TIDAL ORIGIN OF EUROPA'S FRACTURES: A REFINED ANALYSIS, Paul Helfenstein, Department of Geological Sciences, Brown University, Providence, RI 02912.

Europa's icy, relatively crater-free surface contains a global system of fractures exhibiting varied morphologies, and possibly different origins. Three primary types of fractures (dark bands, triple bands, and cuspate ridges) classified by Lucchitta et al. (1) and Pieri (2), may record a history of change in Europa's planetary figure. Previous studies have attributed the fractures to internal convection and thermally induced volume changes (2,3), tidal distortion (4), or some combination of these processes (1). Based upon orientations measured from the U.S.G.S. Preliminary Pictoral Map of Europa (5), Helfenstein and Parmentier (4) suggested that the pattern of fractures is broadly consistent with tidal distortion of Europa's global figure. The present refined analysis based upon this earlier study 1) utilizes a more complete and accurate data base obtained by digitizing individual fractures from Voyager images and 2) considers separately dark bands, triple bands, and cuspate ridges.

The positions of 323 fractures represented by 9630 data points were digitized, covering a total length of 234,075 km. In order to accurately reproduce fracture geometries, spacing of data points along a fracture is controlled largely by its local radius of curvature. Small, highly curved fracture segments are thus represented by more data points than longer, straight segments. Orientations of fracture segments relative to directions of principal stress were computed for tidal distortion of 1) a thin, elastic, spherical shell representing an icy crust mechanically decoupled from a silicate interior and 2) a solid, elastic spherical body. In both cases the volume of the planet was assumed constant. Fracture segments were partitioned into bins based upon whether they occurred in regions of expected thrust, strike-slip, or normal faulting. A statistical measure of orientations was adopted which weights each segment by a factor proportional to its length.

The results shown in Figure 1 are in agreement with earlier studies which suggested a tidal origin for fractures. Dark bands interpreted as strike-slip faults (Figure 1A, II) and cuspate ridges (Figure 1B) may have been produced by orbital recession. The occurrence of cuspate ridges in regions of expected strike-slip and normal faulting can be explained if Europa's volume decreased during recession. Cuspate ridges would then be interpreted as thrust faults crudely concentric to the anti-Jove point (2,4). Orientations of dark bands representing tension cracks near the anti-Jove point (Figure 1A, I) are consistent with tidal distortion of Europa due to orbital eccentricity. Triple bands (not shown) do not appear to occur at orientations consistent with faulting produced by deformation along the present tidal axis.

References:
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Figure 1: Orientations of (A) dark bands and (B) cuspate ridges relative to directions of maximum (minimum) principal stress for increasing (decreasing) tidal bulge amplitude in a thin, elastic shell representing Europa's crust. A tidal axis with one pole located at the present anti-Jove point is assumed. N is percentage of total digitized fracture length represented in the histogram. I, II, and III represent regions of expected thrust, strike-slip, and normal faulting, respectively, for a decrease in amplitude of the tidal bulge. This order is reversed for an increase of amplitude. Normal and thrust faults should have orientations of 0° in I, and 90° in III. Strike-slip faults should occur near 30° and 60°, respectively, for increasing or decreasing tidal distortion.