

Enceladus: The Reflected Ray of Hope

Are we really alone in the Universe? Ok, Universe is a big term, let me ask this, Are we really alone in the Solar System? Is the Earth the only planet that can sustain life? Is there a rule that only a planet can sustain life forms or can even a Moon sustain a life? Is it possible for a celestial body smaller than planets to support life? What if I tell you there is a Moon that has shown some promising features that can support life forms? Yes, there is the Moon of Saturn which has shown the presence of materials that can support life. In this Blog, we will be discussing the moon of Saturn which has reflected a hope of ray that there is a possibility of formation of life form here. The name of this moon is Enceladus.

Enceladus, one of Saturn's most significant moons, was discovered by William Herschel on August 28, 1789. It's the 6th largest moon of Saturn and the 19th largest in our solar system. With a diameter of about 500km, Enceladus is known for its highly reflective surface, made up of fresh, clean ice, making it one of the most reflective bodies in our solar system. Despite reaching temperatures of -198°C at noon, its icy surface reflects all incoming sunlight into space, keeping the interior cold. For a long period, there was very little info available about Enceladus until the Voyager Missions in the 1980s brought fascinating details to light about Enceladus. This event encouraged scientists to explore Enceladus during the Cassini Huygens Mission to Saturn.

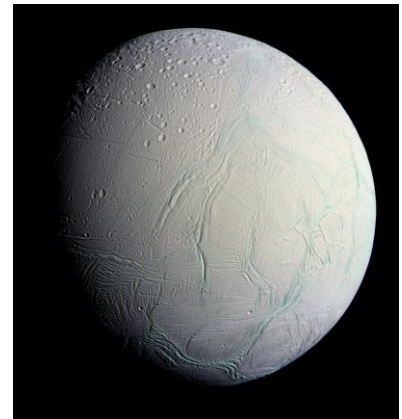


Image Credit: Planetary Society

Characteristics of Enceladus

As mentioned above this is one of the most reflective bodies in the solar system, despite that we won't be able to see this object through our naked eye. It has an Apparent Magnitude of 12.18 making it extremely difficult to spot. The Absolute Magnitude is 2.10 which proves that it is a pretty bright object in the sky.

Apparent Magnitude is the measure of the brightness of the object as seen from the Earth.

Absolute Magnitude is the measure of the brightness of the object seen from a distance of 10 parsec (Approx 3.08×10^{14} km) from the respective object / The object whose brightness has to be determined.

Sidereal Time is 20h 15min 0.4s i.e., the time taken by the body to rotate about its own axis.

It orbits Saturn at a distance of 238000km and takes about 33hr to complete one revolution around Saturn.



Saturn Seen from Enceladus

Image Credit: Stellerium

Who named it as Enceladus? Why Enceladus?

The name Enceladus sounds so weird right? Why not keep name simple like Titan or Rhea something like this? The naming of Enceladus is a very interesting story among the entire moons of Saturn. John Herschel was the person who suggested the name of this particular moon to be "Enceladus". Son of William Herschel, John Herschel suggested that all the large moons must be named after the Titans of Greek Mythology as Titans were huge creatures in the Greek Mythology. Although Enceladus was a Giant but he was not a part of the Titans, his name was given seeing the features of this particular Saturn's Moon.

In the intricate tapestry of Greek mythology, Enceladus, a formidable figure among the Giants, holds a unique place. Born from the blood of Uranus that spilled into the sea, Enceladus was a child of Gaia, the Earth, and Uranus, the ruler of the Universe. These primordial gods of the cosmos had numerous offspring, including the Titans, Cyclopes, and Hecatoncheries.



*To the Right: Cronus holding Sickle,
To the Left: Uranus being killed,
Image Credit: Pinterest*

Uranus, despite his universal dominion, harboured disdain for the Cyclopes and Hecatoncheries, imprisoning them in the ocean's depths. This act of tyranny was met with resistance from one of the Titans, Cronus, and his mother Gaia. In a bid to end Uranus's reign, Gaia crafted a great stone sickle, which she entrusted to Cronus. Seizing an opportune moment, Cronus ambushed and killed Uranus, casting him into the sea.

The Blood of the Uranus which was spilled into the sea led to the birth of Enceladus, a formidable Giant. With Uranus overthrown, Cronus ascended as the new ruler of the cosmos. He married Rhea, another Titan, and fathered Zeus. However, a prophecy foretold that Cronus, like his father, would be overthrown by his offspring. Fearful of this fate, Cronus ate his children at birth. Rhea, however, managed to save Zeus by tricking Cronus into swallowing a stone instead of the newborn.

As Zeus matured, he perceived Cronus as a tyrant who mistreated the Titans. This led him to wage war against his father, eventually overthrowing Cronus and declaring himself an Olympian God. This power shift incited the wrath of Enceladus, Cronus's half-brother. Enceladus challenged the Olympian Gods for the throne of the cosmos, specifically targeting Athena, renowned for her wisdom, prowess in warfare, and striking beauty. He aspired to marry Athena and ascend as the new ruler of the cosmos.



Right: Cronus with Sickle, Left: Zeus with Lightening



Right: Athena, Left: Enceladus
Image Credit: AI Generated

In the ensuing battle between the Giants and Olympian Gods, Athena emerged victorious against Enceladus. She buried him under Mount Etna in Sicily, one of the most active volcanoes. The constant emission of smoke and dust-like particles from Mount Etna led the people of ancient Rome to believe it was the angered breath of Enceladus.

Interestingly, Saturn, also known as Cronus in Greek mythology, was considered the father of all Titans. John Herschel, therefore, proposed naming all of Saturn's large moons after the Titans. However, he made an exception for Enceladus, a moon exhibiting similar features to Enceladus a Greek Mythological Character after his death, such as the constant ejection of dust particles and active volcanic activity on its surface. This parallel between the celestial body and the mythological figure further cements the enduring legacy of Enceladus in both mythology and astronomy.

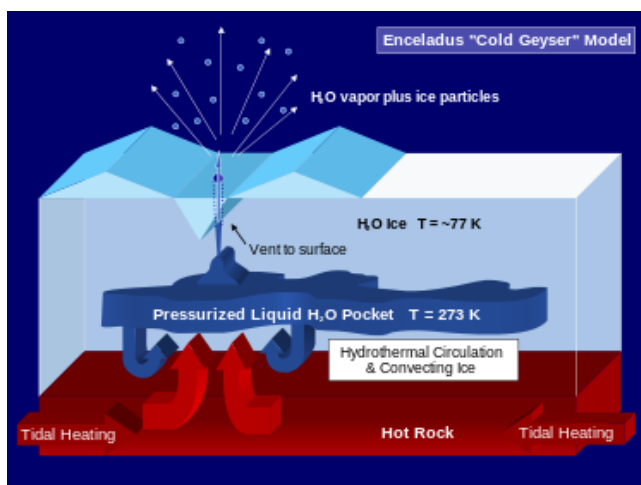


Picture of Athena defeating Enceladus depicted by artists
Image Credit: Pinterest

What is happening inside the Enceladus?

The "Enceladus Cold Geyser Model" explains the behaviour of Enceladus' Surface activities. Tidal heating results from the interactions of gravitational forces between Enceladus and Saturn.

Tidal Heating is also known as Tidal Flexing. Based on orbital mechanics, when two objects rotate and one lighter object revolves around a heavier object (e.g., the Earth revolves around the Sun), it must eventually follow a circular path rather than an elliptic path, which is referred to as Tidal Circularization. However, this is not the case for celestial bodies, as Kepler's rule for planetary motion asserts that celestial bodies always follow an elliptic route, which has been confirmed. Hence to avoid tidal circularization the lighter body revolving around the heavier body produces a certain amount of heat within its core. (This is like the resistance to follow a circular path, and this resistance can be seen in the form of heat energy in the core or interiors of the celestial body). In addition to this, as the celestial bodies also rotate about their axis, heat energy is also produced for this reason as well. Through these phenomena, Heat energy is produced among the celestial bodies which is called Tidal Heating.



The Heat Produced within the surface of Enceladus warms up the particles present in the core or within the surface. The water vapor particles present within the surface are warmed up to 0° C (273K) and the water vapor comes up in liquid phase and freezes as solid ice on the surface as it reaches 0° C. Thus, explaining the icy surface of the Enceladus. This ice surface remains around -200°C.

The Process of Vapours reaching the surface slowly will create a path for the particles to travel through the core. Sometimes, the high pressure due to heat produced in the core causes vapours to reach the surface with higher velocities thus causing vapours to burst out of the icy surface, along with some ice particles present around the vents to go along with the vapours.

The Cassini Spacecraft studied these particles and reported that these particles were water vapours and confirmed the presence of Water beneath the Icy Surface of Enceladus.

Cassini and Enceladus

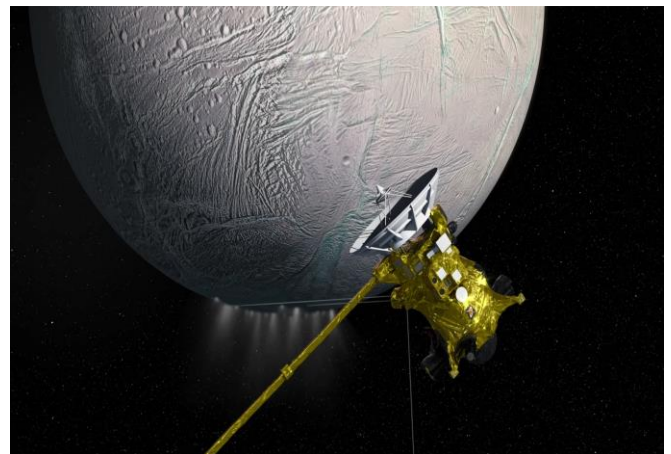
In 2005, the Cassini spacecraft traversed over Enceladus many times, revealing its physical properties, most notably water-rich hot plumes emerging from the surface near Enceladus' polar caps. Plumes are simply columns of matter that rise to the atmosphere, resembling thick dust or smoke. For example, after a nuclear explosion, we can observe a mushroom-like smoke formation in the sky, which is only a plume of gases. These hot springs were cryovolcanoes that were found mostly at Enceladus' South Pole.



*South Pole of Enceladus
Image Credit: NASA*

Cassini investigated Enceladus in February 2005 and discovered a jet-like phenomenon emerging from the South Pole of the planet's surface. The cryovolcanoes discharged a plume of water, ice, and dust particles into space. Approximately 200kg per second of these particles are expelled from the surface via cryovolcanoes, with the majority of the particles falling back to Enceladus' surface and the remainder being lost in space, eventually contributing to the construction of Saturn's beautiful rings.

In 2015, the Cassini probe sailed through these plumes near the South Pole, confirming the presence of volcanoes that are also rather active, hinting that the core of this specific celestial body is likewise warm and geologically active. The existence of water indicates the possibility of life creation. After achieving its mission goals, the Cassini spacecraft could have fallen on the Enceladus surface, providing new information about the Enceladus. But, in actuality, that did not happen; instead, it fell into Saturn itself, since scientists determined that crashing a spacecraft may meddle with the circumstances of Enceladus, which may be favourable to the birth of life, if a spacecraft crashes, the current favourable conditions may alter. As a result, Enceladus is critical to human future deep space missions, as well as a hot issue for extraterrestrial life search missions.



*Artistic Impression of Cassini fly by through South Pole of Enceladus
Image Credit: NASA*

Conclusion

NASA has planned an exclusive space mission to Enceladus called Enceladus Orbilander which will orbit Enceladus for One year and make observations and estimated to be launched in late 2030s. Enceladus, one of Saturn's moons, is indeed a critical focus for future deep space missions and the search for extraterrestrial life. This icy moon has been identified as a potential oasis for life. In conclusion, Enceladus represents a promising frontier in our quest to understand the potential for life beyond Earth. Its unique geophysical characteristics and the presence of a subsurface ocean make it a prime target for future explorations. These missions could provide invaluable insights into the conditions necessary for life and potentially even discover signs of extraterrestrial life.

By Vishnuthirtha SH
(Stargazing Expert)