Global color variations on Io

P.E. Geissler[1], A.S. McEwen[1], D.P. Simonelli[2], R. Lopes-Gautier[3], A.G. Davies[3], J. Granahan[4], T. Denk[5] and the Galileo Imaging Team

1 Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ.
2 Cornell University, Ithaca, N.Y.
3 Jet Propulsion Laboratory, Pasadena, CA.
4 SETS Technology, Inc. and the University of Hawaii
5 DLR, Berlin, Germany

Galileo multispectral imaging of Io augments existing Voyager color data by extending the sensitivity to near-infrared wavelengths. Global 4-color coverage was obtained during Galileo's first two orbits, at resolutions ranging from 10 to 23 km/pixel and phase angles from 4 to 55 degrees [1]. In this poster we present preliminary spectral maps of the global distribution of low albedo materials (usually associated with volcanic centers), bright red deposits, yellow materials, and SO_2 frost. Further Galileo imaging will improve the definition of these spectral units by mapping the surface at a consistent phase angle and sampling diverse terrains at 889 and 968 nm.

Initial efforts have concentrated on the global distribution of the bright red, presumably pyroclastic deposits such as produced by the currently active plume Pele [1, 2]. These materials were noted to be associated with high temperature, low albedo edifices which show significant change between the Voyager and Galileo eras [3]. Observations of the Surt and Aten Patera regions suggest that the red materials fade over relatively short time scales, and thus may be recently emplaced [4]. Compositional candidates for the bright red materials include metastable short-chain elemental sulfur (S_4 and S_3, [2]) and ferric oxide minerals.

To determine the global distribution of the bright red unit, four 4-color image sets obtained during the G1 and G2 orbits were used to produce a global mosaic of Io. Two of the colors correspond to Voyager bandpasses, while the 650 and 756 nm filter images extend Galileo's sensitivity into the near-infrared. False color composites of the Galileo data show that deposits such as those surrounding Pele are distinctly redder than their surrounds, unlike their appearance in Voyager images [4]. Pele's deposits are so large (~1200 km diameter) that they are resolved in Hubble Space Telescope images of Io [2], which confirm that the present plume deposits are distinctly discernible due to their steep spectral slopes in the violet to near-IR wavelength range.

Since the contrast of surface units on Io is strongly dependent on the illumination and viewing geometry [6], spectral mapping of the red deposits is complicated by the range of phase angles at which the Galileo data were acquired. Phase angle dependent Lunar-Lambert photometric corrections [7] were applied to the data prior to assembling the global mosaic, but prominent seams at image boundaries are apparent even after empirical brightness normalizations. Regions of overlap between adjacent images show startling contrast reversals due to differences in the phase-angle dependence of the spectral reflectance of various surface units. Our approach to spectral mapping has therefore been to separately examine each of the photometrically corrected 4-color data sets, employ supervised classification to define the distribution of bright red materials within each scene, and combine the results. Regions of overlap between images were examined to ensure that the regions included in the spectral unit were consistent despite variations in illumination and viewing geometry. Potential sources of uncertainty in the results include inaccuracies in the limb-darkening correction as well as the unknown dependence of the units' spectral reflectance upon phase angle.

The most prominent exposure of the bright red material is associated with Pele itself; a ring of pyroclastic deposits encircles the caldera, with a minimum diameter of over 500 km extending outwards to at least 1100 km. Globally, many smaller regions up to 100 km in length are covered by the red materials. Several of these are associated with known hot spots: bright red deposits are found near Culann, Volund, Malik, and an un-named patera near 19 S, 141 W, all sites of temperature anomalies detected by the NIMS instrument on Galileo [8]. The red unit is also located near a complex low albedo feature in northern Colchis Regio, near which hot spots were observed by NIMS and also by SSI (which detected the thermal anomalies in clear-filter imaging while Io was in eclipse [3]). A prominent red deposit is found near Marduk, which was also identified as a hot spot by SSI (as was Pele). Further associations of hot spots and red deposits can be expected as new thermal observations are made. In general, these smaller deposits are irregular in plan and do not form symmetric rings around the source vents. Nearly all are adjacent to dark caldera and other volcanic edifices, many of which show significant changes in morphology in the 17 years since they were imaged by Voyager [5]. Examples already mentioned include Culann, Volund and Marduk. In addition, bright red deposits are found in a few regions in which surface changes are known to have occurred but no thermal anomalies have yet been observed, such as Euboea Fluctus and an un-named spot at 40 N, 76 W. Because of their association with regions of current or recent geologic activity, the bright red deposits are inferred to have been recently emplaced.

Bright red materials are also found on the margins of yellow flows and in broad, diffuse patches at high latitudes on or near the Jupiter-facing hemisphere. They are notably absent from equatorial regions (except at Pele which is currently active), suggesting that these materials are susceptible to destruction at low latitudes, or that they preferentially form or are preserved on the colder surfaces nearer the poles. The longitudinal asymmetry in the distribution of high latitude deposits argues that the bright red materials are not deposited at the poles by atmospheric condensation. The apparent concentration of the unit on the Jupiter-facing hemisphere suggests that it may be related to presently inactive Pele-type plumes clustered in this region, such as Surt and Aten [9].

Future Galileo imaging is expected to shed light on the composition of the red material and the rate at which it fades with time. Multispectral imaging acquired during the E4 orbit includes the 889 and 968 nm filters, which should help determine whether ferric oxides are a viable alternative to sulfur compounds as compositional candidates. Continued monitoring will show whether the deposits fade over time scales as short as a year.

References: [1] McEwen, A.S., et al., Observations of Io by Galileo SSI during the first half of the tour, this volume; [2] Spencer, J.R., et al., Volcanic resurfacing of Io: Post-repair HST imaging, Icarus, in press, 1997; [3] Belton, M.J.S., et al., Science, 274, 177, 1996; [4] McEwen, A.S., et al., 17 years of changes on Io, this volume; [5] McEwen, A.S., Icarus, 73, 385, 1988; [6] Simonelli, D.P., et al., this volume; [7] McEwen, A.S., Icarus, 92, 298, 1991; [8] Lopes-Gautier, R., et al., Monitoring of Io's volcanic activity using Galileo's Near Infrared Mapping Spectrometer, this volume; [9] McEwen, A.S. and L. Soderblom, Icarus, 55, 191, 1983.