What the Dark Craters on Iapetus Can Tell Us

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Saturn's moon Iapetus is famous for a global black-and-white dichotomy on its surface. The leading side of Iapetus, named *Cassini Regio*, is covered by very dark material, while the poles and trailing side are almost ten times as bright.

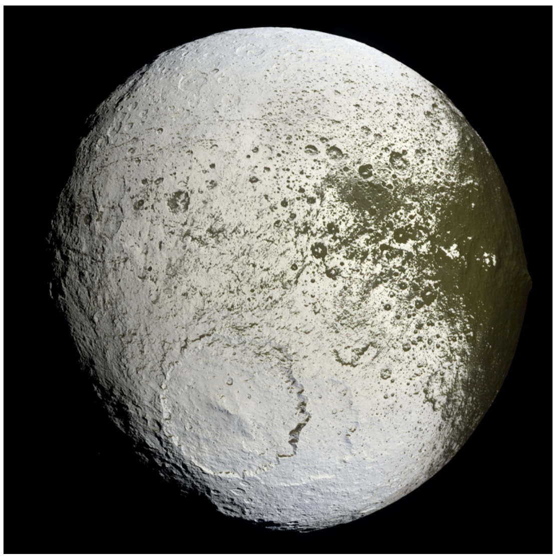

Figure 2: A Cassini ISS image of Iapetus, showing the trailing side. The diameter of Iapetus is 1470 km. This image was taken on the only targeted flyby in September 2007.

In images of the trailing side, dark crater bottoms and troughs with dark floors are common at low latitudes. These smaller-scaled dark areas have very sharp boundaries, even in the highest resolution Cassini ISS images, the typical length of a drop-off in albedo is below the resolution limit. We do not see patches of intermediate albedo. At low latitudes usually the whole floor of the craters is dark, while at mid-latitudes only the walls facing towards the equator are darkened, and at high latitudes we do not see blackened craters at all.
This difference in frequency and shape of the darkened areas gives us significant insight into the nature of the processes involved.
For any given location the surface is in one of two states: Either dark or bright. If

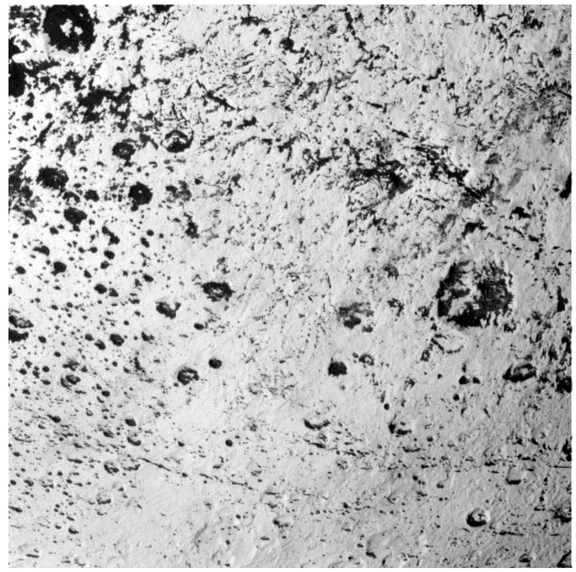

Figure 1: Dark-floor craters on the trailing side of Iapetus. The dark crater on the right, named Hamon, has a diameter of 96 km.

transitions between these states happen, they must be rapid compared to geological timescales. This led *Spencer and Denk* (2010) to the conclusion of the following thermal feedback process: In the initial state the dark material is embedded in a matrix of water ice. By any means at a given time and location on Iapetus more ice sublimes or more dark exogenic material is deposited than at an average place on the surface of Iapetus. This location becomes darker than the comparable surroundings. Therefore, the absorption of sunlight becomes more effective, and the sublimation of water ice is increased. Most of water molecules travel balistically for a distance larger than the surface area undergoing the darkening. The surface area therefore is even more enriched with the dark lag deposit. The process now becomes a runaway feedback.
Thus, at any given location the deposition always works toward brightening and the sublimation (and possible input of dark exogenic material) work towards darkening. Mass wasting and impact gardening tend to

mix darker and brighter ice and always work towards a change of state. For a more detailed description of these processes and how they lead to the global albedo dichotomy of Iapetus see the supporting online material of *Spencer and Denk 2010* and *Denk et. al. 2010.*

Under the assumption that the transition from dark to bright has quite a low probability of being triggered, the current pattern of dark craters gives additional information on the effectiveness of sublimation compared to the other processes. We show that the frequency and shape of Iapetus' craters tell a story about the pathway they evolved by.

The same basic concepts could be used to determine the effectiveness of similiar processes on different icy bodies in the outer solar system. This particular darkening process is strongly dependent on local temperature and therefore the local solar flux. The process must change the optical properties of the surface. Either the rates of change between the visible states have to be low or the number of observations has to be high (sadly usually ruling out purely diurnal or seasonal effects).

Literature:

Spencer, J. R. and Denk, T. (2010), Science 327, 432 – 435

Denk, T. *et al.* (2010), Science 327, 435 - 439