UPDATING THE GEOLOGIC MAPS OF THE APOLLO 15-16-17 LANDING SITES – YEAR 1. W. B. Garry[1], R. A. Yingst[2], S. C. Mest[2], L. R. Ostrach[3] [1]NASA Goddard Space Flight Center, Greenbelt, MD 20771, brent.garry@nasa.gov, [2]Planetary Science Institute, Tucson, AZ, [3]USGS Astrogeology Center, Flagstaff, AZ.

Introduction: Our team is funded by NASA PDART to produce updated geologic maps of the Apollo 15-16-17 landing sites at a regional (1:200k) and landing site (1:24k) map scales. As part of the project, we will map craters to determine crater-age models for newly defined map units and renovate the original, pre-mission geologic maps of each landing site to LRO base maps in ArcGIS (Table 1). These pre-mission geologic maps of the Apollo landing sites preserve a unique moment in the history of human space exploration – the initial interpretations of the lunar surface prior to exploration by the Apollo astronauts. Our new maps will incorporate findings and interpretations from nearly 50 years of studies of the original Apollo data, surface observations, sample analyses, and recent remote sensing data.

Table 1. Summary of project goals

Task 1	Digitize pre-mission geologic maps
Task 2	Create 6 new USGS SIM maps at 1:200k & 1:24k
Task 3	Determine crater-derived ages for new units

Project Milestones – Year 1:

Task 1. Renovation of Pre-Mission Geologic Maps: We have renovated the regional geologic maps for each mission to LROC WAC 100 m/px mosaic: Apollo 15 (1:250k) [1], Apollo 16 (1:250k), and Apollo 17 [2], and Apollo 17 (1:250k) [3]. We created an ArcMap 10.6.1 projects for each map that consisted of a personal geodatabase with layers for nomenclature, map units, geologic contacts, linear/structural features, location features, and surficial deposits. LROC WAC, Clementine, and SLDEM data in Mercator projection were downloaded from the USGS Map-A-Planet website. High-resolution scans of the pre-mission geologic maps (300 dpi, *.jpg2000) available from LPI were cropped in Adobe Photoshop, saved as a *.tif, and imported into the ArcMap projects. Approximately 150-200 control points were used to georeferenced each original map to the WAC base maps. Linework was digitized at 1:10,000 with vector spacing at 50 m, following recommendations in USGS's Standard Operating Procedures for GIS Digitization and Renovation to a New Base Map. Polygons were created from the geologic contacts layer and colorized to resemble the original map color schemes.

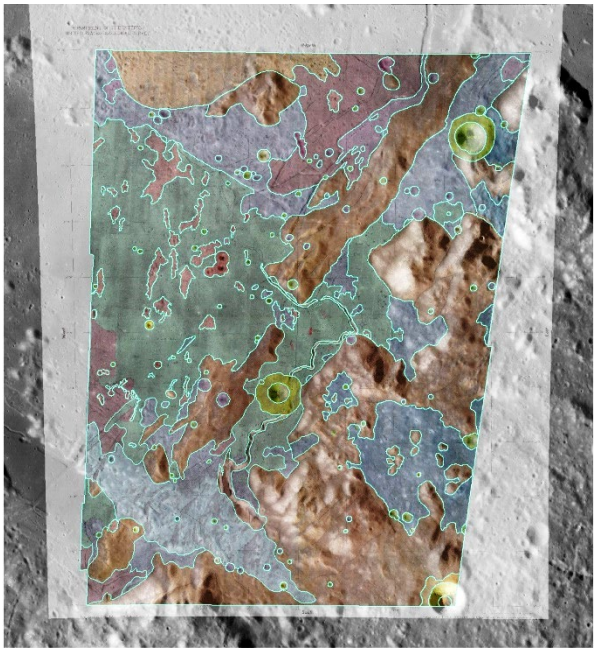

Figure 1. Linework for geologic contacts for the renovation of the regional Apollo 15 pre-mission geologic map (1:250k) [x] on LROC WAC basemap.

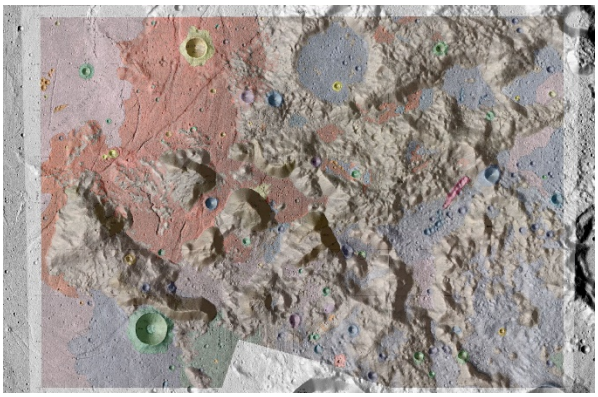

Figure 2. Apollo 17 regional geologic map [x] georeferenced to WAC and overlain on SLDEM hillshade.

Task 2. Updating the Geologic Map of Apollo 15 Landing Site:

GIS Projects. The USGS has created individual ArcGIS projects for each regional and landing site map. The basemaps for the 1:24k maps include NAC mosaics (1.4 m/px), NAC DTM, and hillshade rasters. For the 1:200k maps, base maps include WAC 100 m/px, WAC color, SLDEM topography. Mapping layers for both the

1:24k and 1:200k projects include geologic contacts, linear features, location features, and surface features.

Apollo Stations and Traverse Routes. Collaborator Noah Petro provided shapefiles for the Apollo missions which included point locations of each landing site and science station, and line work for the traverse path of each EVA. These layers were added to the 1:24k maps.

Mapping. We have begun to rough in the line work for linear features for the Apollo 15 1:24k map (Fig. 3) to gauge the types of features that will be mapped and appropriate symbology.

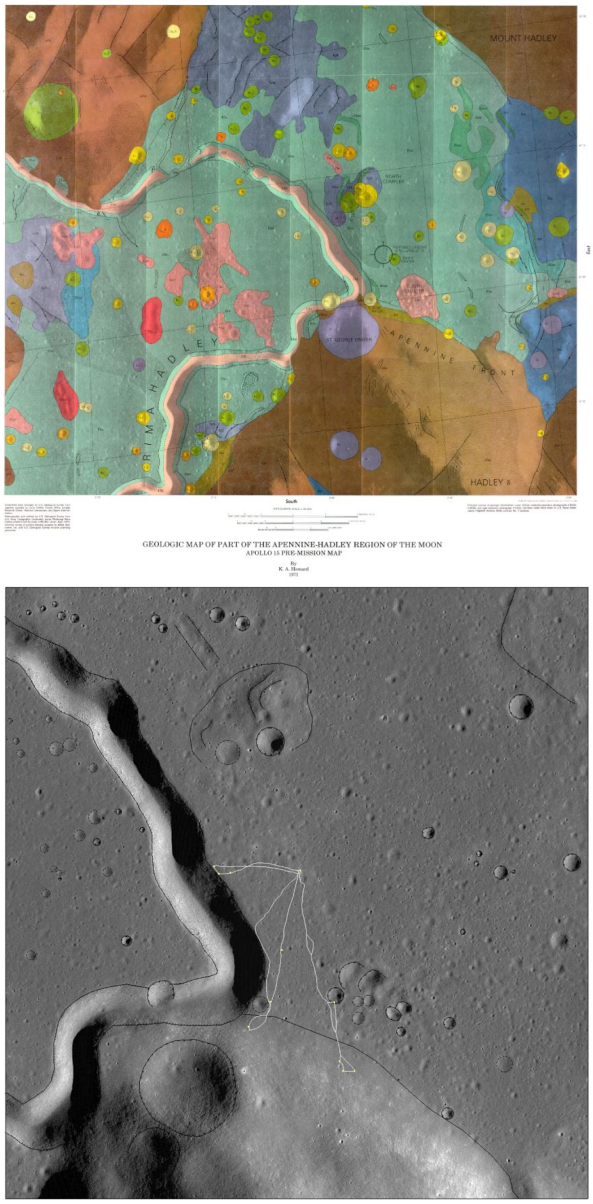

Figure 3. (Top) Original pre-mission geologic map of Apollo 15 landing site [x]. **(Bottom)** We have started to rough in the linear features for the new Apollo 15 1:24k landing site with traverse paths and stations.

Post-Mission Studies. The Apollo 15 Preliminary Science Report [4] included a sketch map of the local geology (Fig. 4), but no in depth geologic maps to use as primary reference for our project. However, there was significant discussion about the outcrops in Hadley Rille [4] and we will adopt a style used by [5] to map Rima Marius and apply it to our map of Hadley Rille. Additional studies are being reviewed for information about possible map units.

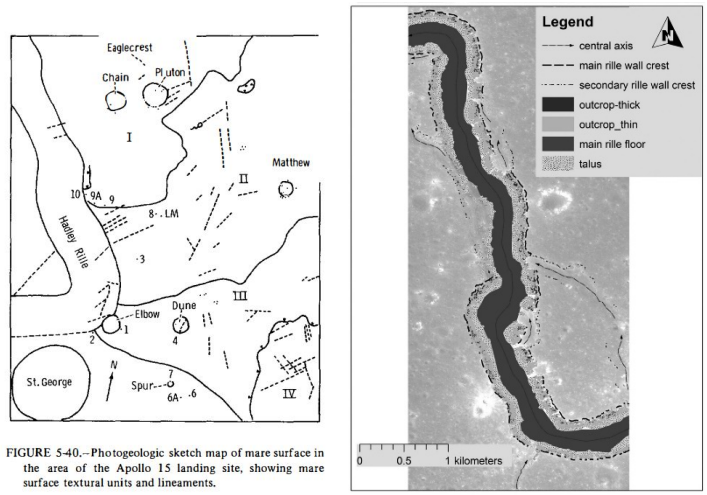

Figure 4. (left) The Apollo 15 preliminary science report only included a general sketch map of the landing site [4]. (right) Mapping style for used for Rima Marius [5] that will be applied to Hadley Rille.

Task 3. Determine crater derived ages for new units: We will begin mapping the craters for each map project starting in year 2.

Note: New geologic maps of the Apollo 11, 12, and 17 landing sites have been produced by another research group unrelated to our project [6, 7].

References: [1] Carr M. H. and El-Baz F. (1971) Apollo 15, *USGS,* I-723, 1:250k. [2] Milton D. J. (1972) Apollo 16, *USGS*, I-748, 1:250k. [3] Scott D. H. and Carr M. H. (1972) Apollo 17, *USGS*, I-800, 1:250k. [4] Swann G. A. et al. (1972) NASA SP-289. [5] Roberts C. E. and Gregg T. K. P. (2019) *Icarus*, 317, 682-688. [6] Iqbal, W., Hiesinger, H., and van der Bogert, C. H. (2019) Apollo 11, 12, *50th LPSC,* Abstract 1070. [7] Iqbal, W., Hiesinger, H., van der Bogert, C. H. (2019) Apollo 17, *50th LPSC,* Abstract 1005.