KINEMATICS OF MICROPLATE ROTATION ON EUROPA: ARGADNEL REGIO. Chad A. Melton[1] (chadmeltone@gmail.com), Joshua P. Emery[1], Louise M. Prockter[2], Geoffrey C. Collins[3], G. Wesley Patterson[4], Simon A. Kattenhorn[5], Catherine M. Cooper[6], Alyssa R. Rhoden[7]. [1]University of Tennessee, Knoxville, TN; [2]Lunar and Planetary Institute, USRA, Houston, TX; [3]Wheaton College, Norton, MA; [4]Johns Hopkins University Applied Physics Laboratory, Laurel, MD; [5]University of Alaska, Anchorage, AK; [6]Washington State University, Pullman, WA; [7]Arizona State University, Tempe, AZ.

Introduction: Modeled tectonic reconstructions of multiple regions on the Jupiter's moon Europa have indicated plate rotation of up to ~40 degrees about a vertical axis or Euler Pole, e.g., [1-5]. These rotations appear analogous to observed kinematic behavior of rotating terrestrial microplates. Results of [5] demonstrated that many Euler poles are relatively close in latitude/longitude to their associated plates, a characteristic observed in terrestrial microplates. Though microplate rotation has been investigated on Earth, the principles of the phenomenon have not been applied extensively on Europa.

Argadnel Regio is of interest due to the high number of pull-apart bands [6] and the unique concentric bands that are ubiquitous throughout the region. The distribution of features in Europa's Argadnel Regio suggests that significant plate rotation may have occurred. Plate rotation is hypothesized to be driven by either of two possible mechanisms, or a combination thereof: lateral flow within the ice shell (i.e., convection related), or lateral forcing from bounding plates (e.g., edge driven) [7]. The objective of this work is to test hypotheses to determine which physical process is responsible for the initiation of rotation of plates in this distinct region.

Background: In rotational kinematics, an instantaneous axis of rotation (IAR) is the axis that passes through the point of instantaneous zero velocity (e.g., intersection of a road with a tire not experiencing slip). The location of an IAR can be used to determine the mechanism driving rotation. IARs that are located on the boundary of a rotating plate and bounding plates suggest laterally forced rotation. IARs located at a distance within plates binding a microplate indicate rotation is occurring due to lateral flow within the ice shell [7]. The "pinned block" (PBM) and the "floating block" (FBM) models have been developed to explain terrestrial microplate rotation [8]. The FBM places the IAR at some distance within the bounding plate, indicating that rotation is being driven from lateral flow within the ice shell. The PBM places the IAR on the margin of the plate boundary, indicating that the plate is rotating due to laterally forcing from binding plates. The PBM was further developed into the "edge-driven" rotation model by [7]. This model suggests that compressive and extensional features should be observable within a rotating plate relative to rotational direction.

Plate rotation should cause deformation at plate boundaries and plate interiors. This deformation can be expressed as tears, fractures, or pseudofaults. In terrestrial oceanic settings, pseudofaults are attached to IAR on opposite sides of a rotating plate. As plates rotate, translate, grow and/or deform, these features will follow and trace the path of the IAR [9].

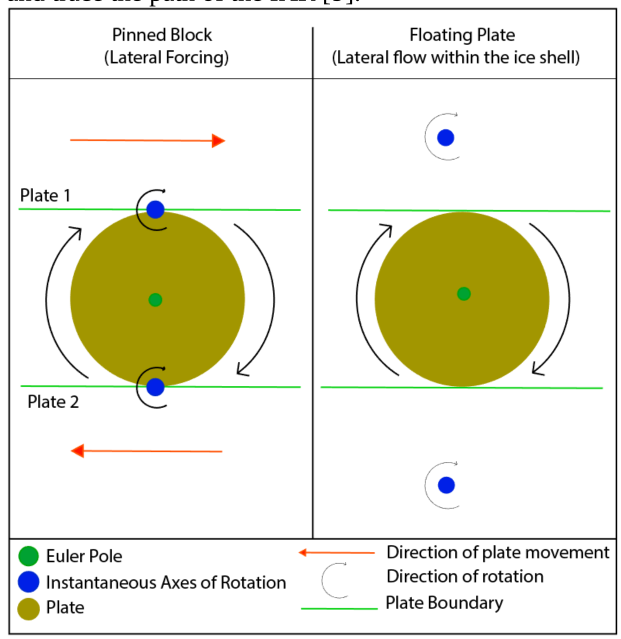

Figure 1: *Modified from [8]. Idealized models for the two end members of microplate rotation. Left: IARs located on boundary of microplate and bounding plate indicate lateral forcing. Right: IARs located within bounding plate suggest rotation occurs from lateral flow within the ice shell.*

Methods: Galileo Solid State Imaging Camera (SSI) images (E17ESTREGMAP01) were processed using the USGS Integrated Software for Imagers and Spectrometers (ISIS3). As the first step in tectonic reconstruction, crosscutting relationships were examined to obtain the sequence of plate motions. Evidence of movement was determined by the observation of offset features. Plate boundaries were drawn at discontinuities in preexisting features. Some uncertainty exists regarding plate boundaries in our reconstruction near lower relative albedo areas due to chaos disruption, and possible cryo-flows or topographic relaxation. Once the tectonic sequence, piercing points, offsets and plate boundaries were constrained, a reconstruction was created of the western portion of Argadnel Regio using GPlates with methods described by [2]. GPlates is an opensource terrestrial tectonic reconstruction program that projects mosaics on to a sphere. GPlates provides the user with an interactive interface that records the degree of plate rotation as well as an animation of tectonic events over a user specified time. The complete tectonic reconstruction is used to extrapolate the relative position vectors on rotating plates, yielding a conceivable location of IAR. If the model presented by [7] is viable for Europa tectonics, morphology and ancillary features should corroborate the determined IAR location.

Results: The reconstruction of the western portion of Argadnel Regio suggests that the region's current state is a result of a multi-stage system with at least six generations of tectonic events. The youngest observable features are chaos zones ranging from ~10 to 40 km in diameter (orange arrows, Fig. 2a). The largest two examples of this chaos flank a series of plates bounded by arcuate diational bands, which outline a circular structure (CC in Fig. 2a). Smaller chaos examples are found within this structure. The second youngest features are concave double ridges that crosscut the CC and which display ~2 and 8 km of relative displacement, respectively (red arrows, Fig. 2a). The larger displacement is may be related to a series of convergent bands to the northwest (purple arrows, Fig.2a) [10].

The oldest reconstructed events were accompanied by the highest degree of rotation. The plates which make up the CC have undergone ~30 degrees of rotation and are related to an event in which dilational bands that range in width from ~7 to 12 km formed throughout the immediate area. Related piercing points record up to 18 km of relative displacement (see Fig. 2). Though the exact IAR location has not yet been determined, the amount of displacement suggests that IARs associated with the rotation of CC are likely located within the plates immediately surrounding CC and are therefore related to lateral flow within the ice shell. Furthermore, the interior of the CC appears to have undergone deformation that could be related to the plates' rotation and can be seen in the possible folding of ridged plains near the center (see Fig.2b).

References: [1] Collins G.C. et al., LPSC XLVII, #1903, 2016; [2] Cutler B. et al., *AGU* 96, Abstract P31B-2059, 2015; [3] Patterson G.W. et al., *J. Structural Geology* 28, 2237-2258, 2006; [4] Perkins R. et al., LPSC XLVIII, #2576, 2017; [5] Rezza C. et al., LPSC XLVIII, #2283, 2017; [6] Prockter et al., *J. Geophys. Res.*, 107, 10.1029/ 2000JE001458, 2002.; [7] Schouten E. et al., *J. of Geophys. Res.*98, 6689-6701, 1993; [8] McKenzie D & Jackson J, *J. Geological Society*, 143:349-353, 1986; [9] Katz et al., *New Jour. Physics*, *7*, 37, 2005; [10] Sarid A.R. et al., *Icarus*, Vol. 158, pp. 24-41, 2002

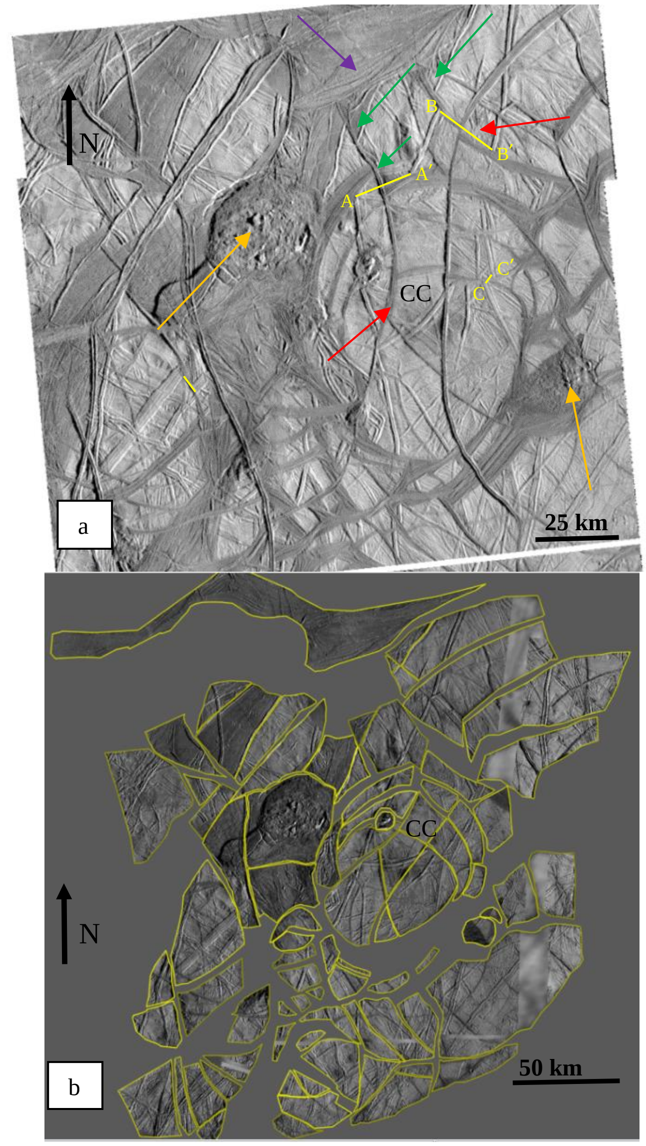

Figure 2: *Preliminary tectonic reconstruction of Argadnel Regio. (a) Current state of Argadnel Regio. Orange arrows represent chaos. Green arrows represent displacements related to convergence from the northwest. Red arrows represent the two dilated double ridges discussed in the text. Yellow lines and characters (e.g., A-A') represent examples of matching piercing points and their relative displacement vectors. Purple arrow indicating convergence [10]. (b) Argadnel Regio at the original configuration within the sequence of this reconstruction.*