EPSC Abstracts
Vol. 6, EPSC-DPS2011-1358, 2011
EPSC-DPS Joint Meeting 2011


# The Snows of Enceladus

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## Abstract

The icy south polar plumes of Enceladus make for a spectacular effect in the Saturn system (e.g., the E-ring), but also profoundly alter the surface of Enceladus itself. Recent models of the plume particle dynamics predict that the heavier particles will reaccrete, effectively "snowing" fine-grained debris back onto the surface in discrete patterns [1], depending on the actual distribution of ejection sites. The densest fallout pattern is dominated by two scytheshaped lobes extending northward from the South-Polar-Terrains along the 40 and 220W longitudes. Recent color mapping of Enceladus demonstrates that IR/UV color asymmetries across the surface match these predicted patterns astonishingly well [2]. Theory and observation therefore confirm the apparent formation of a blanket of very small particles covering most of the surface of Enceladus to different depths, depending on location and plume source changes.

## 1. Introduction

Global maps of the five inner midsize icy Saturnian satellites reveal that Enceladus has a global color pattern distinct from the other satellites. Hemispheric color asymmetries on Tethys, Dione and Rhea have been attributed to plasma and E-ring grain bombardment on the trailing and leading hemispheres, while dark bluish equatorial bands on Tethys and Mimas have been attributed to radiation damage to the surface by high-energy electrons [2]. Enceladus shows no equatorial band but a pronounced global color asymmetry offset 40°W of the apex of motion and defined by relatively bluish material extending northward from the south polar terrain along two antipodal meridians. This antipodal yet offset pattern (Figure 1) matches surprisingly well the deposition pattern predicted for plume fallback onto the surface [1]. The formation of this feature appears to mask or prevent the formation of the lenses and hemispheric asymmetries we see on the other satellites.

## 2. Questions

The apparent confirmation of the predicted fallout patterns in the global color maps raises several interesting Questions:

1. How does snowfall deposition modify the surface we see? Can thickness variations be mapped geologically?
2. What has been the total amount of snowfall on Enceladus and can the duration of plume activity be estimated from these deposits?
3. What is the thermal impact of a thick yet nonuniform deposit of unconsolidated ice particles on the regolith and interior of Enceladus? (e.g., Do such deposits form an insulating blanket?).

Question 3 is beyond the scope of our work, and Question 1 will be answered by detailed geologic mapping (including work by this author and colleagues). Question 2 requires extensive high resolution mapping beyond the SPT, of which only a fraction of the required amount has been as yet attained. Nonetheless, a single observation (Figure 2) may provide direct evidence of snowfall in one southern location totaling up to 100 m. If current modeled surface deposition rates at this site are assumed, total aggregate plume duration is on the order of many 10's of myr, possibly more than 100 myr. Predicted thickness maps are under construction and additional observational constraints are being investigated.

## References

[1] Kempf, S., Beckmann, U., Schmidt, S., 2010. How the Enceladus dust plume feeds Saturn's E ring, Icarus, 206, 446-457.

[2] Schenk, P, D. Hamilton, R. Johnson, W. McKinnon, C. Paranicas, J. Schmidt, and M. Showalter, 2011. Plasma, Plumes and Rings: Saturn System Dynamics as Recorded in Global Color Patterns on its Midsize Icy Satellites, Icarus, 211, 740-757.

# Figures

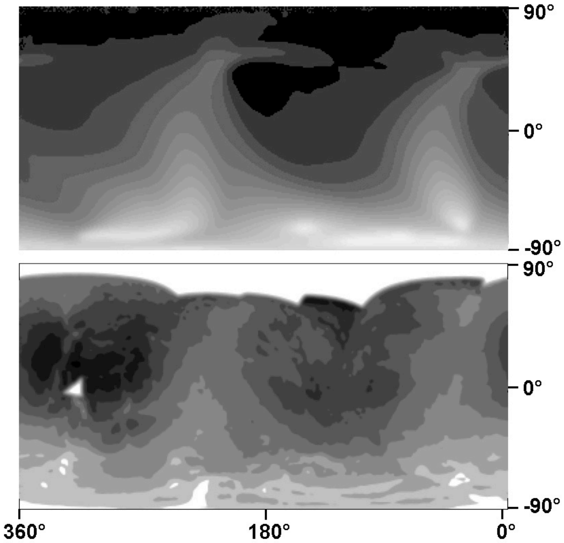


Figure 1: Global predicted plume fallout deposition map (top [1]) and UV/IR color ratio map (bottom [2]) of Enceladus. Brightness in top map indicates highest deposition rates. Although subtle details may differ between the two maps, both deposition and the blue deposits decreases northward along the same two longitudes and "hook" to the east as they cross the equator. Plume sources are visible as bright areas in top map.

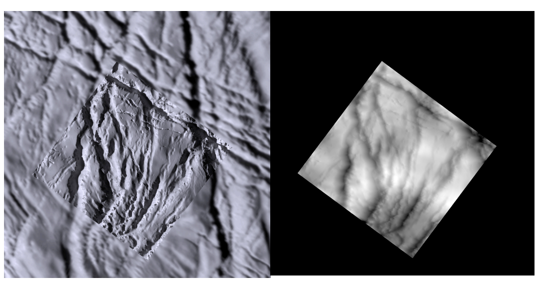

Figure 2: High resolution (12 m/pxl) Cassini view (left) and derived topographic map (right) of fractured terrains apparently mantled by a thick deposit of loosely consolidated material. Material interpreted as plume debris deposits. Location 55°S latitude.