CYCLOIDS AND WEDGES: GLOBAL PATTERNS FROM TIDAL STRESS ON EUROPA. G.D. Bart[1], R. Greenberg[1], and G.V. Hoppa[2]. [1]University of Arizona, Lunar and Planetary Laboratory, 1629 E. University Blvd. Tucson, AZ 85721, (gwenbart@lpl.arizona.edu). [2]Raytheon Missile Systems, Tucson, AZ.

Introduction: Europa's lineaments likely initiated as fractures in Europa's ice crust [1]. It is currently thought that these fractures formed under tension [2,3]. Arcuate lineaments (or cycloids) have been observed and modeled to have formed as tension cracks whose shape is dictated by varying diurnal tidal stresses [4]. Modeling of cycloids allowed the determination of a maximum non-synchronous rotation rate for Europa [5]. The wedges region on Europa has been studied in detail but no mechanism has been proposed for the creation of the highly curved, "boxy" cracks in that region [6,7,8], or in the sub-jovian region diametrically opposite. Diurnal tensile stresses may have formed these boxy patterns in a similar way to the formation of the cycloids.

Global Diurnal Patterns: (Fig. 1) We have computed diurnal cracking patterns on a global scale. Cycloids form along concentric circles about the sub- and anti-jovian points on Europa. Over the rest of the globe, the cycloids form "linear" bands wrapping around the body of Europa from one concentric circular region to the other. Along the boundaries between these regions, diurnal tidal variations allow cracks to form highly curved or boxy shapes.

Diurnal features are strongly dependent on the model input parameters. The variable inputs for my model are the tension required to initiate a crack, the tension below which the crack will stop forming, the speed of the crack's propagation, and the initial direction in which the crack begins propagating, either east or west of the north/south line. One interesting result is that weaker ice (low starting and stopping tension values) tends to increase the size of chaotic boundary region and cause more boxy shapes to form.

Global maps of observed cycloids and related features: (Fig. 2) All cycloids with at least two arcs have been mapped from currently available Europa images. More than 180 cycloids were observed. Typical values for the arc length of cycloids are about 100 km. Arc lengths can range from tens of km to a thousand km in different cycloids. Also mapped are the extreme cases that form boxy patterns. On Europa, they are located near the sub- and anti-jovian points (i.e., the wedges region), just above or below the equator. There are many overlapping features that range from C shaped to almost L shaped.

Comparison of observations with theory: The global model (Fig. 1) provides a framework upon which we can consider fracturing on Europa. It shows where we would expect various features to form. Many real cycloids can be fit to the model simply by shifting them west to account for non-synchronous rotation of Europa since their formation, as had been previously noted for selected cases [5].

The boxy features observed in the wedges and sub-jovian regions are similar in shape and size to the boxy shapes in the boundary region predicted by theory, and are located east of where they should have formed. This may indicate that Europa has rotated non-synchronously since their formation. Note that this interpretation differs from evidence near Astypalaea [5] that only one crack forms in a region for each rotation of Europa; that interpretation implies that the cycloids formed over many of Europa's rotations. If features are preserved for that long, we would expect to see the boxy features in a range of places circling the equator, not neatly grouped to the east of the predicted locations. (However, the observed distribution of wedge-shaped cracks may be a selection effect.)

An important consideration for future research will be to determine to what extent existing cracks in the ice shell will affect the stress field at that location, and how the new stress field will change the cracking patterns. Once cracking has occurred, it would be expected that the crack has relieved at least some of the tension in the ice. In that case, it would be unlikely that cracks forming on Europa could actually curl around to form a box. Possibly the overlapping of several highly curved cracks ultimately forms what we see as a box.

Conclusion: It seems plausible that diurnal tensile cracking could account for more than just the cycloidal features on Europa; the wedges region and the sub-jovian region show evidence that initial crack shapes in these regions were also governed by diurnal stress variations. Future work will consist of more characterization of the real, mapped cycloids and wedges (and other boxy type features). This will include collecting data on location, number of arcs, angles of arcs, lengths of arcs, cross cutting relationships, morphology of ridges, and degrees of non-synchronous rotation required for model matching. Also to be considered are cycloids that may not fit the present stress regime at all and may require polar wander or another explanation altogether. Cycloids and related crack patterns may allow us to answer questions about Europa's rotational and resurfacing history.

CYCLOIDS AND WEDGES: GLOBAL PATTERNS FROM TIDAL STRESS ON EUROPA. G.D. Bart et al.

References: [1] Lucchitta B. K. and Soderblom L. A., in *Satellites of Jupiter* D. Morrison, Ed. (The University of Arizona Press, Tucson, AZ, 1982) pp. 972. [2] Helfenstein P. and Parmentier E. M. (1985) *Icarus, 61,* 175-184. [3] Greenberg R. et al. (1998) *Icarus, 135,* 64-78. [4] Hoppa G. V. et al. (1999) *Science, 285,* 1899-1902. [5] Hoppa G. V. et al. (2001) *Icarus, 153,* 208-213. [6] Schenk P. M. and McKinnon W. B. (1989) *Icarus, 79,* 75-100. [7] Sullivan R. et al. (1998) *Nature, 391,* 371-373. [8] Tufts B. R. et al. (2000) *Icarus, 146,* 75-97.

Fig. 1: Theoretical plot of cracking on Europa for 0.35 bar start, 0.25 bar stop, 4 km/hr, and east to west cracking. Cylindrical projection.

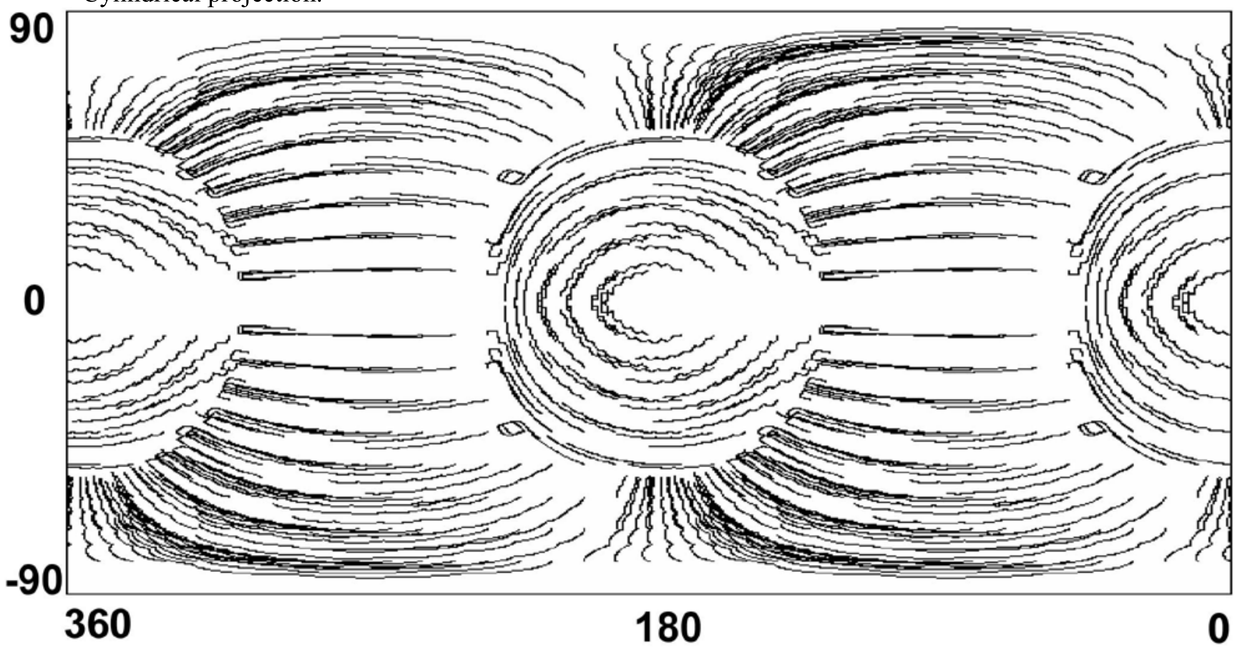

Fig. 2: Map of all observed cycloids and boxy features on Europa. Note that the concentration of features observed depends strongly on the resolution of available images. Cylindrical projection.