**A NEW CLEMENTINE BASEMAP OF THE MOON.** E.M. Lee, L.R. Gaddis, L. Weller, J.O. Richie, T. Becker, J. Shinaman, M.R. Rosiek, and B.A. Archinal, USGS, 2255 N. Gemini Dr, Flagstaff, AZ 86001 (elee@usgs.gov).

**Introduction:** Clementine (officially called the Deep Space Program Science Experiment) was a joint project between the Department of Defense and NASA [1] carried out from February to May 1994. The mission was designed to test advanced spacecraft components but it also collected over a million images of the Moon at different wavelengths from four different cameras. Because of its ~global coverage and high spatial resolution (100 to 200 m/pixel), Clementine data from the Ultraviolet/Visible (UVVIS) camera at near-visible (750 nm) wavelengths were used to create a cartographic mosaic or 'basemap' of the Moon [2]. Approximately 43,000 Clementine frames were radiometrically calibrated, photometrically corrected, geodetically controlled [3], and projected onto a spherical shape model of the Moon [4] to create a global mosaic at a uniform 100 m/pixel resolution. The few gaps in the global mosaic were filled with images taken at 900 nm or 950 nm wavelengths. Because of recent improvements in the geodetic control network of the Moon [5] and the availability of a detailed 3D shape model on which to project the images, we created a new Clementine basemap at 750-nm.

**The Lunar Control Network:** The new global geodetic control network for the Moon was developed by solving for the radii of the control points based on stereo information provided by overlapping Clementine images [5]. This avoids distortion of horizontal positions (of about 7 km average, and up to 15 km or more). A global Digital Elevation Model (DEM) for the Moon was also generated, making it possible to project the Clementine images onto a more detailed lunar topographic model, thus improving their placement in the mosaic relative to each other and to the lunar surface. A 'rubber-sheet' or warped version of the basemap was created as an interim product, but it did not correct distortions and frame-to-frame misregistrations that were present in the earlier mosaic [2]. The misalignment between images due to horizontal distortions could only be corrected by starting with the original 'Level 1' image data, projecting onto a detailed topographic model of the Moon, and mosaicking the files into a new basemap.

**Software and Processing:** The USGS Integrated Software for Imagers and Spectrometers (ISIS) software was used to process the Clementine data [6, 7, 8] for the basemap and subsequent multispectral mosaics. The ingestion, radiometric calibration [9], and merging of low and high exposure image pairs were performed using the program 'uvviscal' in the earlier ISIS 2 software [5]. The analysis of the control network, repair or removal of bad control points in the network, updating of the camera pointing information to correct obvious offsets between images, and creation of the tone-matched mosaic was performed using the newest ISIS 3 software. The images were then photometrically corrected (using the Lunar Lambert photometric model [10] and the 'Moon Albedo' normalization model) and trimmed in ISIS 3. **Table 1** shows the filter, wavelength, and values used for each parameter (where D, E, F, G2, H, and Bsh1= empirically derived coefficients) in the ISIS 3 "photomet" program:

***Table 1.*** *Parameter values for photometric correction of the new Clementine basemap mosaic.*

| Filter | Wave-length (nm) | D | E | F | G2 | H | **Bsh1** |
|---|---|---|---|---|---|---|---|
| LUA | 415 | 0.0 | -0.222 | 0.5 | 0.3 | 0.062 | **2.31** |
| LUB | 750 | 0.0 | -0.218 | 0.5 | 0.4 | 0.054 | **1.6** |
| LUC | 900 | 0.0 | -0.226 | 0.5 | 0.36 | 0.052 | **1.35** |
| LUD | 950 | 0.0 | -0.226 | 0.5 | 0.36 | 0.052 | **1.35** |
| **LUE** | **1000** | **0.0** | **-0.226** | **0.5** | **0.36** | **0.052** | **1.35** |

The photometrically corrected Clementine images were projected at 256 pixels/degree to either an equirectangular or polar stereographic projection using the 3D topographic model from [5]. The mapping parameters were positive east longitude direction, planetographic latitude type, and 180 degree longitude domain. The equatorial radius, polar radius, and center latitude radius are all set to 1737400.0 meters. The DEM used was "ulcn2005_lpo_002.cub" created at USGS [5].

**Clementine Image Database:** Following global processing, the Clementine image database was updated with new image coordinates based on the revised camera pointing. The mosaic order for each quadrangle was then determined by querying the database to sort images based on quality. Oblique, low resolution, and highly saturated images were identified (using the 'morph' parameter such that morph= [average resolution + number of saturated pixels] /cos[emission angle]) and placed on the lowest level of the mosaics. The highest quality images were placed at or near the top.

**Products:** Projected images were mosaicked and divided into regional 'tiles,' and global mosaics were constructed at full and reduced spatial resolutions (**Figure 1**) for release via the Map-a-Planet web site (http://www.mapaplanet.org). The polar tiles were projected at both polar stereographic and equirectangular (centered at 60 degrees N and S) projections to facilitate merging with the equatorial tiles. Note that small residual errors between adjacent 'month 1/month 2' orbits following the radiometric calibration and photometric correction steps result in minor banding in the new mosaics, especially near the equator.

**Summary:** The new Clementine mosaic corrects many of the problems identified in the earlier basemap mosaic. Procedures and processing scripts are now in place that will allow us to easily regenerate the mosaic when a new global geodetic control solution is available. Use of a more detailed and accurate DEM will further improve the registration between overlapping images, especially in areas where the relief in the terrain is greater. Additional refinements to the mosaic are possible in the future, especially at the poles (where the registration between the low and high resolution images can be significantly improved) and near the equator (where the residual brightness differences can be further minimized).

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**References:** [1] Nozette, S. et al., (1994), Science, 266, pp. 1835-1838. [2] USGS (1997). *Clementine Basemap Mosaic*, USA_NASA_PDS_CL_30xx, NASA PDS. [3] Davies, M. and T. Colvin (1997) Clementine Lunar Control Network (unpublished). [4] McEwen, A. and M. Robinson (1997), Adv. Space Res. 19, pp. 1523-1533. [5] Archinal, B.A. et al. (2006), Open-File Report 2006-1367 – Version 1.0. [6] Gaddis, L.R. et al. (1997), LPSC XXVIII, pp. 387-388. [7] Torson, J. and K. Becker (1997), LPS XXVII, 1219. [8] Anderson, J. et al. (2004), LPSC XXXV, #2039. [8] Pieters, C. M. (1999), New Views of the Moon II: Understanding the Moon Through the Integration of Diverse Datasets, abstract 8025. [10] McEwen, A. (1996) LPS XXVII, p. 841-842.

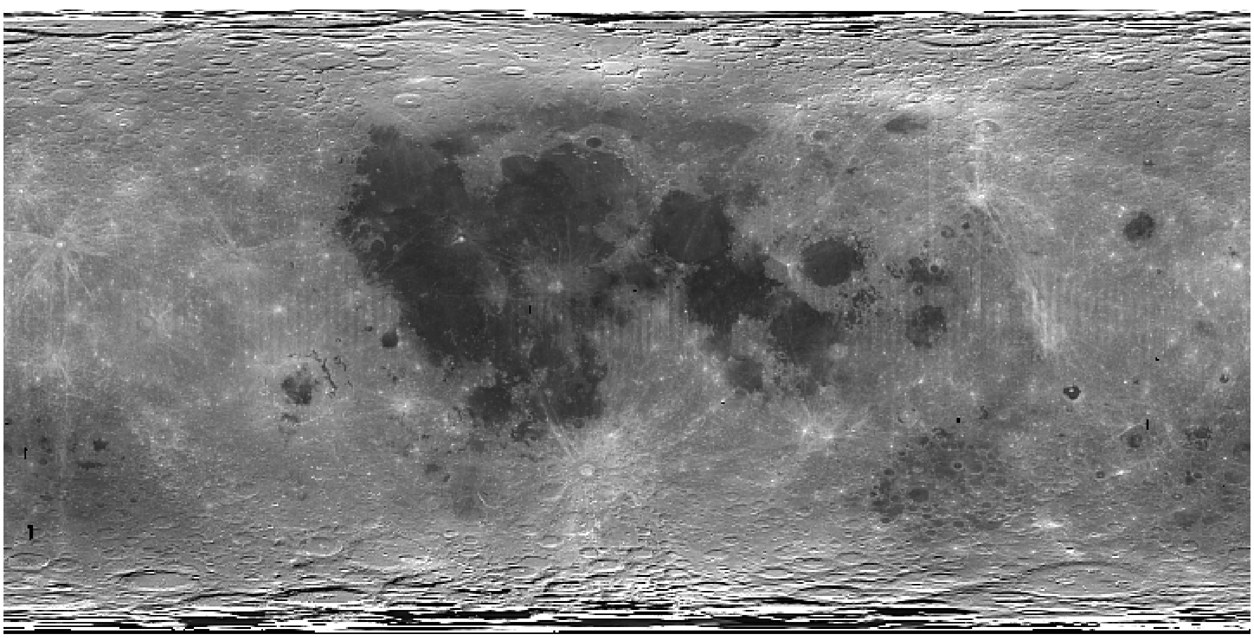

***Figure 1:*** *Clementine global basemap centered at 0 degrees longitude.*