QUANTIFYING EXACT MOTIONS ALONG LINEAMENTS ON EUROPA. J.C. Vetter and S.A. Kattenhorn, Department of Geological Sciences, University of Idaho, Moscow ID 83844-3022. (vett9894@uidaho.edu; simkat@uidaho.edu)

Introduction: Evaluating the precise motions along lineaments on the surface of Jupiter's icy moon, Europa, is a valuable tool for interpreting the development and history of lineaments of various morphologies. Such morphologies include strike-slip faults, dilational bands, ridges, and convergence zones.

However, the exact mode of origin and kinematic behavior of these various lineaments are not obvious based on morphology alone. In fact, the apparent motions implied by displaced crosscut features can provide misleading indications of true motions along lineaments. Identifying the precise motions (combinations of sliding and opening/closing) is critical to the accurate characterization and interpretation of each of these lineament types.

Lineaments of interest (i.e., those having displaced relatively older features in some manner) are identified on Galileo spacecraft images and measurements are made of the total offset, the separation, and relative orientations of crosscut features with respect to the lineament of interest. Specifically, by using these measured quantities and a series of trigonometric equations, the precise motions (i.e., dilation, convergence, strike-slip, or a combination of strike-slip and dilation or convergence) can be determined. These measurements are, however, limited by the resolution of the available images.

This study focuses on motion analysis techniques for Europan lineaments and the precise characterization of fault-orthogonal and/or strike-slip motion along lineaments of varying morphologies. By building on the work of [1], we highlight potential pitfalls of cursory analyses of motion indicators. For example, lineaments with obvious lateral offsets have typically been identified simply as strike-slip faults. This assumption may actually be incorrect, as fault-orthogonal motions may contribute to apparent lateral displacements (offsets or separations). Also, variability in the amount of fault motion along the trace length should theoretically be identifiable using the outlined technique. Strike-slip faults on Europa have conventionally been presumed to have a constant slip magnitude along their lengths; however, we posit that variable distributions of slip may be common, as is typical along terrestrial strike-slip faults.

Technique: Once a lineament of interest is identified, crosscut features are matched on either side of the lineament, and the pertinent measurements are noted. Namely, alpha, total separation, and total offset. These are the three values which can be measured directly from an image, illustrated in blue in Figure 1.

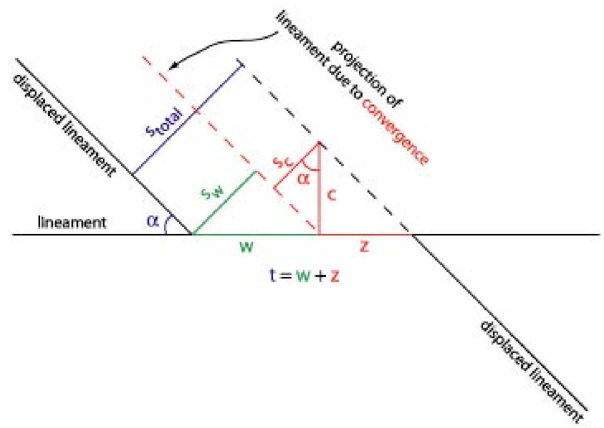

Figure 1. Illustration of the quantities measured, for the case of convergence with left-lateral motion. The measured values include total offset, t, total separation, S_{total}, and the clockwise angle between the lineament and the displaced feature, α. Note there is an *apparent* offset, z, purely the result of convergence.

Total separation values are then normalized against the maximum separation and plotted as a function of alpha. These data are then compared to the analytical solutions for all the possible scenarios of motions. The closest match between actual data and theoretical predictions allows the precise motions to be inferred for the given lineament.

The more crosscut features (at a wide range of alpha values) identified, the more accurate the interpretation of the precise motion across a given lineament. Careful attention must also be paid to sign conventions. Right-stepping separation and right-lateral offsets are positive values; left-stepping separation and left-lateral offsets are negative values, by definition.

Application: The above outlined technique can be applied for a range of lineament morphologies, but its application is limited to straight portions the lineaments. Portions which are *not* very linear resolve differing relative motions, dependent on the local orientation of the trace of the lineament, producing results that are more difficult to interpret. Based on this caveat, ridges are the simplest candidates for such evaluations. Ridges are ubiquitous, often linear, and are imaged at a range of resolutions by the Galileo spacecraft. Furthermore, ridges commonly display apparent lateral offsets [2] which cause them to resemble strike-slip faults.

Discussion: Previous work has focused on rigid block reconstructions of Europan lineaments; however, actual motions may be more complex. By utilizing this developed technique, a detailed record of motions along the length of a lineament is possible. Small amounts of fault-orthogonal motion, not otherwise readily identifiable due to the morphology of the lineament (dilation, for example), can potentially be isolated. Any variability in motions, either strike-slip or fault-orthogonal, can also potentially be identified. Utilizing this technique creates a more complete depiction of the behavior of Europan lineaments. Understanding these motions will allow for an evaluation of previous models for the kinematic behavior of Europan lineaments.

Why use separation as a proxy for lineament motion? Separation is the only measure which accurately depicts fault motions. Using total offset can be misleading, and accurate measurements are potentially difficult. Convergence creates an apparent offset, as a function of both the magnitude of convergence and alpha, and changes the perceived total offset. Since convergence is not necessarily obvious, offset is not an accurate measure of fault motions. Also, total offset does not allow for the isolation of any dilation or convergence. Separation accurately depicts both strike-slip and fault-orthogonal motion.

Deviation of measured values from the analytically predicted values has significance as well. Such deviation means there is either measurement error or that there is true variability in the distribution of motions along the measured lineament, despite potentially little obvious change in morphology. Such variability has important implications for the mechanical development of lineaments. Fracture mechanics models for the deformation of rocks on Earth [3] have been applied to Europa [2, 4] and could potentially be used to explain the distribution of displacement along strike-slip faults.

Further work will include systematically quantifying motions on features of varied morphologies. Doing so will allow for the identification of any trend in motions and may further our understanding of any genetic evolution of lineament morphologies. Analysis of sensitivity to measurement accuracy will also be tested.

References: [1] McBee, J.H. et al. (2003) *LPSC XXXIV* Abstract #1783. [2] Kattenhorn, S.A. (2004) *Icarus* 172, 582-602. [3] Pollard, D. D. and Segall, P. (1987) in Atkinson, B.K. Fracture Mechanics of Rock, 277-349. [4] Kattenhorn, S.A. and Billings, S.E. (2002) *GSA Abs. with Progs* 34(6).

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