DIGITAL PROCESSING FOR A GLOBAL MULTISPECTRAL MAP OF THE MOON FROM THE CLEMENTINE UVVIS IMAGING INSTRUMENT.
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Introduction: The primary scientific objective of the Clementine Mission during its two month orbit about the Moon was to acquire global multispectral imaging of the lunar surface using the UVVIS and NIR camera imaging systems [1,2]. A multi-spectral global Digital Image Model (DIM) of the Moon containing controlled image mosaics has been compiled by the U.S. Geological Survey, in a collaborative effort with the many authors listed above, for distribution to the science community [3]. The recently released DIM consists of the five spectral bands (415, 750, 900, 950, and 1000 nm) from the UVVIS imaging instrument. The imaging has been radiometrically corrected, geometrically controlled to a lunar geodetic control network, and photometrically normalized to form uniformly illuminated mosaics of the lunar surface. Figure 1, a color ratio composite ideally suited for enhancing subtle color differences among lunar terrain types, illustrates the results of the global mapping effort. The global mosaics portrayed are projected in a sinusoidal equal-area projection with a resolution of 1.0 km/pixel.

Radiometric Calibration: Radiometric calibration steps for the UVVIS imaging have been well tested, validated, and documented [4]. The calibration process provides corrections for camera gain and offset operating modes, variable sensitivity across CCD camera array, sensitivity and dark-current dependence on temperature, non-linearity of the analog-to-digital converters, and conversion to radiometric units. We do not attempt any correction for scattered/stray light, although such corrections may be important for examining small high-contrast features, especially dark areas [5]. In assembling the global DIM, we discovered small difference (<5%) between the first and second month orbital data that in part can be attributed to calibration drift of the UVVIS camera. A correction for reconciling calibration differences between the first and second month was developed and applied. This procedure compared month one and month two orbital data in areas of common coverage. Month one orbital data were matched to adjacent coverage of month two data using a latitude-dependent least-squares fit procedure.

Geometry: A global base map created from the UVVIS 750 nm imaging, completed in 1996, provides the geometric control for the multispectral DIM. The base map underwent rigorous cartographic processing to tie the imaging to a lunar geodetic network resulting in an absolute positional accuracy of better than 0.5 km/pixel for 95% of the surface.

The registration of the bands is critically important to mapping compositional variations from the subtle differences in reflectivity with wavelength. Misregistration of less than one pixel can cause color discrepancies along spectral boundaries. We used a procedure to register spectral bands to a precision of 0.2 pixel.

Phase Function Normalization: The Clementine imagery was acquired under a broad range of viewing conditions with phase, emission, and incidence angles varying from 0 to 90° resulting in large scene brightness variations among the image collection. In order to form mosaics with uniform scene brightness a photometric normalization procedure [6] was applied to the individual images before compiling the global mosaic. Differences in phase behavior, especially near zero phase, as a function of terrain type was observed in the resulting mosaics. A second-order correction to the phase function for near zero phase observations was developed and applied to the data. This procedure compared areas of overlap among low and high-phase imaging for determining a multiplicative correction to the low-phase imaging which forced overlapping areas to spectrally match. The resulting multiplicative corrections were then applied to the low-phase imaging in non-overlap areas.

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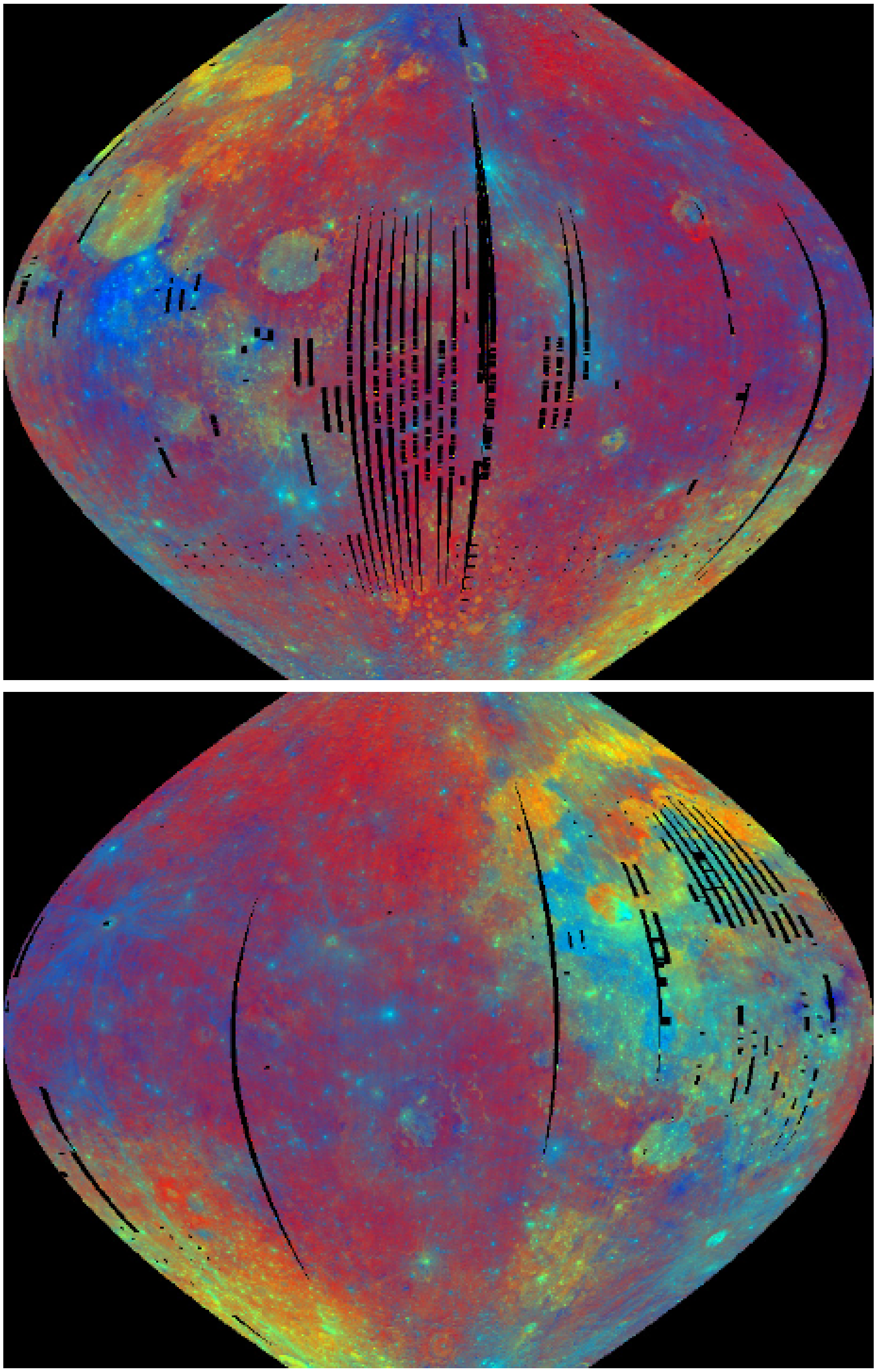

Figure 1 - False color composite of ratioed image showing the eastern hemisphere (top figure) centered at 90° East longitude and the western hemisphere (bottom figure) centered at 90° West longitude. The latitude range extends 70° North and South. The color composite is created using 415/750 nm (blue), 750/950 nm (green), and 750/415 (red). Ratio composites cancel the albedo component and enhance the color signature differences. Blue to red color tones show overall color differences in the ultraviolet to near-infrared. Yellow and orange colors indicate a greater abundance of iron and magnesium-rich materials. The full resolution global image has approximately 110,000 pixels in longitude and 55,000 pixels in latitude.