

TIDAL CONTROL OF JET ERUPTIONS OBSERVED BY CASSINI ISS. T.A. Hurford¹ and P. Helfenstein² and J.N. Spitale³, ¹NASA Goddard Space Flight Center (Greenbelt, MD 20771; Terry.A.Hurford@nasa.gov), ²CRSR (Cornell University, Ithaca, NY 14853), ³Planetary Science Institute (1700 E. Ft. Lowell, Suite 106, Tucson AZ 85719).

Introduction:

Observations by Cassini's Imaging Science Subsystem (ISS) of Enceladus' south polar region at high phase angles has revealed jets of material venting into space [1]. Observations by Cassini's Composite Infrared Spectrometer (CIRS) have also shown that the south polar region is anomalously warm with hotspots associated with geological features called the Tiger Stripes [1,2]. The Tiger Stripes are large rifts near the south pole of Enceladus, which are typically about 130 km in length, 2 km wide, with a trough 500 m deep, and are flanked on each side by 100m tall ridges [1]. Preliminary triangulation of jets as viewed at different times and with different viewing geometries in Cassini ISS images taken between 2005 and 2007 have constrained the locations of eight major eruptions of material and found all of them associated with the south polar fractures unofficially the 'Tiger Stripes', and found four of them coincident with the hotspots reported in 2006 by CIRS [2,3].

While published ISS observations of jet activity suggest that individual eruption sites stay active on the timescale of years, any shorter temporal variability (on timescales of an orbital period, or 1.3 Earth days, for example) is more difficult to establish because of the spotty temporal coverage and the difficulty of visually isolating one jet from the forest of many seen in a typical image. Consequently, it is not known whether individual jets are continuously active, randomly active, or if they erupt on a predictable, periodic schedule. One mechanism that may control the timing of eruptions is diurnal tidal stress, which oscillates between compression/tension as well as right and left lateral shear at any given location throughout Enceladus' orbit and may allow the cracks to open and close regularly [4,5].

We examine the stresses on the Tiger Stripe regions to see how well diurnal tidal stress caused by Enceladus' orbital eccentricity may possibly correlate with and thus control the observed eruptions. We then identify possible mechanisms by which tidal stress can provide access to the surface for volatile material and implications for observed jet activity.

Tidal Stress at Jet Source Locations:

In figure 1, the location of the eight sources identified by Spitale and Porco [3] are shown with respect to the tiger stripes. Sources I, II, III and VI correspond to locations along Damascus and Baghdad sulcus where Cassini CIRS has observed the hottest temperatures and thus the greatest power emitted from the surface [6]. Here we assume that positive detections of plumes

for Sources I, II, III and VI are reliable and are associated with a portion of the Tiger stripe closest to their triangulated source locations. Thus, we focus on the stress at these four source locations and on this basis we compare models of tidal stress variation with the observational record.

We first characterize tensile stress across the Tiger stripes within source regions I, II, III and VI, over the course of Enceladus' orbit, assuming orbital eccentricity is the only source for the stress. Fig. 2 summarizes the results for each of the four source regions, superimposed are the observational results from Spitale and Porco [3]. Here the maximum tensile stress and the maximum absolute shear experienced in the tiger stripe source regions are shown along with the theoretical percent of the region in tension, as a function of orbital position. For each source region, the tiger stripe first experiences tension shortly after pericenter, and in most cases the transition from compression to tension is rapid. By the time Enceladus reaches apocenter, each source region is completely in tension. After apocenter passage the stresses become more compressional, until after pericenter passage, when the cycle repeats.

Throughout the orbit at all source regions, the maximum absolute shear stress experienced remains fairly steady at about half a bar (Fig. 2). During the orbit the shear stress oscillates between right and left lateral senses of shear and the magnitude of shear changes at any given location, but the maximum absolute shear remains somewhat steady over the source region. This is consistent with previous studies which identified source regions are places along the Tiger stripes that experience greater shear [5].

Discussion/Conclusions:

In order for jet activity to occur a conduit from the surface to tap into the reservoir of volatile material must be established. This can be done by 1) tensile stresses directly opening a conduit or by 2) shear failure allowing conduits to form.

Under the assumption that fissures can actively erupt material only while in tension and can remain active as long as the conduit remains open, the majority of the observations of jet activity do occur when each source region is in tension. Of the 26 detections of activity among the four source regions (I, II, III, and VI), 17 or 65% occur at times when the source region is in tension (Fig. 2). This may be a result of the fact that jet observations are more likely to fall in the first half of the orbit when cracks are predicted to experience tension. However, some observations consistently

