Formation mechanisms of Europan ridges with apparent lateral offsets. C. E. Bader and S. A. Kattenhorn, Department of Geological Sciences, University of Idaho, PO box 443022, Moscow, ID 83844-3022. (cbader@vandals.uidaho.edu; simkat@uidaho.edu).

Introduction: Ridges are the most common linear and tectonic surface features on Europa [1,2,3,4] and apparent lateral offsets are often observed along them [4,5]. Ridges have formed throughout Europa's geologic history, creating identifiable crosscutting relationships [3,4]. These crosscutting relationships offer us an opportunity to determine the mechanisms responsible for ridge formation [6,7]. Recent ridge formation models characterize them as shearing-related [8]. We show evidence for both lateral shearing and ridge-orthogonal motion along ridges, indicating that apparent lateral offsets are not purely the result of strike-slip motions.

First, apparent offsets along a ridge (or band) of interest must be large enough to overcome Galileo's image resolution constraints. Therefore, our analysis required us to perform a search of high resolution Galileo images to focus on ridges with these characteristics. Second, in order for our analysis to accurately determine the displacement ratio (DR) of strike-slip offset motion to ridge-orthogonal motion, a ridge must have offset features along its length with both low and high-angle orientations, α, relative to the ridge. At both small and large orientations (0° to 30° and 160° to 180°), apparent offsets due to convergence across the ridge may become relatively large compared to where these angles are closer to 90° (for which pure-ridge orthogonal motion gives an apparent offset of zero). Finally, using ISIS software, each image chosen for our analysis was photometrically corrected and reprojected to preserve local angular relationships and line lengths using a transverse mercator or an orthographic projection, respectively [9].

A technique developed by [6] uses simple geometric measurements to provide a clear mode of fracture development and allows us to create a verifiable model for ridge (and band) evolution. We present an analysis of an unnamed band as a test for our method for determining displacement ratios, and to quantify the deformation mechanisms of both a band and a ridge.

Analytical Technique: The technique uses three parameters that we can measure from each crosscut feature across a ridge or band of interest. Separation (sep) is the perpendicular distance between a displaced feature and its corresponding projection from the opposing side of the ridge or band. Strike-slip offset (w) is the measurable distance along a ridge between two parts of a displaced feature and alpha (α) is defined as the clockwise angle between the ridge or band of interest and the displaced feature.

Fault-orthogonal motion is defined by dilation (+d) or contraction (-d). The measured separation and alpha angles are normalized and corrected to account for the limited range of alpha angles found along the ridge of interest (as detailed in [6]). These data sets are then compared to unique analytical curves of various displacement ratios (DR). Figure 1 illustrates several examples of right-lateral motion plus contraction displacement ratios, and shows that each DR's curve is unique. Analogous curves have been produced for left-lateral motions and for oblique dilations.

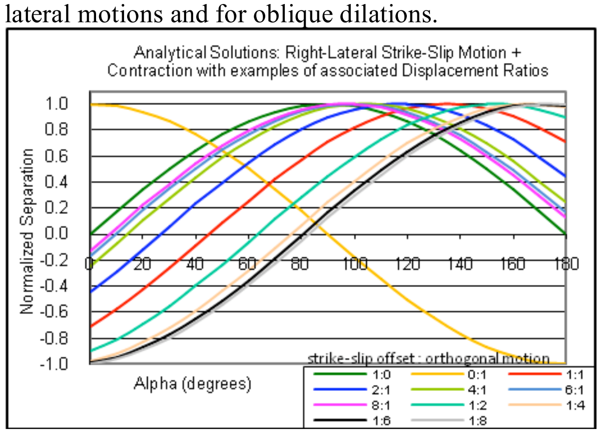

Figure 1. Plots of various analytical solutions have been created to compare against measured results to best determine the DR (strike-slip offset:orthogonal motion) for each ridge or band investigated.

Using a square correlation ratio (SCR) we are able to determine goodness of fit of the data set to a specific type curve. An SCR of 0 indicates that a correlation between the analytical solution and the data set is no better than would be produced by a straight line plotted through the average of the corrected normalized separations. An SCR of 1 would be a perfect correlation between the data set and the analytical solution type curve and all the data points would fall on the curve.

Analysis of an unnamed band: We analyze a simple linear band as a simple test for the effectiveness of our technique (Figure 2). This image shows an unnamed band in Europa's northern trailing hemisphere that both crosscuts numerous lineaments and shows apparent offset of these lineaments along its length. Using the technique described above, an SCR can be determined for the fit of the data to our analytical

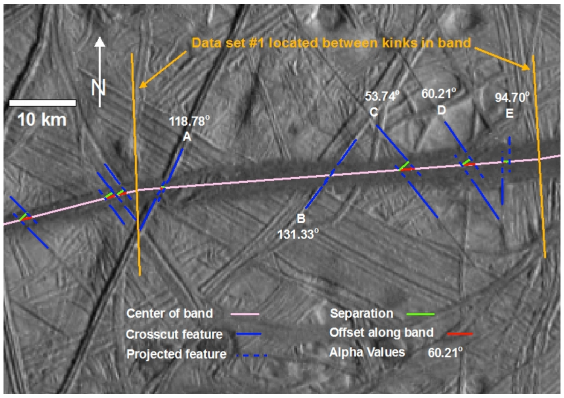

Figure 2. An unnamed band in Galileo image s0449961865r (23.1°N, 221.6°W). Crosscut features are shown in blue, projected features (blue dashed lines), offsets are shown in red and separations are shown in green. Resolution is ~220 m/pix.

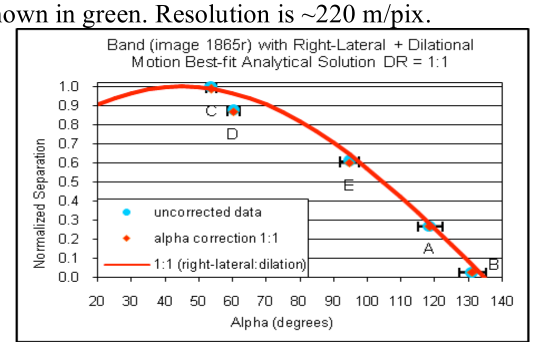

Figure 3. This graph illustrates a good correlation (SCR of 0.976) between the normalized data set and the analytical solution of a DR of 1:1.

curves and a best fit can be found (Figure 3). The displacement ratio (DR) of offset to dilation (opening) is approximately 1:1 indicating right-lateral oblique dilation of this unnamed band. The SCR is high at 0.976 for the 1:1 DR. This high correlation is a reassurance that this method can be used to determine formation mechanisms for linear features of interest that do not have complex geologic histories.

Argadnel Regio Ridge analysis: We analyze a portion of an unnamed ridge in Argadnel Regio (Figure 4) in Europa's southern trailing hemisphere using our technique described above. The SCR is relatively high, at 0.65, for a 2.5:1.1 DR (Figure 5). In other words, this unnamed ridge underwent both right-lateral offset and dilation in the ratio of ~ 2.5:1.1.

Discussion: Our test of the analytical technique indicates that explicit deformation mechanisms can be determined. Numerous linear ridges will need to be examined to better determine deformation mechanisms of ridges that display lateral offsets, especially considering that some ridges appear to show evidence for concomitant offset and contraction [6,10,11]. Favorable ridge characteristics for this analysis will include

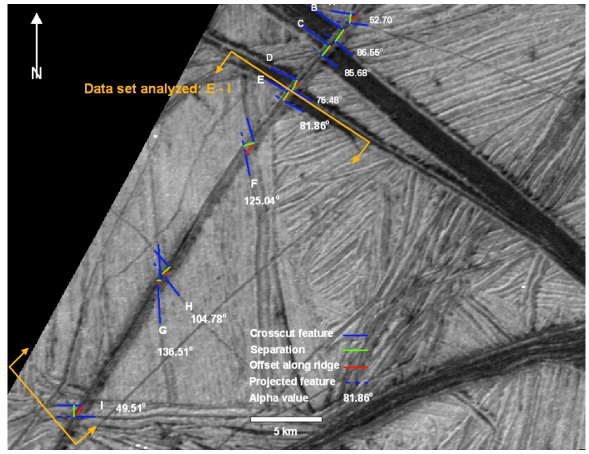

Figure 4. An unnamed ridge is shown here in the Argadnel Regio region (Galileo image number s0426273839r). Features are labeled using the same color scheme as in Fig. 2. Image resolution is ~50 m/pix.

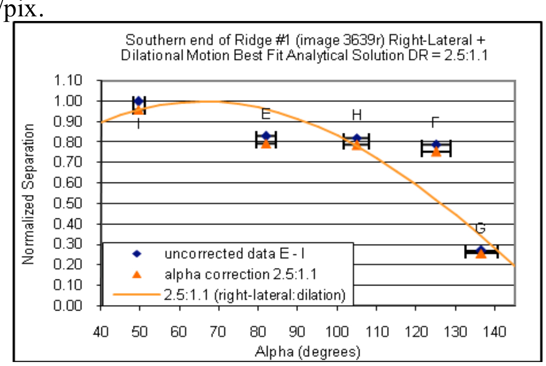

Figure 5. This graph illustrates a relatively good correlation (SCR of 0.65) between the normalized data set and the analytical solution of a DR of 2.5:1.1.

linearity, numerous crosscut features with apparent offsets large enough to overcome image resolutions, a variety of alpha angles along the length of the ridge, and a high resolution to capture the apparent offsets along the ridge.

References: [1] Greenberg R et al. (1998) *Icarus, 135, 64-78*. [2] Figueredo P H & Greeley R (2000) *JGR, 105,* 22,629-22,646. [3] Kattenhorn S A (2002) *Icarus, 157,* 490-506. [4] Spaun N A et al. (2003) *JGR, 108, E6*, 1-21. [5] Kattenhorn S A (2004) *Icarus, 172,* 582-602. [6] Vetter J C (2005) MS Thesis University of Idaho, Moscow, ID, U.S.A., 1-46. [7] McBee J H et al. (2003) *LPSC XXXIV*, Abstract #1783. [8] Nimmo F & Gaidos E (2002) JGR, 107, 1-8. [9] Snyder J P & Voxland P M (1994) USGS Prof. Paper #1453, 1-249. [10] Bader C E & Kattenhorn S A (2007) AGU Abstract P53B-1243. [11] Aydin, A (2006) JSG 28, 2222-2236. **Acknowledgements:** This work is supported by the NASA-Idaho Space Grant Consortium and NASA Grant #NNX06AC12G.