CHARACTERIZING FLANKING FRACTURES TO INVESTIGATE RIDGE FORMATION ON EUROPA. S.M. Jones[1,2], G.W. Patterson[1], A.J. Dombard[3], L.M. Prockter[1], [1]Planetary Exploration Group, Applied Physics Laboratory, 11100 Johns Hopkins Rd., Laurel, MD 20723, Wes.Patterson@jhuapl.edu, [2]Glenelg High School, 14025 Burntwoods Rd., Glenelg, MD 21737, [3]Univ. of Illinois at Chicago, 845 W. Taylor St., Chicago, IL 60607.

Introduction: Ridges are a common landform on Europa, with multiple generations of ridges often found cross-cutting each other [1,2]. The morphological characteristics of ridges can vary from isolated troughs to ridge complexes [3], however, the most common form is the double ridge (Fig. 1). This type of ridge is generally ~0.5-2 km wide, ~100-300 m tall, and possesses a central trough flanked by two topographic highs. Shallow marginal troughs associated with these features have been identified, and subparallel, presumably tensile, flanking fractures can sometimes be found along the outer reaches of these troughs (e.g., dashed lines in Fig. 1)

Several models for the formation of double ridges exist [see 1, 2 for reviews]. All of these models assume that ridges initiate from a pre-existing crack in the ice shell of Europa, and it is thought that the cracks form in response to diurnal or nonsynchronous stresses [e.g., 4-7]. As pointed out by [2], "each model has different implications for the presence and distribution of liquid water at the time of ridge formation." Given that double ridges are such a common landform, it is important to have a better understanding of how ridges form in order to unravel Europa's unique surface history.

We use the presence of subparallel fractures associated with some double ridges on Europa to examine the conditions that led to the formation of the ridge. We assume that ridges represent loads on the surface of Europa that lead to flexure of a relatively thin elastic lithosphere, and that the thickness of the mechanical lithosphere in the vicinity of a ridge is controlled by the presence of a transient and local thermal anomaly [8]. Here, we report on our initial results to characterize fractures flanking ridges on Europa.

Ridge Flexure: Several groups have interpreted the presence of marginal troughs and subparallel flanking fractures associated with ridges as evidence for flexure of the lithosphere in response to a load imposed by the ridge itself [e.g., 9-11]. In this interpretation, the addition of a ridge to the surface causes the lithosphere of Europa to warp locally downward, producing marginal troughs and uplifting a peripheral bulge that may be detectible [11]. Between the bulge and the trough, tensile flexural stresses peak and may lead to the formation of subparallel flanking fractures (dashed lines in Fig. 1). The thickness of the lithosphere in simple elastic models has been typically < 1 km.

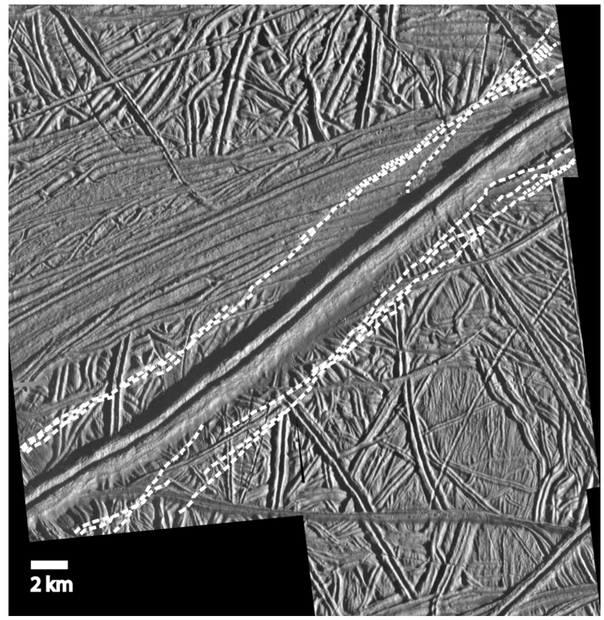

Fig. 1. Portion of Androgeous Linea with associated flanking fractures indicated by white dashed-lines. This mosaic is orthographically projected and was acquired at 20 m/pixel during the E6 encounter of the Galileo mission. North is up.

Thermal Anomalies: Using a particular case of flexure at a double ridge examined by [11], we have previously demonstrated, using a more realistic elastoviscoplastic rheology, that a background heat flow of ~700 mW m^{-2} is required to match the results of the simple elastic-lithosphere model [8]. This is significantly higher then thermal models for the evolution of Europa generally predict [e.g., 7, 12-14] and suggests a discrepancy between the high heat flows indicated by the apparent flexure at ridges and the heat flow likely coming out of Europa. A possible solution may be provided by considering local thermal anomalies.

Because the thickness of the lithosphere is dependent on the thermal state of the system, a thermal anomaly superimposed on a simple conductive temperature profile can result in localized thinning of the lithosphere. There are several means of producing a thermal anomaly within the lithosphere of Europa [15-18]. We have shown that a horizontally extended thermal anomaly from, for example, a cryomagmatic sill can produce the flexure observed in association with ridges on Europa.

Analysis: We are currently constructing a database of the characteristics of subparallel flanking fractures associated with double ridges on Europa (e.g., Table 1). Candidate double ridges with flanking fractures are initially selected for analysis by inspection of Galileo image data. A cursory examination of the data suggests that we are limited to images with resolutions <200 m/pixel (Fig. 2).

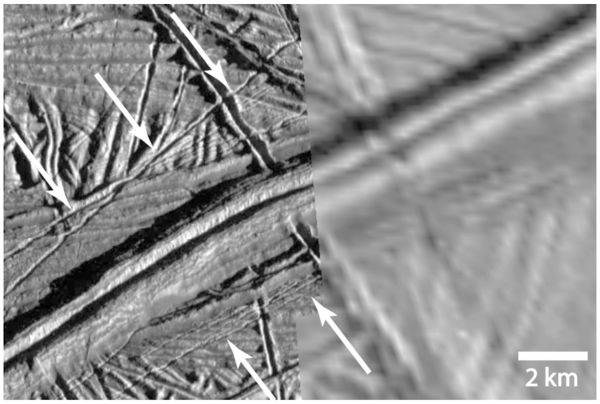

Fig. 2. Portion of Androgeous Linea with associated secondary fractures indicated by white arrows. The left-hand side of this mosaic was acquired at 20 m/pixel during the E6 encounter of the Galileo spacecraft, while the right-hand side of this mosaic was acquired at 220 m/pixel during the E17 encounter. Note that the secondary fractures are not clearly visible in the lower-resolution portion of the mosaic.

We have measured the distances from the fractures to the ridge in several areas. Initial results suggest that a relationship exists between the width of the ridge and the distance to the flanking fractures (Table 1). This serves to verify the flexural nature of ridge formation and gives confidence that they represent valid model inputs.

Galileo Observation	Resolution (m/pixel)	W[a] (km)	X[b] (km)
E4DRKMAT01	28	3.4	3.1
E6BRTPLN01	65	1.2	1.1
E6BRTPLN02	20	2.1	2.8
E11MORPHY01	35	1.3	1.7

Table 1. [a]width of double ridge analyzed; [b]average distance from flanking fractures to double-ridge central trough

These data are being used to determine the thickness of the mechanical lithosphere and to model the details of the thermal anomaly. Close attention will be paid to the locations of the measurements made and the orientations of the associated ridges. The results of our modeling can help to constrain how ridges formed on Europa, and therefore help elucidate the thermal history of the satellite.

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