Cassini closes in on the centuries-old mystery of Saturn's moon Iapetus

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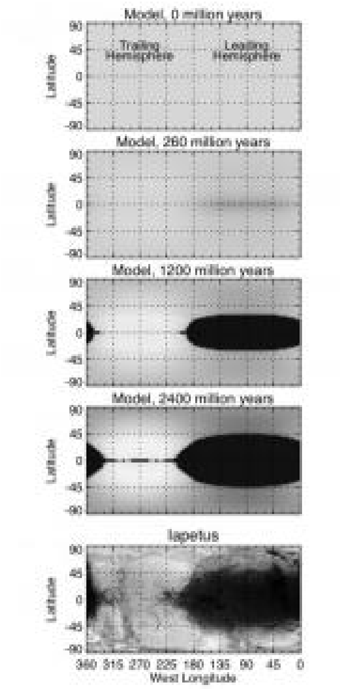
These two global images of Iapetus show the extreme brightness dichotomy on the surface of this peculiar Saturnian moon.

Extensive analyses and modeling of Cassini imaging and heat-mapping data have confirmed and extended previous ideas that migrating ice, triggered by infalling reddish dust that darkens and warms the surface, may explain the mysterious two-toned "yin-yang" appearance of Saturn's moon Iapetus. The results, published online Dec. 10 in a pair of papers in the journal *Science*, provide what may be the most plausible explanation to date for the moon's bizarre appearance, which has puzzled astronomers for more than 300 years.

Shortly after he discovered Iapetus in 1671, the French-Italian astronomer Giovanni Domenico Cassini noticed that the surface is much darker on its leading side, the side that faces forward in its orbit around Saturn, than on the opposite trailing hemisphere. Images from Voyager and Cassini have shown that the dark material on the leading side extends onto the trailing side near the equator. The bright material on the trailing side, which consists mostly of water ice and is 10 times brighter than the dark material, extends across the north and south poles onto the leading side.



This series of maps of Saturn's moon Iapetus shows how a computer model of migrating ice can explain most features of Iapetus' global appearance. The model starts with Iapetus uniformly covered in ice with some dark material mixed in, as shown in the top map. Additional dark material is then slowly added to the leading hemisphere (centered at longitude 90 west). After 260 million years, the leading side has darkened and thus warmed slightly, and ice has begun to evaporate near the equator where temperatures are highest. The ice evaporation leaves dark material behind and thus darkens the surface further. After 1,200 million years, a large dark region that is completely ice-free has developed on the leading side. By 2,400 million years, the dark region has grown to closely resemble the size and shape of the dark region on the global mosaic map of Cassini images of the real Iapetus, shown in the bottom panel. Credit: Southwest Research Institute/NASA/JPL/SSI/Steve Albers, NOAA

One of the papers, led by Tilmann Denk of the Freie Universität in Berlin describes findings made by Cassini's Imaging Science Subsystem (ISS) cameras during the spacecraft's close flyby of Iapetus on Sept. 10, 2007, and on previous encounters. "ISS images show that both the bright and dark materials on Iapetus' leading side are redder than similar material on the trailing side," says Denk, suggesting that the leading side is colored (and slightly darkened) by reddish dust that Iapetus has swept up in its orbit around Saturn.

This observation provides new confirmation of an old idea, that Iapetus' leading side has been darkened somewhat by infalling dark dust from an external source, perhaps from one or more of Saturn's outer moons. The dust may be related to the giant ring around Saturn recently discovered by NASA's Spitzer Space Telescope. However, the ISS images show that this infalling dust cannot be the sole cause of the extreme global brightness dichotomy.

"It is impossible that the very complicated and sharp boundary between the dark and the bright regions is formed by simple infall of material. Thus, we had to find another mechanism," says Denk.

Close-up ISS images provide a clue, showing evidence for thermal segregation, in which water ice has migrated locally from sunward-facing and therefore warmer areas, to nearby poleward-facing and therefore colder areas, darkening and warming the former and brightening and cooling the latter.

The other paper, by John Spencer of Southwest Research Institute in Boulder, Colo., and Denk, adds runaway global migration of water ice into the picture to explain the global appearance of Iapetus. Their model synthesizes ISS results with thermal observations from Cassini's

Composite Infrared Spectrometer (CIRS) and computer models. CIRS observations in 2005 and 2007 found that the dark regions reach temperatures high enough (129 degrees Kelvin or -227 degrees F) to evaporate many meters of ice over billions of years. Iapetus' very long rotation period, 79 days, contributes to these warm temperatures by giving the Sun more time to warm the surface each day than on faster-rotating moons.

Spencer and Denk propose that the infalling dust darkens the leading side of Iapetus, which therefore absorbs more sunlight and heats up enough to trigger evaporation of the ice near the equator.

The evaporating ice recondenses on the colder and brighter poles and on the trailing hemisphere. The loss of ice leaves dark material behind, causing further darkening, warming, and ice evaporation on the leading side and near the equator.

Simultaneously, the trailing side and poles continue to brighten and cool due to ice condensation, until Iapetus ends up with extreme contrasts in surface brightness in the pattern seen today. The relatively small size of Iapetus, which is just 1,500 kilometers (900 miles) across, and its correspondingly low gravity, allow the ice to move easily from one hemisphere to another. "Iapetus is the victim of a runaway feedback loop, operating on a global scale," says Spencer.

Provided by Southwest Research Institute (news : web)

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