CREATING CRATER CATALOGS OF THE APOLLO 15-16-17 LANDING SITES Mohini J. Jodhpurkar[1], Lillian R. Ostrach[1], W. Brent Garry[2], Scott C. Mest[3], R. Aileen Yingst[3], Noah E. Petro[2], Barbara A. Cohen[2] [1]USGS Astrogeology Science Center, Flagstaff, AZ 86001, mjodhpurkar@usgs.gov. [2]NASA Goddard Space Flight Center, Greenbelt, MD 20771. [3]Planetary Science Institute, Tucson, AZ.

Introduction: The Apollo missions will forever be remembered in history for inspiring the field of planetary geology and shaping how we think about planetary exploration, even today. But much of the mapping work done on these missions is dated when compared to the vast amounts of newly acquired lunar data; the Apollo 15 map has not been formally updated in 45 years, while even the Apollo 16 and 17 maps were last updated in 1981. In the past 40+ years, there have been many advances in technology and multiple orbital lunar missions. This availability of recently acquired high-resolution images, multispectral data, and detailed topography and gravity data, when coupled with the Apollo field observations and decades of sample analyses, makes this a prime opportunity to create a series of updated geologic maps for the Apollo missions.

There are no formalized, digital GIS files of the pre-mission geologic maps of the Apollo landing sites. Since the majority of planetary science analyses use GIS software and there is a renewed desire to return to the Moon, there is a need to have these maps digitized and updated using recently obtained lunar data.

We selected the Apollo 15, 16, and 17 missions to update first, as these areas are more geologically diverse, there was greater distance coverage of the surface on longer traverses, and there were additional science investigations associated with the missions. As part of this mapping effort, we will determine the relative and absolute model ages of defined geologic units for both the pre-mission and updated geologic maps. Absolute model ages will be derived from crater measurements obtained from the Lunar Reconnaissance Orbiter Camera (LROC) data and will be compared with previously published values.

Methods: This investigation will produce 6 new USGS Special Investigation Maps (SIM) of the Apollo 15, 16, and 17 landing sites at the regional and landing site scales. The new regional (1:200K map scale) and new landing site (1:24K map scale) maps are mapped at higher map scales than the pre-mission maps (1:250K and 1:50K) to take advantage of the higher resolution of the LROC Wide Angle Camera (WAC) and Narrow Angle Camera (NAC) base maps. Once the renovation of the old maps is complete and combined with our new mapping of geologic units, it will be possible to determine the relative and absolute model ages of each geologic unit for presentation on the new maps.

Concurrent with the geologic mapping efforts, we collected crater measurements at the Apollo 15 landing site on both the 1:200K and 1:24K base maps. Employing standard practices for conducting crater measurements, we used the CraterTools extension to ArcMap 10.7.1 [1] to measure impact craters ≥500 m in diameter on the WAC base map at a digitizing scale of 1:40K and ≥10 m in diameter on the NAC base map at a digitizing scale of 1:4K (Fig. 1). These minimum diameter values were selected based on the resolution limits of the data (i.e., confident identification of craters at 5 pixels or larger [2] and informed by the work published by Robbins et al. [3]), and to maintain consistency with the most recent complete re-assessment of ages at the Apollo landing sites [4].

Initially, all features interpreted to be craters were marked, regardless of apparent origin. Once all features were marked, we began classification based on morphologic features (e.g., primary impact crater, secondary impact crater, volcanic crater). Primary impact craters were identified on the basis of having almost entirely continuous rims with approximately circular shapes. Obvious secondary craters, identified by their occurrence in chains, herringbone patterns, or clustered groups, are in the process of being excluded, along with the area containing them. Once the geologic units are finalized, we will calculate crater spatial density values and generate crater size–frequency distribution plots using the CraterStats2 software [5,6].

We anticipate that some map units will have too small an area to adequately determine a crater-model age [4], especially in the 1:24K landing site maps. In those cases, a relative age will be assigned based on stratigraphic relationships with other units.

Results and Discussion: We have created a crater catalog at the Apollo 15 site to help further define and update (when needed) age interpretations. To date, we have mapped ~6300 craters in the 1:24K map and ~500 craters in the 1:200K map. We are currently in the process of excluding the secondary craters and the areas containing them from the maps.

Most of the area surveyed for the 1:200K map (Fig. 2) was dominated by rougher highland regions, with elevation increasing from northwest to southeast, before dipping lower again. Over half of the craters marked here were between 500 m and 1 km in diameter, while only four were above 5 km in diameter, making them stand out in the base map. At the 1:24K map scale (Fig. 3), the mare regions, which appeared smooth in the 1:200K map, were actually quite densely cratered. We surveyed the craters in the mare first, as it

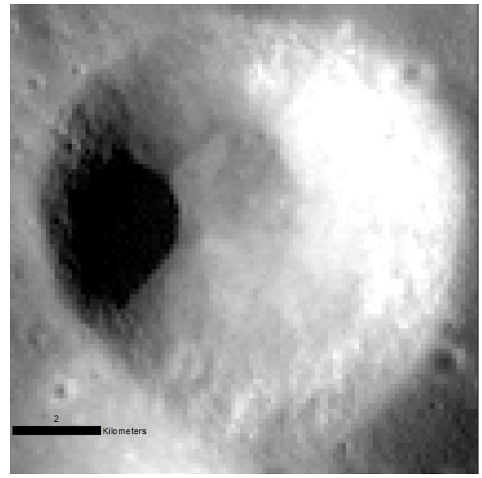

Figure 1 (above): Hadley B is the largest crater (D = 9 km) observed in the Apollo 15 1:200K map region, shown here at the 1:40K digitizing scale [Image: LROC WAC].

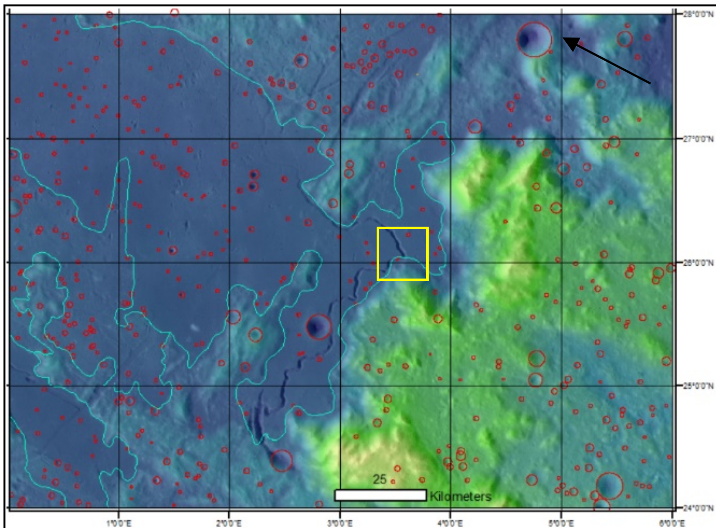

Figure 2 (top left): Craters ≥ 500 m in the Apollo 15 1:200K regional map area are circled in red. The LROC WAC base map is overlaid with the SLDEM showing areas of low elevation in dark blue and purple and high elevation in yellow. The yellow rectangle marks the area of the 1:24K landing site map, and the black arrow points to the location of the crater in Figure 1.

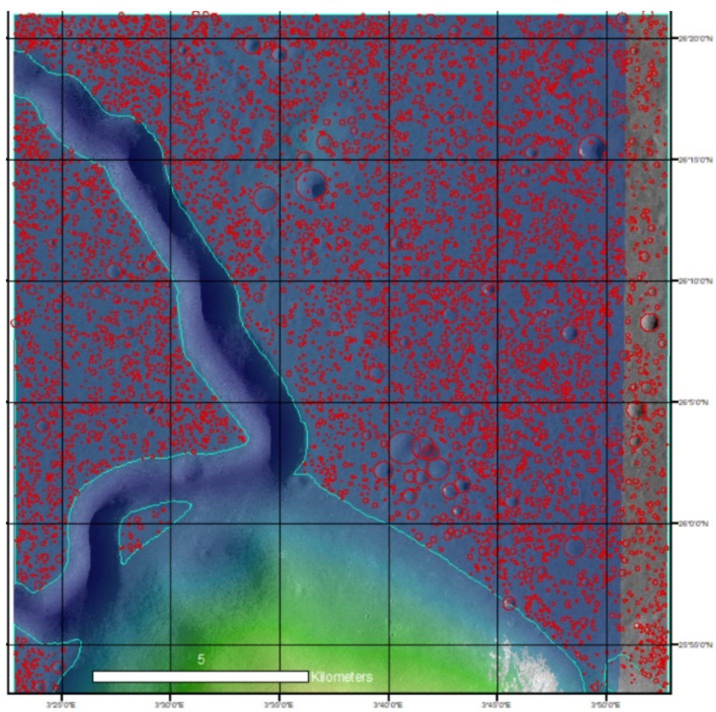

Figure 3 (bottom left) : Craters ≥ 10 m circled in red on the LROC NAC base map of the Apollo 15 1:24K landing site map. The SLDEM also shows areas of low elevation in dark blue and purple and high elevation in yellow.

dominated the landing site area, and, in the future, we plan to include the craters within the rille, if measurable, and the portion of the highlands visible in the area. Over half of the craters marked at this scale had a diameter smaller than 500 m, with only ~500 of them having a diameter above 1 km. Further, many of the larger craters are degraded and difficult to reliably identify, so it is possible that the number of larger craters measured may increase as we continue to validate our data.

Once the geologic units in these two maps are finalized, we can make age interpretations based on these crater catalogs. Future work involves excluding secondary craters and areas containing them from both maps, marking the craters in the currently excluded portion of the 24K map, and creating these crater catalogs at the regional and landing site scale for the Apollo 16 and 17 sites.

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