NEW RESULTS ON IO'S COLOR AND COMPOSITION. P. Geissler[1], A. McEwen[1], C. Phillips[1], L. Keszthelyi[1], E. Turtle[1], M. Milazzo[1], R. Lopes-Gautier[2], D. Simonelli[3], D. Williams[4] and the Galileo Imaging Team.
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Summary: Galileo's recent high-resolution imaging of Io provides several new insights into the nature of the satellite's colorful surface. The new data shed light on the composition and origin of pyroclastic deposits and suggest that Io's mysterious green spots are due to coating or alteration of silicate lavas.

Background: Distant visible and near-infrared multispectral imaging during the Nominal and GEM missions discerned five distinct color units on Io and raised a number of questions concerning the surface composition of the satellite [1-4]. Red, yellow, green, white and black hues are found on Io, presumably caused by a varied composition of sulfur compounds and silicates. Several of these units were particularly puzzling. Bright red deposits similar to the ring around Pele were found to be oblique to other volcanic centers, often asymmetric in plan and situated to one side of a dark deposit. Greenish-yellow materials in small isolated spots on Io's anti-Jupiter hemisphere were first discovered in 3 km/pixel color imaging from orbit 14. Unlike other ionian terrains, these regions have a negative near-infrared spectral slope, suggesting contamination by a non-sulfur component. Io's volcanic centers and high-temperature hot spots are commonly covered by dark deposits, which display a bewildering variety of visible colors ranging from black to red and green. Most dark spots have a shallow spectral absorption feature at 0.9 micron, suggesting magnesium-rich silicates such as orthopyroxene. Until orbit 24, the dark pyroclastic deposits at Babbar, Pele and Pillan had not been imaged at all three of SSI's near-IR wavelengths, and the possibility remained that these large diffuse deposits could be made up of black sulfur.

Observations: *Pillan, Pele and Babbar*: A global view of Io centered on longitude 245 W was obtained during orbit 24 with full color coverage, including near-infrared filters centered at 968 nm, 889 nm, and 756 nm along with visible filters at red, green and violet wavelengths. These data were acquired at 31 degrees phase and 6.7 km/pixel resolution. To test whether the dark pyroclastic deposits displayed a silicate absorption feature at 0.9 micron, we ratioed the 889 nm image by the average of the 756 and 968 nm images. The pyroclastic deposits were found to be 3% to 8% darker at 889 nm than the average of 756 and 968 nm, making Babbar, Pillan and the dark deposits at the center of Pele's red ring appear dark in the ratio image. Spectral obvervations by of these dark spots by HST do not show an absorption near 0.9 micron [5]; the cause of the discrepancy is under investigation.

Prometheus: Near-infrared coverage of the caldera of Prometheus at 133 m/pixel was acquired at 20 degrees phase during orbit 24. A color ratio of these data shows no sign of a 0.9 micron absorption. Earlier observations at 3 km/pixel during orbit 14 also showed a flat near-infrared spectrum for the caldera, whereas dark materials at other volcanic centers displayed prominent 0.9 micron absorptions in the orbit 14 data. These results suggest that either the caldera is coated by fallout from the nearby plume that somehow masks the spectral absorption feature, or there is some compositional heterogeneity among ionian lavas. Note that the caldera is not a current thermal anomaly [6] so the presence of volatile coatings is plausible. Interestingly, Prometheus' prominent plume was found to originate from the toe of an irregular lava flow to the west of the caldera, while a diffuse red deposit was confined to the vicinity of the caldera and to the east. The bright plume deposit can be seen in the orbit 14 data to be made up of three distinct circular rings; the outermost of these corresponds to an SO_2 deposit visible in a 4.2 micron NIMS image from orbit 24.

Tvashtar: A triplet of giant calderas at 60N, 120W was imaged during orbit 25 at 182 m/pixel. While not a color observation, the morphology of this actively erupting volcano may explain an old mystery. Earlier color observations on orbits 14 and 21 showed a greenish spot in the northernmost caldera. In the high-resolution image it can be seen that this coloration corresponds to an abrupt albedo change in the materials coating the caldera. No topography is apparent at the boundary between the two albedo units, but the transition is sharp and well defined. The greenish hues are only found on the silicate lavas, and not on the surrounding plains. Darker lava flows are also seen in this caldera and surrounding the erupting fissure to the south.

Culann: Visible color images of Culann at 210 m/pixel were acquired at 29 degrees phase during or-

bit 25, and are still being transmitted to Earth at this writing. Culann's caldera is also coated by greenish materials. Several lava flows extending from the caldera are tainted by this coloration as well. The greenish unit is marked by sharp boundaries, similar to Tvashtar. Unlike the diffuse red deposits that blanket the area around the caldera and to the southeast, the greenish materials are apparently confined to the lava lake and and the dark flows. Both red and yellow materials are found along a lava tube that issues from the west end of the caldera and feeds the extensive flows to the northwest.

Preliminary Interpretations: High resolution views of Io show that the elongated, irregular dark spots are usually lava flows that erupted from much smaller caldera-like sources. The previously observed variability of their visible colors is likely to be due to coating by sulfur-bearing materials. The greenish material on Io apparently occurs as such a coating. Its distinct color may be due to contamination or physical/chemical alteration of the mantling material [7].

Bright red diffuse deposits tend to be adjacent to the calderas, and may be useful indicators of the locations of eruptive centers in places where this cannot be discerned directly. Apparently the red materials mark vents for lava, whereas SO_2 plumes may mark distal flows. This is consistent with the hypothesis that the red materials derive from high temperature, S_2-rich plumes [8]. The shapes of these bright red deposits might be modified by local winds emanating from SO_2 plumes at the ends of nearby lava flows.

The 0.9 micron spectral feature in the dark diffuse deposits surrounding Babbar, Pillan and Pele suggests that they may have been produced by silicate pyroclastic eruptions similar to those on the terrestrial planets.

Future Observations: Visible and near-infrared color coverage of the Loki region at 3.4 km/pixel resolution has already been acquired by Galileo during orbit 26 but not yet transmitted to Earth. Several important targets are planned for orbit 27. Two more greenish areas are slated for monochrome imaging: Chaac at 7 to 8 m/pixel and Tohil at 165 m/pixel. Prometheus and Amirani will both be observed at moderate resolution with the 756 nm, green and violet filters. Near-infrared, violet and clear filter coverage will be obtained of Tvashtar, permitting spectral investigations of very fresh lavas. Finally, a global view centered on longitude 200W will be obtained in the 756 nm, green and violet filters, useful for monitoring surface changes.

References: [1] McEwen et al., Icarus, 135, 181-219, 1998. [2] McEwen et al., Science, 281, 87-90, 1998. [3] Geissler et al., Icarus, 140, 265-282, 1999. [4] Lopes-Gautier et al., Icarus, 140, 243-264, 1999. [5] Bagenal et al., Fall AGU, 1999. [6] Lopes-Gautier et al., this conference. [7] Kargel et al., Icarus 142, 249-280, 1999. [8] Zolotev and Fegley, Icarus 133, 293-297, 1999.