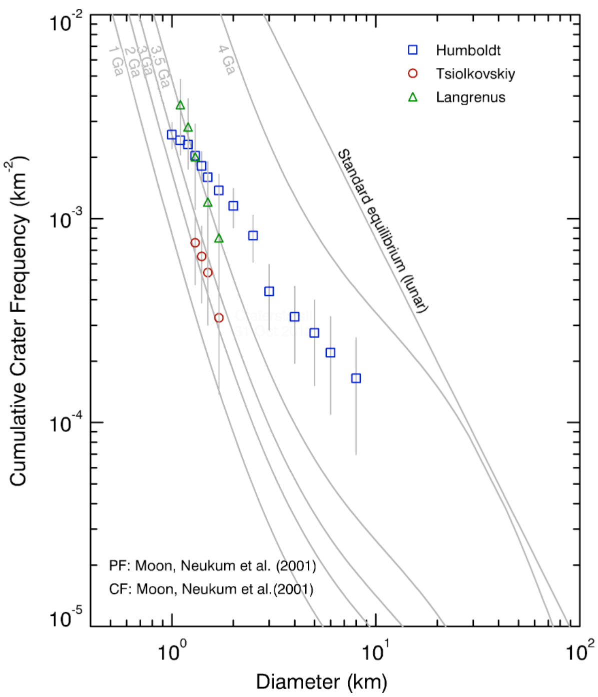

Figure 3. Crater counts for the floors of three craters described in the text, based solely on craters larger than 1 km in diameter. Crater plot created using the Craterstats software tool [13].

Based on the number of craters on the floors of these craters, Tsiolkovskiy is the youngest of the three craters (Figure 3). As noted in Neish *et al.* [7] any massive exterior melt deposits outside of Humboldt have eroded to the point where they are indistinguishable from the meter-scale rock abundance and decimeter-scale roughness of the background regolith. This potentially places some constraints on how long exterior impact melt deposits can be preserved.

Implications, Conclusions, and Future Work: The preliminary crater counts presented here suggest that the mare fill in Tsiolkovskiy Crater is between 3.12 to 3.41 Ga, younger than previous estimates [9, 5]. Clearly the age of the mare does not directly place an age of the crater itself, and future work will focus on the ages of impact ejecta and melt deposits exterior to Tsiolkovskiy. However, the "younger" age of Tsiolkovskiy suggests that the blocky melt deposits [6, 7] have been "preserved" for at least 3.12 Ga. When this finding is compared to other similar craters with more degraded impact melt deposits (i.e., Humboldt), it is clear that Tsiolkovskiy and its impact melt are relatively well preserved for a crater of its age.

Future tasks to be addressed are:

1. Determine the relative age of Tsiolkovskiy ejecta and impact melt deposits in and around the crater, using LRO Narrow Angle Camera images which provide the best possible resolution for small scale features [15]. This will better constrain the age of the crater itself. In particular, avoiding areas near possible Aristarchus secondary craters in the mare.
2. Map distribution of impact melt features around Tsiolkovskiy and other large craters using different instrument datasets [6, 7] to constrain the timescale at which melt deposits retain their roughness on decimeter to meter scales.
3. Determine the relative ages of other craters with similarly well-preserved impact melt deposits [7]. This will address how unusual the preservation of Tsiolkovskiy melt may be. If Tsiolkovskiy is indeed older and larger than other craters with blocky melt deposits, then we will need to address why these deposits are so well preserved (e.g., impactor velocity and/or composition, change in impact flux, strength of melt flows).

Acknowledgements: The support of the Diviner and Mini-RF science team, and LRO Project Science Office are appreciated.

References: [1] Guest, J. E. and J. B. Murray, (1969) *Planetary and Space Science*, 17, 121. [2] Guest, J. E., (1971) Geology of the farside crater Tsiolkovsky, 93-104. [3] Wilhelms, D. E. and F. El-Baz, (1977) Geologic Map of the East Side of the Moon, I-948. [4] Whitford-Stark, J. L. and B. R. Hawke, (1982) Geologic Studies of the Lunar Far Side Crater Tsiolkovsky, 13, 861-862. [5] Tyrie, A., (1988) *Earth Moon and Planets*, 42, 245-264. [6] Greenhagen, B. T., (2013) *LPSC 44*. [7] Neish, C. D., (2013) *LPSC 44*. [8] Gornitz, V., (1973) *Moon*, 6, 357-379. [9] Walker, A. S. and F. El-Baz, (1982) *Moon and Planets*, 27, 91-106. [10] Wilhelms, D. E., (1987) *The Geologic History of the Moon*, 327 p. [11] Neukum, G., et al., (2001) *Space Science Reviews*, 96, 55-86. [12] Stoeffler, D., et al., (2006) *New Views of the Moon*, Cratering History and Lunar Chronology, 519-596. [13] Michael, G. G. and G. Neukum, (2010) *Earth and Planetary Science Letters*, 294, 223-229. [14] Hawke, B. R., et al., (1977) Impact melt on lunar crater rims, 815-841.
[15] Hiesinger, H., et al., (2012) *J. Geophys. Res.*, 117, E00H10.