INVERSE TOPOGRAPHIC MODELING: A TOOL FOR FINDING SUBJACENT WRINKLE RIDGE FAULTS. Chris H. Okubo and Richard A. Schultz, Geomechanics-Rock Fracture Group, Department of Geological Sciences/172, Mackay School of Mines, University of Nevada Reno, NV, 89557-0138 (http://unr.edu/homepage/chriso; chriso@mines.unr.edu).

Summary: Current studies of wrinkle ridge development suggest that wrinkle ridges are the surface expressions of thrust folds. Specifically, wrinkle ridges may develop in a manner similar to terrestrial blind thrust anticlines [1].

The mechanical models presented here show that the width of the blind thrust anticline is dependent on fault dip and height, and that anticline height is sensitive to the slip magnitude and fault depth. These models can be used to extract subjacent fault and lithologic information from wrinkle ridge topography.

Introduction, Methods and Results: Mechanical modeling of coseismic surface displacements to extract subjacent fault parameters have been previously employed to analyze data from active terrestrial blind thrust anticlines such as Whittier Narrows [2], Kettleman Hills [3], and Coalinga [4]. These studies, as well as others, have extracted reliable fault parameters such as dip, slip, and depth by analyzing observed coseismic displacements. Similar mechanical modeling studies have been performed using topographic data from blind thrust anticlines [e.g., 5].

Understanding the interplay between thrust folding and fault slip & geometry is the first step in utilizing mechanical models to analyze wrinkle ridges as blind thrust anticlines. In this abstract, we summarize results from a series of mechanical models designed to test the sensitivity of thrust-related deformation to variations in fault parameters. We also compare our model results against findings of previous mechanical models.

Our mechanical models are created using COULOMB [6] (Fig. 1). Key model parameters are fault slip, fault dip, and fault depth. Variations in lithologic parameters such as Poisson’s ratio have little effect. Results of our sensitivity tests are summarized for a range of values of fault dip (Fig. 2), fault slip (Fig. 3) and fault depth (Fig. 4). In each run, the test parameter was varied systematically while holding the remaining fault and lithologic parameters constant. The constant parameter values are: 3 m of fault slip, 20 degrees of fault dip, 8 km depth to the upper fault tip, 9.5 km depth to the lower fault tip, and Young’s modulus of 70 GPa, Poisson’s ratio of 0.25.

The values of fault dip, slip and depth, used in our tests are based on estimates of fault geometry previously obtained by mechanical modeling of the Coalinga thrust fold. Measurements of coseismic deformation that produced this fold are plotted along with our model results in figures 2–4. A comparison of the results from our model runs with topographic measurements of the growing fold show ranges of possible values for each fault parameter tested. The Coalinga thrust fault can be predicted to have a dip of 15–20 degrees, 3–5 m of slip, and a depth to the upper fault tip of 4–8 km.

Our model predictions of the Coalinga fault geometry are comparable to the results of others [4, 5, 6, 7] (for the case of a thrust fault). Their models predicted 15–30 degrees of fault dip, 1.5–3.0 m of slip, and a depth to the upper fault tip of 7.0–8.0 km, an excellent agreement between several independent numerical modeling techniques.

Conclusion: The results of our sensitivity tests show that surface deformation systematically varies with values of fault slip, dip, and depth to the upper tip. Our tests of the COULOMB model returned results consistent with previous work. Therefore, COULOMB can be used to model these systematic variations and predict fault geometries below wrinkle ridges.

Fig. 2. Variations in fault dip. Small angular variations result in marked changes in deformation magnitude for dips of 10–30 degrees. Subsidence occurs within the hanging wall at fault dips between 10–40 degrees. Alternately, subsidence occurs within the footwall at fault dips between 40–80 degrees. Subsidence occurs in both the hanging wall and footwall at a 40-degree dip. The crest of the anticline migrates from above the upper tip to above the lower tip with increasing dip angle.

Fig. 3. Variations in fault slip. The magnitude of uplift above the fault plane and subsidence behind the fault increases with increases in fault slip. Therefore, the height of the anticline and depth of the trailing syncline is less with lower slip.

Fig. 4. Variations in depth to the upper fault tip. The magnitude of surface deformation decreases with increasing depth. No trailing syncline is apparent beyond 16 km depth.