PRELIMINARY REPORT OF LUNAR OBSERVATIONS BY THE NEAR-INFRARED MAPPING SPECTROMETER (NIMS) DURING THE SECOND GALILEO EARTH-MOON ENCOUNTER; R.W. Carlson[1], H.H. Kieffer[2], K.H. Baines[1], K.J. Becker[2], G.E. Danielson[3], K. Edwards[2], F.P. Fanale[5], J. Forsythe[4], L.R. Gaddis[2], J.C. Granahan[5], J. Hui[1], T.V. Johnson[1], R. Lopes-Gautier[1], L.W. Kamp[1], D.L. Matson[1], T.B. McCord[4,5], R. Mehlman[6], A.C. Ocampo[1], L.A. Soderblom[2], W.D. Smythe[1], J. Torson[2], P.R. Weissman[1], [1]Jet Propulsion Laboratory, Pasadena, Calif.; [2]U.S. Geological Survey, Flagstaff, Ariz.; [3]California Institute of Technology, Pasadena, Calif.; [4]SETS Technology, Inc., Mililani, Hawaii; [5]Univ. of Hawaii, Honolulu, Hawaii, [6]Univ. of California, Los Angeles, Calif.

The Galileo encounter with the Earth-Moon system on December 8, 1992, provided a unique opportunity to observe the Moon. Galileo's closest approach to the Moon was at an altitude of about 110,000 km above an area at about latitude 60N, longitude 60E. During the 12 hours surrounding the time of lunar closest approach, 12 observational sequences were executed by the near-infrared mapping spectrometer (NIMS), many in coordination with other Galileo instruments. These NIMS observations provided nearly complete coverage of the illuminated crescent from phase angles of 123° to 14°. This phase-angle coverage with nearly constant illumination is not possible from Earth; it is expected to provide substantial new information on the nature of the lunar photometric function over wavelength [1]. As of January 1993, most of the analysis has focused on the highest resolution data (55 km/pixel).

NIMS covers the spectral region of 0.7-5.2 μm with 12-nm bandwidth with 2 silicon detectors and 25-nm bandwidth longward of 1 μm with 15 InSb detectors (see [2] for a detailed description of the instrument and its many operating modes). NIMS builds up spectral images by measuring 17 wavelengths at a time, spaced uniformly over the full spectral range, along a strip of 20 pixels imaged by the scanning secondary mirror in 1/3 s. The spectrometer grating can be stepped to the adjacent "comb" of wavelengths while the scan mirror is changing direction. In this "full-map" mode, a line of 20 complete spectra is acquired in 4-1/3 s. Slow motion of the scan platform approximately perpendicular to the NIMS mirror scan builds up swaths of coverage 20 pixels wide; up to 4 swaths were required to cover the lunar disk. Of the lunar observations, 4 were in full-map mode; 4 were in "short-map" mode (obtained by double-stepping the grating between mirror scans requiring 2-1/3 s to acquire a spectrum); and 4 had a fixed grating position (1/3 s for a spectral comb).

Spectral registration is at present based on reconstructing the geometry of the NIMS observations by using the engineering data of platform attitude and the spacecraft trajectory. Because of the strong brightness gradients that occurred over the lunar target, NIMS spectra were very sensitive to small motions of the scan platform while a complete spectrum was acquired; such motions included both the planned slew and erratic motions. For this reason, it is often necessary to remove from the spectrum a pattern correlated among the 17 detectors for each grating position in that spectrum. Thus far, this "de-patterning" has been done separately for each pixel. Major improvements by the spacecraft team to reduce random jitter have made the data collected from the second Earth-Moon encounter much cleaner and easier to reduce than data from the first encounter [3].

The NIMS spectral range includes the overlap region between solar reflection and thermal emission; this region must be carefully treated to extract reflection or emission spectra, and the de-patterning must be carried out simultaneously but separately for the two sources.

Because NIMS was designed to operate at Jupiter, many of the bands beyond 1.1 μm were saturated on the Moon except near the terminator. Due to this saturation, our global lunar studies with the NIMS are limited to the 0.7- to 1.1-μm region. Fortunately, this is an important region containing a broad absorption feature near 1 μm attributed to pyroxenes and olivine. In addition, high-quality unsaturated spectra covering the entire NIMS spectral range (0.7-5.2 μm) are available for a 20-degree-wide strip along the terminator in the highest spatial resolution mosaic collected. This strip extends from western Mare Frigoris, through the north polar region, down to Mare Marginis on the lunar farside. These data allow analysis of NIMS spectra containing both the 1-μm features as well as important features in the 2- to 2.5-μm region attributed largely to pyroxenes and glasses.

The NIMS radiometric response is quite sensitive to the thermal environment in which the instrument is operated. Consequently, onboard calibration targets are used to validate and refine the instrument response. Unfortunately, observations of the reflected solar radiation from the photometric calibration target (PCT) that were acquired during the encounter were also largely saturated (again because the instrument was designed to operate at Jupiter). Hence the initial analysis of the NIMS lunar spectra involved dark-current correction, then ratioing of the spectra to that of a standard area (usually a relatively bland highland region), resulting in normalized spectra from which instrument and solar spectral functions were removed. The de-patterning autocorrelation techniques mentioned above were then applied to suppress artifacts introduced by scan-platform jitter.

The 1-μm band was analyzed for the entire high-resolution north polar mosaic. This data set covers mostly the nearside north polar region and Frigoris, Imbrium, Serenitatis, Tranquilitatis, Fecunditatis, and Crisium Maria. The parameter that can most rigorously be derived is the 1-μm band depth, which shows large variations in mafic mineral content both in highlands and maria. Parts of Mare Frigoris and Mare Imbrium show the strongest absorption; parts of the Crisium basin ejecta and highlands west of Mare Tranquilitatis show the weakest. Preliminary studies of the 1-μm band shape and of slopes of the continuum near that band show that the NIMS observations can be analyzed with more refined techniques to yield information related to the total pyroxene/olivine abundance, the Ca content of the pyroxenes, and the Fe/Mg abundance. Like the 1-μm bands, absorption features in the 2- to 2.5-μm region reveal variations over the maria covered by the terminator strip mentioned above. As an example, comparison of spectra in western Mare Frigoris and flooded crater floors north of Mare Marginis show similar depths and shapes for the 1-μm bands but quite different strengths for the 2- to 2.5-μm bands, which are much stronger in Mare Frigoris. These observations suggest variations in the relative abundance of olivine and pyroxene as well as in pyroxene composition, which largely control shapes and depths of the two bands.

NIMS observations of the north polar region also provide unique spectral and geometric coverage that allows a search for absorption features associated with water in some form that might exist in the polar regions; our analysis in this area is underway.

In anticipation of the relatively high temperatures in Jupiter's atmosphere in the 5-μm region, NIMS has an extremely wide sensitivity range beyond 4.3 μm. For the lunar observations, this range will allow useful measurements from 200 to 350 K. As a consequence, NIMS observations near the poles and on the lunar farside, outside the range of Earth-based observations or the Apollo orbits, can provide new information on the physical properties of the lunar surface.

References: [1] Lane, A.P., and Irvine, W.M. (1973) *Astron. Jour.*, *78*, 267;
[2] Carlson, R.W. et al. (1992) *Space Sci. Rev.*, *60*, 457-502; [3] McCord, T.B. et al. (1993) work in progress.