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Ice volcanoes on Saturn’s moon Titan?

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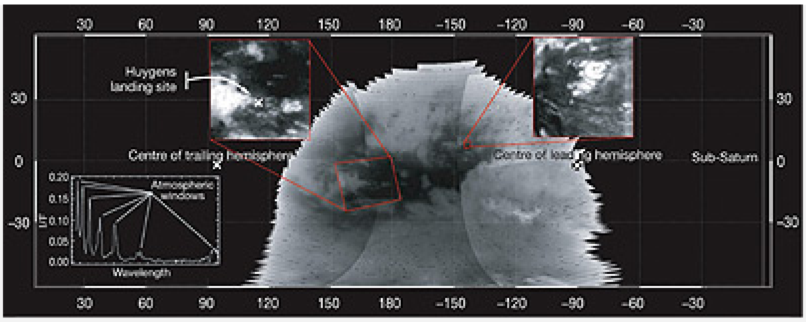
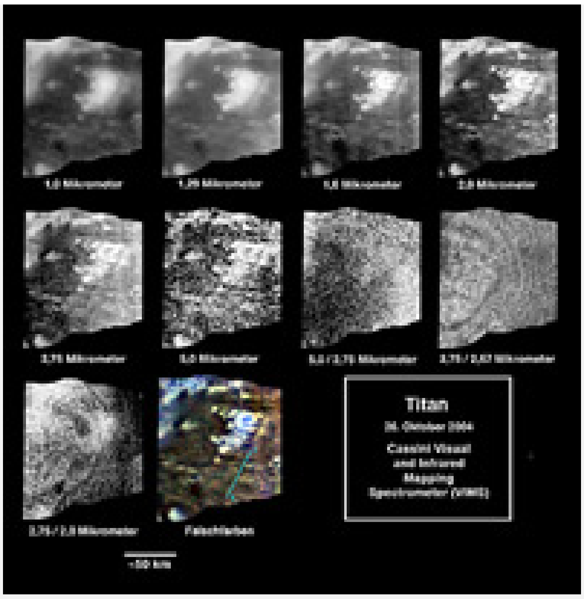


Global map of Titan

Berlin/Cologne - Saturn’s moon Titan may have volcanoes. That’s the result of spectrometer data taken by the NASA space probe Cassini from Saturn’s largest satellite. Christophe Sotin of the University of Nantes in France and Ralf Jaumann from the German Aerospace Center (DLR) along with other scientists present their analysis of the data in tomorrow’s edition of scientific journal 'Nature'.

On the edge of a large, dark area known as Xanadu, the scientists of the Cassini spectrometer team have discovered a striking formation, some 30 km across and several hundred metres high. From the perspective of the probe the formation resembles a snail’s shell, with a depression to be seen in the centre. “The only plausible explanation for this landscape form is that it is a volcanic dome with a central caldera, a chimney, as is frequently found in volcanoes here on Earth,” says Ralf Jaumann.



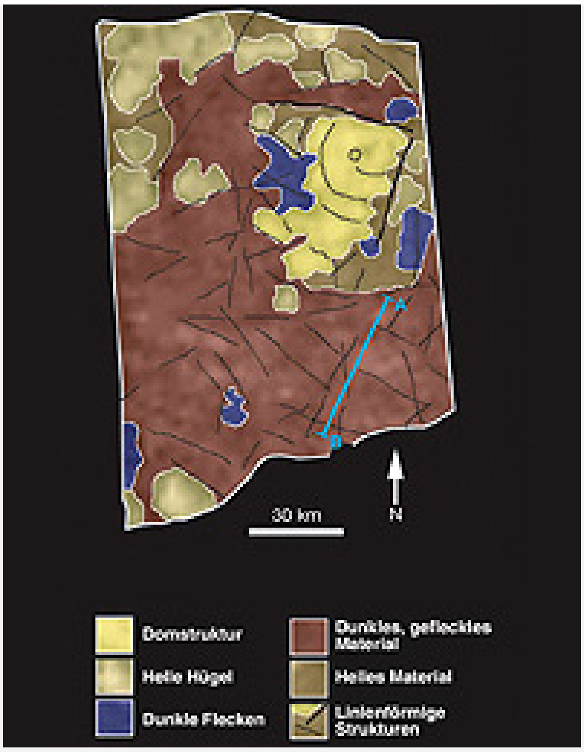
The "snail's shell" on Titan

The observed structure is located about three degrees north of Titan’s equator and 142 degrees west, and appears to soar in a dome shape several hundred metres above the surrounding terrain. “We have never seen anything like it on any other ice moon in the Solar System,” says Ralf Jaumann. “Our preferred interpretation is that methane is escaping from this mountain, coming to the surface from underground, and leaking into Titan’s atmosphere.”

While attempting to interpret the curious ‘snail’s shell’ structure, the researchers also examined the possibility that this could be explained by a weather-related phenomenon in Titan’s atmosphere - for example a spiral-shaped cloud vortex recorded by the VIMS (Visible and Infrared Mapping Spectrometer). However, the cloud theory can be fairly confidently ruled out because 48 days later, when Cassini made its next fly-by of Titan, the ‘snail’ was still in the same position with an identical profile.

Scientists are surmising that the structure is located in an area where Titan’s crust is subject to increased tension, causing material to be forced upwards from underground at a tectonic fissure. The fine light/dark pattern of the ‘snail’ could be the result of grooves or channels on the ice volcano, into which escaping material has flowed.

Because Titan experiences such low temperatures, as cold as -180º Celsius, the hydrocarbon compound methane (CH_4) would be precipitated on the surface as ice rain. In addition to methane, carbon dioxide, water ice and ammonia could also form part of the ‘cryo-lava’. Combinations of these compounds can reduce the freezing point and a mixture of different liquids which have not yet had the chance to refreeze could move across the surface.



Geological sketches of the "snail's shell" structure on Titan

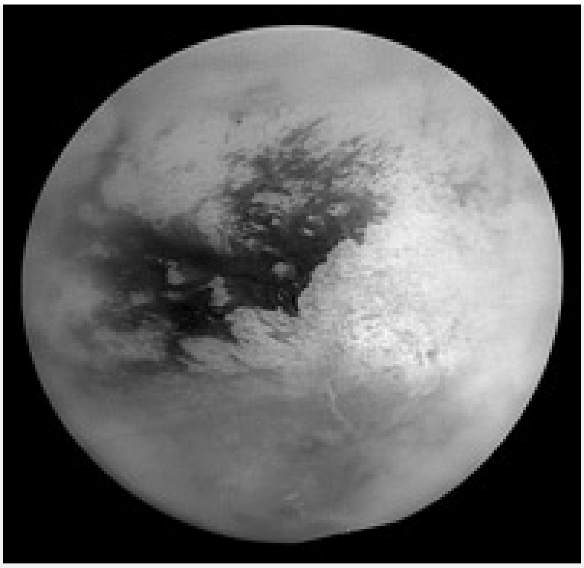
For many years, planetary geologists have been searching for confirmation of theories which suppose that liquids from the warmer interior of the ice moons of Saturn, or even Jupiter and Neptune, could make their way to the surface and emerge in the form of ‘cryovolcanoes’ (*kryos* being the Greek word for ‘ice’), leaving their mark on the terrain before quickly freezing. A cryovolcano like this might work rather like a geyser in active volcanic areas on Earth. Alternatively, liquid might be ejected like a terrestrial lava flow, with a less explosive effect.

The heat required to partially melt Titan’s core could be created by tidal friction. Because its orbital path around Saturn is not a perfect circle, the moon, with a diameter just over 5000 km, is subject to varying levels of gravitational force, causing considerable tension in its core and generating frictional heat.

Titan is the only moon in the Solar System to be surrounded by a dense atmosphere. This 200 km-thick mantle of nitrogen and methane vapour renders it impossible for conventional telescopes or cameras to view the surface of Titan directly. This is the reason why one of Cassini’s main scientific objectives is to explore this unusual body using a range of spectrometers and radar equipment. On 14 January 2005, having been transported by Cassini to the Saturn system, the European probe Huygens landed on

Titan’s icy outer shell with the aid of a parachute and sent back some spectacular images of a landscape in motion, covered with methane rivers and swamps. At the landing site, situated about 500 km from the cryovolcano discovered by Cassini, ice debris can be seen in a landscape which can be interpreted as a flooded plain.

As it circles around Saturn, Cassini is carefully steered very close to Titan. On 26 October 2004, the NASA probe came within a mere 1200 km of the second largest moon in the Solar System. The VIMS spectrometer, built in Italy, France and the USA, is designed to record images simultaneously in visible light and near and medium infrared. This allows VIMS to see through the murky vapour to the surface of Titan through ‘spectral windows’ in certain wavelengths.



Global view of Saturn’s moon Titan.

Once the spectrometer data had been carefully calibrated and corrected for atmospheric effects, the scientists on the VIMS team then began to puzzle over the unusual ‘snail’ structure visible in the captured images. Ralf Jaumann is a member of the VIMS science team and was at the VIMS centre at Tucson University in Arizona to study the data gathered by the instrument immediately after the Titan fly-by. “It seems that we can now confirm the findings of the Huygens landing probe: that this moon has a much more diverse geology than was previously suspected.” If further observations made by the Cassini instruments during the mission confirm the presence of cryovolcanoes on Titan, this would make it the first body in our Solar System to feature ice volcanoes.

Unlike the ‘rocky’ planets and moons of the inner solar system, the bodies of the outer solar system - Jupiter, Saturn, Uranus, Neptune and their satellites (Pluto being a special case) – contain a much higher proportion of volatile elements. Hydrogen, in particular, combines with other light elements such as carbon, nitrogen and oxygen to form a wide range of chemical compounds. Because of the very low temperatures in this region, usually below -150º Celsius, the satellites of these planets have icy surfaces, combined in varying proportions with other volatile substances and also minerals as we see with Earth-like planets.

VIMS: the imaging spectrometer

The VIMS (Visible and Infrared Mapping Spectrometer) on board Cassini is an imaging spectrometer for visible light and near infrared which can simultaneously map a surface in 352 ‘colours’ in wavelengths of between 0.3 microns (thousandths of a millimetre; blue light) and 5.1 microns (medium infrared). All materials reflect light in a unique way. This means that we can identify molecules and compounds by the characteristic way in which they reflect or absorb ‘discrete’ colours of specific wavelengths. During the Cassini mission, the VIMS team will be identifying the composition of the atmosphere and surface of Titan as the orbiter performs its fly-bys of the moon. The VIMS team is made up of scientists from the USA, Germany, France and Italy and the VIMS centre is located at the University of Arizona in Tucson, Arizona.

* Published in "Nature", 9 June 2005, Vol 435, pp. 786-789: Release of volatiles from a possible cryovolcano from near-infrared imaging of Titan. Von C. Sotin, R. Jaumann, B.J. Buratti, R.H. Brown, R.N. Clark, L. A. Soderblom, K.H. Baines, G. Bellucci, J-P. Bibring, F. Capaccioni, P. Cerroni, A. Coradini, D.P. Cruikshank, P. Drossart, V. Formisano, Y. Langevin, D.L. Matson, T.B. McCord, R.M. Nelson, P.D. Nicholson, B. Sicardy, S. LeMouelic, S. Rodriguez, K. Stephan and C.K. Scholz

Related Contacts

Prof.Dr. Ralf Jaumann
German Aerospace Center
Institute of Planetary Research, Planetary Geology
Tel: +49 30 67055-400
Fax: +49 30 67055-402
E-Mail: Ralf.Jaumann@dlr.de

Elke Heinemann
German Aerospace Center (DLR)
Corporate Communications, Online Communication - DLR Web Portal
Tel: +49 2203 601-2867
Fax: +49 2203 601-3249
E-Mail: elke.heinemann@dlr.de
