SATURNIAN MOON IAPETUS – GLOBAL ALBEDO ENIGMA AND CASSINI ISS OBSERVATIONS.
T. Denk1, J.R. Spencer2, Th. Roatsch3, N. Schmedemann1, and G.G. Galuba1, 2Freie Universität Berlin, Germany (Tilmann.Denk@gmx.de), 2SwRI, Boulder, CO, 3DLR (German Aerospace Center), Berlin, Germany.

Introduction: Iapetus, the outermost body of Saturn's regular moon system (a = 3.56·10^6 km; P = 1904 h) and the third largest of all moons of Saturn (Ø = 1425 km x 1495 km) is most famous for its unique global albedo dichotomy. It was discovered by J.-D. Cassini almost 340 years ago [1] as the first ever recognised surface structure on a solid body outside the Earth-moon system. Cassini did not try to explain the reason for this dichotomy, and it remained a mystery until the Cassini spacecraft observed Iapetus.

Voyager: Before Cassini's arrival at Saturn, Iapetus has been observed from the ground and by the Voyager spacecraft. Low resolution images (9 km/pixel or less) allowed a global characterization of the albedo dichotomy including the findings that the dark terrain faces precisely towards the apex of motion and that the polar regions are bright. The bright hemisphere was found to be heavily cratered and thus understood to be old [2]. A reinvestigation of Voyager images in the 1990s revealed an oblate spheroidal shape, large basins, a similar crater size-frequency in parts of the dark terrain as in the adjacent bright area, and giant mountains near the equator on the anti-Saturn hemisphere [3].

Cassini imaging: Cassini imaging of Iapetus during one targeted (on 10 Sep 2007) and several more distant flybys mainly in the first years of the mission revealed an alien and often unique landscape [4,5]. The data show numerous impact craters on the bright and dark terrain, very complex and sharp boundaries between the dark and bright material with no "gray shading", equator-facing dark and pole-facing bright crater walls, additional huge impact basins, small bright-ejecta or bright-rim craters within the dark terrain, only minor endogenic geologic features, and a giant ridge which spans across half of Iapetus' circumference exactly along the equator with mountains up to ~15 km tall. A global color dichotomy was discovered besides the albedo dichotomy; it is presumably formed by dust from retrograde irregular moons [5]. Major parts of the surface have been mapped at a scale of 1:3,000,000 [6]. Neither precisely at the center of the trailing side (at 425 m/pixel resolution) nor elsewhere, a black crystalline monolith with dimensions 1:4:9 was found.

The extreme global albedo dichotomy, where the trailing side and poles were found to be more than 10x brighter than the leading side, has been characterized in great detail. For example, the small bright-ray craters [5] as well as Cassini RADAR data [7] suggest a very thin dark blanket in the order of decimeters on an otherwise bright, icy surface.

Albedo dichotomy enigma: Various attempts to explain the global albedo dichotomy have been published since the mid-1970s. Especially the deposition of exogenic dark material on the leading side, originating from outer retrograde moon Phoebe, was a leading hypothesis, but it could not explain the global shape, sharpness, and complexity of the transition between Iapetus' bright and dark terrain. Mainly with Cassini spectrometer (CIRS) and imaging (ISS) data, all these characteristics and the asymmetry's large amplitude are now plausibly explained by runaway global thermal migration of water ice, triggered by the deposition of dark material on the leading hemisphere [8].

This mechanism is unique to Iapetus among the Saturnian satellites for many reasons: (1) Size (mass) of Iapetus and (2) distance to the sun (=> right temperature; sublimed water molecules can migrate globally, but do not escape at substantial rates); (3) slow and synchronous rotation (=> temperature issue again, and there is a leading and a trailing side); (4) Iapetus orbits outside of the magnetosphere (=> very fine-grained dust from outside is not disturbed); (5) Iapetus is the outermost of the regular moons (=> it is the first obstacle for dust from outside); (6) the impact gardening rate on the surface is "about right" (=> preventing the whole surface from getting dark); (7) Hyperion and Titan, the moons next to Iapetus, either do not rotate synchronously or have a thick atmosphere (=> can not form a comparable surface dichotomy); (8) Saturn has retrograde outer moons (which deliver refractory dusty material). The combination of these circumstances makes the albedo dichotomy a unique feature on Iapetus in the solar system.