GLOBAL MULTISPECTRAL MAPPING OF THE MOON BY CLEMENTINE

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ABSTRACT:

The Clementine spacecraft was built and operated by the Naval Research Laboratory, carried a suite of lightweight sensors designed by the Lawrence Livermore National Laboratory, and mapped the Moon from Feb. 19 to May 3, 1994. Near global coverage of the lunar surface was acquired in 11 spectral bandpasses from 415 to 2780 nm and at resolutions of 80-250 m/pixel (UVVIS and NIR cameras) (Nozette et al., 1994). A thermal-infrared camera (LWIR) sampled ~20% of the surface at 8575 nm in thin strips of data that stretch from pole-to-pole. A high-resolution camera (HIRES) mapped the polar regions and acquired visible color in four wavelengths (415 - 750 nm) for areas of high scientific interest. Finally, a lidar altimeter (LIDAR) mapped the large-scale topography of the Moon up to latitudes of 75 degrees N and S. Clementine was in a polar, elliptical orbit, ~400-450 km periselene altitude. Periselene latitude was -30 degrees for the first month of systematic mapping, then moved to +30 degrees. This strategy maximized the resolution uniformity for the 11 band global color dataset. NASA is supporting the archiving and analysis of the ~1.8 million lunar images and ancillary datasets. The raw data are stored on CD-ROM (available through INTERNET access) that are being widely distributed to the science community and the general public.

The first major step in the systematic processing of the UVVIS and NIR global imaging data is the production of an accurate base map, to which all other products will be geometrically registered. Current maps and control points of the Moon are not adequate. The previous RAND control network (Davies., et al., 1994) is accurate to 500 m in the regions of the Moon covered by the Apollo missions (15% of the Moon's surface). This previous control network is accurate to about 1-2 km for regions covered only by telescopic, Galileo, and Mariner 10 observations. However, most of the far side is not included in the network, and the only other positional dataset for these regions (Duxbury, *et al.*, 1994) contains errors as large as tens of kilometers. Based on our current best measurements of the spacecraft orbit and pointing, UVVIS geometric distortions, and time tags for each observation, we expect the SPICE data alone will provide positional accuracies better than 1 km over most of the Moon (McEwen, et al., 1995).

Our goals are to provide better than 0.5 km/pixel absolute positional accuracy everywhere on the Moon except for gaps in nominal coverage that were filled by highly oblique data (< 1% of the surface). The new global geodetic network is being constructed from ~43,000 images from which 0.5 million match points have been selected. The average relative positional error, after match point comparison and camera updating, is about 80 m, less than 1 pixel. The average absolute positional accuracy is estimated to be better than 250 m/pixel. This vastly improved control network will facilitate future lunar exploration, as well as provide an invaluable base for geologic mapping.

The global base map is being constructed with 750 nm filter images. After this mosaic is completed the corresponding UVVIS (415, 900, 950, 1000 nm) and NIR (1100, 1250, 1500, 2000, 2600, 2780 nm) bands are to be coregistered. This 11 band image cube will provide the opportunity to map global lunar mineralogy at a resolution of ~250 m/pixel. These wavelengths were specifically selected to diagnose known spectral characteristics of returned lunar samples. In addition to the multispectral mapping, Clementine also acquired stereo image data for the lunar polar regions, the Orientale basin region, and other selected targets. These data can be processed to obtain digital terrain models (DTMs) that portray topography on a pixel-by-pixel basis (Oberst, *et al*, 1995). Combined with global scale lidar topography (Zuber, *et al.*, 1994) these high resolution stereo models will allow for quantification of internal and surficial lunar processes.

Many scientific questions concerning the origin of the Moon, the nature of its crust, styles of volcanic eruptions, surface weathering, and impact history (to name just a few) remain in question. This new dataset will greatly alter our understanding of the Moon. Early science results include: 1) a global model of crustal thicknesses (Zuber, *et al.*, 1994); 2) new information on the topography and structure of multiring impact basins (Zuber, *et al.*, 1994, Spudis, *et al.*, 1994); 3) evidence suggestive of water ice in large permanent shadows near the south pole (Nozette et al., 1994); 4) global determination of crustal iron abundance (Lucey *et al.*, 1995); 5) reevaluation of the Copernican impact crater population (Moore and McEwen, 1996); 6) an extension of known regions of anorthositic crust (McEwen et al., 1994); 7) improvements in lunar stratigraphic relationships

(Shoemaker, *et al.*, 1994, Pieters *et al.*, 1994); 8) improved understanding of the lunar photometric function (McEwen, 1996); and 9) the discovery of five broad compositional-altimetric units (Lucey *et al.*, 1996). Many additional results are expected following completion of systematic processing efforts, now underway.

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