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Iapetus: Leading/ trailing side color dichotomy, and the origin of the brightness dichotomy

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The Saturnian satellite Iapetus has been known since 1672 for its extreme and unique albedo dichotomy between the leading and trailing hemispheres. In 1980 and 1981, the Voyager spacecraft revealed that the brightness dichotomy does not exactly separate Iapetus into two hemispheres that correlate with the orbit orientation. Instead, the poles are bright on both hemispheres while the dark terrain extends to the trailing side at equatorial latitudes (Smith et al., Science 1981, 1982). Cassini data showed that the dark hemisphere is very homogeneous at low latitudes, patchy at mid-latitudes, and absent at high latitudes (Porco et al., Science 2005).

Cassini data from October 2004 and November 2005 now show that there is, in addition to the ellipsoidal-shaped brightness dichotomy, a color dichotomy that almost exactly correlates with the leading/ trailing side orientation. Areas located at latitudes between 0˚W and 180˚W (leading side) show significantly redder colors than areas between 180˚W and 360˚W (trailing side). This is not just the case for the bright material, but also occurs for the dark terrain which thusfar has been thought to be covered only by a homogeneously reddish-colored dark material.

For the origin of Iapetus' dichotomy, a combination of two models appears plausible: Reddish material from outer Saturnian satellites (Buratti et al., Icarus 2002) causes an ongoing reddening and slight darkening of the leading hemisphere of Iapetus, quite precisely aligned with the hemispheres (leading/ trailing side). The extreme darkening itself, however, would be caused by thermal segregation of native dark materials as described by Spencer et al. (LPSC, 2005). This effect acts latitudinal at first glance. To explain the observed location of Cassini Regio, a slightly darker leading side is required to allow the effect of ice re-distribution to act preferentially on the lower latitudes of the leading side (Spencer et al., 2005).

Our measurements now suggest that in-falling reddish residue from the outer satellites might initially have acted as a "trigger" for the thermal re-distribution of water ice on the leading side, and would directly contribute significant amounts of the coloring agent. Besides accounting for the Iapetus brightness and color dichotomies, such a scenario might explain the lack of bright spots within Cassini Regio (with both processes active, fresh craters might be darkened and reddened over a time interval of only millions of years), the bright, polewards-facing crater walls at mid-latitudes (correlated to the solar incidence angle), the relatively bright, but reddish surface of Hyperion (if the thermal effect is absent or only acts on crater floors, Spencer, priv-comm. 2005), the similar crater densities of the bright and dark terrains, the probably rather low thickness of the dark blanket (Porco et al., Science 2005), as well as other detailed properties of Iapetus.

While the above mechanism is straightforward, it is still doubtful that the very complex albedo patterns at equatorial latitudes revealed by Cassini images (Denk et al., LPSC 2005) are also produced entirely by these two rather simple processes. Close-up imaging planned for 10 Sep 2007 will provide additional information that might ultimately solve the Iapetus riddle.