ROCK MASS STRENGTH CRITERION APPLIED TO RIDGED PLAINS ON MARS: IMPLICATIONS FOR ELASTIC BUCKLING. **T. R. Watters**, Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560, **R. A. Schultz**, Geomechanics-Rock Fracture Group, Department of Geological Sciences, Mackay School of Mines/172, University of Nevado, Reno, NV 89557

Summary. We are taking a new look at elastic buckling of the ridged plains of Mars using a more comprehensive strength criterion for the fractured basalts. Our results show that the modulus contrast, critical stress, and the required thickness are more reasonable than in previous determinations.

Background and Method. The ridged plains of Mars are one of the predominant units on the planet. Based on indirect evidence, the ridged plains are thought to be volcanic in origin, most likely akin to flood basalts [1,2]. The wrinkle ridges that are found in these plains, based on terrestrial analogs such as the anticlinal ridges in the flood basalts of the Columbia Plateau, are interpreted to be compressional tectonic structures [2], reflecting a combination of folding and thrust faulting [3,4,5]. Wrinkle ridges, particularly those in the ridged plains of the Tharsis Plateau, are periodically or regularly spaced with an average spacing of 30 km [4]. It has been suggested that this spacing reflects buckling of the ridged plains at a critical wavelength of folding [4,6].

The ridged plains basalt sequence is modeled as series of elastic plates resting on a substrate of finite thickness which in turn overlies a rigid half-space subjected to an in-plane horizontal end load [4]. It should be noted that a thick or thin plate, or the rigidity of the basement, is not crucial to the present approach. Our focus here is on the strength criterion for the plate. A similar approach could be used with full lithospheric involvement [6]. The critical stress of buckling is given by

$$\sigma_c = \left[\frac{tEE_0}{3(1-\nu^2)h_0 n} + \frac{tE\rho_0 g}{3(1-\nu^2)n} \right]^{\frac{1}{2}}$$

where t, n, ν, and E are respectively, the thickness of an individual plate, the number of plates, Poisson's ratio and Young's modulus of the plates and, h_0, E_0, and ρ_0 are the thickness, Young's modulus and density of the substrate respectively. The critical wavelength of folding is given by

$$\lambda_c = 2\pi \left[\frac{Ent^3}{12(1-\nu^2)\rho_0 g} \left(\frac{1}{1 + \frac{E_0}{\rho_0 g h_0}} \right) \right]^{\frac{1}{4}}$$

If the critical stress exceeds the compressive strength of the basalt, fracturing and faulting will be favored over buckling.

In previous analyzes, Byerlee's law was used to estimate the strength of the basalt. Buckling

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was predicted only for a narrow range of model parameters and required relatively large modulus contrasts [see 4]. Byerlee's law as applied to basalt sequences has several problems. It requires a major or through-going fault or set of faults for the criterion to be applicable [7]. Observations of basalts in places such as the Columbia Plateau indicates this is not the case. To overcome the limitations of Byerlee's law to fractured rocks like basalts, rock mass strength criteria have been developed and used extensively in engineering geology. We incorporate the widely used criterion for rock mass strength developed by Hoek-Brown for near-surface fractured strata given by

$$\sigma_1 = \sigma_3 + \left(m\sigma_c\sigma_3 + s\sigma_c^2\right)^{\frac{1}{2}}$$

here σ_1 and σ_3 are the greatest and least principal stresses at the initiation of failure, σ_c is the unconfined compressive strength of intact basalt, and *m* and *s* are empirical parameters directly related to the Rock Mass Rating (RMR) which is a classification system that characterizes the distribution of fractures and the condition of the rock [8]. The strength modulus of a fractured rock mass is given by the deformation modulus (E*) and is directly related to RMR [see 9].

In a companion study, we reevaluated elastic buckling on the Columbia Plateau using the same approach [10, 11]. The results show that the required modulus contrast was significantly reduced.

Elastic buckling of Martian basalts was evaluated using the lower limit of the RMR estimated for the Pomona flows of the Columbia River Basalt Group (RMR = 45) [10] and the corresponding E* (7.5 GPa). The lower value of RMR is considered appropriate for ridged plains basalts that are additionally fractured by impacts and possibly weathered.

Results and Conclusions. The results indicate that the average spacing of wrinkle ridges on the Tharsis Plateau can be obtained with a broader, less limiting set of model parameters. For example, at $n = 2$, wavelengths ranging from about 20 to 34 km are obtained for a range in h ($h = nt$) of 2,000 to 4,000 m with a modulus contrast of 250 and h_0 = 5,000 m. Using the Hoek-Brown criterion, the required thickness of the basalt sequence is significantly reduced and the required modulus contrast is reduced by as much as a factor of 4. Over the same range in model parameters, using Byerlee's law, no admissible wavelengths are obtained.

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