

**GEOMORPHIC TESTS OF THE GEYSER AND DUST DEVIL MODELS FOR TRITON'S PLUMES** S.M. Metzger, Desert Research Institute - Quaternary Sciences Center, Reno NV, 89512, metzger@scs.unr.edu

**Introduction** The Voyager Neptune Encounter in 1989 revealed plumes rising over Triton's southern hemisphere with diameters that range between tens of meters and 1.5 km to an altitude of 8 km whereupon their plumes are blown at least 100 km to the west. The plumes, in conjunction with dark surface streaks, have been explained as either nitrogen geysers developed by a solid-state greenhouse mechanism in the polar nitrogen ice [1] or as dust devil thermal vortices forming over and entraining material from darker surface patches [2]. This examination explored both models from a geomorphic perspective to identify and test relevant predictions of each mechanism that should be visible in available imagery.

Triton's surface of nitrogen and methane frost or ice [3] has a surface temperature of  $38 \pm 3$  °K and pressure of  $16 \pm 3$   $\mu$ bar [1]. The southern hemisphere is currently toward the sun and undergoes active resurfacing [4]. Triton shows significant aeolian activity [5]. The dark surface streaks are methane and nitrogen ice mixed with complex organic heteropolymers [6,7]. Such dust may only be bonded with van der Waals forces and have very little cohesion [8]. The streaks often fan out from a distinct source area and may extend 10 km to over 100 km. The streaks exist from 5° to 70° S latitude and especially between 15° and 45°. Surface wind direction, determined from those streaks, is 40° to 80° as seen looking from the north pole [5]. Winds were identified at the 1 to 3 km altitude level blowing toward the east as shown by the motion of clouds and hazes. The plumes occur between 49° and 57° S latitude.

**Geyser Model** This mechanism develops when solar radiation penetrates methane or nitrogen ice and is absorbed thereby subliming that ice whereupon the gas migrates along fractures until it explosively vents into the atmosphere [1]. Frosts in excess of 1 m thick on top of a layer of dark streak material will permit a "super" greenhouse to operate [9,10]. Pure ice requires a greater thickness (approx. 1 km). Because solid nitrogen transitions between its  $\alpha$  and  $\beta$  forms at 35.6°K with a considerable accompanying change in volume, seasonal fluctuations in temperature will result in fracturing the ice [11] allowing gas and entrained dark organic dust to collect laterally until an escape vent is found to the surface. Calculations indicate that the gas need only achieve 4°K higher than the ambient surface temperature of 38°K to reach an 8 km altitude [1] but require at least 10 km<sup>2</sup> of frost source area to provide the observed plume fluxes.

In the geyser model, streaks and plumes should emerge within or adjacent to bright frost patches. Dark streaks will have well defined sources and boundaries, broadening as they disperse downwind. Surface winds may shear it downwind once vented. Dissipation of the plume is expected above the vent even though a well-defined warm column may rise through the cooler atmosphere.

**Dust Devil Model** These vortices form when insolation heats the surface, destabilizing ground-level air and forming buoyant thermal plumes with strong rotation [12]. Darker surfaces promote absorption and plumes are enhanced along contrasting-albedo surfaces. Vortex torque effectively entrains material off well-crustured surfaces in terrestrial deserts [13,14,15]. [8] calculate that 10 m s<sup>-1</sup> winds should commonly exist at Triton's surface while velocities as low as 0.5 m s<sup>-1</sup> may be able to entrain low-cohesion grains in the 1 to 10  $\mu$ m diameter range. [2] calculate the rotational velocity of a large Triton dust devil could exceed 20 m s<sup>-1</sup>. Once entrained, dust is balanced between centrifugal forces and air swept into the vortex. Subsequently a considerable amount of material can be transported to great altitudes. [16] found Martian dust devils rising to 6 km.

Consistent with the dust devil model, numerous plumes are likely to spring up at the same time [12,13,16]. They should form over dark surfaces, perhaps adjacent to boundaries with the lighter surfaces. Their sedimentation will produce diffuse dark patches of redistributed material that are unlikely to lead back to sharply defined source areas. They may form sets of subparallel lineations or tracks in accordance with surface wind trends [17].

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Coarser particles ejected from the rotating column form a fuzzy, bulbous base.

**Results** East plume rises over an area of moderate albedo near several large frost patches. There does not seem to be a sufficient supply of appropriate material on the surface to sustain such a plume. While there are dark streaks between east plume and the moon's limb, no other plume activity is apparent in the region. West plume is considerably more distinct and rises over an arcuate dark band adjacent to a bright frost patch. Two other dark streaks or bands abut the frost patch. The column's base is clearly bulbous, the mid-portion is very narrow, and the top spreads out like a thunder cell's sheared anvil shape before trailing off into a long (> 100 km) downwind plume. Despite the presence of numerous dark areas, no other plumes are active in this region.

On top of a background of circular and irregular polygonal surface markings within a wide mid-latitude swath in the southern hemisphere are a number of prominent dark streaks that share a common orientation (with the wind coming from 40° to 80° as seen from the north). Most of these dark patches begin at moderate to bright patches and dissipate outward from them. A few are slightly sinuous or appear to deviate around surface topography but most are straight. Some are very narrow and elongate. No active plumes are visible throughout the entire mid-latitude zone northward of 49°S.

When individual streaks in the mid-latitudes are examined the relationship between frost and dark, wind-dispersed tails is clearly articulated. Some show a bright frost ring with a very dark streak emanating from a small area directly on the ring's edge. The streak's borders become increasingly fuzzy as distance increases away from the ring.

**Discussion** The defined source points for the dark streaks and the presence of sinuous tails that appear to follow local terrain indicate that Triton's surface winds are able to entrain and deflect aeolian material. If dust devils were active on Triton their tangential shear surface forces would be able to entrain even more material than typical turbulent winds [13]. There is little supporting visible evidence, however, that the active plumes or surface streaks were formed by dust devil processes. Commonly, numerous dust devils will form when conditions are right [15] yet only two very large plumes are clearly active with no sign of smaller ones nearby. Thermal vortices need not develop at the leading edge of a dark patch. The dark streaks consistently share a pattern of distinct source points with increasing downwind dispersal. No scour tracks, subparallel lineations nor fuzzy sedimentation swaths indicate the passage of dust devils. Indeed, given the atmospheric dynamics, the current question is why dust devils are NOT active on Triton.

Observed plume activity is consistent with the geyser model predictions [8]. Geysers are likely to form close to or within their frost source areas, as illustrated by most dark streaks. Since the south pole is increasingly oriented more toward the sun, we should expect to see remnants of geyser activity in the mid-latitudes and current plumes closer to the pole; as observed. Although Triton's surface winds may have the opportunity to redistribute dark particulates before new frost covers them, dust fallout from geyser plumes should produce the streak pattern observed. Sinuous streaks may result when weak geysers vent plumes close to the ground that are carried by gentle winds around terrain features.

### References

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