Creating Crater Catalogs of the Apollo 15-16-17 Landing Sites

#1590

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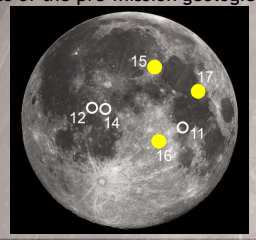
Background:

- The Apollo missions inspired the field of planetary geology and shaped how we think about planetary exploration, even today.
- However 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 updated maps.
- There are no formalized digital GIS files of the pre-mission geologic maps of the Apollo landing sites.



Yellow dots indicate the locations of the Apollo 15, 16, and 17 landing sites relative to the surface of the Moon.

Objectives:

Since the majority of planetary science analyses use GIS software, 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, covered greater traverse distances, and there were additional science investigations associated with these 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.

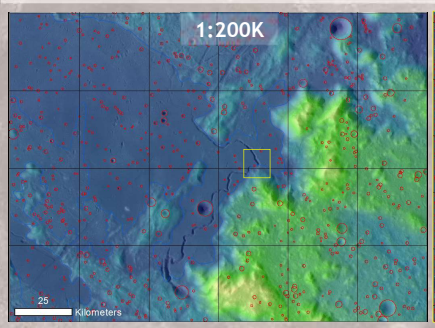
Methods:

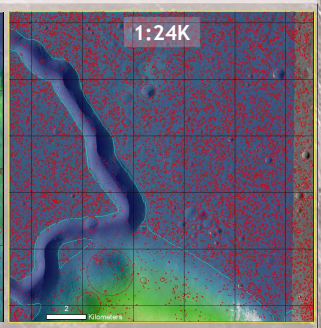
- This work focuses on producing 6 new USGS Special Investigation Maps of the Apollo 15, 16, and 17 landing sites at the regional and landing site scales.
- The new regional (1:200K map scale) and new landing site (1:24K map scale) maps will be published at higher map scales than the pre-mission maps (1:250K and 1:50K).
- Concurrent with geologic mapping efforts, we are collecting crater measurements at all three sites and both scales using the CraterTools extension to ESRI ArcMap (Kneissl et al., 2011).
- Impact craters ≥500 m in diameter on the LROC Wide Angle Camera (WAC) base map and ≥10 m in diameter on the Narrow Angle Camera (NAC) base map were measured – these minimum diameter values were selected based on the resolution limits of the data.
- First, all features interpreted to be craters were marked, regardless of apparent origin; now, we are in the process of excluding secondary craters and the areas containing them.
- Once geologic units are finalized, it will be possible to make age interpretations based on crater counts – if a unit has too small of an area to determine a crater age, a relative age will be assigned based on stratigraphic relations with other units.

Regional (200K) and Landing Site (24K) Crater Maps for Apollo 15, 16, and 17

Craters ≥500 m on the 1:200K regional map area and ≥10 m on the 1:24K landing site map are circled in red. Both the LROC WAC and LROC NAC base maps are overlaid with SLDEMs showing areas of lower elevation in dark blue and purple and higher elevation in yellow. Yellow rectangles mark the area of the landing site maps on the regional maps.

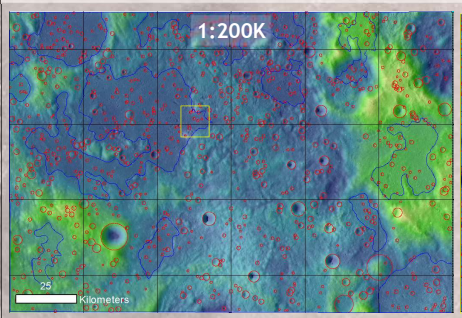
Apollo 15

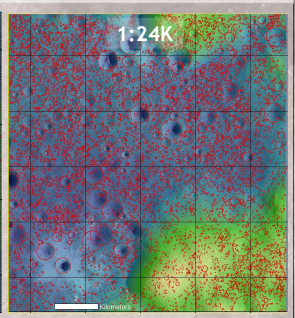




The Apollo 15 1:24K landing site map is comprised primarily of smooth mare and dominated Hadley Rille, which has far less craters on its inside due to the slope.

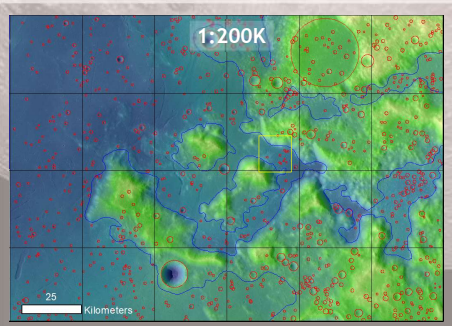
Apollo 16

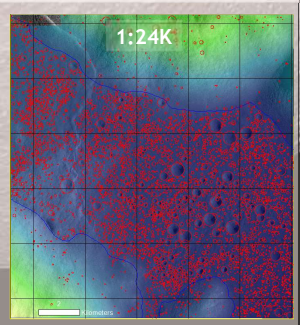




The Apollo 16 1:24K landing site map exhibits larger superposed craters, and notably a fresh crater with visible ejecta deposit in the lower left obliterated much of the smaller craters surrounding it.

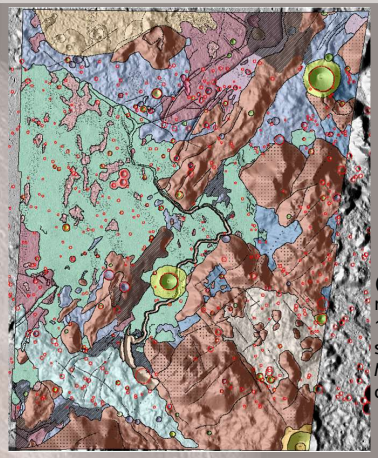
Apollo 17



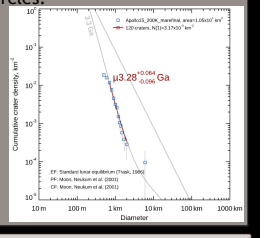


At the Apollo 17 landing site, an abundance of secondary craters in dispersed clusters in in the 1:24K landing site map poses a challenge for measuring the primary crater population for age determinations.

Results:



(Left) Draft updated and revised 1:200K map at Apollo 15, with geologic units and structural symbols marked. Measured craters shown as red circles.



(Right) Based on this cumulative crater density plot, the age of the mare unit (partially shown in green above) at the 1:200K scale was interpreted to be ~3.3 Ga. This agrees with previously published age interpretations of the mare in this region(eg. Stoffler et al.,2006), along with current work (Iqbal et al.,2020).

Conclusions:

- To date, we have mapped ~640 and ~8250 craters for the Apollo 15 regional and landing site maps respectively,~900 and ~6480 craters for the Apollo 16 maps, and ~830 and ~4110 for the Apollo 17 maps.
- All three areas have different geologic characteristics that influence their crater density (for instance, the Apollo 17 landing site map has half the crater content of Apollo 15 in part because it has less mare).
- Most of the area for the regional scale maps were dominated by highlands, while the landing sites themselves were dominated by mare.
- Most craters at the regional scale have diameters between 500 m and 1 km.
- Most craters at the landing site scale, however, have diameters less than 500 m.
- Preliminary age interpretations based on the crater count at the regional scale for the mare unit at Apollo 15 suggest the age is approximately 3.28 Ga, in line with previous research.

Future work:

Future work involves excluding secondary craters and areas containing them for the Apollo 16 and 17 maps, along with the Apollo 15 landing site map; making age interpretations based on these crater catalogs for the aforementioned maps once those geologic maps are completed; and calculating crater spatial density values along with generating crater size-frequency distribution plots using CraterStats2 software.

References: [1] Iqbal et al. (2020) *Lunar Planet. Sci. LI*, 1073 (abstract) [2] Kneissl T. et al. (2011) *Planet. Space Sci.*, 59, 1243-1254. [3] Stoffler et al. (2006) *Rev. Min. Geochem.* 60, 519-596.

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