Renovating and Digitizing the 1:25k Geologic Map of the Apollo 11 Landing Site. B. McCardle[1] and W. B. Garry[2], [1]Kutztown University of Pennsylvania, [2]NASA Goddard Space Flight Center.

Introduction: In order to decide where to safely land on the moon, scientists working on Apollo created pre-mission geologic maps of several locations on the Moon. These geologic maps are unique in that they represent the initial geologic interpretations of various areas prior to surface exploration. However, there are no publicly available geographic information system (GIS) files available for these maps, which is the common format in use today. Another issue is that these maps have not been formally updated in nearly 40 years despite the wealth of information from the astronauts' observations, post-mission sample analyses, and data from recent orbital missions. The original Apollo 11 pre-mission landing site map was created by Maurice J. Grolier in 1970 **[1]** and is only available digitally as scanned images, making it difficult to compare original maps with more recent data sets.

The USGS has digitally restored the 1:5M geologic map of the Moon **[2,3]** but have not completed any of the landing site maps. Our project goal is to digitally restore the pre-mission geologic map of the Apollo 11 landing site for use with recent data sets from images from the Lunar Reconnaissance Orbiter Camera (LROC) onboard the LRO spacecraft. This reconstructive map will not only serve as a tool for future analyses, but to also preserve the scientific history of past-missions.

Methods: LROC Narrow Angle Camera (NAC) images for the targeted area were processed using the USGS astrogeology Planetary Image Locator Tool (PILOT) and Projection on the Web (POW) website **[4]**. Images were processed at 0.5 m/pixel and Mercator projection to match the original map. A set of low-sun angle images were selected to highlight the morphology of the landing site. Each image was imported into ArcMap where we georeferenced and aligned them by hand to correct slight offsets at the image boundaries. The images were edited through touch-ups of contrast and brightness for a consistent appearance across the new renovated basemap **(Figure 1**).

The 1970 original geologic map was then imported into ArcMap and georeferenced to the NAC basemap using control points. Small craters and other surface features visible on the original geologic map were matched with the new registered basemap (**Figure 2**). We used over 100 control points and the map was stretched using the *adjust* transformation process in ArcMap's georeferencing toolbar.

Next, to recreate the map features in ArcMap a new geodatabase was created with the following mapping layers: geologic contacts, linear features, and map units. Unit names, contact types, and map symbols matched the original map. Each contact line and linear feature were traced to recreate the line work done from the original map. Once recreated, the geologic contacts are converted to polygons, and joined with the map units, then colorized with the color scheme to create the new digital version of the original map (**Figure 3**).

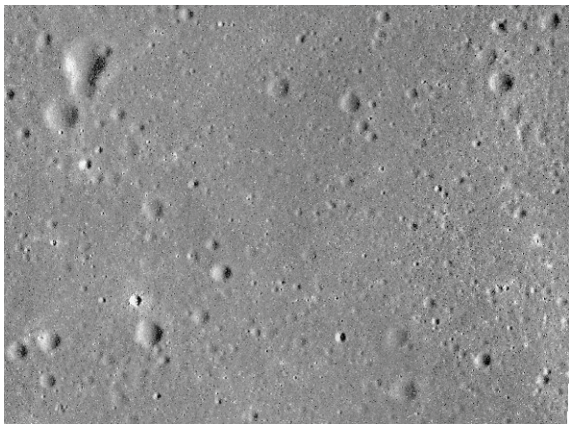

Figure 1: Using images from LROC-NAC processed on the USGS POW PILOT website, a new higher resolution mosaic was created in Arcmap to serve as the new basemap.

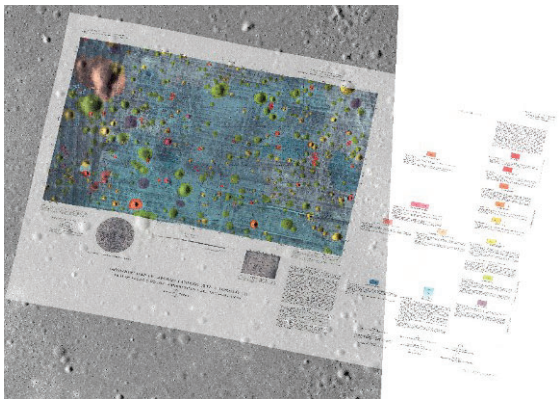

Figure 2: Overlay a digital scan of the original Apollo 11 landing site map **[1]** georeferenced to the higher resolution LROC NAC basemap in Arcmap using control points.

Discussion: The digitized version provides a clearer view of the original interpretation and map units on a higher resolution basemap. Additional basemaps (e.g., NAC at different sun angles and multi-spectral maps) can also be imported for comparison with the map contacts and features. Individual map layers can now be turned off to

isolate certain aspects of the map for comparison and correlation with various basemaps and data. This map is part of an ongoing effort to renovate and digitize each of the Apollo pre-mission maps for the USGS online archive **[5]**. These GIS projects will be accessible by the public and science community for future research of the lunar surface including comparisons with any updated geologic maps or work at of these landing sites **[e.g., 5, 6]**.

Summary: A digital version of the map was reconstructed using ArcGIS mapping software and high-resolution images from LROC Narrow Angle Camera. The quality of the digitally restored map has been significantly improved and the original geologic interpretation of the Apollo 11 landing site **[1]** can be compared with a variety of other data sets from more recent missions.

References: **[1]** Grolier, M. J. (1970) Geologic map of the Apollo landing site 2 (Apollo 11), 1:25k, *USGS I-619*. **[2]** Fortezzo, C. M. and Hare, T. M. (2011), *42nd LPSC*, abstract 2293. **[3]** Fortezzo, C. M. and Hare, T. M. (2013) *44th LPSC*, abstract 2114. **[4]** USGS (2018) Projection on the Web, https://astrocloud.wr.usgs.gov/. **[5]** Garry, W. B. et al. (2018) *AGU Fall Meeting*, abstract P23E-3498. **[6]** Iqbal, W., Hiesinger, H., van der Bogert, C. H. (2017) *48th LPSC*, abstract 1258.

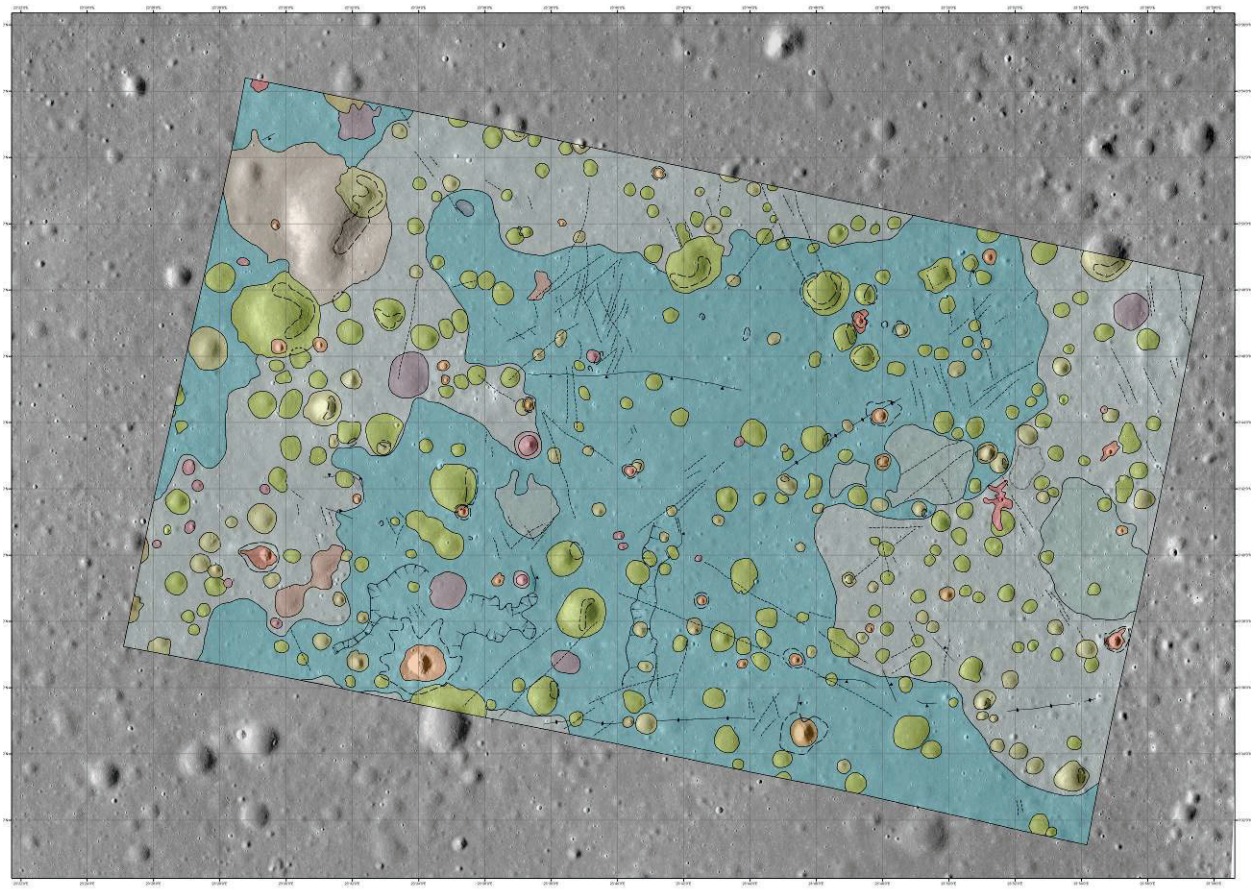

Figure 3: Renovated version of the original 1:25,000 Apollo 11 pre-mission landing site geologic map **[1]** overlain on a renovated basemap of LROC NAC images. The GIS project is being prepared to submit to the USGS online cartography archive for public access.