THE DARK SIDE OF IAPETUS. J.F. Bell, M.J. Gaffey, and R.H. Brown, Hawaii Inst. of Geophysics, Univ. of Hawaii, Honolulu, HI 96822; D.P. Cruikshank and R. Howell, Inst. for Astronomy, Univ. of Hawaii, Honolulu, HI 96822.

The Saturn satellite Iapetus (S8) exhibits a degree of hemispheric asymmetry unmatched by any other known object in the solar system (1,2). The "trailing" hemisphere (in the sense of orbital motion around Saturn) has a surface dominated by water ice (3,4) as do the inner satellites of Saturn, while the "leading" hemisphere is covered with a dark material whose composition and mode of origin remain a mystery. We have obtained spectrophotometric data which cast new light on these questions.

Solar Phase Function: In 1979 a rare phasing of the orbital positions of Iapetus and Earth allowed photometry of the dark hemisphere near 0° phase angle and an accurate measurement of the opposition brightness surge. The solar phase function out to 6° resembles closely that of the moon. (A similar result is reported (5) from preliminary analyses of Voyager images.) This suggests that the dark material is in the form of a granular regolith.

Reflectance Spectra: Spectrophotometric observations in the McCord 25-color system and VJHK photometry were obtained with the Mauna Kea 2.2-meter telescope, and are shown in Figure 1 together with 1.4 - 2.6 μm spectrophotometry obtained with the 3.8-meter United Kingdom Infrared Telescope. In the 0.3 - 1.0 μm region, the leading hemisphere of Iapetus exhibits a very red but nearly linear reflectance curve similar to those of some asteroids in the outermost portions of the asteroid belt (variously called "RD-type" or "D-type"). A shallow absorption band may be present near 0.6 μm. In the infrared a generally flat spectrum is seen in agreement with other JHK photometry (6). Shallow water ice absorption bands visible in the narrow-band IR data are due to light from the icy "polar caps" which extend onto the leading hemisphere (2). With allowance for this effect, the Iapetus spectrum is a close match to a laboratory spectrum of the carbonaceous phases of the Murchison C2 chondrite, shown shifted down for clarity in Figure 1. (The Murchison organic material was provided by E. Anders; its isolation is described in ref. 7). An organic-rich mixture produced by Gradie and Veverka to simulate the "D-type" asteroids (8) also has a visible-wavelength reflectance curve similar to that of Iapetus. These data therefore suggest that the Iapetus dark material is spectroscopically dominated by organic material similar to that in carbonaceous chondrites, but in higher abundance than in any known meteorite. More recently, spectrophotometry in the 3.1 - 3.8 μm region has indicated the presence of an absorption similar in shape to that found in some asteroids (9) and attributed to bound water.

Origin of the dark material: The peculiar distribution of the dark material has led to the suggestion that it is the result of some asymmetry in the external environment. (Arguments against a purely internal, "volcanic" origin include: A. The precise alignment of the dark unit with the satellite's velocity vector; B. The fact that this axis is orthogonal to the direction of internal mass asymmetry unlike the lunar maria; C. The close correspondence between the positions of the light/dark boundary seen by Voyager I and the predictions of ref. 10). The asymmetric velocity distribution of impacting debris from outside the Saturn system, proposed to explain hemispheric asymmetries on Dione and Rhea (2), appears inadequate for Iapetus (10). However, Iapetus is unique among large satellites in orbiting immediately inside a retrograde satellite, S9 Phoebe. Small particles ejected from Phoebe by impacts will spiral toward Saturn due to Poynting-Robertson drag (11) and reach Iapetus in 1-3 million years. These particles will require about 10 years to diffuse inward across the 1440-km diameter of Iapetus, and are likely to collide head-on with the leading side at 7 km/sec or more. The reflection spectrum of Phoebe (12) differs considerably from that of the Iapetus material, so simple accretion of Phoebe material does not occur. We suggest that the dark material may have originated as a minor contaminant in the icy surface, and was concentrated in a thin surface deposit by selective vaporization of the ice due to Phoebe-dust impacts. Further telescopic studies and analyses of Voyager images may resolve the questions regarding this unusual object.

References:

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5) Veverka, et al., BAAS 13, 720.
6) Veeder and Matson, AJ 85, 969.
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8) Gradie and Veverka, Nature 283, 840.
9) Lebofsky, AJ 85, 573.
10) Cook and Franklin, Icarus 13, 282.
11) Burns, et al., Icarus 40, 1.
12) Degewij, et al., Icarus 44, 541.

Fig. 1: