CARTOGRAPHIC PROCESSING OF DIGITAL LUNAR ORBITER DATA. L.R. Gaddis, T. Sucharski, T. Becker, and A. Gitlin, Astrogeology Team, U.S. Geological Survey, 2255 N. Gemini Drive, Flagstaff, AZ (lgaddis@usgs.gov).

Introduction: We have completed work for a pilot project demonstrating our capabilities for high-resolution digitization and cartographic processing of 5 full Lunar Orbiter (LO) IV frames: 109H, 110H, 114H, 115H, and 114M. These data cover Eratosthenes crater on the west to Mare Serenitatis in the east, and Archimedes crater in the north to Rima Hyginis in the south. Geologic features in this area include parts of the Apennine Mountains, the KREEP-rich Apennine Bench Formation, Rima Bode pyroclastics, Mare Vaporum, Sulpicius Gallus, and the Imbrium basin ejecta southeast of the basin rim. This region provides an excellent introduction to this image product because it encompasses a wide variety of lunar geologic units, processes, and ages. Thus it should be a valuable resource for the lunar science community. Finally, these high-spatial-resolution digital data will provide a very useful complement to numerous other digital geochemical, geophysical, and multispectral data for this central nearside region.

Background: The full LO dataset consists of 967 medium-resolution and 983 high-resolution frames [1]. The LO images were photographic products acquired on the spacecraft in five missions (LO I through V) while in orbit over the lunar surface ([2]). The original high-resolution photographic exposure consisted of a 55 mm x 219.18 mm scene on 70 mm film. The LO data were transmitted to Earth as analog data after onboard scanning of the original film into a series of strips. Upon receipt on the ground, data for each framelet were written onto 35 mm film covering 20 mm x 66.44 mm, thus the film strip written on Earth was 7.5 times larger than the strip on the spacecraft. Photographic prints from these film strips were hand mosaicked into sub-frame (for high-resolution data) and full-frame (for medium-resolution data) views and widely distributed. The resulting outstanding views were of generally very high spatial resolution and covered a substantial portion of the lunar surface, but they suffered from a "venetian blind" striping, missing or duplicated data, and frequent saturation effects that hampered their use.

Data Processing: Archival LO positive film strips [1] were scanned commercially at 25-micron/pixel (e.g., ~16 m/pixel for high-resolution frames). Each scanned film strip consists of a 16377 x 766 pixel image, with overlap between strips of ~37 pixels. Our processing of these digital data included (1) *geometric rectification and mosaicking* into subframes (3 subframes or 96 strips per frame), (2) *cosmetic rectification* (largely destriping and noise removal), and (3) *cartographicy controll* through coregistration to the 750-nm Clementine image base [2] via manual tie-pointing and warping (**Figure 1**).

Geometric rectification and mosaicking. We made use of several aspects of the original LO film to perform the geometric rectification. Prior to the LO flights, the photographic film was exposed with strip numbers, nine-level gray-scale bar, resolving power chart, and reseau marks. Each film strip has ~35 reseaux, and a single high-resolution frame has ~2185 reseaux. Reseaux locations are used to compensate for film distortion in the creation of the digital mosaic and in the geometric rectification process **(Figure 1a**). During our processing, reseaux were manually identified, but plans are to automate this procedure in the future. Geometric rectification was performed using a weighted least-squares fit to a 1st order polynomial describing the orthogonal positions of the reseaux.

Cosmetic rectification. Cosmetic clean-up focused largely on the removal of stripes through the application of spatial filters. To minimize artifacts during this process film numbers and other extraneous data were assigned to a null value. An image of the striping patterns is created for each subframe mosaic by applying a series of low- and high-pass spatial filters with parameters that define the approximate widths of the stripes. This image of the stripe pattern is then subtracted from the subframe mosaic, substantially improving the appearance of the mosaic (**Figure 1b**). Further improvements to this process are possible and would include temporary removal of the reseaux and other bright features that produce ringing and aliasing artifacts during filtering.

Cartographic control. The digital LO subframe mosaics are cartographically controlled through coregistration to the Clementine 750-nm controlled image base via manual tie-pointing and warping with a weighted least-squares fit to a 2nd order polynomial (**Figure 1c**). Future improvements to this process will include the development of a LO camera model and comparison to the Clementine coordinate system for updating the LO spacecraft pointing information and evaluating optical distortion of the LO camera.

Summary and Future Work: Final products (**Figure 1**) include digital mosaics for each subframe and ISIS processing procedures for reseau location, destriping and cosmetic correction. Interim products

(e.g., rectified subframe mosaics without destriping) are available upon request. The ISIS procedures for noise and stripe removal can also be applied with excellent results to data from the Digital Lunar Orbiter Photographic Atlas (**Figure 2**; [3]) to further enhance that valuable data archive.

Only a fraction of the LO data have been processed as described. We will request further comment from the user community to identify high-priority frames for possible future processing. Global coverage of the Moon with LO data at high spatial resolution would be possible with ~400 frames from LO IV and LO V.

References: [1] Bowker and Hughes, 1971, Lunar Orbiter Photographic Atlas of the Moon, NASA SP-206. [2] Eliason *et al.*, 1999, Mission to the Moon, The Clementine UVVIS Global Mosaic, PDS CL_4001-4078. [3] Gillis (ed.), 2000, Digital Lunar Orbiter Photographic Atlas of the Moon, LPI Cont. #999, CDROM.

Figure 1a. The raw LO IV 109H3 subframe mosaic.

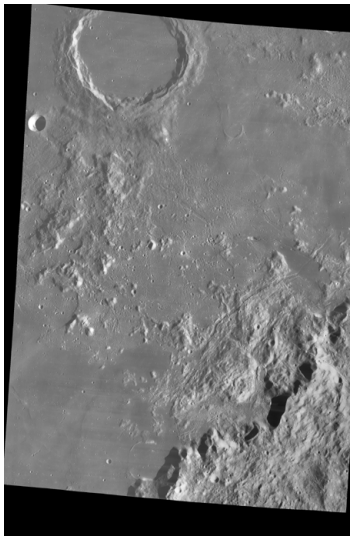

Figure 1b. The geometrically and cosmetically rectified subframe mosaic for LO IV 109H3 (trimmed to match the Clementine data).

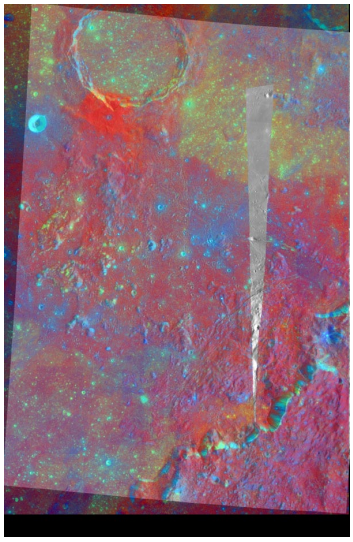

Figure 1c. The rectified LO IV 109H3 subframe mosaic with superimposed color-ratio Clementine mosaic (red=750/415; green=750/950; blue=415/750).

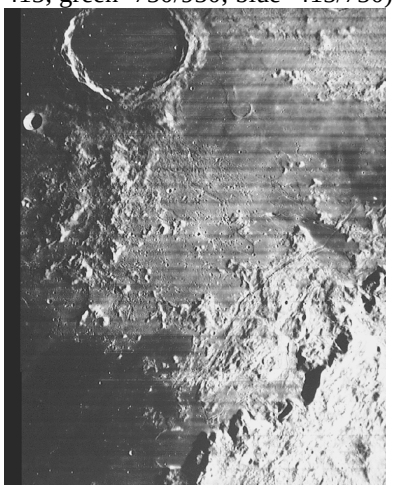

Figure 2a. Original image of LO IV 109H3 from the Digital Lunar Orbiter Photographic Atlas [3].

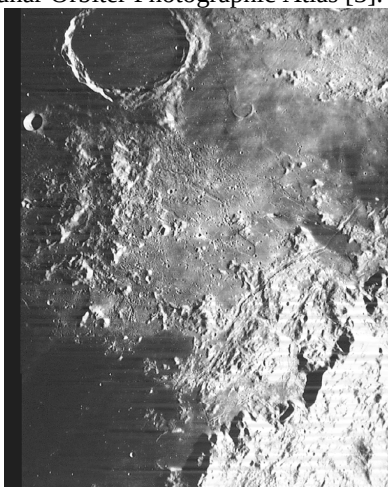

Figure 2b. Cosmetically corrected LO IV 109H3 [3].