NATURE AND ORIGIN OF WRINKLE RIDGES IN THE FLOOR MATERIAL OF KASEI VALLES, MARS. Thomas R. Watters and Robert A. Craddock, Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560

Wrinkle ridges on Mars occur almost exclusively in smooth plains material referred to as ridged plains. One of the largest contiguous units of ridged plains occurs on Lunae Planum on the eastern flank of the Tharsis rise. The eastern, western and northern margins of the ridged plains of Lunae Planum suffered extensive erosion in early Amazonian channel-forming events. The most dramatic example of erosion of the ridged plains is in Kasei Valles. Robinson and Tanaka [1,2] describe two stratigraphic units exposed in Kasei Valles. The surface of the upper unit is the surface of the ridged plains material, most of which has not been effected by erosion [3]. The surface of the lower unit is estimated to be 1,000 m below the surface of the ridged plains [1].

Some landforms on the lower surface are recognizable as wrinkle ridges, but they are rare and generally heavily degraded (Fig. 1). The degraded ridges are dimensionally equivalent to first-order ridges [4] and their orientations are consistent with those on Lunae Planum. This suggests that they are erosional remnants of preexisting ridges formed in the same tectonic episode that produced the Tharsis circumferential wrinkle ridge system [5]. If this is the case, the existing topographic relief of the ridges in the lower unit represents some fraction of the total structural relief and suggests that the entire ridged plains section has deformed or buckled [4].

In addition to the degraded ridges, more pristine appearing ridges have been identified (Fig. 2). These ridges are rare and are smaller-scale features relative to the degraded ridges, in the size range of second-order ridges [see 2]. The pristine wrinkle ridges, in contrast to the degraded ones, appear to be the result of post-erosion deformation. The limited number and extent of these structures suggests that they are the result of local compressional stresses, confined to the lower unit or floor of Kasei Valles. One explanation for the origin of the compressional stresses is that they are the result of the removal of the overlying material. If the materials behave elastically and are laterally confined so that uniaxial strain can be assumed (the horizontal components of strain are zero), then the horizontal stresses can be determined from elastic theory. Given that the state of stress in the materials prior to erosion is lithostatic, erosion reduces the horizontal stress by

$$[\nu/(1-\nu)]\rho g\Delta h$$

where Δh is the thickness of the section removed and ν is Poisson's ratio. The horizontal stress is thus given by

$$[(1-2\nu)/(1-\nu)]\rho g\Delta h$$

[6,7]. The horizontal stress as a function of Δh, assuming a mean density of the overburden is equal to that of basalt (2,900 kg m^{-3}), is shown in Fig. 3. If as much as 1,000 m of material was removed by erosion, the horizontal stress in the lower unit would be on the order of 7.3 MPa, perhaps sufficient to generate small scale wrinkle ridges. Thermal as well as mechanical effects may influence the horizontal stress after erosion [see 5]; however, because the thermal gradient on Mars is estimated to be low, this effect is considered to be negligible.

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Fig. 1. Heavily degraded first-order ridge on the floor of Kasei Valles. (From MTM 25062.)

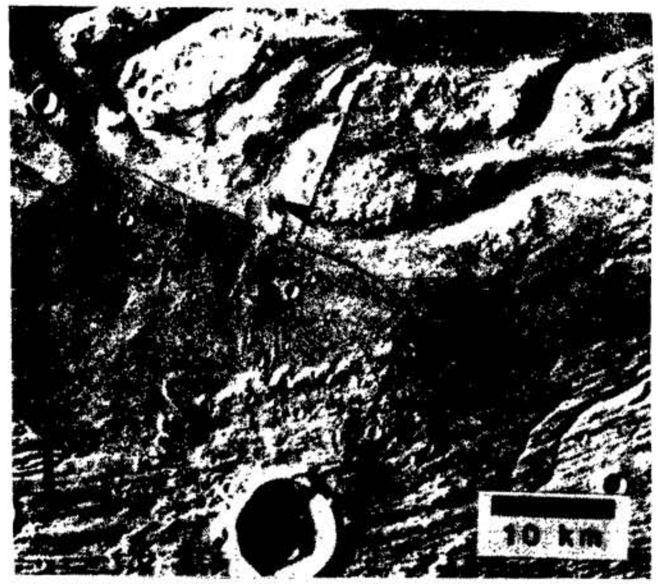

Fig. 2 (upper right). Pristine, small ridge which deform channel materials. Such ridges may be the result of overburden removal after channel formation. (From MTM 25062.)

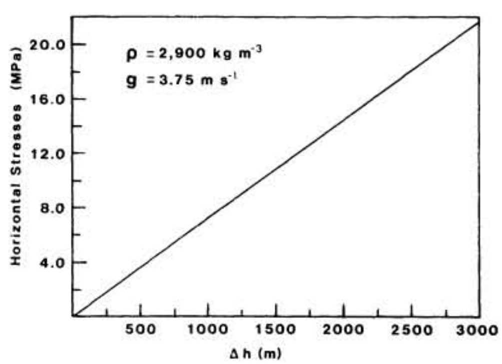

Fig. 3 (right). Diagram showing horizontal stress as a function of the amount of overburden removed (Δh). As much as 3 km of material may have been removed in areas of Kasei Valles [2].

References Cited:
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