AXIAL SURFACE MAPPING OF WRINKLE RIDGES ON SOLIS PLANUM, MARS FROM MOLA TOPOGRAPHY: CONSTRAINTS ON SUBSURFACE BLIND THRUST GEOMETRY. A. Vidal¹, K. Mueller¹, and M.P. Golombek², ¹Department of Geological Sciences, University of Colorado, Boulder, CO 80309-0399, ²Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109.

Introduction: We undertook axial surface mapping of selected wrinkle ridges on Solis Planum, Mars in order to assess the subsurface geometry of blind thrusts proposed to exist beneath them. This work builds on previous work [1] that defined structural families of wrinkle ridges based on their surface morphology in this region. Although a growing consensus exists for models of wrinkle ridge kinematics and mechanics, a number of current problems remain. These include the origin of topographic offset across the edges of wrinkle ridges, the relationship between broad arches and superposed ridges, the origin of smaller wrinkles, and perhaps most importantly, the trajectory of blind thrusts that underlie wrinkle ridges and accommodate shortening at deeper crustal levels. We are particularly interested in defining the depths at which blind thrusts flatten under wrinkle ridges in order to provide constraints on the brittle-ductile transition during Early Hesperian time. We also seek to test whether wrinkle ridges on Solis Planum develop above reactivated faults or newly formed ones.

Strategy and Methods: Previous work [1] that measured ridge morphology from over 4000 topographic profiles on Lunae and Solis Plana suggests that a variety of wrinkle ridge types exist in these regions. These include four end-member ridge types, including: 1) arch with high-relief superposed hill; 2) simple asymmetric ridges without a broad arch; 3) blocky ridges that have no clear asymmetry; and 4) monoclinal ridges [1]. We limited our analysis to simple asymmetric ridges in order to avoid structural complexities associated with other ridge types, in particular the development of backthrusts [2].

Axial surface mapping has been developed for terrestrial fault-bend folds [3] in order to define subsurface blind thrust geometry and to distinguish styles of folding. Although work by Tate [1] has already suggested most simple ridges on Lunae and Solis Plana form as east-vergent fault-propagation folds, we worked to define backlimb morphology of these structures which form by fault-bend folding mechanisms. Limb widths defined by axial surface mapping offers a means of assessing fault slip and the trajectory of blind thrusts that steepen upward (i.e. are convex upwards). For folds that form above laterally propagating thrusts, axial surface mapping also provides a means of assessing variation in displacement to length ratios, which have implications for whether faults grow as new fractures, or reactivate old ones.

Ridge Morphology: Our maps confirm that simple ridges on Solis Planum form above west-dipping blind thrusts that steepen upward. Axial surface mapping of backlimbs suggest the elevated centers of ridge segments on Solis Planum propagate relatively more rapidly early in their development and slow abruptly in relation to their lengths as they approach adjacent ridges. This is consistent with studies of terrestrial dip-slip fault populations [4] that interact at their endpoints. Our mapping also suggests that broad, gently-curved backlimbs are kinematically consistent with listic (i.e. shovel-shaped) blind thrusts whose convex-upward shape corresponds with large radii of curvature. In addition, backlimbs of some ridges also exhibit more abrupt increases in elevations that are analogous to narrow-kink bands. The width of these kink bands more closely approximate fault slip, although they are still clearly greater than actual slip based on the
total relief at ridge segment centers. We interpret the broad arches as formed by uplift above gently curved (and perhaps gently dipping) fault segments that steepen upward through the brittle-ductile transition. We interpret narrow ridges (superposed on the broad arch) to form above more steeply-dipping updip segments of the same blind thrust. Narrow wrinkles, that are often barely visible as the resolution of the MOLA digital elevation model are interpreted as secondary folds formed above flexural slip faults that form in response to bending of volcanic flow units.


Figure 1. Figure of digital elevation model of wrinkle ridges in southwestern portion of Solis Planum. Broad areas of light blue are uplifted above shallowly dipping blind thrusts that transfer shear through the brittle-ductile transition. Higher elevations denoted by orange and red colors form above more steeply-dipping portions of the same thrust ramps.

Figure 2. Figure of digital elevation model of wrinkle ridge from the center of Solis Planum. Note onset of backlimb as dark to light blue elevation change on left side of fold. Aqua colors denote edge of abrupt step-up in topography, interpreted as being produced by fault-bend folding above a more abrupt increase in ramp angle on the underlying thrust. We attribute the region of SE-dipping blue located east of the sharp leading edge of the fold as a product of regional dip and not uplift above a blind thrust.