PLATE KINEMATICS AND ITS USE AS AN INDICATOR OF THE MECHANICAL BEHAVIOR OF EUROPA'S LITHOSPHERE. G. W. Patterson and J. W. Head, Department of Geological Sciences, Brown University, Providence, RI 02912 (Gerald_Patterson@brown.edu)

Introduction: Voyager and Galileo images of Europa have shown its surface to be highly deformed by tectonic features. The formation of these features has been attributed to deformation of the outer ice shell from stresses induced by diurnal tides, nonsynchronous rotation, and/or polar wander [1]. The effects of these stress fields (acting independently or in concert) are inferred to fracture the ice shell into plates that subsequently translate and/or rotate with respect to one another (e.g., [2]).

Using Voyager image data, [3] showed that the dark material that composed the interior of some features could be removed, allowing the margins of the features to fit closely together and surrounding preexisting offset lineaments to be reconstructed. The successful reconstruction of these preexisting features indicates that, at the scale of the observations, these plates behaved rigidly during deformation (i.e. deformation was accommodated at the margins of the plates). A number of successful reconstructions involving extensional and strike-slip features have reinforced this result (e.g., [4-6]) and led to the general assumption that tectonic plates behave rigidly on Europa.

Exceptions to this assumption have been identified by [7] and [8], using tectonic reconstructions of Europa's surface. The former involved analysis of the extensional band Thynia Linea. A reconstruction of the band, using the displacement azimuths of preexisting features, indicated that displacement magnitude decreased toward either end of the extensional band. It was suggested that this behavior was akin to a ''tear'' in a nonrigid Europan lithosphere. The latter involved the reconstruction of a set of ridges and a band-like complex surrounding Castalia Macula, using an inverse modeling technique. The application of this technique indicated that deformation associated with the formation and/or modification of these features had been accommodated within one or more tectonic plates in the region. Both reconstructions suggested nonrigid behavior on the kilometer-scale.

The identification of nonrigid behavior associated with tectonism on Europa raises several questions. Are these two regions unique or is nonrigid behavior more common then has been previously recognized? Is there a scale dependence for the occurrence of nonrigid behavior? Can we quantify nonrigidity and how it affects the mechanical behavior of Europa's lithosphere? To search for answers to these questions, we examine a tensile feature on Europa's equatorial trailing hemisphere that defines a number of tectonic plates that have translated/rotated with respect to each other (Fig. 1a).

Study Area: The morphology of the feature we analyze and its relationships with the surrounding terrain suggest it is an extensional band [6,9,10]. For the purposes of this analysis, we refer to it hereafter as band A. It trends E-W and diverges into two bands in the western portion of the image (A_1 and A_2 in Fig. 1b). The width of the band ranges from 5-15 km. Bands A_1 and A_2 interact with each other three times within the available image coverage. These interactions separate the region between bands A_1 and A_2 into three plates (Fig. 1b). Plates 2 and 3 have surface areas of ~6000 km^2 and plate 4 has a surface area of ~1500 km^2. The boundaries of plates 1 and 5 extend beyond the image coverage of the region and therefore cannot be defined strictly (Fig. 1).

Only six lineaments post-date the formation of band A (Fig. 1b), indicating that it is a relatively young feature. There are a number of preexisting lineaments that have been offset by the formation of the band (Fig. 1b). These can be used to reconstruct the deformation history of the region during the formation of band A. Assuming that the band formed by extension, our expectation is that the only modification of any reconstructable preexisting lineaments along band A are the offsets created by the addition of new material within the boundaries of the band. This suggests that, in a rigid-plate environment, a reconstruction of any of the plates defined by band A should realign preexisting offset lineaments along the boundaries of the plates with comparable accuracy.

Results: When reconstructing the region modified by the formation of band A_1, we hold plate 1 fixed and translate plates 2-4 with respect to it (Fig. 1c). The realignment of preexisting offset lineaments along band A_1 in the reconstructions of plates 3 and 4 suggest that these plates behaved rigidly. However, while preexisting features offset by band A_1 along the boundary of plate 2 can be reconstructed such that they have a negligible strike-slip offset, a significant amount of band A_1 remains in the reconstruction (Fig. 1c). This suggests that some component of nonrigid behavior could be associated with plate 1 and/or 2.

For the reconstruction of plate 5, we hold plates 1-4 fixed. Preexisting lineaments offset by band A_2 along the boundary between plates 3 and 4 and plate 5 are realigned with negligible offsets. However, the offsets of preexisting lineaments along the boundary between plate 2 and plate 5 retain a significant strike-slip component. This suggests that some component of nonrigid behavior could be associated with plate 2 and/or 5.

These preliminary results suggest that nonrigid behavior of Europa's lithosphere is not unique to the two instances reported previously [7,8]. They also suggest that the occurrence of nonrigid behavior is not scale dependent (plates 2 and 3 are similar in scale yet one displays evidence for nonrigid behavior and the other does not). Quantifying the amount of nonrigid behavior present here would be difficult using this analysis. However, this region is an excellent candidate for use with the inverse modeling technique developed by [8]. The application of the technique to this region offers a means of quantitatively verifying the occurrence of nonrigid behavior in the region, as well as possibly quantifying the amount of nonrigid behavior if it were present.

References: [1] Greeley et al., *Geology of Europa*, 329-362, 2004; [2] Sullivan et al., *Nature*, 391, 371-373, 1998; [3] Schenk and McKinnon, *Icarus*, 79, 75-100, 1989; [4] Tufts et al., *Icarus*, 141, 53-64, 1999; [5] Hoppa et al., *JGR*, 105, 22617-22627, 2000; [6] Prockter et al., *JGR*, 107, 10.1029/2000JE001458, 2002; [7] Pappalardo and Sullivan, *Icarus*, 123, 557-567, 1996; [8] Patterson et al., *J. Struct. Geology*, submitted; [9] Greeley et al., *Icarus*, 135, 4-24, 1998; [10] Figueredo and Greeley, *JGR*, 105, 22,629-22,646, 2000.

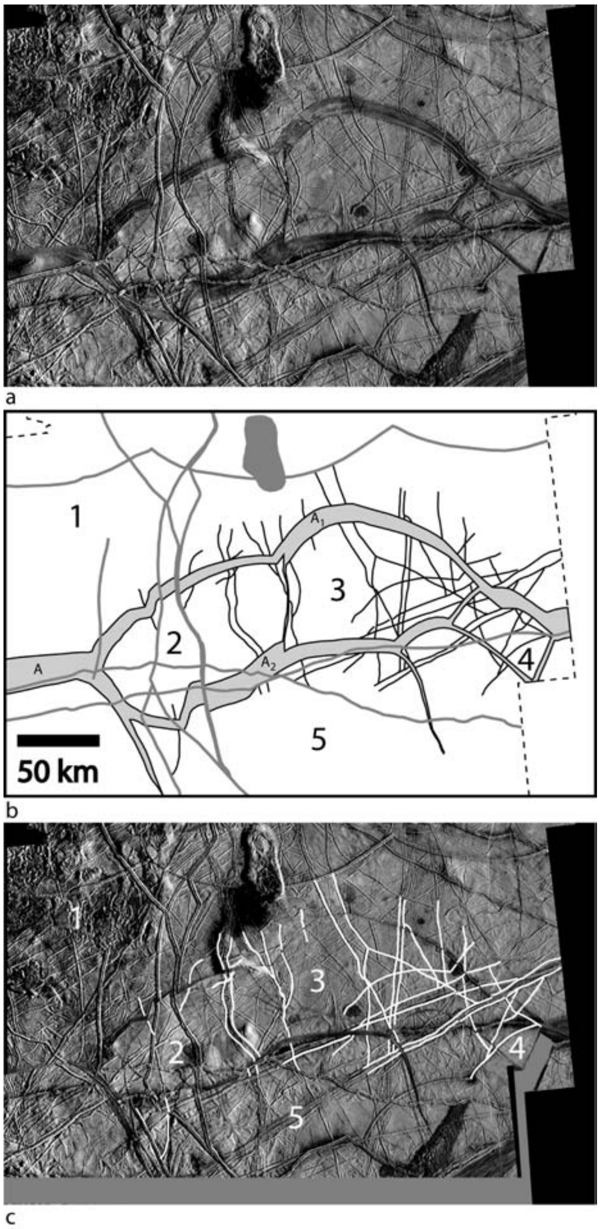

Fig. 1 a) Mercator projection of an image mosaic (Europa_pole_2_pole01.cub) produced by the University of Arizona's Planetary Image Research Laboratory centered at ~0° lat and 227° lon and at a resolution of 220 m/pix. b) Sketch map of the region with the band that is reconstructed shown with a gray fill and plates defined by this feature numbered 1-5. Prominent features that post-date the formation of the band are shown in gray and offset preexisting features are shown in black. c) Reconstruction of the region with previously offset features shown in white.