ON THE STATE OF STRESS AND FAILURE PREDICTION NEAR PLANETARY SURFACE LOADS. **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/ schultz/; schultz@mines.unr.edu).

Summary. The state of stress surrounding planetary surface loads has been used extensively to predict failure of surface rocks and to invert this information for effective elastic thickness. As demonstrated previously, however, several factors can be important including an explicit comparison between model stresses and rock strength as well as the magnitude of calculated stress. As re-emphasized below, failure to take stress magnitudes into account can lead to erroneous predictions of near-surface faulting. This abstract results from discussions on graben formation at Fall 1995 AGU.

The Problem. The stresses due to planetary surface loads were calculated by Schultz and Zuber [1] for an axisymmetric mare basin load on the Moon. The results they obtained are equally valid for loads on other planetary surfaces. Loading of the lithosphere by the mare basin fill causes the lithospheric plate to flex downward under the load and upward beyond the load at the surface. The state of stress is changed in the plate in response to the load. The amounts of flexure and stress change are greatest at the surface and decrease both with depth and with distance from the load.

Calculated stress differences in the plate are extremely large, with the radial stress σ_{rr} being tensile and well beyond the strength of any rock, much less a fractured rock mass or lunar megaregolith, to support without failure. As shown in Fig. 1, the three normal stress components vary both with distance from the load, *r/a*, and with depth. Note that a cursory examination of the plots in Fig. 1, with σ_{rr} being huge and tensile from the surface down to 2–3 km in the region of maximum bending stress, should caution the modeler that the calculated stresses, taken at face value, are probably not reliable as a predictor of initial failure (which is the purpose of such a stress analysis that excludes explicit provisions for strain).

The Solution. The total stresses applied to the plate are clearly too large. Reduction in the size of the load [1] shows that (1) failure of the near-surface rocks will occur by tensile cracking to produce a generally concentric array of steeply dipping joints in the region of maximum elastic bending stress, and (2) the associated stress differences below the surface for *smaller* loads, e.g., at 1 km depth, are not sufficient to produce faults of any type, whether normal or strike-slip (i.e., the proximity to failure, Fig. 2, is much less than one at depth). As shown in Fig. 3, the rates of increase of the stress components vary with with position. Any calculated state of stress would be irrelevant to fault-type prediction, regardless of which stress component is the greatest one, if it is less than the failure strength of the lithosphere at that depth.

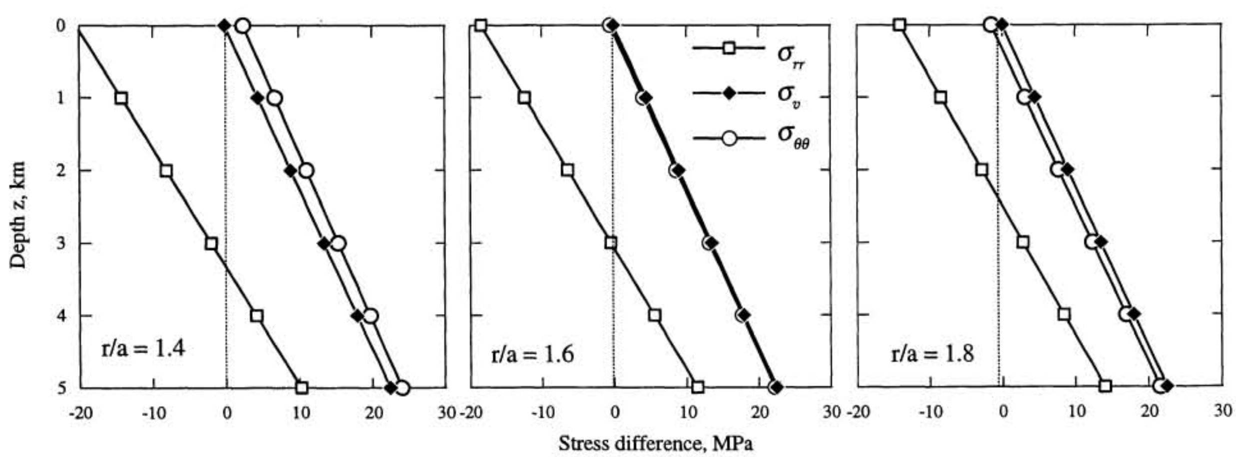

Fig. 1. Variations in stress due to loading with depth for locations near peak bending stress and observed concentric grabens. Dotted lines show typical tensile strengths for near-surface rock masses of breccia and/ or basalt (i.e., ~0 MPa). Using conventional criteria (stress geometry only), strike-slip faults could be predicted (incorrectly) at a variety of depths for *r/a* = 1.4, where σ_v is the intermediate stress. Such a prediction lacks credence because the stresses are insufficient to fail the rock in shear.

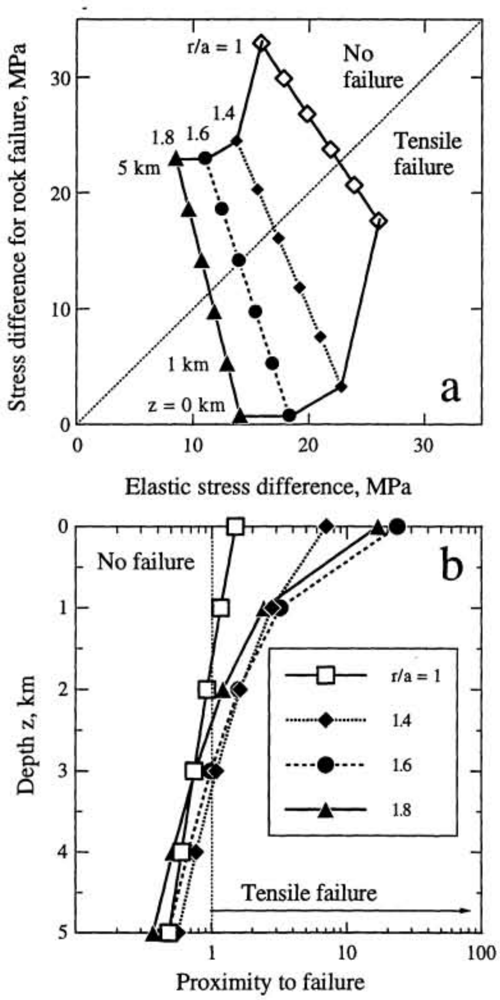

Fig. 2. Comparison between elastic stresses calculated by the model for the flexed plate beyond the load with the stress difference required for failure of the rock mass. In (a) the stress differences are sufficient to cause failure, which is tensile, to several km depth. An explicit comparison of elastic stresses divided by failure strength in (b) demonstrates the dependence of failure prediction on *both* model stress and rock strength.

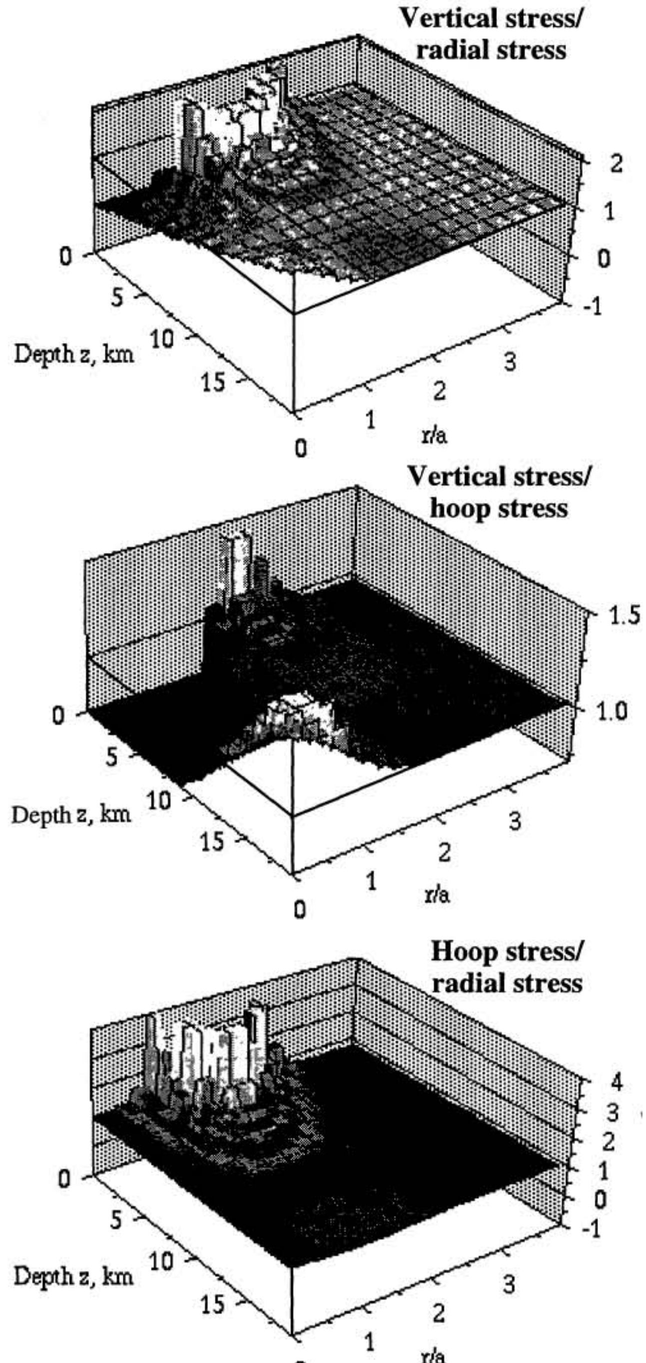

Fig. 3. Plots showing inhomogeneous stress states in the flexed plate. The vertical, radial, and circumferential (hoop) stresses all increase with depth at different rates.

Reference: [1] Schultz and Zuber, Observations, models, and mechanisms of failure of surface rocks surrounding planetary surface loads, *JGR*, **99**, 14,691–14,702, 1994.