3D FAULT INTERACTION AND DEPTH OF STRIKE-SLIP FAULTING ON MARS. K. S. Artita[1] and R. A. Schultz, Geomechanics-Rock Fracture Group, Department of Geological Sciences/172, Mackay School of Earth Sciences and Engineering, University of Nevada, Reno, NV, 89557-0138. [1]kimby@mines.unr.edu.

Summary: We identify two distinct types of strike-slip fault stepover geometries (push-up ridges) on Mars: "large" and "small". We first mapped strike-slip faults and push-up ridges in the Thaumasia region [1] using GIS. Next we reproduced push-ups seen in MOLA-based topography by modeling "large" and "small" stepovers using the dislocation software Coulomb [2]. By classifying and analyzing stepover geometries, depth of faulting can be determined for both Martian and terrestrial strike-slip fault systems.

Introduction: Echelon strike-slip fault arrays in the Thaumasia Strike-Slip Province (TSSP) east of the Coprates Rise produce rhombohedral shaped push-up ridges at stepovers [1] (**Fig. 1**). Push-ups occur for right-stepping left-lateral faults or left-stepping right-lateral faults. Pull-apart basins occur when the opposite is true (but are not found in this area).

Terrestrial studies show that in map view, the length to width ratio of basins is ~3:1 [3] and overlap of fault strands increases proportionally to separation [4]. Basins are also more common than push-ups and their mechanics better constrained [3,4,5]. We found that push-ups in the TSSP do not obey this dimensionality and instead have a length to width ratio of ~1:1. In addition, push-ups and their associated fault strands form in two distinct geometries.

In this abstract, we show how push-ups develop as "large" or "small" and demonstrate that these geometries are the result of 2D or 3D fault interaction.

Methods: We used GIS to map faults in the TSSP and analyze their spatial relationships. The USGS PIGWAD Mars General map was imported into ArcMAP. Mapping and measurements were made on the MDIM (231 m/pixel) sublayer.

Based on mapview geometry, fault stepovers can be categorized as "large" or "small". When overlap (*2o*) and separation (*2s*) are normalized by the fault half-length (*2k*) two distinct fields form (**Fig. 2.a**). For "large" 2D tunnel faults where the map trace L is less than the height (depth of faulting) H, o/k and $s/k < 0.5$. For "small" 3D blade-like faults where $L > H$, o/k and $s/k > 0.5$.

Push-up models. In order to test the "small" and "large" fault geometries, first we choose L, o/k, s/k, and H. For "large" faults, $L < H$, $H = 50$ km, o/k and s/k ~0.25, and $L = 10$, 5, and 1 km. For "small" faults, $L > H$, $H = 1$ km, o/k and s/k ~0.75, and $L = 10$, 5, and 1 km. Next we choose the maximum relative dis-

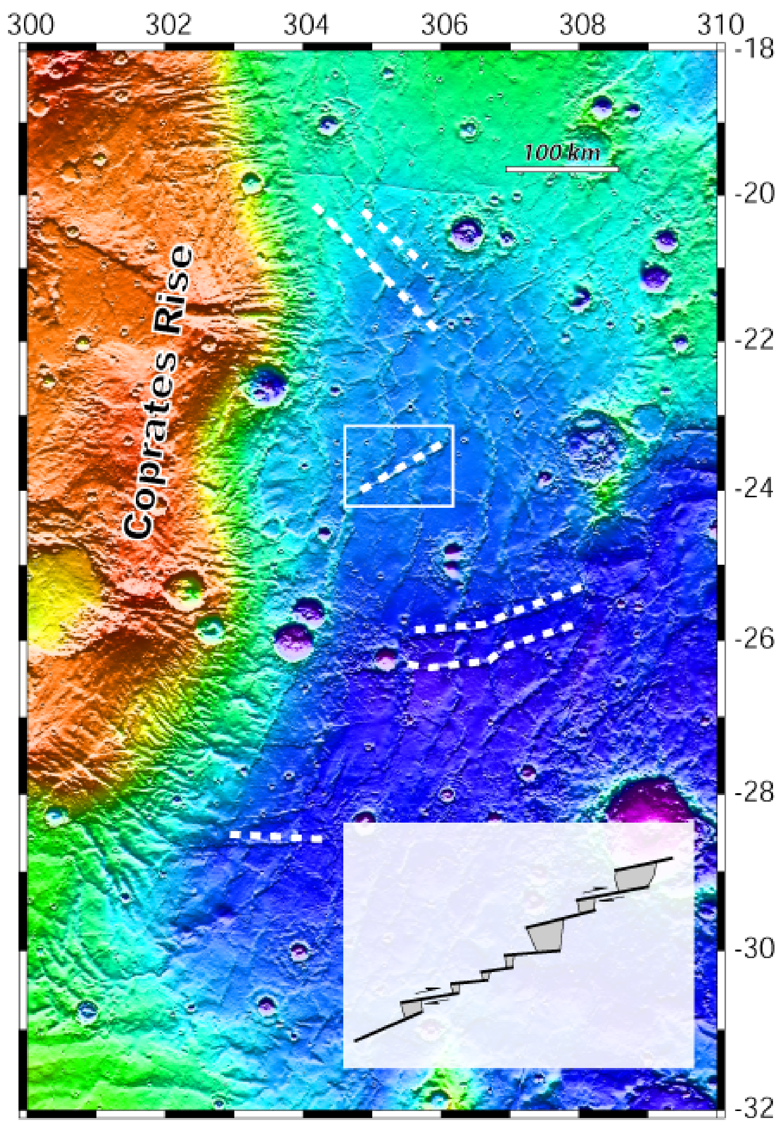

Figure 1 – MOLA DEM showing location of major strike-slip fault arrays in the Thaumasia Strike-Slip Province. *Inset*: example of push-ups at left-stepping right-lateral echelon faults.

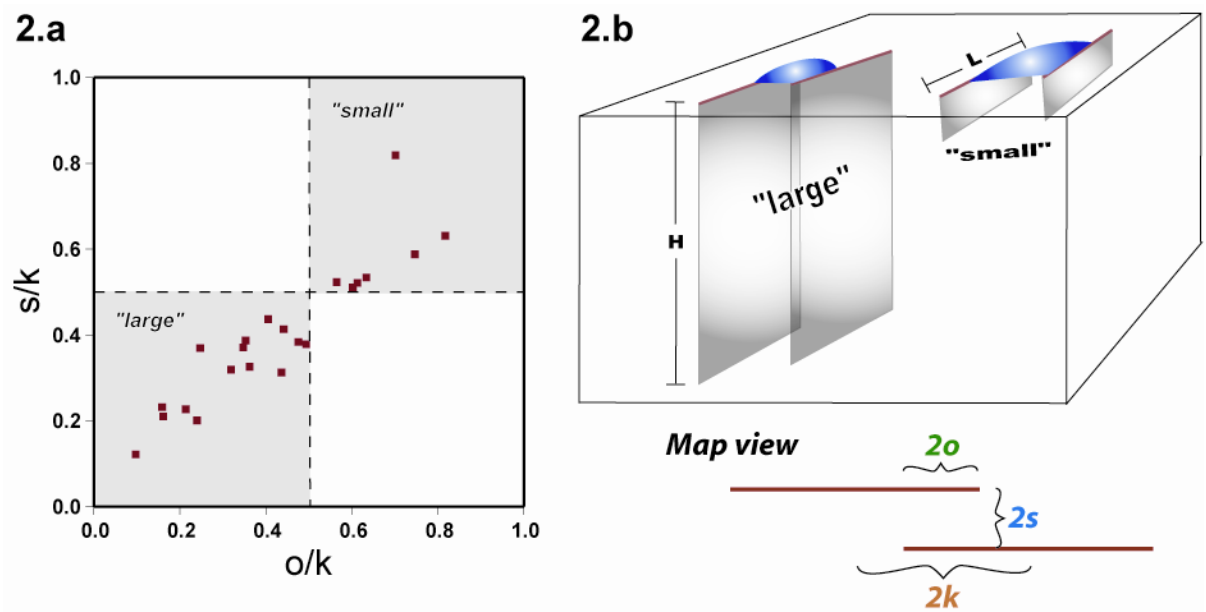

Figure 2 – 3D geometries and spatial relationships of fault strands that produced push-up ridges at stepovers. **2.a**) Normalized overlap (*o/k*) vs. separation (*s/k*) of TSSP faults. **2.b**) Cartoon of idealized fault geometries. For "small" 3D faults, interaction between fault strands is controlled by the vertical dimension or height (*H*) where the horizontal trace (map length) $L > H$. For "large" faults, interaction is controlled by *L*.

placement distribution D_{max} such that $D_{max} = \gamma L$. We set $\gamma = 10^{-3}$. Using Coulomb's Taper program, we convert D_{max} to D_{ave} along the fault. The surface topography produced by the fault stepover (push-up ridge) is then calculated using Coulomb.

It is inferred that these different fault geometries will yield different *D-L* scaling relations. Terrestrial studies have shown that displacement magnitude and fracture interaction distance is controlled by the shorter dimension [6,7,8]. For simple "large" 2D geometry, no adjustment is made. However, in order to more accurately model "small" geometries, we use the following 3D D-L scaling relations [9,10]:

$$D_{\max}' = \frac{1}{\Omega} D_{\max}$$

$$\Omega = \sqrt{1 + 1.464\left(\frac{L}{H}\right)^{1.65}}$$

Coulomb calculates the surface displacements produced by displacement along the fault strands. These displacements are directly related to the topography. Each model is run with several iterations to see which configuration produces the best match to the topography observed in the MOLA data.

Results and Implications: This work is on-going. Our preliminary calculations suggest that the two sets of fault stepover geometries can be related in a general way to the ratio between fault length (*L*) and depth of faulting (*H*) (**Fig. 2.b**). For simple 2D "large" geometries, $L < H$, *o/k* and $s/k < 0.5$, and fault interaction is controlled by *L*. For 3D "small" geometries, $L > H$, *o/k* and $s/k > 0.5$, and fault interaction is controlled by *H*. Using GIS, if the fault stepover can be classified as "small" or "large", the depth of faulting can be predicted using dislocation software by the maximum vertical displacement at the stepover and estimated displacement along the fault strands.

References: [1] Schultz R.A. (1989) *Nature, 341,* 424-426. [2] Toda S. et al. (1998) *JGR,* 100, 24543-24565. [3] Aydin A. and Nur A. (1982) *Tectonics, 1,* 91-105. [4] Aydin A. and Schultz R.A. (1990) *JSG, 12,* 123-129. [5] Katzman R. et. al. (1995) *JGR, 100,* 6295-6312. [6] Pollard D.D. and Segall P. (1987) *Fracture Mechanics of Rock*: Academic Press, 277-349. [7] Segall P. and Pollard D.D. (1980) *JGR, 85*, 4337-4350. [8] Willemse E.J.M. et. al. (1996) *JSG, 18*, 295-309. [9] Schultz R.A. and Fossen H. (2002) *JSG, 24*, 1389-1411. [10] Anderson T.L. (1995) *Fracture Mechanics*: CRC Press, 115-116.

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