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"Blood Stains" on Tethys: Evidence for Recent Activity?

P. M. Schenk (1), B. J. Buratti (2), P. K. Byrne (1), W. B. McKinnon (3), F. Nimmo (4) and F. Scipioni (1)
(1) Lunar & Planetary Institute, Houston TX, (2) Jet Propulsion Lab, Pasadena, CA, (3) Washington Univ., Saint Louis, MO
(4) Univ. California, Santa Cruz, CA (schenk@lpi.usra.edu)

Abstract

A distinctive set of arcuate, reddish-colored lineaments has been identified on Tethys. These markings are slightly darker than adjacent cratered terrains but have a flatter green–IR spectral slope. The lineaments form an arcuate pattern centered on the tidal axis with Saturn. High-resolution image data show only the faintest traces of surface distortions, collocated with small, low-albedo spots <1 km in diameter. One possibility is that these markings may be nascent fractures, accompanied by relatively reddish discoloration from venting and deposition of material from the interior.

1. Introduction

Tethys is unusual among icy moons for its low bulk mean density of 0.985 g/cm^3, suggesting a low rock mass fraction and/or high porosity. Tethys also has an intense fracture history [1], including Ithaca Chasma as well as several hundred arcuate and linear troughs, grooves, and cracks. A distinctive set of linear features has been recognized on Tethys in areas viewed by Cassini under high solar illumination conditions (Fig. 1). These markings are characterized by a strong "reddish" color signature: a slightly lower albedo and flatter spectral signature in the green–IR range (Fig. 2).

1.1 IR-Lineations

There are at least three prominent sets in the northern anti-Saturn hemisphere, centered on the anti-Saturn meridian (Fig. 3). Each set consists of ~5–10 parallel lineations a few kilometers across and 50–250 km long. The lineations are remarkably curvilinear (i.e., non-sinuous), do not follow great circles, and are not deflected by major impact structures: they cross the floor of the 400-km-diameter, 8–10-km-deep Odysseus impact basin as if it were not there.

Although spatially limited, sub-Saturn hemispheric color imaging at low-phase angle clearly shows a similar set of arcuate, reddish lineations on that hemisphere, which is dusted by E-ring particles from Enceladus [2].

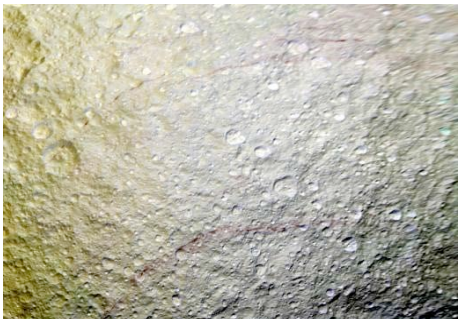

Figure 1: Color view of Tethys showing IR lineations (reddish arcs). Cassini IR3, green, UV3 composite.

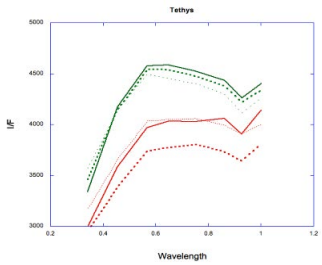

Figure 2: Spectral plot showing IR lineaments (red) and adjacent cratered plains (green).

One set of lineaments (~25° N, 185°W) has been imaged at high resolution. Mapping at ~90–125 m/pixel (Fig. 4) (together with stereo and lower resolution color imaging) shows no discrete scarp, ridge, or other tectonic manifestation along the ~100 km portion of the feature so imaged. Instead, a faint discoloration and intermittent distortion of the surface has been identified (Fig. 5). This set ignores topography. Further, 22 dark spots 200–800 m in diameter lie along this set of lineaments. These spots are characterized by very low albedos, sharp boundaries, and no evidence of raised rims consistent

with an impact origin. Of these 22, 60% (15) are situated at the bottom of impact craters.

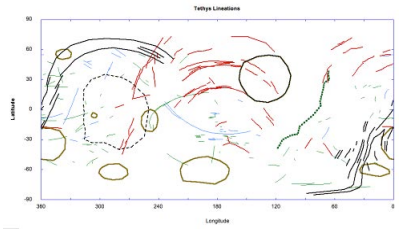

Figure 3: Global map of fractures, ridges, and lineations on Tethys. IR lineations are shown in red. Odysseus is circled at upper center.

2. Origin of IR-Lineaments

The spatial pattern of IR lineaments on Tethys shows a remarkable symmetry (Fig. 3), centered on the current tidal axis with Saturn. A lack of correlation with local geology might suggest an exogenic origin. Conversely, there are no rayed craters at the radial centers of these features. Further, the locations of the patterns on both the sub- and anti-Saturn hemispheres, and the lineaments' parallel orientations, argue against a disrupted comet origin (à la SL9). Hence we explore a possible endogenic origin.

Figure 4: High-resolution, 90 m/pixel mosaic of IR lineaments, merged with IR3–Gr–UV3 color mosaic.

The lineaments have no systematic orientation relative to Odysseus, indicating that stresses arising from the relaxation of that basin are not responsible for these features. Other stress mechanisms might have produced the pattern we observe. The IR lineaments match patterns of strain predicted to result from a non-synchronous rotation stress state, although this is unlikely for a cold, triaxial body like Tethys. The pattern less obviously fits a polar wander-induced stress state, but further testing of the proper rotation magnitude and path is required. Formation due to tidal recession stresses is another candidate scenario being tested.

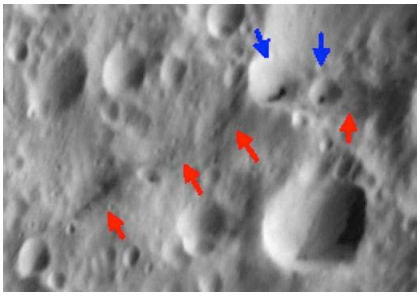

Figure 5: Enlargement of high-resolution view showing lineament (red arrows). Small dark spots are visible (blue arrows), which form within 10 km of the IR lineament.

The lack of obvious tectonic deformation despite the strong color signature is unusual (although features may exist below the current resolution limit). The lineaments could be reactivated ancient fractures, producing a temporal discoloration. At present there is no topographic or morphologic signature to support this. If tectonic, the lineaments might be still forming, with deformation only on a scale below that which we can resolve.

The coloration, and collocated dark spots, are consistent with active alteration of the surface, given that E-ring accumulation is expected to remove intrinsic color signatures in a geologically short time period. Low-volume but persistent outgassing and emplacement of volatiles from the interior, the colors of which are distinct from the evolved surface and/or result from exposure to the space environment, may be responsible. Differences in particle sizes of the outgassed material may add to this spectral distinctiveness.

References

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[2]. Schenk, P., D. Hamilton, R. Johnson, W. McKinnon, J. Schmidt, M Showalter, Plasma, plumes, and rings: Global color patterns on Saturn's midsize icy satellites, Icarus, 211, 740-757, 2011.