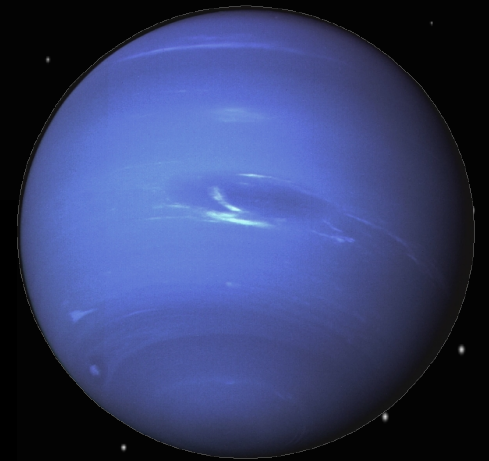
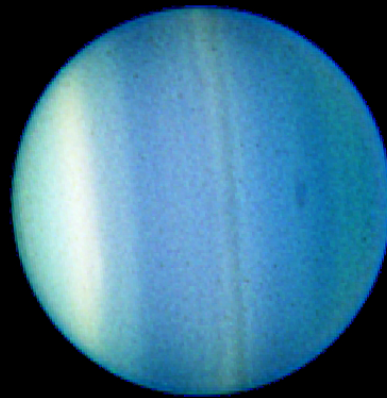
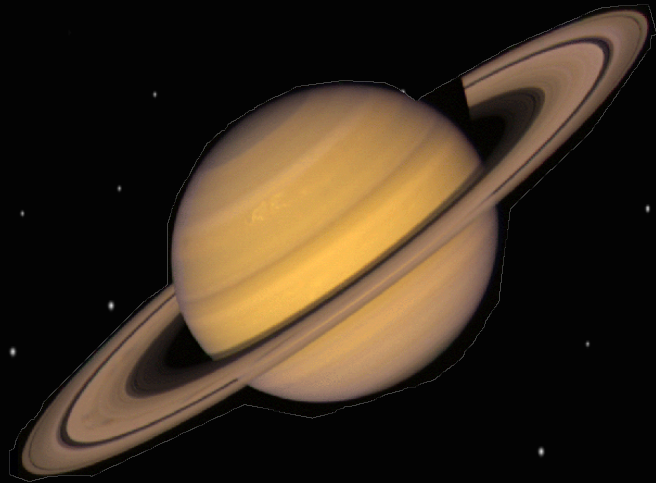


Outer Solar System Exploration



Outer Planets
Assessment Group
(OPAG) Report
November 2014

OPAG Assessment

- OPAG regularly evaluates **outer solar system exploration goals, objectives, investigations** and required measurements on the basis of the widest possible community outreach. The group assembles twice per year to **assess the current state of outer solar system exploration, goals for future exploration, and technology development needed to achieve those goals.**
- Most recent OPAG meeting was a townhall at the DPS, 13 November 2014
- ***The purpose of the townhall was to discuss the new science goals document that we are composing***
- A new articulation of the mativation for exploring the outer solar system is essential considering the challenges we are facing

New OPAG Science Goals Document

Posted on the OPAG website:
<http://www.lpi.usra.edu/opag/>

Scientific Goals for Exploration of the Outer Solar System

*How did the outer planets mold the solar
system and create habitable worlds?*



OPAG Report
DRAFT
14 August 2014

Science Goals articulated by OPAG

- Last full document was in 2006
 - “Scientific Goals and Pathways for Exploration of the Outer Solar System”: A Report of the Outer Planets Assessment Group (OPAG) 2006
 - Plus the Decadal Survey white paper 2009
 - Plus the Technology Recommendations 2009
- Vision & Voyage is written and that effort is complete
- Going forward, we decided it was time to update the OPAG Scientific Goals and Pathways report
- Following that we will update the technology plan

New OPAG Science Goals Document

Status

- Initial draft was written by OPAG Steering Committee
 - Organized by targets
 - Top 5 – 6 goals, not a lengthy laundry list
- At the townhall the community was invited to give us feedback and provide more content
- Concurrently we're looking at unifying science objectives
 - Theme threads: Origins and Habitability
- Community feedback will be incorporated between now and the February 2015 OPAG meeting
- Will “publish” on our website, but will continually update in response to new discoveries as needed
 - E.g. Europa's Plumes

FINDINGS

- *Our biggest concern remains the looming gap in missions to the outer solar system*
- The near-term future is bright
 - Juno at Jupiter
 - Cassini at Saturn
 - New Horizons flyby of Pluto
- After that outer solar system exploration consists of only
 - Limited participation in JUICE
 - Possible New Horizons flyby of a KBO

Our top finding from the July OPAG meeting, repeated here for emphasis:

1. Achieve a new start for a Decadal-Survey-responsive Europa mission

1. Get a mission to Europa started

- **Europa** remains the highest priority mission destination for the outer planets community. The next Europa mission **should address a majority of the goals for Europa science outlined in Vision and Voyages (V&V)**. *We continue to strongly support the **Europa Clipper** as a scientifically compelling, technologically feasible and fiscally responsible approach to exploration of Europa.*
- **OPAG finding: OPAG commends NASA for the significant progress that has been made on Europa exploration opportunities, especially releasing the PEA for Europa Instrument Investigations. We were also pleased to see funding for a Europa mission study specifically called out in the FY15 budget, albeit at a modest level.**
- **However, we are concerned about the longer term funding of these projects and the implementation of a Europa mission. OPAG would like clarification on the strategy that PSD has in mind for the out years. We request that the next report to OPAG include a national schedule (perhaps expressed in relative time) for moving the Europa mission from a study to the launchpad.**

NUGGETS

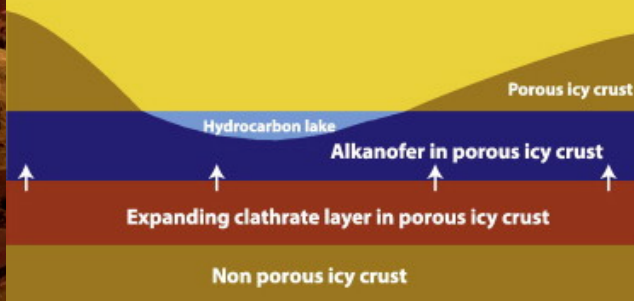
Hidden Reservoirs of Propane and Ethane on Saturn's Moon Titan?

New research indicates that Titan's methane rainfall may transform into propane or ethane underground through interaction with a layer of icy sediments called "clathrates."

- Cassini may be able to differentiate between rivers or lakes that emanate from hidden reservoirs of propane and ethane, as opposed to rivers or lakes that are dominated by rainfall.
- The research could help scientists better understand the volume of Titan's underground hydrocarbon reservoirs and their role in the exchange of methane between the surface and atmosphere.
- The research contributes to models of Titan's methane cycle which drives Titan's active weather processes, and is akin to the cycle of water on Earth.

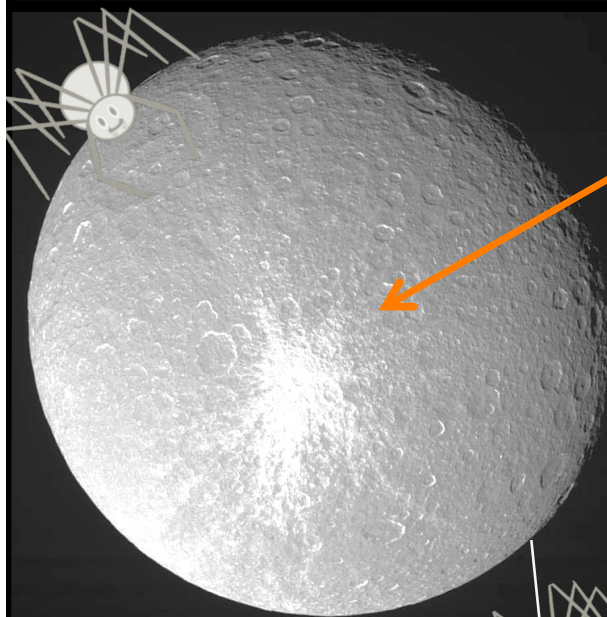
Rain-fed methane aquifers, or "alkanofers," may interact with Titan's porous icy crust to form a lower layer of clathrates - compounds in which molecules of one component are physically trapped within the crystal structure of another.

The clathrate layer grows into the methane reservoir, transforming the liquid into propane and ethane. Rivers and lakes fed by such reservoirs may be detectable.



"Equilibrium composition between liquid and clathrate reservoirs on Titan," Mousis et al., Icarus, 239, 39-45, 2014.

Rhea's Creepy Crater

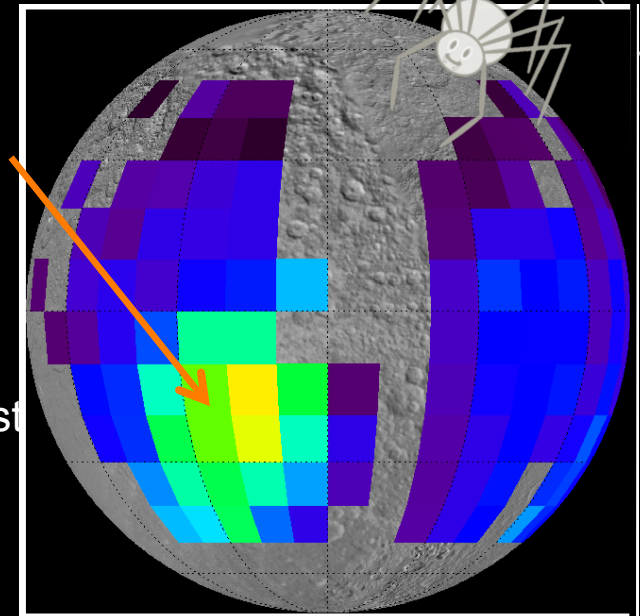


Named for the Lakota spider-god "Inktomi," this long-legged crater stretches across most of the leading face of Saturn's icy moon Rhea.

Infrared measurements from Cassini show that Inktomi's icy splatter cools down more slowly at night than its surroundings. This means the Inktomi debris is either denser or made of larger particles, enabling it to retain heat.

Inktomi's splatter stands out as much warmer than the rest of Rhea's surface, which is comprised of fluffy, snow-like ice and cools rapidly at night.

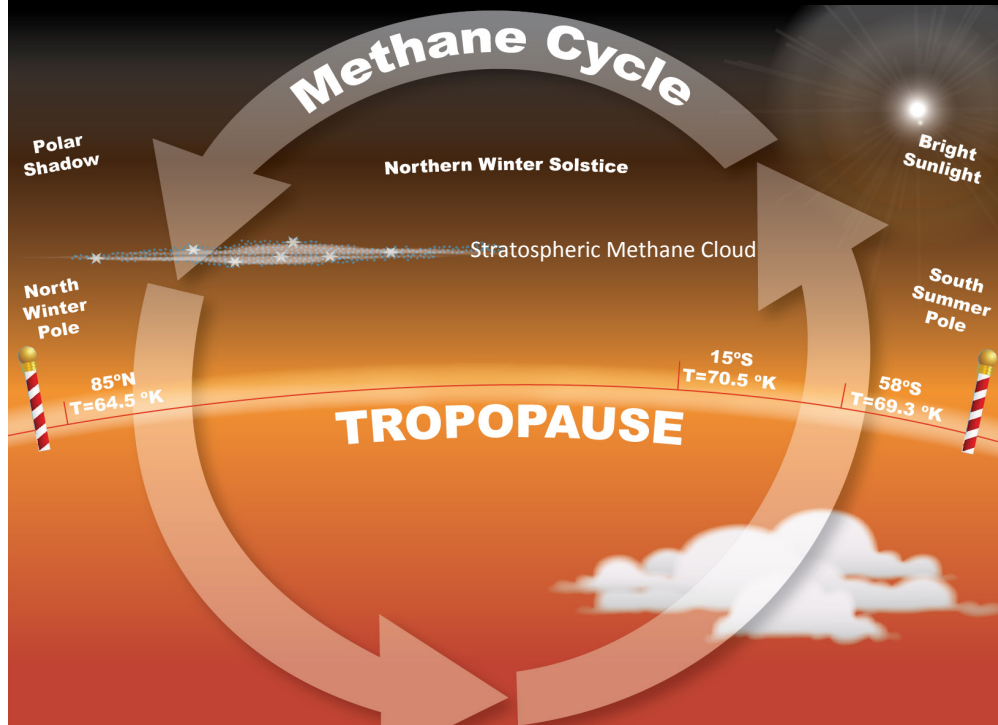
We already know that impacts on Earth alter its surface composition. Now we know that the impact that formed Rhea's creepy crater also changed its surface, from fluffy to snowballs!



Quickly Slowly
Rate of surface heat gain/loss

Cassini Finds Methane Ice in Titan's Stratosphere

New findings from Cassini show that Saturn's moon Titan shares yet another similarity with Earth – high-altitude ice clouds – indicating seasonal change. However, unlike Earth's Polar Stratospheric Clouds (PSCs) that are composed of water ice, these are composed of methane ice.



Even though methane vapor rises in Titan's summer hemisphere, general circulation causes it to subside and cool over Titan's winter pole. This gives rise to methane ice clouds in Titan's lower stratosphere. These clouds are similar to Earth's Polar Stratospheric Clouds, like those shown below near Iceland.



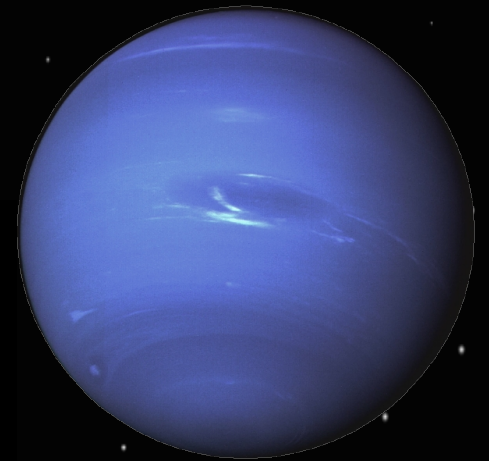
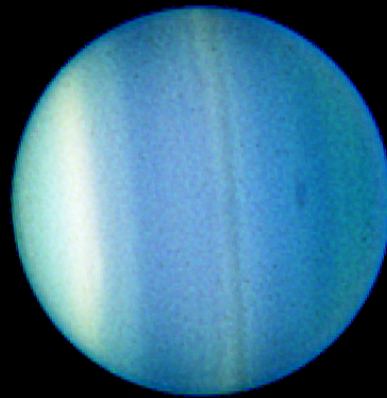
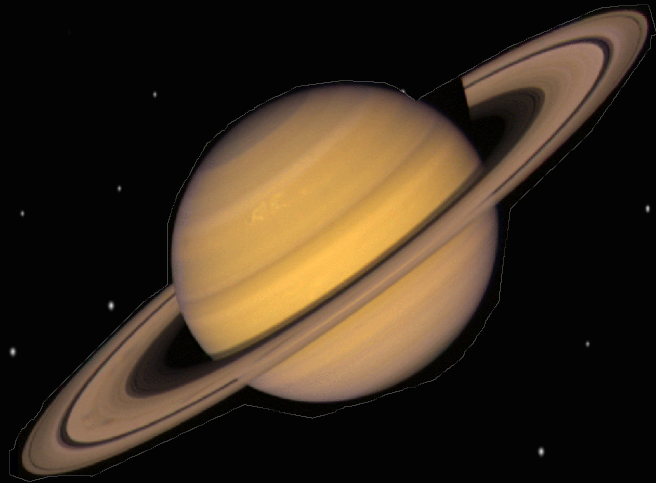
(above) Polar Stratospheric Clouds observed over Iceland (image credit: NCAR)

(left) Polar Stratospheric Cloud observed in Titan's Northern Hemisphere

Analyses of data from infrared and radio instruments reveal that temperatures near the tropopause above 65°N latitude are unexpectedly several degrees colder than at lower latitudes. At that frigid temperature, some of the available methane vapor will condense into ice crystals forming PSCs. This Earthlike phenomenon, previously thought to be highly unlikely at Titan, shows yet another characteristic shared by these two worlds.

"Subsidence-induced methane clouds in Titan's winter polar stratosphere and upper troposphere," C.M. Anderson, et al. Icarus, 243, 129-138, 2014.

Outer Solar System Exploration



Worth the journey