Cracks Or Cryovolcanoes? Surface Geology Creates Clouds On Titan

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Like the little engine that could, geologic activity on the surface of Saturn's moon Titan-maybe outgassing cracks and perhaps icy cryovolcanoes-is belching puffs of methane gas into the atmosphere of the moon, creating clouds.

This is the conclusion of planetary astronomer Henry G. Roe, a postdoctoral researcher, and Michael E. Brown, professor of planetary astronomy at the California Institute of Technology. Roe, Brown, and their colleagues at Caltech and the Gemini Observatory in Hawaii based their analysis on new images of distinctive clouds that sporadically appear in the middle latitudes of the moon's southern hemisphere. The research will appear in the October 21 issue of the journal Science.

The clouds provide the first explanation for a long-standing Titan mystery: From where does the atmosphere's copious methane gas keep coming? That methane is continuously destroyed by the sun's ultraviolet rays, in a process called photolysis. This photolysis forms the thick blanket of haze enveloping the moon, and should have removed all of Titan's atmospheric methane billions of years ago.

Clearly, something is replenishing the gas-and that something, say Roe and his colleagues, is geologic activity on the surface. "This is the first strong evidence for currently active methane release from the surface," Roe says.

Adds Brown: "For a long time we've wondered why there is methane in

the atmosphere of Titan at all, and the answer is that it spews out of the surface. And what is tremendously exciting is that we can see it, from Earth; we see these big clouds coming from above these methane vents, or methane volcanoes. Everyone had thought that must have been the answer, but until now, no one had found the spewing gun."

Roe, Brown, and their colleagues made the discovery using images obtained during the past two years by adaptive optics systems on the 10-meter telescope at the W. M. Keck Observatory on Mauna Kea in Hawaii and the neighboring 8-meter telescope at the Gemini North Observatory. Adaptive optics is a technique that removes the blurring of atmospheric turbulence, creating images as sharp as would be obtained from space-based telescopes.

"These results came about from a collaborative effort between two very large telescopes with adaptive optics capability, Gemini and Keck," says astronomer Chadwick A. Trujillo of the Gemini Observatory, a co-author of the paper.

"At both telescopes, the science data were collected from only about a half an hour of images taken over many nights. Only this unusual 'quick look' scheduling could have produced these unique results. At most telescopes, the whole night is given to a single observer, which could not have produced this science."

The two telescopes observed Titan on 82 nights. On 15 nights, the images revealed distinctive bright clouds-two dozen in all-at midlatitudes in the southern hemisphere. The clouds usually popped up quickly, and generally had disappeared by the next day. "We have several observations where on one night, we don't see a cloud, the next night we do, and the following night it is gone," Roe says.

Some of the clouds stretched as much as 2,000 km across the 5,550 km

diameter moon. "An equivalent cloud on Earth would cover from the east coast to the west coast of the United States," Roe says.

Although the precise altitude of the clouds is not known, they fall somewhere between 10 km and 35 km above the surface, within Titan's troposphere (most cloud activity on the earth is also within its troposphere).

Notably, all of the clouds were located within a relatively narrow band at around 40 degrees south latitude, and most were clustered tightly near 350 degrees west longitude. Both their sporadic appearance and their specific geographic location led the researchers to conclude that the clouds were not arising from the regular convective overturn of the atmosphere due to its heating by the sun (which produces the cloud cover across the moon's southern pole) but, rather, that some process on the surface was creating the clouds.

"If these clouds were due only to the global wind pattern, what we call general circulation, there's no reason the clouds should be linked to a single longitude. They'd be found in a band around the entire moon," Roe says.

Another possible explanation for the clouds' patchy formation is variation in the albedo, or brightness, of the surface. Darker surfaces absorb more sunlight than lighter ones. The air above those warmer spots would be heated, then rise and form convective clouds, much like thunderstorms on a summer's day on Earth.

Roe and his colleagues, however, found no differences in the brightness of the surface at 40 degrees south latitude. Clouds can also form over mountains when prevailing winds force air upward, but in that case the clouds should always appear in the identical locations. "We see the clouds regularly appear in the same geographic region, but not always in

the exact same location," says Roe.

The other way to make a cloud on Titan is to raise the humidity by directly injecting methane into the atmosphere, and that, the scientists say, is the most likely explanation here.

Exactly how the methane is being injected is still unknown. It may seep out of transient cracks on the surface, or bubble out during the eruption of icy cryovolcanoes.

Although no such features have yet been observed on the moon, Roe and his colleagues believe they may be common. "We think there are numerous sources all over the surface, of varying size, but most below the size that we could see with our instruments," he says.

One large feature near 350 degrees west longitude is probably creating the clump of clouds that forms in that region, while also humidifying the band at 40 degrees latitude, Roe says, "so you end up creating areas where the humidity is elevated by injected methane, making it easier for another, smaller source to also generate clouds.

They are like weather fronts that move through. So we are seeing weather, on another planet, with something other than water. With methane. That's cool. It's better than science fiction."