# LUNAR MARIA AND RELATED DEPOSITS: PRELIMINARY GALILEO IMAGING RESULTS

*R. Greeley*[1], *M. Belton*[2], *L. Bolef*[1], *M. Carr*[3], *C. Chapman*[4], *M. Davies*[5], *L. Doose*[6], *F. Fanale*[7], *L. Gaddis*[1], *R. Greenberg*[6], *J. Head*[8], *H. Hoffman*[9], *R. Jauman*[9], *T. Johnson*[10], *K. Klaasen*[10], *R. Kolooró*[6], *A. McEwen*[11], *S. Murchie*[8], *G. Neukum*[9], *J. Oberst*[9], *C. Pieters*[8], *C. Pilcher*[12], *J. Plutchak*[8], *M. Robinson*[6], *R. Sullivan*[1], *J. Sunshine*[8], *J. Veverka*[13] 1. Ariz St U, Tempe, AZ. 2. NOAO, Tucson, AZ. 3. USGS, Menlo Park, CA. 4. PSI, Tucson, AZ. 5. Rand, Santa Monica, CA. 6. U AZ, Tucson, AZ. 7. U Hawaii, Manoa, HI. 8. Brown U, Providence, RI. 9. DLR, Munich, Germany. 10. JPL, Pasadena, CA. 11. USGS, Flagstaff, AZ. 12. NASA, Washington, D.C. 13. Cornell U, Ithaca, NY.

During the Earth-Moon flyby the Galileo Solid State Imaging (SSI) system (1) obtained new information on lunar maria. Imaging data in 7 spectral bands (0.4 to 1.0 µm wavelength) provide color data for deposits on the western limb, including the Orientale basin (2) and part of the farside (3). General objectives were to determine the composition and stratigraphy of mare and related deposits for areas not previously seen well (or at all) in color, and to compare the results with well-studied nearside maria (4). The imaging sequence began with observations of the Apollo 12 and 14 landing sites and extended west to include Oceanus Procellarum and the Humorum basin. This sequence enabled relative calibration of Galileo data using previous earthbased multispectral observations and spectral data obtained from Apollo samples. A later imaging sequence extended around the western limb and provided new color data for mare deposits in the Orientale basin and those associated with the craters Grimaldi, Riccioli, and Schickard. The last imaging sequence covered part of the farside and included mare deposits in the Apollo basin, light plain deposits such as those in the Korolev basin, and dark mantle (pyroclastic?) materials.

Initial results from images reduced with preliminary calibrations show that Galileo spectral reflectance data are consistent with previous earthbased observations. Color visualization images were prepared from ratios of Galileo SSI filter data (violet/0.76→blue, 0.76/violet→red; 0.76/IR→green) in order to assess the relative titanium (blue is relatively high Ti, red is relatively low Ti) and mafic content of maria. Galileo results are comparable to those derived from earthbased spectra for Oceanus Procellarum (7) and Humorum (8). The relative color of mare units correlates with photogeologic features and the titanium content as determined from lunar samples (5 and reviewed by 6). These areas and the general western nearside maria are highly complex and include volcanic centers of the Rümker Hills, Marius Hills, and Aristarchus Plateau (9-14). Mare units in these areas also have a wide range of titanium contents (15) and ages (16). Galileo data show the compositional complexity of western nearside maria and demonstrate that calibrated images can be used to map the color of maria on the farside and in limb areas not readily seen from Earth such as regions of the western limb. For example, small deposits of Imbrian-age lavas are seen on the western margin of Oceanus Procellarum. Galileo data suggest that these deposits consist of relatively bluer flows that were erupted early in the emplacement of lavas in the area. Also seen on the western limb are the impact structures Grimaldi, Riccioli, and Schickard. Grimaldi is a 430 km basin centered at 5° S, 68° W and contains a 230 km ring filled with mare deposits of Eratosthenian age. It is a major mascon mare (17, 18). Riccioli is a 146 km crater superposed on the northwestern part of the outer ring of Grimaldi; patches of mare deposits (undated) occur on the floor and in the northern half of Riccioli. Irregular depressions in the mare deposits may indicate subsidence of lava lakes (19). Galileo SSI data distinguish the mare deposits associated with Grimaldi and Riccioli.

Schickard is a 227 km basin centered at 44° S, 55° W. Unlike most lunar structures of this size, it has no apparent ring or central peak complex. It is filled with light plains material and mare deposits of Imbrian age. The light plains may represent ejecta from the Orientale basin (6). Galileo color data for Schickard maria are consistent with previous spectral reflectance measurements, showing an intermediate (violet/0.76) color. In addition, a strong mafic component is seen around Schickard and extends as a large regional patch southeast toward Schiller. This area corresponds to the zone proposed to be an older mare deposit now mantled by light plains (20,

**LUNAR MARIA AND RELATED DEPOSITS: R. Greeley et al.**

28). It was suggested that dark halo craters excavated basaltic materials from beneath the light plains and Galileo results support this model.

Mare deposits in the Orientale basin include Mare Orientale, Lacus Veris (between the Inner and Outer Rook Mountains), and Lacus Autumni (between the Outer Rook and Cordillera Mountains), as described by (23-25). Earthbased spectral reflectance data obtained by Spudis et al. (26) suggest that Lacus Veris and Lacus Autumni are "contaminated" by material derived from the local highlands. Except for this mixing, they proposed that the mare deposits are similar in composition to nearside maria. Galileo spectral reflectance data show heterogeneities in Mare Orientale, with the eastern region being more Ti-rich than the western region.

Apollo is a 505 km basin containing a central ring 250 km across, centered at 36°S, 151°W. A partial third ring has also been described (6). Patches of maria fill parts of the Apollo basin. The superposition of Apollo on the rim of the South Polar-Aitken basin may have enhanced the eruption of mare lavas (10). Galileo SSI data distinguish the mare deposits, but await further calibration before assessment of composition. The general area within the South Pole-Aitken basin shows a strong mafic component. This signature can be attributed to iron-rich material excavated from the lower crust or upper mantle, or to the presence of a cryptomaria. The possible cryptomare deposits in both the South Polar and Schickard basins may represent very early volcanism on the Moon.

Dark mantle deposits are seen in the Aristarchus Plateau, southeast of Copernicus, and in the Orientale basin. Consistent with earthbased observations (29, 30), Galileo data show the Aristarchus deposits to be similar to Apollo 17 orange glass whereas the deposits southeast of Copernicus are similar to the Apollo 17 black glass deposits. Dark mantle deposits on the southwestern part of the Orientale basin form a ring about 200 km in diameter. Galileo data suggest that these presumed pyroclastic deposits have closer affinities with the black glasses found at the Apollo 17 site than the orange glass.

In the mid 1970s a simple two-fold model of mare basalts was developed that involved high and low titanium lavas; it was thought that low titanium lavas erupted during early lunar volcanic history from shallow magma chambers, and that high titanium lavas were erupted later from deeper sources. Subsequently, it was recognized that mare lavas have a wide range of titanium content and neither their ages nor depth of origin correlate well with titanium content. Galileo results confirm this complexity. The preliminary results presented here are given in qualitative terms relative to earthbased observations of the Oceanus Procellarum-Humorum region. Calibration efforts currently underway (3, 27) should lead to quantitative spectral reflectance data obtained from the Galileo images for extrapolation to the lunar western limb and farside.

1. Belton, M.J.S. et al., 1991 (this vol.) 2. Head, J.W. et al., 1991 (this vol.) 3. Pieters, C.M. et al., 1991 (this vol.) 4. Fanale, F., 1990. EOS, Dec 8. 1803-1804 5. Pieters, C.M., 1978. *Proc. Lunar Planet. Sci. Conf. 9.* 2825-2849 6. Wilhelms, D.E., 1987. *U.S. Geol. Surv. Prof. Paper* 1348 302 p 7. Pieters, C.M. et al., 1980. *J. Geophys. Res.*, 85. 3913-3938 8. Pieters, C.M., et al., 1975. *Proc. Lunar Sci. Conf. 6.* 2689-2710 9. Guest, J.E., 1971. *Geo. and Phys. of the Moon.* Ch. 4. 41-53 10. Head, J.W., 1976. *Rev. Geophys. and Space Phys.* 14. 265-300 11. Head, J.W., Gifford, A., 1980. *Moon and Planets* 22. 235-258 12. Whitford-Stark, J., Head J.W., 1977. *Proc. Lunar Planet. Sci. Conf. 8.* 2705-2724 13. Whitford-Stark, J., Head J.W., 1980. *J. Geophys. Res., 85.* 6579-6609 14. Greeley, R., Spudis, P.D., 1978. *Proc. Lunar Planet. Sci. Conf. 9.* 3333-3349 15. Papike, J.J., Vaniman, D.T., 1978. *Geophys. Res. Lett.* 5. 433-436 16. Boyce, J., 1976. *Proc. Lunar Planet. Sci. Conf. 7.* 2717-2728 17. Sjogren, W.L. et al., 1974. *The Moon, 9.* 115-128 18. Solomon, S.C., Head, J.W., 1980. *Rev. Geophys. and Space Phys.*, 18. 107-141 19. Schultz, P.H., 1976. *Moon Morphology.* U. Texas Press 20. Hawke, B.R., Bell, J.F., 1981. *Proc. Lunar Planet. Sci. 12b.* 665-678 21. Head, J.W., 1974. *The Moon 11.* 327-356 22. Moore, H.J. et al., 1974. *Proc. Lunar Sci. Conf. 5.* 71-100 23. Greeley, R., 1976. *Proc. Lunar Sci. Conf. 7.* 2747-2759 24. McCauley, J.F., 1977. *Phys. Earth Planet. Int. 15.* 220-250 25. Scott, D.H. et al.,1977. *USGS Misc. Invest. Map I-1034* 26. Spudis, P.D. et al., 1984. *J. Geophys. Res.* 89. C197-C210 27. McEwen A. et al., 1991 (this vol.) 28. Bell, J.F., Hawke, B.R., 1984. *J. Geophys. Res. 89.* 6899-6910 29. Adams, J.B. et al., 1974. *Proc. Lunar Planet. Sci.* 5. 171-186 30. Gaddis, L.R. et al., 1985. *Icarus, 61.* 461-489.