THE RIDGED PLAINS OF MARS.

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The ridged plains of Mars, for example Lunae Planum, are the oldest wide-spread units on Mars with the exception of the cratered terrains. We have studied the ridged plains as part of a larger effort to understand the volcanic and tectonic history of Mars. The ridged plains appear to represent the earliest recognizable volcanic events, and they also apparently record, in their ridge patterns, tectonic events.

In order to better understand the nature of this early volcanism and the accompanying or later tectonism, we have studied the nature of the plains and their mechanical characteristics. We have considered what the origin of the plains might be, their relative age, their thickness, possible volatile content, the nature of the substrate, whether other volcanic materials or ancient cratered megaregolith. We have considered the distribution and origin of the ridges on the plains, whether they are structural or volcanic in origin. We have examined the relationship in detail of the ridge orientations to regional stress projectories. We have examined the question of what controls the ridge patterns.

In the regions near the Tharsis plateau, the ridge orientations are remarkably consistent with compressional stresses arising from the load associated with the central Tharsis region (Phillips and Lambeck, 1980) and thus may be interpreted to be related to the long-term viscous response of crustal rocks to the Tharsis load.

Under this hypothsis, it is appropriate to consider the mean ridge spacing as a dominant wavelength of folding. The theory of folding of viscoelastic media (Biot, 1961) suggests that the ratio of this wavelength (L_d) to the thickness of the layer (h) is related to the ratio of the viscosity of the layer (η) and underlying medium (η_1) by:

$$\frac{L_d}{h} = 2\pi \sqrt[3]{\frac{\eta}{3\eta_1}}$$

We need also to estimate the thickness of the plains. This is done by methods developed by DeHon (see for example DeHon, 1979) which involves a relationship between crater rim heights and their diameters. These parameters are given in Table 1.

It is interesting that the ratio of ridge spacing to plains thickness is approximately constant (around 30) over a range of ridge spacing and over widely separated plains units. The results imply a viscosity ratio, plains to substrate, of about 500. The tends to confirm the hypothesis that ridge spacing is related to dominant wavelengths of folding of surface materials in response to a load centered at Tharsis. Although the present stresses are low, they probably represent a relic of some larger initial stress. Also folding can occur at very low stresses in a viscous medium.

The observation that the substrate is several orders of magnitude less viscous than the surface may be explained by a variation in temperature or mechanical properties. Plains are underlain by cratered terrain which may be best characterized as megaregolith. The effective viscosity of this largely unconsolidated material could be much less than the plains if the plains are in fact extrusive volcanic material. The apparent anomaly or deviation in this relationship in Amazonis may be explained by the fact that

Amazonis is in the northern lowlands and may be underlain by other volcanic materials rather than by cratered terrains.

We have also looked at the morphology of fresh craters on the ridged plains and the presence or absence of central peaks as a function of crater diameter. We find that craters with the lobate distal ridge ejecta (flower craters) patterns are much more frequent near the equator than they are nearer the poles. Also, near the poles, the smallest diameter of craters having distal ridge ejecta are much larger. In contrast, the smallest craters with central peaks are about 5 km near the equator while they are nearly 20 km near the poles.

In conclusion, the relationship between the ridge spacing, the apparent thickness of the ridged plains, and a viscosity relationship suggest that the substrate is similar in mechanical characteristics where the ridged plains overlie cratered terrain. The viscosity ratio of ridged plains to underlying substrate is about 500. The subparallel ridges form on plains that are thicker than about 900 m, while in those plains areas that are apparently thinner than about 900 m, irregular reticulate patterns form, as in the Noachis-Hellas area. In the immediate vicinity of Tharsis, the ridges conform very closely to stresses that would arise from a Tharsis load according to a simple flexural rather than isostatic model. In regions distant from Tharsis, there is no clear global pattern to the ridge orientations, and the ridges appear to be responding more to local stresses. Although we might expect crater morphology to be related in some way to the thickness of the ridged plains, we find that that does not appear to be the case. There is no clear relationship between the crater ejecta types or the diameter of craters with central peaks and the plains thickness. The relationship seems to be controlled more by latitude which we suspect is reflecting the amount and subsurface distribution of water as ice or liquid.

REFERENCES:

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TABLE 1 Ridge Spacing and Thickness of Ridged Plains

REGION	THICKNESS, KM (h)	SPACING, KM (L)	L/h	TYPE
Amazonis Planitia	.950	40 ± 20	42	Parallel
W. Lunae Planum	1.500	50 ± 20	33	Parallel
E. Lunae Planum & E. Chryse Planitia	1.050	30 ± 15	29	Parallel
W. Solis Planum	1.500	50 ± 15	33	Parallel
E. Solis Planum	.800	20 ± 10	25	Reticulate
Hesperia Planum & Syrtis Major Planitia	.866	25 ± 15	29	Reticulate
Noachis-Hellas	.600	15 ± 10	25	Reticulate