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Sourcing Enceladus' Plume

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1. Introduction

In 2005, Cassini began a thirteen-year tour of the Saturnian system and observed eruptions at the Southern pole of Saturn's satellite, Enceladus. A complex of rifts in Enceladus' ice crust ejects water vapor and icy particles into space (Spitale and Porco 2007, Porco et al. 2014, Spitale et al. 2015) and sustains Saturn's E ring (Mitchell et al. 2015). Local hotspots were found to correspond with four cardinal fractures and, in 2007, jetting activity was mapped (Spitale and Porco 2007). More recently, with the intention of tracking the moon's eruptive patterns at various orbital positions, maps of broad activity represented by higher altitude, curtain-like emissions have been revised from Spitale at al. 2015 and submitted for review.

2. Analysis

Backlit images of the plume and South Polar Terrain (SPT) were captured by Cassini's Narrow Angle Camera and document variable eruptive activity. The images occur in observational sequences representing fifteen epochs between 2009 and 2015, each covering a specific range of mean anomalies. Synthetic curtains representing material cast from source fractures assuming an active state were superimposed over the Cassini images. In cases where fractures were active, shadows and features visible in the image matched the projected curtains. These fractures were marked "active". All other fractures were classified as "inactive", "degenerate", or "indeterminate". A probability map was produced for each epoch based on the number of times each fracture was marked "active" divided by the number of times it was observed, and the standard deviation of those maps illustrates where variability occurs.

3. Results

We found that about 80% of the fractures were detectably active in every epoch we mapped. The outstanding 20% of fractures that cycled between active and inactive were almost entirely positioned along the fringes of the fracture system.

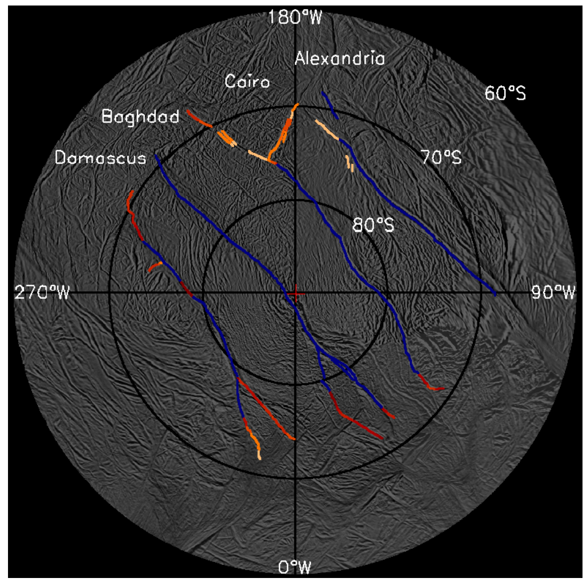

Figure 1: Standard deviation of fracture activity. Most of the variability occurs around the fringes of the fracture system.

4. Discussion and Conclusions

The pattern of variability we find in the eruptions may simply reflect the topography of the ice shell and corresponding depth of the liquid reservoir, assuming isostatic equilibrium. In that case, where the height of the ice above and below the water line will maintain a constant ratio, the overburden stress of the thicker ice surrounding the SPT could generate fringe variability if the fractures sample a common reservoir. In the fringe zone where the ice is thickest, more tidal stress would be required for fracture failure at the waterline, and we would therefore expect to see failure over a more limited range of mean anomalies in those locales compared to the central part of the fracture system.

References

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