CRYOVOLCANISM AT RHADAMANTHYS LINEA, EUROPA AND THE ROLE OF TIDAL STRESSES.

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Introduction: Triple bands on Europa have low-albedo margins which may be indicative of intrusive or explosive cryovolcanism [1]. Explosive cryovolcanism has also been suggested as the cause of the putative Europan plumes detected by Hubble [2]. At Rhadamanthys linea the low-albedo areas are localized, causing a distinctive pattern of spots [1]. In this work we investigate possible causes of this localization and the potential effects of tidal stresses.

Tidal Stresses: On Europa, the oscillating tidal stresses can produce secular strike-slip offsets via "tidal walking" [3]. On Enceladus, tidal stresses modulate the observed cryovolcanic plume behavior, by opening and closing individual cracks [4,5].

Localization: On Earth, fire-fountain eruptions are frequently observed to evolve over a timescale of hours from curtain eruptions to localized vents [6]. The most likely mechanism driving this localization is a feedback between vent width and flow temperature [6,7]. Wider vents result in less cooling, producing less solidification and/or lower magma viscosities. Both effects promote higher local flow rates, producing a feedback which concentrates the flow.

Application to Rhadamanthys linea: Figure 1 is an image of part of Rhadamanthys, showing the low-albedo spots. The spots frequently appear at locations where the orientation of the linea changes.

One possible explanation for this observation is that the local tidal stresses are different at these locations. Figure 2 plots the maximum normal stresses due to eccentricity tides at each location, using the method of [5]. There is a weak apparent preference for spots to appear at locations with high maximum normal stresses. If correct, this suggests that the eruption mechanism resembles that seen at Enceladus [4,5].

An alternative, and perhaps more likely, possibility is that the spots are a consequence of the overall pattern of motion on the fault. Tidal walking is expected to drive left-lateral motion at Rhadamanthys [3,8]. In this case, the spots will experience trans-tension and become pull-apart basins. Such areas would be natural foci for cryovolcanism.

Pull-apart regions should experience shell thinning and hence higher heat fluxes, perhaps promoting intrusive cryovolcanism. Lateral flow in the shell of Europa is expected to be rapid at short wavelengths, unless the shell is thin [9]. As a result, these regions will not necessarily be topographic lows. Trans-tension will also generate tension cracks or normal faults, either of which could provide conduits for sub-surface water and volatiles to erupt explosively [10,11].

Given the location of the spots at pull-apart basins, it may not be necessary to appeal to other localization mechanisms. Furthermore, the low viscosity of water as compared to silicate magma likely makes the feedback mechanisms proposed less effective. Future work will focus on investigating the tidally-driven mechanisms in more detail and incorporating other stresses (e.g. obliquity tides, non-synchronous rotation) [12].

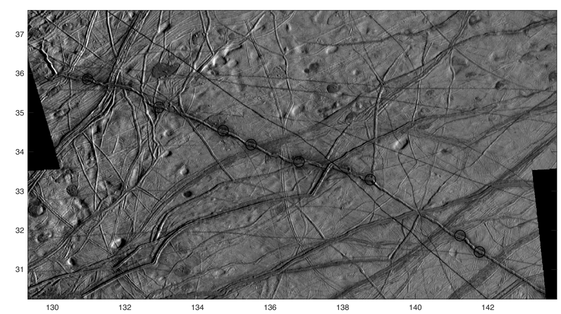

Figure 1. Image of Rhadamanthys linea showing the location of the dark spots (black circles). Here east longitude is being used.

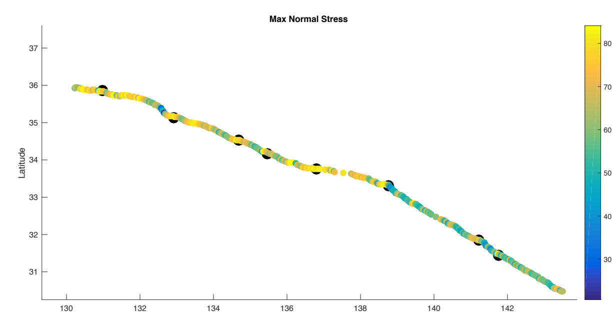

Figure 2. Maximum normal stresses arising from eccentricity tides calculated at each location. Units are kPa.

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