Geysers or Dust Devils on Triton?

When Voyager 2 whizzed by Neptune last year, it was the planet's moon Triton that stole the show. Ice-lava lakes, cantaloupe-skin terrains, and subtle peach hues made Triton a celebrity, but Voyager's most remarkable discovery may have been the 8-kilometer-tall plumes of gas and debris rising through Triton's atmosphere. In the frenzy of instant science at the Voyager encounter, the first thought was that the plumes were gargantuan geysers, originating in hot spots below the moon's surface.

Now the idea that Triton is the Yellowstone Park of the outer solar system is being challenged, and by one of Voyager's own. In one of a series of papers devoted to Triton appearing in this issue, meteorologist Andrew Ingersoll of the California Institute of Technology, a member of the same Voyager imaging team that came up with the geyser idea, suggests that the plumes are not geysers after all (see p. 435). He and Caltech colleague Kimberly Tryka propose instead that the plumes might be swirling funnels of dust, like dust devils on Earth.

The dust devil idea has a certain appeal because, if correct, it would mean that nothing—neither heat nor gas nor "dust"—would have to come from beneath Triton's surface. That would sidestep a problem confronting proponents of plumes as geysers. Those researchers have to explain how subsurface heat sources, which have been waning for billions of years, can produce such dynamic plumes from an icy surface hovering just a few tens of degrees above absolute zero.

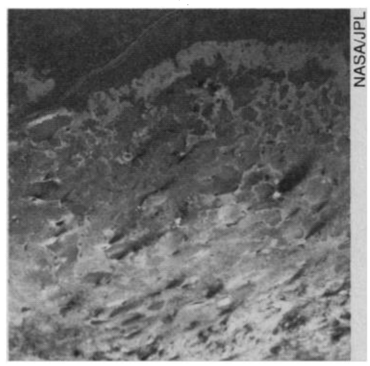
Ingersoll and Tryka came up with the dustdevil idea after Leonard Tyler of Stanford University and his colleagues reported that the temperature of Triton's atmosphere behaves most peculiarly. The Tyler group's analysis of the changes in Voyager's radio signals as they passed through Triton's vanishingly thin atmosphere indicated that the atmosphere gets warmer with increasing altitude instead of cooling, as Earth's atmosphere does.

Dust devils might explain these odd temperature results, Ingersoll and Tryka suggest. The frigid 38 K temperature at the bottom of the atmosphere could be maintained, they point out, by the chilling effects of the nitrogen frost thought to cover much of Triton's surface. Assuming that there could be small frost-free areas, Ingersoll and Tryka propose that the feeble sunlight could make these locations perhaps 15 K warmer than surrounding areas. Then, just as happens on some parts of Earth and Mars, the warmed layer of atmosphere overlying a frost-free area could begin swirling, forming funnels that carry dust—and heat—upward, thereby establishing the unusual temperature gradient.

Dust devil proponents have to contend with a couple of potential problems, however. The plumes in the Voyager images are blown into streamers by high-altitude winds. One streamer was 150 kilometers long. The images also show long dark streaks on Triton's surface, which are presumably deposits laid down by plumes. How could an ephemeral, scurrying dust devil stay in one place long enough to create a straight 150-kilometer streamer or the dark streaks? Simple enough, Ingersoll maintains. Dust devils would not stray from their warm patches and they could reform every Triton day.

Then comes the most serious problem: As Ingersoll himself points out, Triton's atmospheric pressure is so low—only 15 microbars or one fifteen-millionth of Earth's atmospheric pressure—it's hard to see how the proposed dust devils could pick up their dust. At such a low pressure, Triton's "soil" would have to be 1,000 to 10,000 times less cohesive than Earth's in order to be lofted by the dust devil whirlwinds. Ingersoll points out, however, that Triton's "dust" might include particles of water ice. Triton's cold might so diminish their stickiness that even the thin atmosphere could pick them up.

Meanwhile, the geyser proponents are attempting to undercut the dust devil idea by challenging the view of Triton's atmosphere that originally inspired Ingersoll and Tryka's proposal. Roger Yelle, Jonathan Lunine, and Donald Hunten of the University of Arizona find enough uncertainty in the Tyler group's atmospheric temperature data to allow another interpretation of the temperature gradient. They say that the temperature decreases with altitude in the normal fashion up to a height of about 10 kilometers before beginning to increase. If the temperature gradient of the lower atmosphere were not inverted, there would be no need for dust devils to pipe heat upward.



What streaked Triton? *Planetary scientists are debating whether these dark dust streaks on Neptune's moon Triton were deposited from swirling winds or from explosive ejections of gas.*

Moreover, planetary cloud specialist James Pollack of NASA Ames Research Center at Moffett Field, California, and his colleagues report on page 440 that Triton's clouds appear to be made of frozen nitrogen. If so, the lowermost 8 kilometers of the atmosphere could not be as warm as Ingersoll and Tryka would have it. Nitrogen simply could not freeze in such warmth. Pollack also points out that the heat released by the formation of nitrogen ice clouds would tend to destroy the inverted temperature gradient assumed by Ingersoll and Tryka.

Nevertheless, geyser supporters can't claim that their pet hypothesis is home free either. They are still struggling to explain where the energy to drive a geyser would come from on a frigid, geologically moribund moon. As discussed in several papers in this issue, one idea is that geysers are generated by subsurface hot spots formed when sunlight penetrates the translucent icy surface to be trapped greenhouse-like below the surface.

What's it going to take to resolve the Triton plume question? Tyler's team will be doing a final analysis of the radio data that started the dust devil idea in the first place. Tyler, for one, believes their preliminary interpretation will hold up. At the same time, planetary geologists will be looking for more plumes and following up on signs that dark streaks are associated with likely geyser sources. But with no spacecraft likely to visit Triton for many decades, researchers will have to try to resolve their differences with the Voyager data. Up to now, says planetary geologist Torrence Johnson of the Jet Propulsion Laboratory, "This is free-form thinking."

■ RICHARD A. KERR