

A SEARCH FOR DESPINNING FRACTURES ON IAPETUS. Kelsi N. Singer and William B. McKinnon. Department of Earth and Planetary Sciences and McDonnell Center for the Space Sciences. Washington University, St. Louis, MO 63130; ksinger@levee.wustl.edu, mckinnon@wustl.edu.

Introduction: De-spinning of planetary bodies may leave a tectonic signature indicative of the relaxation or partial relaxation of an equatorial bulge. This pattern can be complex depending on the thickness of the lithosphere and it can be modified by global expansion or contraction [1-2]. Iapetus has retained a fossil bulge which corresponds to a body spinning at ~ 16 hours [3]. It is now synchronously revolving around Saturn with a period of ~ 79 days [4]. Iapetus has despun, but far from relaxed. Although Iapetus does not have a strong tectonic signature, there are several classes of distinctly linear features. Analysis of these features can help us examine the tectonic history and interpret the principal stresses affecting Iapetus.

Identification of Linear Features: Linear features were identified in images obtained of Iapetus during the December 31st, 2004 Cassini flyby. High resolution was only available on the dark leading side of Iapetus, and the analysis was contained within $\pm 40^\circ$ latitude due to increasingly acute observation angles and the splattered albedo transition region obscuring features near the poles. Lineaments on Iapetus fall into 4 main categories:

1. Lineaments that appear dark
2. Lineaments that appear bright (including a few unusually long/linear central peaks inside craters)
3. Linear Crater wall segments
4. Linear features that appear to be secondaries on the basis of morphology and because they are radial to a large crater.

Examples of each type of feature are given in Fig. 1. In total approximately 90 lineaments (of various lengths) were identified and measured for length and azimuth. Of those ~ 35 are crater rim segments, ~ 10 are bright lineaments, ~ 15 are dark lineaments and the ~ 30 remaining are secondary-like rays.

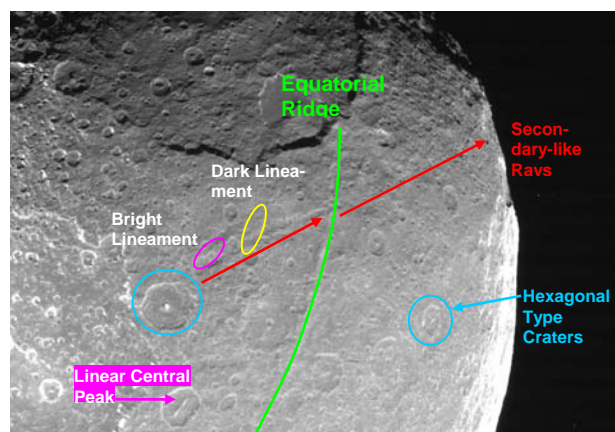
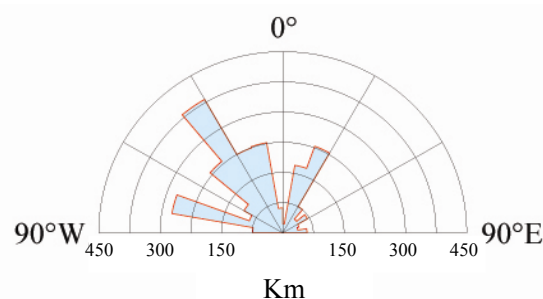


Figure 1. Examples of linear features on Iapetus. The bright and dark lineaments are hard to distinguish on this scale.

Analysis: The rose diagram of all lineament data shows a broader, more random distribution than a plot of crater rim and linear central peak segments only (Fig. 2a, b). Looking only at the crater data, so as to eliminate the influence of structures created by secondaries, the data shows a concentration of lineaments between 10 and 30° off of the N-S line which would indicate the principal stress direction (σ_1) was N-S and compression occurred parallel to it. This result is opposite of that predicted by models for despinning with relaxation, in which the principal stress direction should be E-W [1]. Despinning models predict that the azimuthal stress ($\sigma_{\phi\phi}$) is always larger, or more compressive, than the meridional stress ($\sigma_{\theta\theta}$) whereas the Iapetus results suggest the azimuthal stress was greater.

a. All Lineaments



b. Craters Only

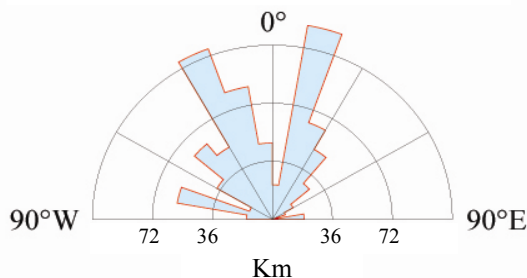


Figure 2. Rose diagrams of lineament length and direction for (a) all lineaments and (b) lineaments associated with craters including rim segments and linear central peaks.

Discussion: If the approximately $\pm 20^\circ$ angle for the Iapetus lineaments is significant, it is smaller than the angles seen on terrestrial planets. This angle between the fault plane and σ_1 is dependent on the coefficient of friction of the material, and tends to produce $\sim 30^\circ$ angles in rocks on Earth [5]. A higher coefficient of friction would result in a smaller angle for the faults, but laboratory experiments have shown that the frictional strength of ice is significantly less than that of rocks and tends to fail at a 45° angle [6-7]. These experiments were done at temperatures from 77 to 115 K and pressures from 0.1 to 250 MPa. Temperatures on Iapetus are estimated to range from ~ 130 to 70 K over the course of the Iapetus day in the dark regions [8], and thus the above experiments are in the correct temperature range.

Stresses on Iapetus. Iapetus has not or is only partially relaxed, and has been strong enough to support a large hydrostatic bulge since early in its history. We expect some stresses associated with maintaining this bulge, but they are apparently poorly expressed. Perhaps the very thick lithosphere has led to small stress magnitudes, or possibly the great age of Iapetus's surface has allowed its tectonic grid to "crumble." Younger craters do show well defined linear wall segments, however, indicating that some joints and faults persist.

Comparison to lineament grid on Mercury. In the case of Mercury, only with lineaments which were not radial to a large crater, including linear scarps, ridges, troughs and crater walls were analyzed [10]. Features inside craters were included in the Iapetus data, but excluded from those used for the Mercury rose diagrams. The Iapetus lineaments cover less than $1/5^{\text{th}}$ the total length of the lineaments measured on Mercury, but Iapetus is a smaller body and less than half of the surface was imaged at high enough resolution during the Dec. 2004 flyby to find lineaments on. Also

the lineaments on Mercury do form more a grid-like pattern on the hand-drawn schematic diagram, but the actual data shows a spread in lineament azimuths, similar to that of the Iapetus data, with a concentration of lineaments forming an acute angle with the E-W line [10].

Conclusions: In analogy to work done on Mercury [10-11], the linear features on Iapetus were analyzed for a tectonic signature. We find that the tectonic pattern on Iapetus does not match that of previous models of a despun planet and in fact shows the opposite principal stress than predicted and seen at Mercury. Future analysis of the bright side of Iapetus may confirm or deny the existence of a conjugate pair at approximately $\pm 20^\circ$ and may reveal other interesting linear features.

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