FIRST IMAGING RESULTS FROM THE *IAPETUS* B/C FLYBY OF THE CASSINI SPACECRAFT.

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Abstract/ Introduction. The first of two relatively close Iapetus flybys in Cassini's primary mission occured on Dec 31, 2004 18:49 UTC near apoapsis from orbit "B" to "C" at an altitude of ~123,400 km over the northern leading hemisphere, resulting in a minimum pixel scale of 740 m for the ISS narrow angle camera (NAC) [1]. Data revealed details of a >1300-km-long ridge that had been discovered just one week earlier in optical navigation images [2, 3]. Individual mountains within the western part of the ridge reach heights of ~20 km over surrounding terrain. The data set provides constraints on the origin of the albedo dichotomy. It appears very likely that the dark material is overlying an ice crust, but no evidence for emplacement of dark material via surface flows is apparent. Instead, signs for dark-material emplacement through processes that included ballistic transportation are visible. No bright-floor ("punch-through") craters have been found on the dark hemisphere. The ridge discovery may revive the idea of an endogenic origin of the dark side [4].

Data acquisition. All 288 planned images were successfully transmitted to Earth. A total of 8 NAC mosaics were obtained, ranging in spatial resolution from 1030 to 740 and then back to 1100 m/pxl. The phase angle increased from 51° to 140°. Three sequences included multi-color observations (from 0.25 to 1 µm). 55 images were taken of parts of the surface that were primarily illuminated by Saturn shine. During the observation period from 31 Dec 2004 01:53 UTC to 01 Jan 2005 14:30 UTC, the sub-spacecraft point moved from 29°N/ 70°W north-eastwards to 66°N/ 0°W and then back in a southeast direction to 47°N/ 300°W. The sub-solar point moved from 106°W to 113°W at 7.5°S latitude. Therefore, almost no part of the trailing side or poles was illuminated by the sun and visible from Cassini's perspective.

Ridge system. The ridge system shows a large variety of landforms [3]. It includes isolated peaks as well as single ridges >200 km long, and even parts where two or three ridges run in parallel [3]. Its average height decreases towards eastern parts of Cassini Regio, and the whole system might end near 50°W, close to the large 550 km impact basin. It is covered by numerous craters, and some large craters completely destroyed it locally [3]. This indicates that its formation occured relatively early in Iapetus' history. One crater near 100°W shows a white rim, suggesting that the ridge is composed primarily of icy material. Its origin is a puzzle so far, and no similar geologic feature has been observed elsewhere in the solar system. Possibly, further evidence about formation may come from topographic data.

Craters in the dark hemisphere. Craters of all sizes can clearly be seen at 1 km/pxl resolution. In general, crater flanks appear very steep with an abrupt transition to a flat floor. This gives them a "pan-shaped" appearance, similar to what was observed by Cassini on Dione. Central peaks are common.

Deep within Cassini Regio, rims and central peaks of craters appear somewhat less covered by dark material than their floors and walls, reminiscent of Callisto [5]. However, bright spots on Callisto can be recognised at pixel scales of 10 km or worse, while the dark hemisphere of Iapetus appears homogeneously dark at the 10 km scale (Fig. 2 in [6]).

Further away from the equator and closer to the northern transition zone, several large craters exhibit steep, bright rims, especially on their north-facing flanks. No dark layers can be seen on top of these bright crater walls. Since the best image resolution is 740 m/pxl, it is probable that the dark layer is less than ~1/2 km thick in regions about 30° north of the equator.

Dark crater rims and streaks in the transition zone. The color image of the northern transition zone removes all doubts about asymmetric deposits of dark material on crater walls. Almost every crater at high latitudes shows a dark, south-facing wall and central peak (when present) [3]. Additionally, numerous dark streaks cover wide parts of the transition terrain. Whitish patches are in most cases correlated to north-facing slopes. These observations strongly suggest that the dark material did not flow over the surface, like lava from the interior, but was distributed over this part of the surface from a distant source [3]. The relative brightness of local areas appears to depend on local topography and on latitude. This is also consistent with the bright, polewards facing crater walls, which might have never been hit by dark material. A possible dependence on longitude is less obvious and under investigation.

Landslide crater. A 120 km-sized crater is located at the southwestern edge within the 550-km basin [1] at ~5°N/35°W. Almost half of its floor is covered by a giant landslide, which appears to have originated from the wall of the giant basin which is ~15 km high and has a very steep slope of at least 45°. Unfortunately, large parts of the wall lie in shadow so that no detailed structure can be seen. However, an area immediately adjacent to the crater on its northern side is also covered by the landslide. As in the crater, this area is rather sparsely cratered.

A second curiosity of the landslide crater is that the crater floor shows no impact craters, but is very flat. Since the landslide crater itself is quite large, and because the landslide itself is covered by a few craters, it appears more likely that it has been resurfaced rather than being a very recent impact. Possibly, a relaxation of a locally weak ground removed all topography. Alternatively, deposits of fine materials might be considered, although the reason for this very localized appearance is not clear in either cases.

Interestingly, the dark material coverage on the landslide and on the crater floor do not look different from each other or from other locations. This suggests that the process causing the dark blanket ended later than the flattening of the crater -- perhaps even ongoing today.

Trailing side. Parts of the trailing side including the "moat structure" (an ~250 km wide crater, see [1] for details) have been imaged in Saturn shine. Various mid-sized and small craters are visible, as is a complex albedo pattern of the "moat area" in the vicinity of the equator. One relatively large dark-floor crater with a diameter of ~50 km has been detected near ~10°N/ 300°W, more are possible but uncertain due to their closer position near the 270°W meridian which forms the boundary for Saturn-shine illumination. Several very small (mainly <10 km sized) craters closer to Cassini Regio also exhibit dark floors or partial coverage by dark material. The overall appearance of dark/ bright material distribution on the trailing side still appears very puzzling.

No equatorial ridge is obvious, but illumination conditions might have prevented an immediate detection. Note that even the crater morphology of the "moat" is not obvious in the Saturn-shine images.

Origin debate. The new Iapetus data set several constraints. No bright-floored crater was found on the dark hemisphere, which means that either the dark material is younger than resolved craters, too deep to be excavated by craters, or most likely a combination of both. The dark material looks like a blanket on top of an icy crust with a maximum thickness of 1 km, probably less than 1/2 km (at the locations where bright north-facing crater walls are visible; it could be thicker near the center of Cassini Regio). The streaks and equatorwards-facing dark crater walls indicate that the dark material was emplaced as "spacefall" from a direction close to the apex of motion. This is in principle consistent with accretion of exogenic material or with ballistic emplacement from an equatorial source [3].

A new endogenic origin hypothesis was developed in the Imaging Team after seeing the newly detected ridge. Following this idea, the ridge, its flanks or the area nearby might act as a source of the dark material [3]. Possibly, venting-like plumes regularly erupt intimately mixed dark and bright material onto the surface, with the lighter icy component diffusing into space and the heavier dark component depositing on the surface. The position of the ridge system on Iapetus is well suited for this: It is located along the equator, bisecting Cassini Regio. The poles on the leading side would have remained bright because the plume deposits would not extend this far. Eruption along the ridge might explain why the dark area extends to the trailing side on the equator. However, a major problem is the energy source for such volcanism. Within the ISS Team, it was proposed that energy from Saturn is dissipated through the relatively rapid precession motion of Iapetus' orbit plane. This would imply that the process might be ongoing even today, weakening the problematic finding that no kilometer-scale bright-floor crater was detected inside Cassini Regio. However, no detailed theoretical modelling on this problem has been done so far, including a determination of the power of such a hypothetical energy source.

Alternative options of an exogenic origin remain valid. The data are consistent with models that predict that the dark material should have been deposited in a direction from the apex of motion or nearby. However, the existence of the dark-floor craters on the trailing side or the complex pattern of the transition zones at the equator remain difficult to explain by either model. The latter is in particular a problem for the "Phoebe-dust theories" [7], while catastrophic collision hypotheses [8] suffer the problem of the very low probability of such an event at more recent times.

This leaves the origin debate open; more work, maybe new ideas (and/or data) are needed. Possibly, several processes were acting independently, and different explanations are needed for the genesis of the ridge, the dark blanket, and the dark-floor craters? Despite our lack of understanding, a certain fact is that Cassini Regio exists.

References. [1] Porco, C.C. *et al.* (2004) *Space Sci. Rev.* 115, 363-497. [2] Denk T. *et al.* (2005) *LPSC XXXVI*, abstract. [3] Porco C.C. *et al.* (2005) *Science*, under review. [4] Smith B.A. *et al.* (1982) *Science* 215, 504-537. [5] Greeley R. *et al.* (2000) *Plan. Space Sci.* 48, 829-853. [6] Denk T. *et al.* (1999) LPSC XXX, abstract #1841. [7] e.g., Burns J.A. *et al.* (1996) *Phys. Chem. Dyn. of Interplan. Dust*, ASP Conf. Series 104, 179-182; Buratti B.J. and J.A. Mosher (1995) *Icarus* 115, 219-227. [8] e.g., Tabak R.G. and W.M. Young (1989) *Earth, Moon, and Planets* 44, 251-264; Matthews R.A.J. (1992) *Q. J. Roy. Astron. Soc.* 33, 253-258; Denk T. and G. Neukum (2000) *LPSC* XXXI, abstract #1660; Owen T.B. *et al.* (2001) *Icarus* 149, 160.172; Marchi S. *et al.* (2002) *Astron. Astrophys.* 381, 1059-1065.

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Images. There's so much new information in the data that the available space did not allow us to include figures to the abstract. However, images are available at various places in the WWW, such as:

Cassini Imaging Team: http://ciclops.org

NASA: http://photojournal.jpl.nasa.gov/target/Iapetus

JPL: http://saturn.jpl.nasa.gov/multimedia/images/images.cfm?subCategoryID=14

FU Berlin: http://userpage.fu-berlin.de/~planeten/de/projekt/cassini/N_ia.htm