LUNAR ORBITER REVIVED: VERY HIGH RESOLUTION VIEWS OF THE MOON. L. Weller, B. Redding, T. Becker, L. Gaddis, R. Sucharski, D. Soltesz, D. Cook, B. Archinal, A. Bennett, T. McDaniel, Astrogeology Team, U.S. Geological Survey, 2255 N. Gemini Drive, Flagstaff, AZ (lweller@usgs.gov).

Introduction: During the mid-1960's, NASA launched an investigation of the Moon consisting of five identical unmanned spacecraft. One objective of this Lunar Orbiter (LO) program was to collect photographic data to survey potential future landing sites and increase man's general knowledge of the lunar surface. LO missions I, II, and III photographed areas primarily to locate and confirm suitable landing sites for the Apollo program. Mission IV covered a broader area in a more systematic fashion. The tasks of mission V included completing both the site certification for candidate landing sites and to complete far-side coverage not acquired by mission IV.

The initial effort of processing Lunar Orbiter imagery by the U.S. Geological Survey Astrogeology Program emphasized global coverage of the Moon. The outcome of this work will be a global, cartographically accurate, digital mosaic of the Moon [1-5]. Concurrently, a subset of low altitude, very high resolution (VHR) 35mm filmstrip data from LO missions III and V were scanned, archived and processed through scene assembly. These reconstructed scenes are commonly referred to as frames [6]. Current work on these data includes cartographic control and cosmetic processing. We report on the progress of both the Lunar Orbiter global and very high resolution projects at the USGS.

VHR Data: Nearly 400 successful exposures at low altitude were obtained of the Moon's near side during LO missions III and V [7]. Each Lunar Orbiter exposure ideally resulted in two photographs – one each from the medium-resolution (MR) and high-resolution (HR) cameras. Ground resolutions range from 1-5 meters/pixel for the HR camera, and 10-40 meters/pixel for the MR camera. Divided nearly evenly between areas covering potential Apollo landing sites and those of general interest, these data provide vertical, oblique, and stereo views of the Moon's surface in never before seen detail.

Encompassing 86 photographed areas (or sites), the VHR data include nearly 800 individual images to choose from. The objective of the VHR Lunar Orbiter task was to scan as much high resolution data as possible in a year's time, and subsequently archive and construct the data into the familiar frames as viewed by the spacecraft. A reasonable number of these frames were selected by a panel of lunar experts. Chosen photographs were based on historical and scientific interest and include such notables as the Apollo Landing Sites, Copernicus crater, and a number of sites covering lunar rilles.

VHR Project Products: Raw frame construction is complete and was accomplished using ISIS [8-10] and procedures developed by the global project. We have scanned, archived and constructed 164 VHR frames, falling within 27 sites and comprising ~20% of the available LO III and V low altitude imagery of the moon. Digitally constructed LO frames in a 'raw' (non-cosmetic) format can be obtained at 100-micron resolution from the Lunar Orbiter web site (http://astrogeology.usgs.gov/Projects/LunarOrbiterDigitization/). Cartographically controlled and cosmetically enhanced data will be distributed online as it becomes available.

VHR Cartographic Control: Geometric control of VHR frames is proceeding on a site by site basis. The first stage of establishing control involves collecting tie-points among overlapping VHR data frames falling within the same geographic location. Iterative triangulations of these point positions to adjust camera pointing will ensure coregistration between all frames within a single region. The final stage of geometric control will involve collection of tie-points between VHR LO data frames and corresponding LO IV global frames referenced as truth. The result of this adjustment will be LO VHR map-projected frames that coregister to the LO global mosaic. These data will be made available online.

VHR Cosmetic Processing: A cosmetic procedure which aesthetically enhances the VHR dataset while preserving detailed features is being developed and will be applied to all frames. The white synchronization marks found along the sides of individual LO film strips are distracting and limit the quality of the imagery. Removing these elements and smoothing the data with a Gaussian-type filter will offer a clearer view of the Moon with a minimal degree of compromise to the integrity of the data. Every effort is being made to preserve small features situated in close proximity to the synchronization lines, but complete preservation of these features can not be guaranteed. Cosmetically enhanced products will also be made available online.

Global Mosaic Update: Construction of the global mosaic using LO III, IV and V moderate resolution digital frames is near completion (***Figure 1***). A 60 meters/pixel mosaic will be accessible through the Astrogeology/Planetary Data System web tool Map-a-

Planet (http://pdsmaps.wr.usgs.gov/maps.html). Geometric control for the global mosaic is based on the recent Unified Lunar Control Network (ULCN) 2005 [11]. Individual LO digital frames remain available on the USGS Astrogeology web site.

Summary: These global and very high resolution Lunar Orbiter data present unique views of the lunar surface in support of current lunar science and future lunar exploration. The many detailed scenes of the Moon delivered by the LO VHR cameras have not been available for scientific use through any other historic or contemporary dataset, making this digital archive an invaluable collection. In particular, these VHR data of the lunar surface provide some of the best views of soils, boulders, and other features on the surface of the Moon. Historically exciting features such as the crater Vitello (***Figure 2***) can now be viewed and studied in a high resolution digital format.

References: [1] Gaddis et al. (2001), *LPS XXXII*, #1892. [2] Lunar Orbiter Pilot Project: http://astrogeology.usgs.gov/Projects/LunarOrbiterDigitization/. [3] Gaddis et al. (2003), *LPS XXXIV*, #1459. [4] Becker et al. (2004), *LPS XXXV*, #1791. [5] Becker et al. (2005), *LPS XXXVI*, #1836. [6] Bowker and Hughes, (1971), NASA SP-206. [7] Hansen (1970), Guide to Lunar Orbiter Photographs, NASA SP-242. [8] Torson et al., (1997), *LPS XXVIII*, #1443. [9] Eliason, (1997), *LPS XXVIII*, #331. [10] Gaddis et al. (1997), *LPS XXVIII*, #387. [11] Archinal et. al., this volume.

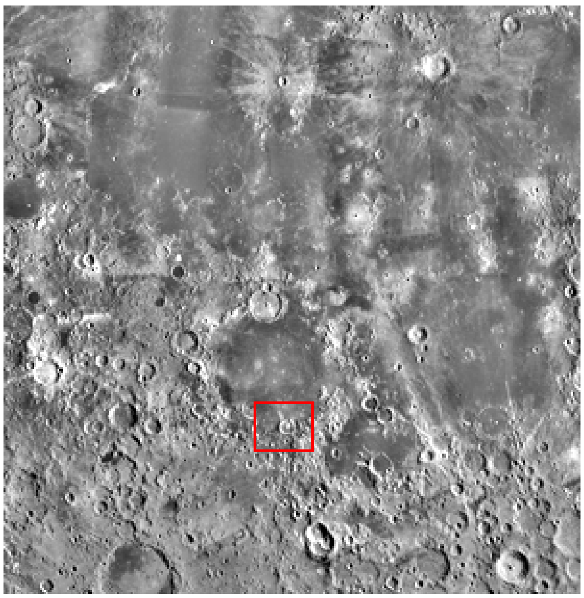
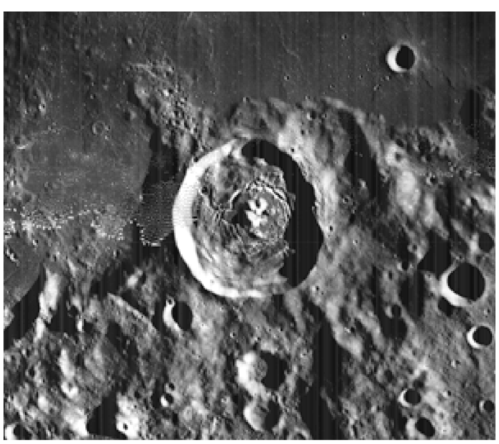
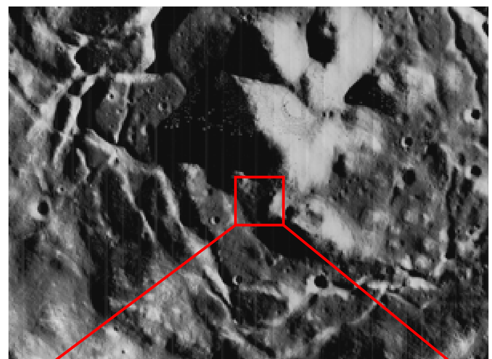


Figure 1. Portion of LO global mosaic (45°S-17°N, 4°W-70°W) showing Copernicus crater, Mare Insularum, Procellarum, Mare Humorum, Tycho crater, and Mare Nubium. Inset box centered on crater Vitello in Mare Humorum.



(a)



(b)

(c)

Figure 2. North is up in all images. (a) VHR LO V Frame 168M, Vitello crater and surrounding area. (b) VHR LO V Frame 168H2, showing central peak of Vitello crater. (c) Full resolution view of Figure 2b revealing rolling boulders in the vicinity of central peak. The area of this scene is 855 x 825 meters and has a ground resolution of 1.9 meters/pixel.