N94-16394

LUNAR MULTISPECTRAL MOSAICS FROM GALILEO'S SECOND EARTH-MOON FLYBY;

A.S. McEwen, T.L. Becker, U.S. Geological Survey, Flagstaff, Arizona; M.S. Robinson, Planetary Geosciences Division, Univ. of Hawaii, Honolulu, Hawaii; K.P. Klaasen, C. Heffernan, Jet Propulsion Lab, Pasadena, California; J.M. Sunshine, Brown Univ., Providence, Rhode Island; and the Galileo SSI Team.

Introduction

Galileo's Solid-State Imaging (SSI) experiment acquired about 800 images of the Moon from the second Earth-Moon flyby (EM2) in December of 1992. Ten major sequences were acquired (Table 1); each consists of mosaics of the entire or nearly entire visible and illuminated surface from each viewing geometry in at least six spectral filters (effective wavelengths for the Moon of 420, 564, 660, 756, 890, and 990 nm). The geometries of LUNMOS numbers 3, 4, 5, and 6 were designed to provide stereo data at the best possible resolutions. Preliminary science results are described in a series of abstracts in this volume [1-4]. The purpose of this abstract is to describe the sequences, calibration, processing, and mosaicking, and to present a set of color products in a poster session.

Data Quality

The SSI EM2 data are generally superior to those acquired during the first Earth-Moon flyby [5], because (1) the spacecraft passed closer to the Moon, so the spatial resolutions are about 3 times better; (2) the exposure times were better, resulting in about 2 times better signal-to-noise ratios; (3) the cover was removed (prior to the Gaspra flyby), thus eliminating the "ghost" images [6] and enlarging the effective aperture area; and (4) target motion compensation (TMC) was fully implemented, thus enabling acquisition of closely matched filter sets, which minimizes the effects of scattered light on the subtle spectral differences.

Unfortunately, the compression algorithm used on the EM2 images resulted in some truncation of significant digits over "busy" image areas, such as topographically rough highland areas imaged at high sun angles. The effects of this truncation are noticeable in the color ratios. This "compression noise" is less noticeable in data acquired at low sun angles. It may be possible to design a filtering sequence that will remove the patterns.

Calibration

In-flight images of the Photometric Calibration Target (PCT) on the spacecraft were acquired for the first time during the first week of December 1992. The PCT images were processed with the pre-flight calibration files for a check on whether the calibration has changed significantly since the pre-flight calibration; the results revealed changes of up to about 5% in all filters and gain states. Calibration errors greater than about 1% are considered significant for the mapping of subtle spectral variations in mature lunar soils or on Gaspra [7]. The largest errors occur near the corners of the frames, especially the bottom corners, and in a central area of about 70 x 200 pixels. Errors in the central area are due to the emplacement of a series of dust particles on the quartz radiation shield. Effects of these dust particles were not seen in the Venus or EM1 images, and the particles were probably emplaced when the cover was removed. Evidence for calibration problems in the corners has been seen in Venus and EM1 images.

We expect new calibration files for SSI to be completed by February 1993. For preliminary analyses before the new calibration files are available, we derived calibration correction files for each filter from a subset of the PCT images, chosen to minimize possible errors due to shading variations of the PCT, changes in the shutter speed, or changes in the gain state ratios. Comparisons of overlapping lunar images show that the errors were probably reduced to less than 1% with the correction files.

SSI's scattered-light problem has not disappeared with the cover removal. This problem is minimized by using matched filter sets and masking the boundaries so that color ratios are not made with data from neighboring filter sets. Small residual frame-to-frame offsets seen in the mosaics will be normalized by histogram matching, as was done for the EM1 mosaics [8].

Following the flat-field corrections, further refinements on the absolute and relative spectra were carried out as described by Pieters et al. [4].

Subpixel Registration

Pixel-to-pixel misregistration (i.e., between corresponding pixels from images acquired through different spectral filters) is a major source of error in the spectral analysis of highly correlated multispectral datasets. For example, in the EM1 lunar mosaics [8],

subpixel misregistration is probably the largest source of error near high-contrast boundaries when spectra are extracted or spectral units are mapped. A series of new programs have been developed in PICS (Planetary Image Cartography System) that resample highly correlated images for co-registration to an accuracy of 0.2 pixel. We applied these techniques to the EM2 images and the results have been excellent. For the matched color sets acquired with TMC, the subpixel registration turned out to be better than expected in some cases, accurate to about 0.1 pixel.

Geometric Control and Mosaicking

Absolute geometric control was achieved by tying a few points per image in one filter to points in the unified control net [9,10]. Match points on overlapping frames were used to adjust the camera angles to improve the frame-to-frame matches in each mosaic. Following completion of a mosaic in one filter, images from the other five filters were tied directly to the corresponding frame in the controlled filter, to subpixel accuracy.

Mosaics have been completed for LUNMOS numbers 4, 7, and 8 (Table 1). Prior to mosaicking, each frame is reprojected to an Orthographic projection centered at a location within the range of subspacecraft latitudes and longitudes for each sequence. After we have completed LUNMOS numbers 5, 6, and 9, we will apply photometric normalizations and mosaic the "best" coverage (defined as a function of resolution and signal:noise) from all six sequences, as well as from the EM1 mosaics, into a single mosaic covering about 75% of the lunar surface.

Photometric Function

For the EM1 mosaics [8], the Hapke photometric-function parameters derived for disk-integrated lunar observations [11] were applied to normalize the albedo. However, it was obvious in the normalized images that this function over-corrected the brightnesses at high planetary latitudes (which were also high photometric latitudes for these observations). This problem is eliminated by reducing the parameter for mean macroscopic roughness (θ) from 20° to 5°. For a preliminary map of normal albedo, we applied these Hapke parameters (but with θ = 5°) to the images of LUNMOS7, the EM2 sequence with the lowest phase angles (Table 1).

Color-Ratio Composites and Special Products

For press-release images we have generally utilized the color-ratio composite consisting of 756/420 as red, 756/990 as green, and 420/756 as blue. However, we used the 660-nm filter in place of the 756-nm filter in the LUNMOS4 composite because of the loss of a 756-nm frame. For this poster, we expect to present composites with other color-ratio combinations in addition to the press-release versions. The color-ratio composites are presented both alone and merged with albedo and/or topography images.

References

1. Greeley, R., et al., this volume.
2. Head, J.W., et al., this volume.
3. McEwen, A.S., et al., this volume.
4. Pieters, C.M., et al., this volume.
5. Belton, M.J.S., et al., 1992, Science 255, 505-652.
6. Belton, M.J.S., et al., Advances in Space Research, in press.
7. Belton, M.J.S., et al., 1992, Science 257, 1647-1652.
8. McEwen, A.S., et al., submitted to JGR.
9. Davies, M.E., et al., 1987, JGR 92, 14177-14184.
10. Davies, M.E., et al., submitted to JGR.
11. Helfenstein, P., and Veverka, J., 1987, Icarus 72, 342-357.

Table 1. Major EM2 SSI Lunar Sequences

Sequence Name	Resolution (km/pixel)	Sub-Spacecraft Lat, Long (°)		Phase Angle (°)
LUNMOS01	2.0	49	200	119-123
LUNMOS02	1.7	53	206	112-118
LUNMOS03	1.4	62	224	85-111
LUNMOS04	1.1	67	290	74-78
HIRES	1.1	61	311	58-74
LUNMOS05	1.1	54	323	54-58
LUNMOS06	1.3	35	341	26-46
LUNMOS07	1.9	16	353	14-21
LUNMOS08	4.3	4	13	24-25
LUNMOS09	5.3	5	29	37-38