Planetary Science Vision 2050
NASA HQ 02/27/17

LPI Contrib. No. 1989

Riddles of the Sphinx: Titan Science Questions at the End of Cassini-Huygens

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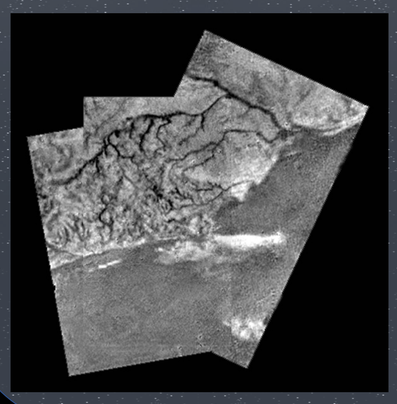
Abstract: During the 13 years of the Cassini-Huygens mission, the two spacecraft have returned a wealth of scientific data about Saturn's enigmatic moon, Titan. New discoveries have included the vast equatorial dune fields[1], and the north polar lakes and seas of liquid hydrocarbons[2]. Despite these advances, many questions remain open about Titan's origin, history, geological and chemical processes, and potential for life. Resulting from a recent workshop to examine the legacy of Cassini-Huygens at Titan, we here describe the key open questions that will require a next generation of robotic missions to answer.

Origin and Evolution

(1A) How did Titan form, and was this early or late in the solar system?

(1B) Why does Titan have an atmosphere, and how has it changed over time?



(1C) What is the age of the features we see on Titan's surface?

Figure: Titan fluvial networks observed by Huygens[3], but how recently did these rivers run with methane?

Interior and Surface

(2A) How thick is the icy shell and how deep is the ocean?

(2B) Is Titan geologically active today (figure)?

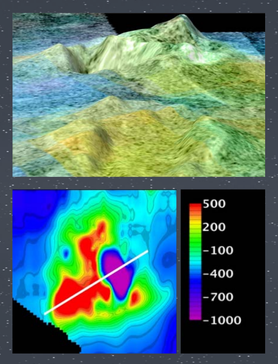


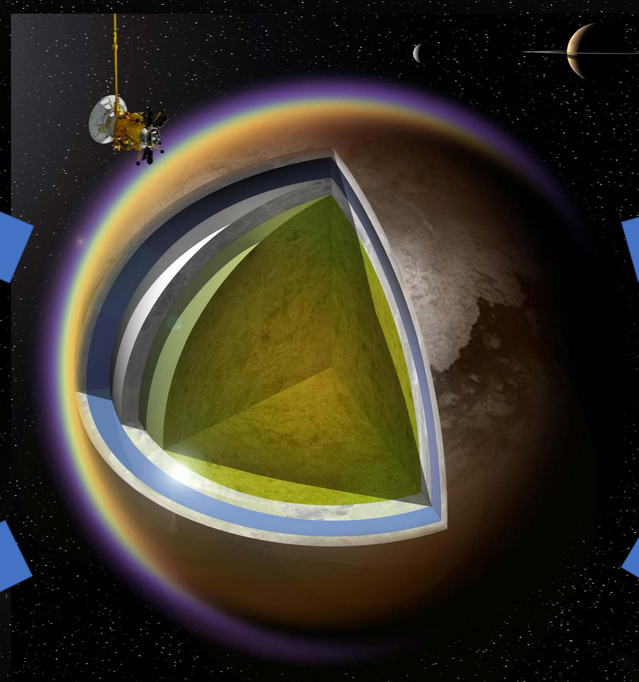
Figure: (upper) Doom Mons 3D elevation from Cassini Radar; (lower) topographic map of Doom Mons and Sotra Patera a potential cryovolcano?

(2C) What materials are exposed on the surface?

(2D) What factors influence the distribution of the lakes and seas?

(2E) What is the composition of the lakes and seas?

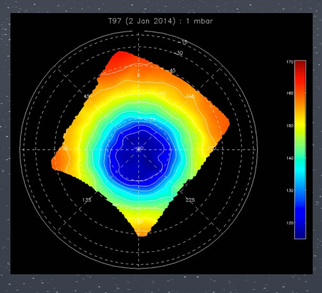
(2F) What degree of prebiotic chemical complexity has been reached in surface environments?

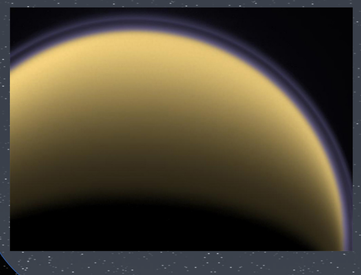


Lower and Middle Atmosphere

(3A) How can we explain the observed variations in Titan's hydrogen profile?

(3B) How can atmospheric models be reconciled with observations of clouds in the lower atmosphere?





(3C) Why is the stratospheric axis tilted with respect to Titan's solid body (above)[4]?

(3D) What is the reason for the detached haze layer (left)?

Upper Atmosphere and Exosphere

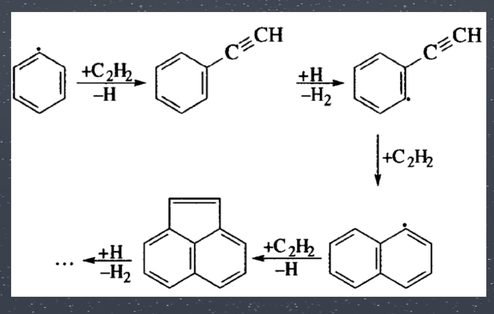


Figure: possible formation mechanism for PAHs by HACA mechanism[5] (hydrogen abstraction, C_2H_2 addition)

(4A) What chemical processes lead to the formation of complex molecules, including aromatics (above)?

(4B) How rapidly is Titan's methane escaping into space?

(4C) What gives rise to the observed electron density profile?

(4D) Do we see the expected nitrogen torus?

Why the Sphinx?

Like Titan, the Sphinx:

- Has blue upper layers
- Has orange lower layers
- Is 1000s of years old (at least)
- Has an enigmatic smile.
- Poses riddles to us.

References:
[1]Lorenz et al., "The Sand Seas of Titan: Cassini RADAR Observations of Longitudinal Dunes" (2006), *Science,* **312,** pp. 724.
[2]Stofan et al., "The lakes of Titan" (2007), *Nature,* **445,** pp. 61-64.
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[4]Achterberg et al., "Observation of a tilt of Titan's middle-atmospheric superrotation" (2008), *Icarus,* **197**, pp. 549–555.
[5]Cherchneff, "The formation of polycyclic aromatic hydrocarbons in evolved stellar environments" (2010), PAHs and the Universe, Eds: Joblin & Tielens, EAS Series.