IMPROVING TECHNIQUES FOR DETERMINATION OF LUNAR BASIN CRATER RETENTION AGES M.J. McBride, Motivating Undergraduates in Science and Technology at Goddard Space Flight Center, mariejulia12@gmail.com and H.V. Frey, Planetary Geodynamics Lab, Goddard Space Flight Center, Greenbelt, MD 20771, Herbert.V.Frey@nasa.gov.

Summary: Using an inventory of candidate basins ≥ 300km diameter that includes several new features found in GRAIL crustal thickness data and LOLA topography data, N(50) Crater Retention Ages were determined in three ways: a whole basin Average Age (AA), an Overlap Corrected Age (OCA) and a Small Area Age (SAA). These were compared to ages of small areas of likely Oldest Crust (OC).

Introduction: The GRAIL mission collected crustal thickness data that was much more precise than the previous LRO-based crustal thickness data. Based on this, 4 new basins, including a large basin on the North Pole, were added to the previous list of 85 basins [1]. The new 89 basin candidate list is used throughout this study. Figure 1 shows basin MM-1 one of the new basins added to the new candidate list.

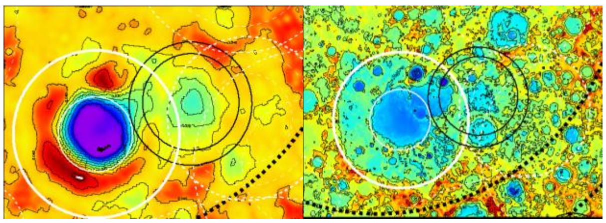

Figure 1: Candidate basin MM-1 was discovered using the new GRAIL Crustal Thickness data (left) and is shown along with the LOLA topographic data (right)

One basin was also removed from the list based on the new data. To determine the age of a lunar basin, craters ≥50km in diameter are counted within the basin to determine the N(50) Crater Retention Age (CRA). The areas used in these counts are actually 1.2 times the diameter of the basin, to account for the thickness of the basin rim.

Average Ages (AAs): Average Ages were determined by counting superimposed craters over the entire area of the lunar basin. The distribution of these, shown in Figure 2, an obvious two-peak character, as was found previously [1]. This suggests the possibility there were two periods of heavy bombardment in the history of the Moon.

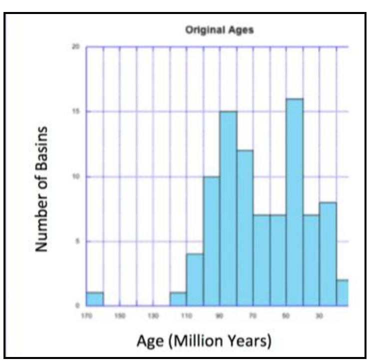

Figure 2. The distribution of whole basin average N(50) Crater Retention Ages shows two distinct peaks.

Overlap Corrected Ages (OCAs): The whole basin Average Age does not account for the resurfacing and removal of superimposed craters that takes place when a smaller younger basin is superimposed on an older larger basin. Therefore the whole basin average age can be lower than the actual formation age since there are a reduced number of craters to count. To correct for this we calculate Overlap-Corrected Ages. All basins and portions of basins that were superimposed on the basin being counted were removed (along with the craters in those areas) from the calculated area. Figure 3 shows an example for South Pole Aitken (SPA), which has a large number of smaller basins superimposed on it whose whole basin Average Ages are significantly younger than the Average Age for SPA. The N(50) CRA of only the remaining area was then determined as before. This should be a much closer approximation to the actual formation age of a basin that has experience significant resurfacing than is the whole-basin Average Age.

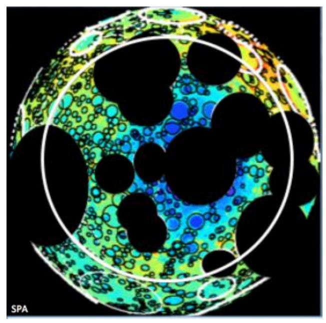

Figure 3: The dark circles are the areas subtracted in the determination of the Overlap-Corrected Age for SPA. In general this produced older ages than the whole-basin Average Age, as shown below in Figure 4.

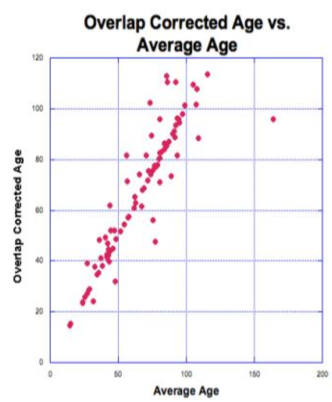

Figure 4. N(50) Overlap-Corrected Ages (OCA) vs Whole-Basin Average Ages (AA). For most basins, correction for overlap results is older ages.

OCAs can be compared with AAs in figure 4 and 5. Note the two peak character in the OCA distribution is at least as obvious as that for the AA in Figure 2.

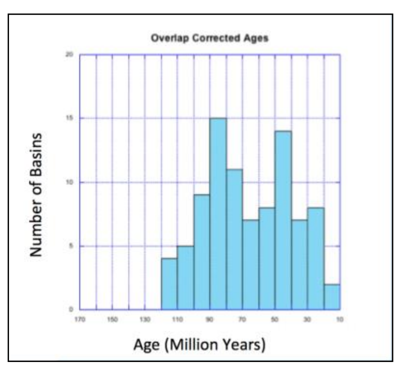

Figure 5: The histogram shows the differences in the AA and the OCA. It is evident that the ages get greater as a unit because the histogram retains the same shape.

Small Area Ages (SAAs): Overlap correction does not account for other forms of interior resurfacing that can remove craters previously superimposed on a basin. It is possible that the CRA that most closely approximates a basin formation age comes from the most densely cratered areas of the impact basin. We determined N(50) CRAs for small areas within large basins that were at least as large as the smallest basins in our inventory (D≥300 km). Figure 6 shows an example where SPA was divided for SAA counts. Figure 7 shows a comparison all of the different ways we determined ages for SPA, including a large number of SAAs. The red and blue lines represent the AA and OCA respectively. It seems likely the best N(50) age for SPA is ~ 145 MY.

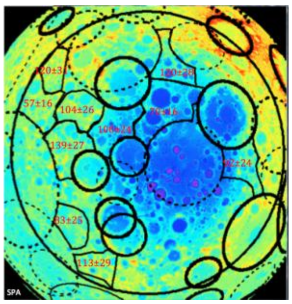

Figure 6: An example of how SPA can be divided into small areas to determine a possible maximum age.

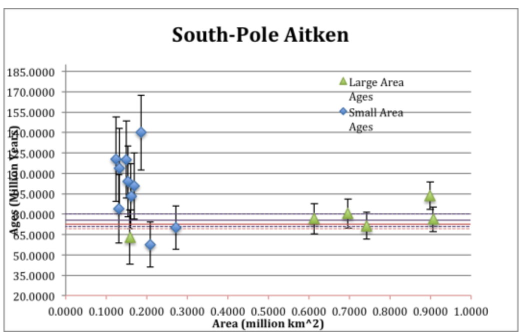

Figure 7: Comparison of all the methods for deriving N(50) CRAs for SPA. It is evident that the AA and OCA could greatly underestimate the actual retention age of the basin.

We determined SSAs for all the lunar basins ≥ 800 km diameter and compared them with the OCAs in Figure 8. In nearly all cases the SAAs are older, sometimes significantly so.

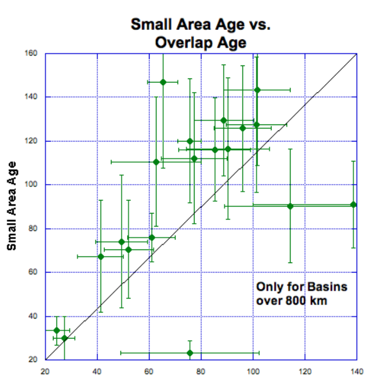

Figure 8: Small Area Ages (SAAs) plotted vs Overlap-Corrected Ages (OCAs) for basins ≥ 800 km diameter only. SAAs are almost always older and may be a better representation of formation age.

Oldest Lunar Crust Ages: We searched for regions on the Moon that could older than the oldest basins by looking at inter-basin areas and determining their N(50) CRAs. Examples of these small areas are shown in Figure 9. Note these are relatively small and never far from any large old basin. None of the N(50) ages we found in a preliminary study were substantially older than the oldest Small Area Age we found for some very old basins. This may suggest that the formation of the large number of basins > 300 km diameter has affected the entire accessible crust of the Moon.

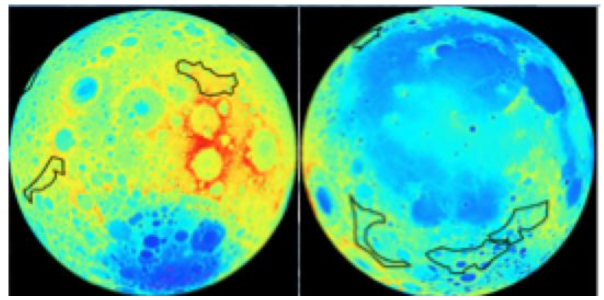

Figure 9: The outlines areas were used to test if older crust could be found between the large impact basins

Future Work: The Small Area Ages for large basins (D>800 km) are substantially older than the Overlap-Corrected Ages, and SSAs should be determined for even smaller basins. This will enable us to determine the distribution of likely formation ages and see if the two-peak character of Figures 2 and 5 is still present when likely maximum ages are used. We will also continue to look for isolated areas that may have N(50) ages older than the oldest SSA basin age we have found.

Summary: Using an inventory of candidate basins ≥ 300km diameter that includes several new features found in GRAIL crustal thickness data and LOLA topography data, N(50) Crater Retention Ages were determined in three ways: a whole basin Average Age (AA), an Overlap Corrected Age (OCA) and a Small Area Age (SAA). These were compared to ages of small areas of likely Oldest Crust (OC).

References. [1] Frey, H.V. (2012) LPSC 43, abstract #1852. [2] Romine, G. and H. Frey (2011) LPSC 42, abstract #1188. [3] Frey, H. V., H. M. Meyer and G. C. Romine (2012a) *Early Solar System Impact Bombardment II*, Abstract #4005. [4]] Wieczorek, M.A. (private communication). [5] Meyer, H.M. and H.V. Frey (2012) LPSC 43, abstract #1936. [6] Fassett, C.I. et al., JGR (Planets) LRO special issue.