ORIGIN OF TRIPLE BANDS ON EUROPA. Matthew Golombek and Eileen Bruckenthal*, Lunar and Planetary Institute, 3303 NASA Rd. 1, Houston, TX 77058; *Present Address: Box 516, Brown University, Providence, RI 02912

Triple bands are prominent surface lineations on Europa named for their characteristic bright central stripe flanked on either side by dark stripes. The most obvious explanation of triple bands and other lineations on Europa is that they represent some type of fracture infilled with silicate contaminated water-ice. The origin of the central bright stripe is enigmatic but has been suggested by Finnerty et al. (1) to be the result of a subsequent clean ice extrusion. In this paper we will briefly review the salient characteristics of triple bands, point out the difficulties in the clean ice extrusion origin for the central stripe, and propose a simpler, morphologically more consistent, and less ad hoc origin for triple bands on Europa.

Triple bands are generally less than 10 km wide and hundreds of kilometers long (2). The central bright stripe is a few kilometers wide, has a higher albedo than the flanking dark stripes, and actually appears as a topographic ridge near the terminator (3). The dark, lower-albedo stripes that flank the central stripe may grade into discontinuous spots (2). At the resolution of the Voyager images the boundaries between the stripes appear to be sharp as if structurally controlled. Triple bands are reported (2) to merge with ridges near the terminator and dark bands elsewhere.

Finnerty et al. (1) suggested that triple bands are lithospheric cracks filled with a breccia of frozen water and silicates (dark flanking stripes) which subsequently extruded silicate-free ice to form the central bright stripe. To explain triple bands they call for a complex process analogous to gas-driven kimberlite eruptions on the earth. While such a process may be possible and may provide a driving mechanism for forcing silicate-rich ice onto the surface, simple geometric constraints are not consistent with the second extrusion required to form the central stripe. First, it is unclear why a second ice-free extrusion would occur exactly along the center of a previously filled crack; more likely a second extrusion would follow the previously formed fractures and extrude along the sides of the structure. Second, it is difficult to make sharp, apparently structurally controlled topographic ridges (central stripes) by the extrusion of liquid water. Finally, it is not clear why the initial eruption of silicate-rich material is followed by an eruption of silicate-free material. Given these problems with a second extrusion to explain the central bright stripes of triple bands we propose the following hypothesis for their formation.

Because global expansion has been evoked to explain the pervasive lineaments on Europa (1) and grooved terrain on Ganymede, and because grabens are the most probable extensional features on Ganymede (4), it is reasonable, by analogy, to explore the possibility that lineanements on Europa are, in fact, grabens or kindred structures. One possibilty is that triple bands are infilled graben complexes with uplifted central horsts. Assuming this to be the case, we suggest the following evolution for triple bands. Extension of Europas' icy crust results in numerous grabens, including some with central horsts (Fig. 1). Because liquid water is more dense than the ice I presumed to make up the surface of Europa, some pressurized driving mechanism is required to get the silicate-rich liquid to the surface. One possibility is the gas-driven eruption mechanism of Finnerty et al. (1); another is some variation of the hydraulic pressure developed by progressive freezing of trapped water originally suggested for Ganymede by Croft (5). Pressurized silicate-rich liquid water would migrate along the pre-existing fractures of the grabens en route to the surface. This liquid would both fill in the depressions of the graben yielding the dark

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flanking stripes, and, because it is pressurized, bow up the central horst resulting in an uplifted ridge (Fig. 2).

The hypothesis that triple bands are infilled grabens with uplifted central horsts is consistent with most of the observed characteristics. The sharp boundaries between the light and dark stripes are simply a result of the bounding faults which structurally control the infilling water ice. Places where the dark flanking stripes are discontinuous spots is a natural consequence of not enough extruded silicate-rich dark ice to completely cover the original downfaulted clean ice. The observation that triple bands grade into simple dark bands is easily explained as a result of the central horst being covered by extruded ice and/or not being uplifted and is consistent with dark bands being simple infilled grabens (2) without uplifted horsts. In this hypothesis the brightness of triple bands observed on images may be simply a result of the positive topographic relief of the central stripe exactly analogous to the brightness of ridges observed on Europa. Alternatively, the material comprising the central horst is fractured during uplift, and the brightness of triple bands is due to the increased reflectivity of the highly fractured material.

In conclusion, the origin of triple bands as infilled grabens with uplifted horsts is consistent with their observed characteristics, simple - requiring only one extrusion, a natural consequence of, and consistant with the required pressurized extrusion of silicate-rich water ice on the surface, and a natural and probable variation of interpretations of other lineations on Europa as flooded graben.

References

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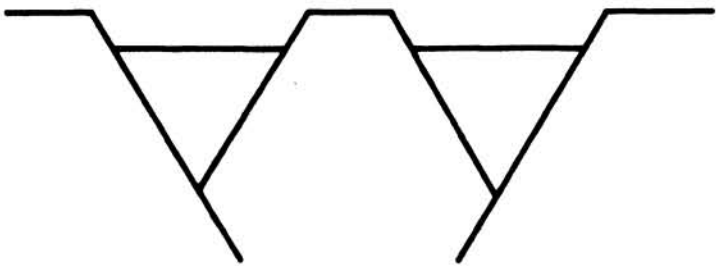

Fig. 1. Cross section of initial graben and horst structure proposed for triple bands on Europa.

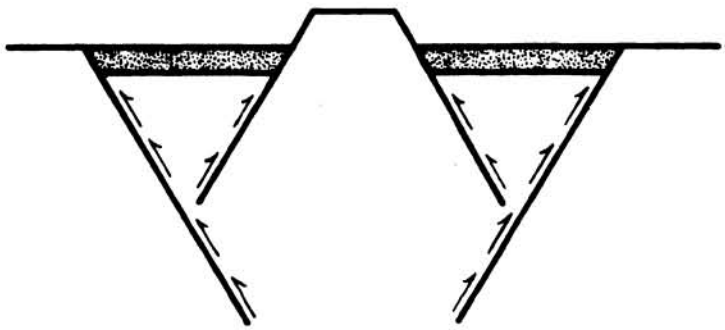

Fig. 2. Infilled graben and uplifted central horst result from the movement of pressurized silicate-rich water ice toward the surface (arrows indicate path).

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