PRELIMINARY CRATER RETENTION AGES FOR AN EXPANDED INVENTORY OF LARGE LUNAR BASINS

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Summary: Based on LOLA topography and a new crustal thickness model, the number of candidate lunar basins > 300 km in diameter is at least a factor 2 larger than the traditional number based on photogeology alone, and may be as high as 95. Preliminary N(50) crater retention ages for this population of candidate basins shows two distinct peaks.

Introduction: Frey [1] suggested, based on Clementine-era topography (ULCN2005) and a crustal thickness model based on Lunar Prospector data [2], that there could be as many as 98 lunar basins ≥300 km diameter. Many of the weaker cases have not stood up to recent testing [3,4,5] using LOLA data and a newer crustal thickness model based on Kaguya gravity data and LOLA topography data [6]. As described in companion abstracts [4,5], we have deleted from the earlier inventory 1 more named feature (Sikorsky-Rittenhouse; LOLA data show that its diameter is actually < 300 km), 11 Quasi-Circular Depressions (QCDs) identified in the ULCN topography, and 11 Circular Thin Areas (CTAs) found in the earlier crustal thickness model [2]. We did this by repeating the scoring exercise originally done in [1] but with the new data [4,5]. Topographic Expression (TE) and Crustal Thickness Expression (CTE) scores were determined for each candidate on a scale of 0 to 5 (5 being a strong, circular signature, 0 for those with no discernible circular topographic or crustal thickness signature). These scores are added together to produce a Summary Score which has a range of 0 to 10. We eliminated all candidates with a Summary Score <3, as well as other cases where, for example, the TE went to zero because what looked like a single large circular QCD in the lower resolution ULCN data was in fact a cluster of smaller deep impacts readily apparent in the newer higher resolution LOLA data. This process reduced the original inventory from 98 to 75 candidates.

But the new data also suggest additional candidates not previously recognized [4,5,7]: 12 new QCD candidates and 8 new CTA candidates. These additional 20 features raise the current working inventory to 95, all with Summary Scores ≥ 3. The distribution of Summary Scores is shown in Figure 1. Named basins (red) tend to have very high Summary Scores, as might be expected, but there are 7 with scores <8 and 4 with scores <6. QCDs and CTAs generally have lower scores (if QCDs had significantly higher scores they would likely have been recognized photogeologically and been named), but 20 have scores >6 and 37 have >5. It may be that not all of these will survive further study. But even with an inventory of candidates having Summary Scores ≥5, the total number could be 64. This is still a factor 2 larger than the number of named basins that have topographic structure and have survived the culling process described earlier.

Crater Retention Ages for Candidate Basins. N(50) Crater Retention Ages (CRAs) were determined for all 95 candidates in the working inventory, using LOLA data to identify all features larger than 50 km in diameter superimposed on or near the basin rim and in the basin interior. This includes QCDs in mare-filled basin interiors where those could be identified. We find a significant number of these interior QCDs; an example for Nectaris is shown in Figure 2.

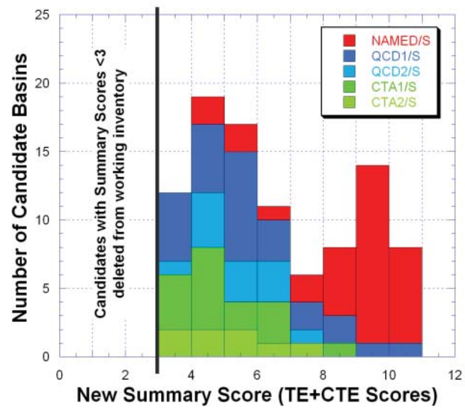

Figure 1. Distribution of Summary Scores for 95 candidate large lunar basins having scores ≥ 3.. Red = surviving named basins from Wilhelms' [8] list having topographic structure. Blue = additional QCDS. Green = CTAs. The lighter shades represent new QCDs and CTAs added from study of LOLA data and a new crustal thickness model [4,5,6].

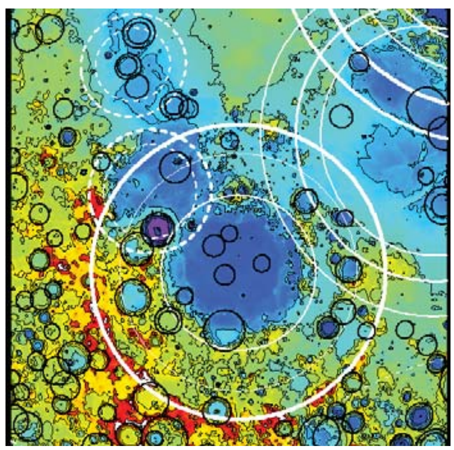

Figure 2. LOLA topography for the area near Nectaris and Fecunditatis (large solid white circles). Reds = high elevations, blues = low elevations. Two newly found CTAs [5] are shown as dashed white circles to the NW of Nectaris. Black circles are QCDs ≥ 50 km diameter and are the basis for determining the N(50) CRA for large basins. Note the four QCDs in the flooded interior of Nectaris (and similar features in Fecunditatis and in mare areas NW of Nectaris) which extreme stretching of the LOLA data has revealed. These are included in the counts for these basins.

Going to smaller diameters leads to rapid loss of these possible buried interior craters. Though the statistics will be poorer than that based on recent studies of a much smaller number of basins [7], the inclusion of all likely superimposed craters > 50 km in diameter may yield a closer approximation to the actual CRA of this larger number of basins.

N(50) CRAs were determined for two cases: a minimum age based only on superimposed QCDs on the basin interior and rim, and a maximum age based on also including QCDs very near the rim, which would likely not have survived basin formation and so likely post-date the basin. Only the maximum ages are shown in Figure 3, but minimum age distributions are similar. These CRAs should be considered preliminary, especially the maximum ages, as a more systematic way of including those near-rim QCDs needs to be developed that takes into account the likely extent of crater removal by basins of different sizes.

The distribution of N(50) CRAs in Figure 3 shows two distinct and separate peaks, centered at N(50) ~ 40-50 and ~80-90. This is not dependent on the type of feature: named basins, QCDs and CTAs all contribute to both peaks. Also, as shown in Figure 4, the two peaks do not depend on basin diameter. Both large and small basins populate both peaks which can be seen in the basin age vs diameter plot, and which appear separable in terms of their errors.

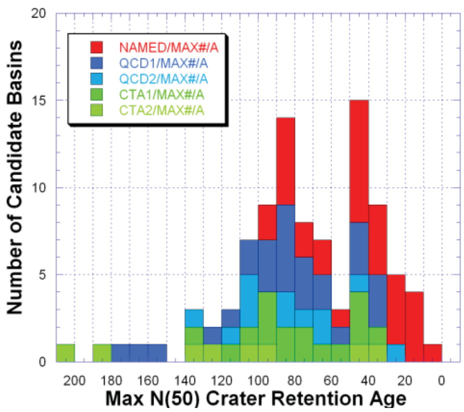

Figure 3. Preliminary maximum N(50) Crater Retention Age for 95 candidate basins. Color coding of candidates the same as in Figure 1.Two distinct peaks are obvious, one at N(50) ~ 40-50 and one at ~80-90. The older peak is broader. Both peaks contain all three kinds of features.

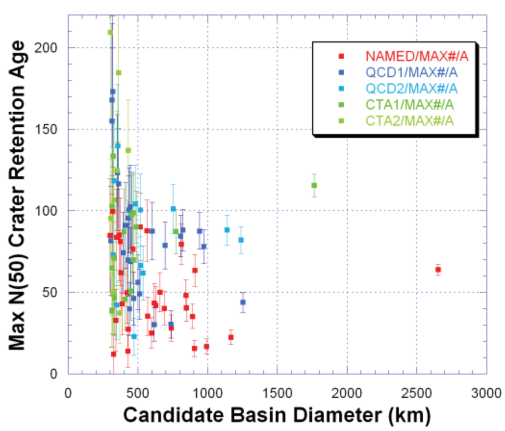

Figure 4. Maximum N(50) CRA versus basin diameter. Color code same as in Figures 1 and 3. Error bars are counting errors. Both large and small basins contribute to both peaks.

This seems to be a robust result, despite the obvious weak statistics associated with the N(50) ages, and as indicated by the error bars.. It does not appear to depend on the Summary Score of the candidates. Figure 5 shows that removing those with scores of 3-4 or even 5-6 does not remove the two peak character.

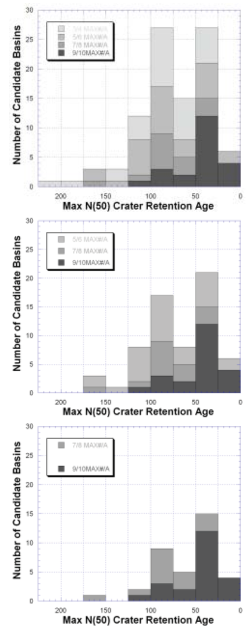

Figure 5. Distribution of the maximum N(50) Crater Retention Ages for all 95 basins with Summary (TE + CTE) Scores ≥3 (top), the 64 candidates with Summary Scores ≥ 5 (middle), and the 36 basins with Summary Scores ≥ 7 (bottom). The age bins have been widened to 25 to accommodate the reduction in numbers as lower score candidates are removed. The two peak character of the N(50) CRAs appears to be a robust feature. If real, this may indicate two distinct populations of impactors in early lunar history

Summary. Preliminary N(50) Crater Retention Ages have been obtained for 95 candidate lunar basins in a current inventory that includes 32 named basins, 39 additional QCDs, and 24 CTAs, all with Summary Scores ≥ 3. These counts include QCDs in mare filled interiors where those can be seen. The distribution of both minimum and maximum ages shows two distinct peaks which hold true even for the smaller number of most likely basins (with Summary Scores ≥ 7). This may represent two distinct populations of impactors early in lunar history.

References. [1] Frey, H.V. (2010) Chapter 2, GSA Special Publication *Recent Advances and Current Research Issues in Lunar Stratigraphy*. [2] Wieczorek, M.A. et al. (2006) New views of the Moon: Reviews in Mineralogy and Geochemistry, vol. 60, 221-364, 2006. [3] Romine, G. and H. Frey (2011) LPSC 42, abstract #1188. [4] Meyer, H.M. and H.V. Frey (2012) LPSC 43 (this meeting). [5] Frey, H. V., H. M. Meyer and G. C. Romine (2012a) *Early Solar System Impact Bombardment II,* Abstract #4005, and LPSC 43 (this meeting). [6] Wieczorek, M.A. (private communication). [7]] Frey, H. and G. Romine (2011) LPSC 42 abstract #1190. [8] Wilhelms, D.E, (1987) The Geologic History of the Moon, USGS Professional Paper 1348. [9] Fassett, C.I. et al. (2012) J. Geophys. Res., Special Issue on LRO.