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## In This Issue



## Planetary Environments, Part 10: Saturn's Moons

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This is the tenth article in the *Astrofax* series on planetary environments. The first nine in the series appeared in the previous nine issues of *Astrofax*:

1. *Planetary Environments, Part 1: Introduction* (Volume 31, Issue 2, Summer 2023)
2. *Planetary Environments, Part 2: The Moon* (Volume 31, Issue 3, Fall 2023)
3. *Planetary Environments, Part 3: Mercury* (Volume 31, Issue 4, Winter 2023)
4. *Planetary Environments, Part 4: Venus* (Volume 32, Issue 1, Spring 2024)
5. *Planetary Environments, Part 5: Mars, Part 1* (Volume 32, Issue 2, Summer 2024)
6. *Planetary Environments, Part 6: Mars, Part 2* (Volume 32, Issue 3, Fall 2024)
7. *Planetary Environments, Part 7: Jupiter* (Volume 32, Issue 4, Winter 2024)
8. *Planetary Environments, Part 8: Jupiter's Galilean Moons* (Volume 33, Issue 1, Spring 2025)
9. *Planetary Environments, Part 9: Saturn* (Volume 33, Issue 2, Summer 2025)

This article is a continuation of Part 9 of the series. Ideally, the reader will be familiar with that article before reading this one.

## Introduction

As of 2025, Saturn has 274 moons with confirmed orbits. This is by far the most of any planet in the solar system and does not even include many tiny moonlets. This article will consider the seven moons which are large enough to be approximately spherical due to gravitational effects. Titan is the largest and most Earthlike of them. In order of distance from Saturn and with their diameters, they are: Mimas (396 km), Enceladus (504 km), Tethys (1062 km), Dione (1123 km), Rhea (1527 km), Titan (5149 km) and Iapetus (1470 km) (reference). Fig 1, a Pioneer-11 event cover, shows them in that order, with correct relative sizes, along with a few other moons.

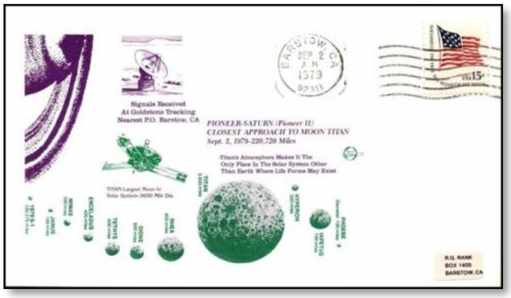

Figure 1. Pioneer-11 event cover; SV Cachet. 1979

Titan was discovered in 1655 by Christiaan Huygens. Tethys, Dione, Rhea and Iapetus were discovered between 1671 and 1684 by Jean-Dominique Cassini (the stamp in the SS1 (souvenir sheet of 1) of Fig 2 depicts Cassini and Rhea, and its margin shows Saturn and Titan; Cassini is also depicted in the stamp in the SS1 in Fig 10). Mimas and Enceladus were discovered in 1789 by William Herschel (the  MS4 (minisheet of four stamps) in Fig 3 depicts him as well as Huygens and Cassini). The names of all those moons were suggested by astronomer John Herschel (William's son) in 1847 (Fig 4 depicts John at the right and William at the left in both the stamp and the similar cachet).

Figure 2. Liberia. Unknown. 2024

Figure 3. Benin. Illegal. 2018[?].

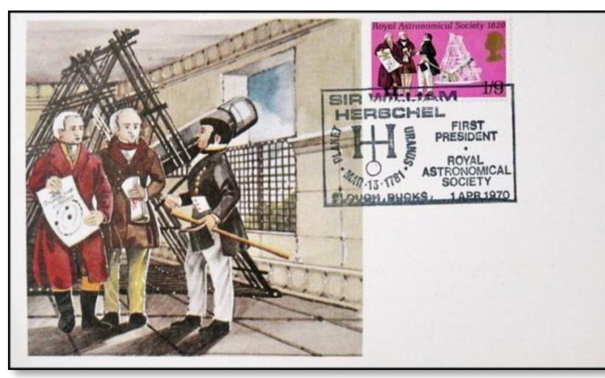

Figure 4. Great Britain, Sc616. FDC. 1970

Saturn is so far away that few details about its moons can be obtained with small telescopes. However, large ground-based telescopes and space telescopes have used remote-sensing techniques such as spectroscopy and observations in various wavelengths (e.g. IR (infrared) and UV (ultraviolet) in addition to visible) to provide a trove of scientific information in the late 20th and 21st centuries.

"The Saturnian system is the most distant radar-detected planetary object in the solar system … Ground-based radar observatories have made several observations of Saturn's moons, including Titan, Iapetus, Rhea, Dione, Tethys, and Enceladus" (reference).

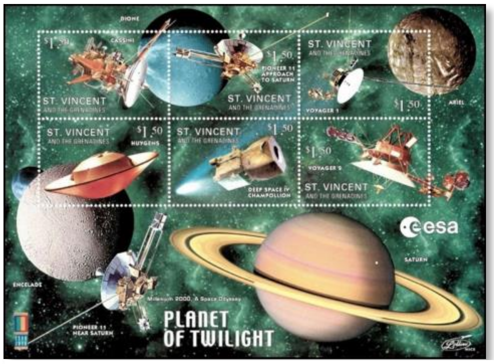


Figure 5. St. Vincent, Sc2793. 2000

As described in Part 9 of this series, four spacecraft have visited the Saturnian system: Pioneer-11, Voyager-1 and 2, and the Cassini-Huygens orbiter/lander. They are all depicted in the context of Saturn and its moons in Fig 5 (Enceladus and Dione are featured while Ariel, at the upper right, is a Uranian moon). The Champollion spacecraft in stamp 'e' would have had nothing to do with Saturn and in any case was canceled.

**Titan**

Titan is similar to Earth in some ways and extensive scientific information about it is available. Good summaries are found here and here. Many of the details below come from this reference.

Titan is by far the largest Saturnian moon (larger even than the planet Mercury) and its mass dwarfs that of all the other Saturnian moons combined. In a solar system full of moons, only Jupiter's Ganymede is slightly larger, but Ganymede has only a tenuous exosphere. As we shall see, Titan has a dense atmosphere, which makes it unique among all the moons of the solar system.

In 1908, the Catalan astronomer Josep Comas i Solà published his observations of the limb darkening of Titan. This was the first evidence that it has an atmosphere (with no atmosphere, there would be no darkening). In the 1930s the German Rupert Wildt calculated that Titan is massive enough and cold enough that it could hold onto an atmosphere composed of gases with molecular weights of 16 or greater. Thus methane, with its molecular weight of 16 g/mol, could be present. In 1944 the Dutch-American astronomer Gerard Kuiper found spectroscopic evidence of the absorption of sunlight by methane on Titan and estimated that its partial pressure at the surface must be at least 100 hPa (on Earth, the total surface pressure is around 1000 hPa).

"During the 1960s, various measurements of Titan's brightness at different wavelengths gave inconsistent values of the surface temperature, but all the theories led to higher temperatures than expected. In 1973 Carl Sagan, a former student of Kuiper, and Joseph Veverka of Cornell University proposed a greenhouse effect, which required the presence of more than methane in the atmosphere" (reference).

In the 1970s, Earth-based spectroscopic observations confirmed the presence of methane in Titan's atmosphere and led scientists to deduce that nitrogen must be present as well. Other measurements showed that complex hydrocarbons such as ethane, ethylene and acetylene were also present, and that temperatures were warmer than expected from a simple blackbody, which implied that a greenhouse effect must exist. This was consistent with the hypothesis of Sagan and Veverka. What could cause such an effect? Clouds and/or an aerosol haze? In 1977 Donald Hunten at the University of Arizona (Ref 1) proposed a model that predicted a surface temperature of -186 °C and a surface pressure of 2 bars (about twice that of Earth).

Pioneer-11's closest approach to Titan (at 355,000 km distance) took place on 2 September 1979 (Fig 1). Its best image, at a resolution of 179 km per pixel, showed a fuzzy and featureless orange disk. It measured a cloud top temperature of -198 °C and observed an opaque and hazy atmosphere, from which it was concluded that the forthcoming Voyagers would most likely be unable to view the moon's surface.

As a result, it was decided to put Voyager-1 on a path that would take it very close to Titan, at the expense of sacrificing a possible extended voyage to Uranus and Neptune. It grazed the moon at around 6500 km altitude on 11 November 1980 (Fig 6) – the closest that either Voyager ever flew by any planet or moon. The stamp in Fig 7 commemorates this event and includes the text "Voyager-1, Titan, Saturn"). Voyager-1 observed an orange haze obscuring the moon's surface, with detached haze layers up to 500 km above the thicker atmosphere. It measured the atmospheric composition as mostly nitrogen with about 10% methane and traces of hydrocarbons. Surface data (temperature around -179 °C, and pressure around 1.5 bars, which is 50% greater than Earth's) were inferred through the radio occultation technique. Those values are reasonably close to what had been proposed by Hunten.

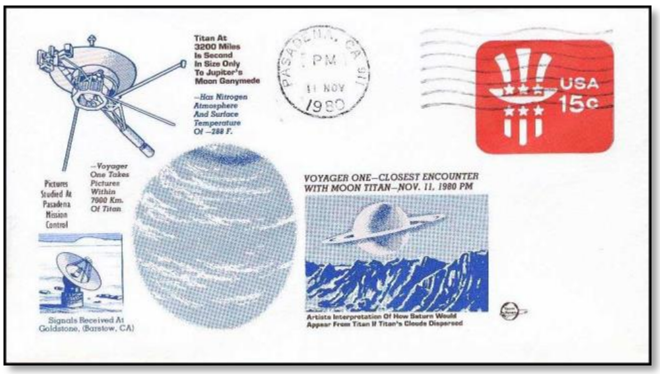


Figure 6. Voyager-1 Event Cover, SV Cachet. 1980

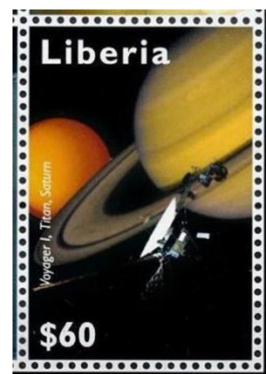


Figure 7. Liberia. Sc2515d. 2008


Figure 8. Voyager-2 Event Cover, SV Cachet. 1981

The success of Voyager-1 cleared the way for Voyager-2 to slingshot around Saturn and extend its mission to Uranus and Neptune. Voyager-2's first significant images of Titan were made on 23 July 1981, and the spacecraft made a distant pass (664,000 km) of the moon on 25 August 1981 (Fig 8). Voyager-2 didn't discover anything new about Titan, and almost 23 years would pass before another spacecraft would visit it.

The Cassini-Huygens spacecraft went into orbit around Saturn on 30 June 2004. For 13 years it explored both the ringed planet and some of its moons. The Huygens probe was released on 24 December 2004 (Fig 9) and on 14 January 2005 descended by parachute for 2.5 hours in Titan's atmosphere (Fig 10). It successfully landed on "a frigid floodplain, surrounded by icy cobblestones" (Fig 11 and reference) where it transmitted data for more than an hour until its batteries were drained. The Cassini spacecraft studied both Saturn and some of its moons, including more than 100 flybys of Titan, 12 of which were close flybys. For example, Fig 12 shows an event cover for the T-114 Titan flyby, in which the spacecraft's closest-approach altitude was 10,000 km. In the foreground of the cachet is an image of Titan composed of a mosaic of IR images from the T-114 flyby (reference). That composite is the basis of the depiction of Titan in Fig 13.


Figure 9. C-H Event Cover. Unknown cachet maker. 2004


Figure 10. Guinea. BL1485. 2007


Figure 11. Tanzania. Sc 2537d. 2009

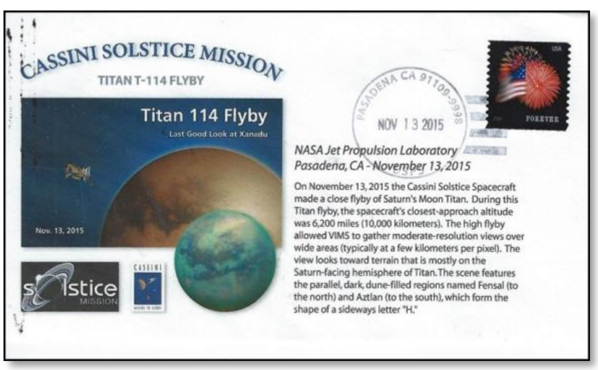


Figure 12. C-H Event Cover. JPL Cachet. 2015


Figure 13. Great Britain. Sc3118. 2012

"Ground-based radar observations of Titan revealed a number of specular reflections from its surface. These observations suggested the existence of large areas that are relatively smooth at the centimeter scale, likely due to the presence of paleolakes or paleoseas" (reference). However, most of our knowledge of Titan comes from observations made by the Cassini orbiter and the Huygens probe. For example, a detailed summary of the composition and structure of Titan's atmosphere is found here. "Methane plays a similar role to water on Earth when it comes to weather. It evaporates from the surface and rises into the atmosphere, where it condenses to form methane clouds. Occasionally it falls as a chilly, oily rain onto a solid surface where water ice is hard as rocks" (reference). For comparison, Earth's hydrologic cycle is illustrated in Fig 14 (the lower-left margin of a minisheet of two stamps issued by Argentina). "We now know that Titan is a world with lakes and seas composed of liquid methane and ethane near its poles [and] with vast, arid regions of hydrocarbon-rich dunes girdling its equator" (reference).


Figure 14. Argentina. Sc2533. 2009

Modern Earth-based and space-based telescopes, such as the Keck Observatory telescope in Hawaii, the JWST (James Webb Space Telescope) and the HST (Hubble Space Telescope) are used in studies of the solar system. Fig 15 depicts the JWST in the context of Titan. Fig 27 depicts the HST with Iapetus and Saturn. The SOFIA airborne observatory also conducted planetary studies. In 2018 it observed an occultation in which Titan passed in front of a distant star. Information about the moon's atmosphere and how it had changed since the last similar observation in 2003 was obtained. The Zadko telescope of the University of Western Australia was also able to capture this occultation (reference).


Figure 15. Central Africa. Unknown. 2023

Dragonfly is a NASA mission that will send a robotic helicopter to Titan for much more detailed scientific studies. It is expected to arrive there in 2034 after a 2028 launch.

**Enceladus**

Pioneer-11 and Voyager-1 and 2 made some early observations of Enceladus and found that it was bright white all over (i.e. it had very high reflectivity), from which it was deduced that the moon is covered in ice or snow. The Cassini orbiter studied Enceladus in much more detail. In 2005 it made a major discovery: geysers of water ice particles and vapor spewing from parts of the surface at 400 m/s. Most of that material falls back like snow to the surface, which explains why the moon is so bright: in fact Enceladus has the highest reflectivity (i.e. the highest albedo) of any body in the solar system. Some of that ice dust also forms a "plume" around the moon, which in turn supplies material to Saturn's E-ring (reference). The JWST has also detected that plume (reference).

Cassini observed that the cryovolcanism is most active around Enceladus' south pole in a region of large fissures known as "tiger stripes" (reference). The spacecraft measured surface temperatures near the moon's equator at around -193 °C, while the south pole is not as cold (-188 °C in the mean, and -163 °C or even warmer locally). It is likely that "portions of the polar region are warmed by heat escaping from the interior of the moon. This would make Enceladus only the third solid body in the solar system, after Earth and Jupiter's volcanic moon Io, where hot spots powered by internal heat have been detected" (reference). What is the source of that internal energy? It is thought to be caused by the moon's stretching and squeezing by tidal forces related to Saturn's gravity and also the 2:1 dynamical resonance between Enceladus and Dione (reference). This process probably generates enough heat to support a liquid water ocean beneath Enceladus' icy shell.

The geysers generate Enceladus' tenuous atmosphere, an exosphere mainly composed of water vapor, with trace amounts of nitrogen, carbon dioxide and methane. Fig 5 includes a depiction of Enceladus, and Fig 16 features an artist's drawing of the moon's geysers. Fig 17 documents Cassini's E-21 flyby of Enceladus, which was the spacecraft's "deepest dive through the plume" and brought it to "within 48 km of the surface of Enceladus' south polar region."

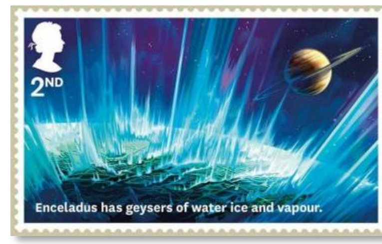


Figure 16. Great Britain. Sc3939. 2020

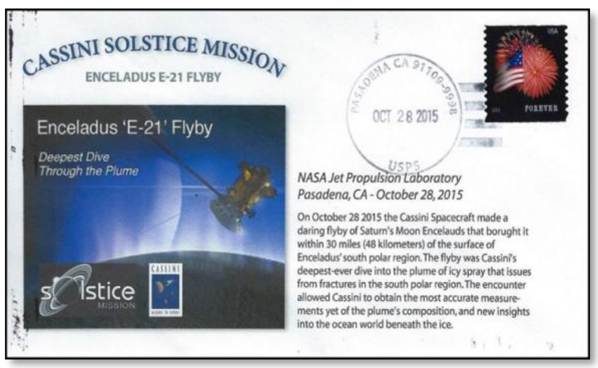


Figure 17. C-H Event Cover. JPL Cachet. 2015

**Dione, Rhea and Tethys**

These three small, icy and heavily cratered moons orbit next to each other and are roughly similar. This video compares them.

The two Voyager spacecraft returned the first images of Dione. Part of the cachet of the cover in Fig 18 depicts the moon, with the accompanying text "Voyager-1 takes [the] first significant pictures of Saturn's moon Dione: Nov. 9, 1980". Those pictures revealed the moon's mysterious bright thin wispy lines. "Cassini flybys starting in 2005 showed "the wisps" as bright canyon ice walls (some of them several hundred meters high), probably caused by subsidence cracking. The walls are bright because darker material falls off them, exposing bright water

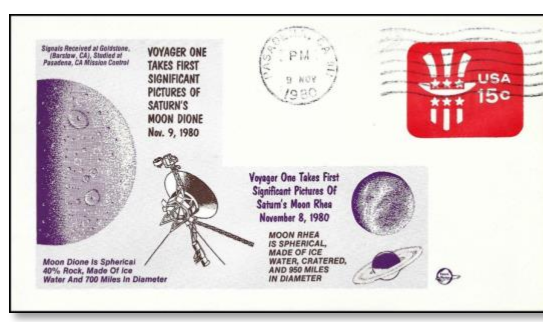


Figure 18. Voyager-1 Event Cover. SV Cachet. 1980

ice. These fracture cliffs suggest Dione experienced tectonic activity in its past. They could be a mature phase of the so-called “tiger stripes” on Enceladus” (reference). Dione’s average temperature, a frigid -186 °C, makes its ice surface behave much like rock. On 7 April 2010, during its close (500 km) flyby D2 above Dione, Cassini detected an exosphere composed of oxygen ions (reference). Its “seasonal and spatial variability suggest winter polar condensation and sublimation” (reference). Its density is “5 trillion times less dense than the air at Earth's surface … equivalent to conditions 480 km above Earth” (reference). As already mentioned, Dione is also of interest because of its orbital resonance with Enceladus (it completes one orbit of Saturn for every two completed by Enceladus). This is thought to be one source of Enceladus’ internal heat. Similar tidal heating effects might allow Dione to have a subsurface liquid ocean as well. Dione is depicted in Fig 5. Cassini did five close flybys of this moon. Fig 19 shows a cover that was issued for the fourth of them, D4, during which the spacecraft obtained “close-up views of [the] wispy streaks and searched for signs of [cryovolcanic] activity” as it flew as close as 516 km above the moon’s surface.

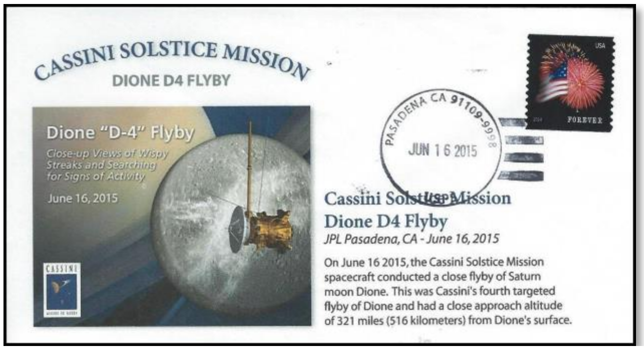


Figure 19. C-H Event Cover. JPL Cachet. 2015

Pioneer-11 and Voyager-1 and 2 captured early images of Rhea. Part of the cachet of the cover in Fig 18 depicts the moon, with the accompanying text “Voyager-1 takes [the] first significant pictures of Saturn’s moon Rhea: November 8, 1980”. Those Voyager-1 images also revealed thin wispy lines like those on Dione, and they were later explained in the same way, as high-albedo ice-fracture cliffs. Rhea is depicted in the stamp in the SS1 of Fig 2. Most of our detailed knowledge of this moon comes from the Cassini spacecraft. For example, on 2 March 2010, during its close (100 km) flyby R2, Cassini’s INMS (Ion Neutral Mass Spectrometer) “detected a very thin atmosphere known as an exosphere, infused with oxygen and carbon dioxide, around Rhea … It was the first time a spacecraft directly captured molecules of an oxygen atmosphere — albeit a very thin one — at a world other than Earth” (reference). As mentioned above, Cassini discovered Dione’s oxygen exosphere about a month later. Rhea’s surface temperature was measured at around -174 °C in the sunlight and from -200 °C to -220 °C in the shade. Cassini conducted in total five close flybys of

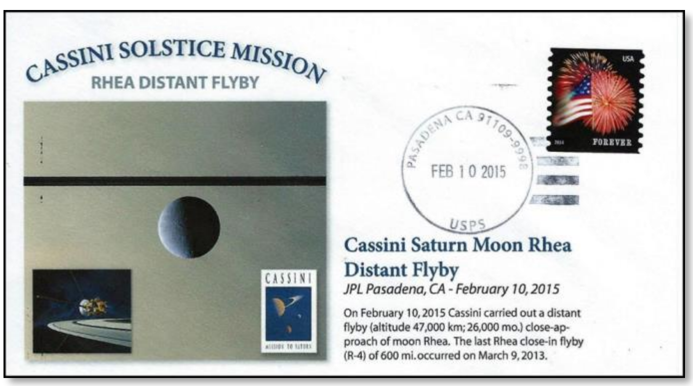


Figure 20. C-H Event Cover. JPL Cachet. 2015

Rhea, as well as distant flybys. The cover in Fig 20 commemorates one of those distant flybys.

Pioneer-11 and Voyager-1 and 2 also provided early images of Tethys. Part of the cachet of the cover in Fig 21 depicts this moon, with the accompanying text "Voyager-1 takes first significant pictures of Saturn's moon Tethys: Nov. 10, 1980". The surface of the moon is cut by some large fractures, one of which (apparently the huge Ithaca Chasma) is included in the cachet's drawing. Tethys was the Saturnian satellite most fully imaged by the Voyager spacecraft. "Tethys has a low density of 0.98 g/cm$^3$, the lowest of all the major moons in the solar system, indicating that it is made of water ice with just a small fraction of rock" (reference). Rhea and Dione are denser and so contain more rock than Tethys.


Figure 21. Voyager-1 Event Cover. SV Cachet. 1980

The Cassini spacecraft made only one close flyby of Tethys (on 24 September 2005). One of its distant flybys in 2015 is commemorated in Fig 22. Tethys is highly reflective (i.e. it has a high albedo, though not as high as that of Enceladus) which also supports "a composition largely of water ice, which would behave like rock in the Tethyan average temperature of -187 °C. Many of the crater floors on Tethys are bright, which also suggests an abundance of water ice. Also contributing to the high reflectivity is that Tethys is bombarded by Saturn E-ring water-ice particles generated by geysers on Enceladus" (reference). To the authors' knowledge, no exosphere has been detected at Tethys.

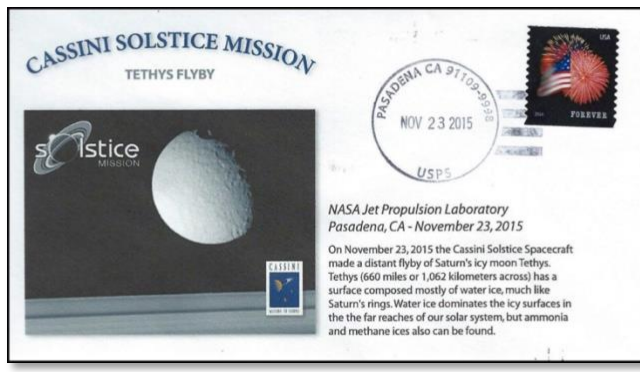


Figure 22. C-H Event Cover. JPL Cachet. 2015

**Mimas**

Voyager-1 and 2 provided the first images of this moon in 1980. Part of the cachet of the cover in Fig 21 depicts Mimas, with the accompanying text "Voyager-1 closest approach to Saturn's moon Mimas – 89,000 miles – November 12, 1980". The stamp in Fig 23 commemorates "Voyager-2" and "Saturn and Mimas". It features an artist's depiction of the ringed planet as seen from the surface of the moon. The Cassini spacecraft later did flybys of Mimas (for example, on 13 February 2010 it flew within 9500 km of its surface) and obtained detailed images of it. The authors have not come


Figure 23. Ghana. Sc1226d. 1990

across any covers for any of those flybys, though. Readers who may have images of such covers are invited to send them to us.

"Crater-covered Mimas is the smallest and innermost of Saturn's major moons … Its low density suggests that it consists almost entirely of water ice, which is the only substance ever detected there … Its most distinguishing feature is a giant impact crater – named "Herschel" after the moon's discoverer – which stretches a third of the way across the face of the moon, making it look like the Death Star from *Star Wars* … That Mimas appears to be frozen solid is puzzling because Mimas is closer to Saturn and has a much more eccentric (elongated) orbit than Enceladus, which should mean that Mimas has more tidal heating than Enceladus. Yet Enceladus displays geysers of water, which implies internal heat, while Mimas has one of the most heavily cratered surfaces in the solar system, which suggests a frozen surface that has persisted for enough time to preserve all those craters. This paradox has prompted the "Mimas Test" by which any theory that claims to explain the partially thawed water of Enceladus must also explain the entirely frozen water of Mimas" (reference). However, recent studies (from 2022 and 2024) hypothesize that Mimas could indeed have an internal ocean (reference). The Cassini spacecraft measured the moon's surface temperatures, with unexpected results. The public domain image in Fig 24 (online here) shows at the left a visible image of Mimas and its "Death Star" crater, and at the right a "Pac-Man" pattern of observed temperatures. The color-coded temperature scale is found here. The warm yellow tones are in the range of -177 to -180 °C, the intermediate reds around -183 to -185 °C, and the cold blues from -193 to -199 °C. The pattern remains unexplained. To the authors' knowledge, no exosphere has been detected at Mimas.

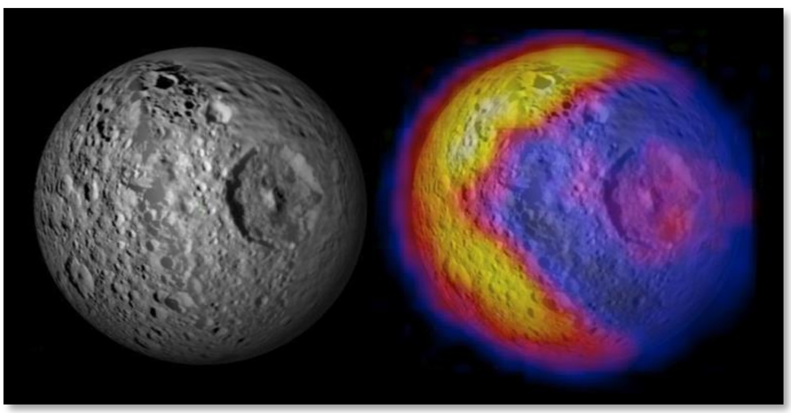

Figure 24. Visible image of Mimas and observed temperatures. NASA

**Iapetus**

Pioneer-11 and Voyager-1 and 2 provided the earliest images of this moon. Fig 25 is a cover issued for the event "Voyager-1 takes first significant photos of Saturn's moon Iapetus: November 6, 1980". Those images confirmed Cassini's deduction (described below) which the cachet summarizes by saying that this "unique moon is 6 times brighter on one side than the other". Part of the cachet of the cover in Fig 26 depicts Iapetus, with the accompanying text "Voyager-2 closest approach to moon Iapetus, at 560,000 miles: Aug. 22, 1981". It also includes the statement that this "unique moon is 6 times brighter on one side than the other".

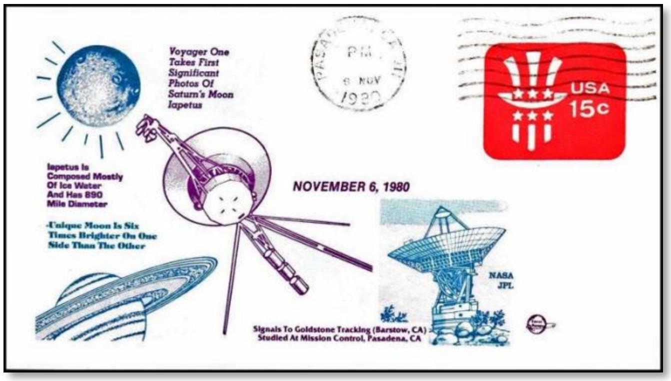


Figure 25. Voyager-1 Event Cover. SV Cachet. 1980

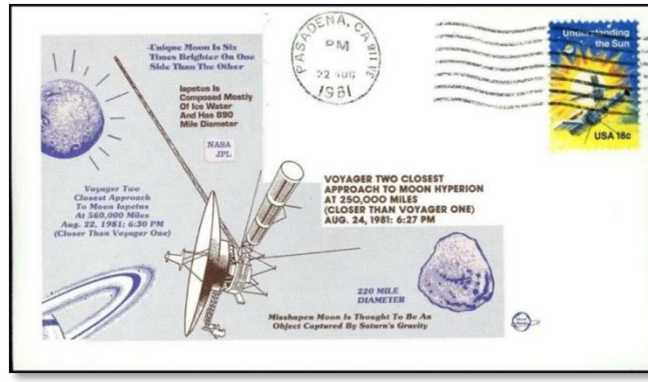


Figure 26. Voyager-2 Event Cover. SV Cachet. 1981

Iapetus is the outermost of Saturn's large moons, orbiting much farther away from the planet than its next closest major moon, Titan. "The great distance from Saturn's tidal forces and from most of the other moons and ring particles has probably allowed the Iapetus surface to be largely unaffected by any melting episodes that could have caused some smoothing or "resurfacing" as on some of the moons closer to Saturn … Iapetus has been called the yin and yang of the Saturn moons because its leading hemisphere has a reflectivity (or albedo) as dark as coal (albedo 0.03-0.05 with a slight reddish tinge) and its trailing hemisphere is much brighter at 0.5-0.6" (reference).

In 1671, Giovanni Cassini "discovered Iapetus when the moon was on the western side of Saturn, but when he tried viewing it on the eastern side some months later, he was unsuccessful. This was also the case the following year … Cassini finally observed Iapetus on the eastern side in 1705 with the help of an improved telescope, finding it two magnitudes dimmer on that side. Cassini correctly surmised that Iapetus has a bright hemisphere and a dark hemisphere, and that it is tidally locked, always keeping the same face towards Saturn. This means that the bright hemisphere is visible from Earth when Iapetus is on the western side of Saturn, and that the dark hemisphere is visible when Iapetus is on the eastern side" (reference). This is a marvellous example of scientific deduction. It was the first time that a surface property of a celestial body had ever been detected outside the Earth-Moon system. The cachet in the cover of Fig 27 shows the HST and Saturn and an unidentified moon, which must be Iapetus because of its contrasting white and black surfaces (it's not a shadowing effect because no such pattern is seen on Saturn in the drawing). The HST has observed Saturn


Figure 27. US. Sc2572 Cover. 1991

as well as some of its moons. For example, the HST's STIS (Space Telescope Imaging Spectrograph) was used in 2018-2021 "to study the bright and dark hemispheres of Iapetus" (reference).

What might cause that bright/dark pattern? In the past it was proposed that "Iapetus may be sweeping up particles from the more-distant dark moon, Phoebe" or that it might somehow be the result of cryovolcanism. However, "the September 2007 Cassini flyby of Iapetus showed that a third process, thermal segregation, is probably the most responsible for Iapetus' dark hemisphere. Iapetus has a very slow rotation, longer than 79 days. Such a slow rotation means that the daily temperature cycle is very long, so long that the dark material can absorb heat from the sun and warm up. (The dark material absorbs more heat than the bright icy material). This heating will cause any volatile, or icy, species within the dark material to sublime out, and retreat to colder regions on Iapetus. This sublimation of volatiles causes the dark material to become even darker -- and causes neighboring bright, cold regions to become even brighter. Iapetus may have experienced a (possibly small) influx of dark material from an external source [Phoebe?], which could have warmed up and triggered this thermal segregation process." (reference). That long daily temperature cycle also implies that "Iapetus would have had the warmest daytime surface temperature and coldest nighttime temperature in the Saturnian system even before the development of the color contrast; near the equator, heat absorption by the dark material results in a daytime temperatures of -144 °C in the dark Cassini Regio compared to -160 °C in the bright regions" (reference).

Cassini's only close flyby of Iapetus took place on 10 September 2007, when it flew within 1644 km of the moon's surface. Fig 28 shows a cover issued for a distant flyby on 31 December 2004, when the spacecraft passed "within 123,400 km of the moon and captured detailed images of its striking two-toned surface and prominent equatorial ridge" (reference). To the authors' knowledge, no exosphere has been detected at Iapetus.

Figure 28. C-H Event. JPL Cachet. 2004

This finishes our discussion of Saturn's principal moons. The next article in this series will feature Uranus and its major moons.

**Other References**

Ref 1: Hunten, Donald M. "Titan's Atmosphere and Surface", in *Planetary Satellites* (ed. Joseph A. Burns), pp 420–437, The University of Arizona Press, 1977.

Some readers may also wish to refer to the authors' extensive online lists of philatelic items for Planetary Environments and Un-manned Spacecraft.

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# Autumn Skies

**By Gene R. Major**

The northern hemisphere autumn night skies brings cooler weather (hopefully) and clearer skies. Autumn skies brings a host of mythological figures in the form of constellations. The most notable are the Perseus—Andromeda—Pegasus—Cassiopeia grouping. From Greek mythology, Perseus (Fig 1), son of Zeus, was tasked with slaying and bringing back the Gorgon Medusa's head. On his journey home, Perseus encounters Andromeda (Fig 2), the princess daughter of Cassiopeia (Fig 3), who had boasted that she and her daughter, Andromeda were the most beautiful, which was an insult to the sea god Poseidon. Cassiopeia's husband, Cepheus, had Andromeda chained to a rock to appease the sea god. Using Medusa's head, Perseus turned the monster into stone, saving Andromeda. The winged horse, Pegasus (Fig 4), was born of the blood from the slain Medusa.


Figure 1. Perseus and head of Medusa. *Urainia's Mirror*, constellation cards, c. 1825, London

Figure 2. Andromeda, *Urainia's Mirror*, constellation cards, c. 1825, London



Figures 3 and 4. Cassiopeia and Pegasus. Johannes Hevelius from *Uranographia* (1690)