

Methane Everywhere

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Abstract: *This paper contains technical notes based on lectures I attended during my graduate studies at the Department of Aerospace Engineering at the University of Michigan in Ann Arbor, USA.*

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I. Introduction

Titan, a Saturn's moon, is the second biggest moon in the Solar System. It is the only large Solar system body, except for the Earth, which has predominantly nitrogen atmosphere. In contrast, a Jupiter's moon Ganymede, which is the biggest moon in the Solar system, does not have any atmosphere. Titan was discovered by C. Huygens in 1655. Here are some basic facts about Titan.

Mass=1.345x10²³ kg (0.023x Earth's).

Mean distance from Saturn=1211850 km (about 3.1xEarth-Moon distance).

Orbital eccentricity=0.0292.

Radius=2575 km (0.98xGanymede; 0.76xMars).

Mean density=1881 kgm⁻³.

Rotational period=15 days 22 hours.

Orbital period=15 days 22 hours.

Mean surface temperature=93.5 K, which is close to the triple point of methane.

Atmospheric pressure=1.5 bars.

Atmospheric density=4.4xEarth's atmosphere.

Titan's dry and cold atmosphere causes a 300 km thick layer of smog, which forms when sunlight interacts with hydrocarbon molecules. This smog accounts for reddish-brown color of Titan. Titan's atmosphere consists of 87-99% nitrogen, 1-6% argon and 1-6% methane. Here is some information about the minor constituents in parts per million.

Hydrogen (H₂) 2000,

Ethane (C₂H₆) 20,

Acetylene (C₂H₂) 4,

Carbon monoxide (CO) 50.

II. Information about Titan obtained before Huygens landing.

For many years Titan was observed from ground-based telescopes, which showed methane-containing clouds. It could mean that Titan's weather cycle is similar to the Earth's one. In 1980 Voyager 1 provided the first images of Titan which showed orange opaque atmosphere. The origins of methane on Titan are under debate. One of the theories stated that methane was produced on Titan, became frozen, and, about 500.000.000 years ago, the surface components containing methane melted and released methane into the atmosphere. Methane provides warming in the Titan's atmosphere which is due to hydrocarbon haze in the stratosphere and H₂-N₂ and CH₄-N₂ opacity in the troposphere. This warming is critical to sustain the atmosphere of nitrogen. The fate of methane on Titan is uncertain because it is being destroyed irreversibly by photochemistry. Without a constant source of methane, the existing methane on Titan will be destroyed in 10.000.000 years, and this would lead to the collapse of the atmosphere because the smog particles ultimately would fall to the ground. This observation led to a speculation that Titan's surface might be covered by an ocean of liquid hydrocarbons, mostly methane and ethane, about one kilometer deep. It was also thought that there might be water ice on the planet, and that there might be some forms of life there. On earth, methane is produced in peat bogs and is released into the atmosphere as a byproduct of the digestive process of some grass-eating mammals, so it was conjectured that methane on Titan might have had an organic source.

III. Huygens's data

Huygens probe was sent from Cassini on 25 December, 2004. The probe showed that the surface of Titan is orange and is covered with about 10cm of mud. It was confirmed that methane was produced on Titan very deep under the surface and did not come from living organisms. It was suggested that a hydrogeological process between water and rocks deep inside the moon is producing the methane. There are Earth-like processes

on Titan, but ingredients are different, with methane taking the part of water. The planet has a cycle of surface evaporation, condensation, cloud formation and rain, like the hydrological cycle on Earth. At the altitude of 17-20 km Huygens detected a thick cloud or haze layer with 100% humidity. However, when methane molecules reach the uppermost part of the atmosphere, they are broken by the ultraviolet light and the byproducts combine to produce organic molecules, including ethane and benzene. Ethane falls from the atmosphere as a liquid and benzene contributes to the smog layer and to the mud on the surface. Laboratory tests suggested that amino acids can form in Titan's upper atmosphere, but they were not found. No signs of life have been found, but the planet has methane rain and water-ice. The oceans were not found, liquid methane was not found, but there is evidence that liquid was flowing on the planet surface.