WRINKLES IN THE ELASTIC SHELL OF MARS. K. F. Sprenke[1],
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Introduction: Recent physics laboratory experiments have investigated the wrinkling of thin elastic sheets [1]. The stress accommodated by wrinkles depends on the 4th power of the wavelength and the square of the elastic sheet's thickness [2]. Figure 1 shows a thin polymer elastic film wrinkling under the load of a water drop. The elastic sheet itself is resting on a flat water surface. Apparently, at the edges of the drop, the elastic sheet is stretched vertically while the water underneath resists, shortening the film horizontally, and making wrinkles. Can this wrinkling mechanism scale up to planetary proportions?

The geoid of Mars is dominated by the Tharsis bulge, a broad elevated region extending over 30 million square kilometers. Large-scale volcanism centered on Tharsis loaded the outer elastic shell of the planet with voluminous extrusive and intrusive magmatic deposits [3]. For this study, I have searched the martian geoid for evidence that the Tharsis load resulted in wrinkles in the elastic shell of Mars.

Method: The radial symmetry of the wrinkles in the physics experiments (Fig 1) suggests that the place to look for wrinkles on Mars is in the higher degree tessoral spherical harmonics centered on Tharsis. The center of Tharsis was placed by inspection at 8°N, 254°E. The geoid used in this study was the Goddard Mars Model 2B [4]expanded to spherical harmonics degree 20, and rotated to a pole at Tharsis. The tessoral harmonics above degree and order 5 were then recomputed at the rotated orientation.

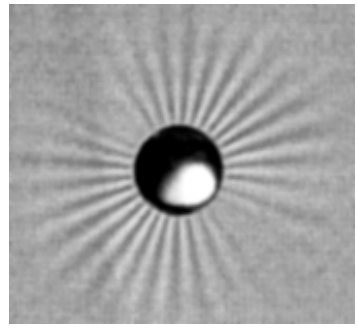

Figure 1. Optical microscope image of a water drop on a thin elastic film. The water drop is about a millimeter in diameter; the film is 233 nm thick. Modified from J. Huang et al. [1].

Results: Wrinkles in the martian geoid extend radially out from Tharsis (Fig. 2). The wrinkles appear to be associated with degree and order 8 of the tessoral spherical harmonics. The eight wrinkles have peak-to-peak amplitudes of 30-60 m, well above the estimated 1.8 m uncertainty of the geoidal measurements [4]. Some of the wrinkles coincide with major features (e.g. Valles Marineris and Elysium), others do not. Perhaps laboratory-scale studies of thin elastic sheets do in fact have relevance at planetary scales.

References: [1] J. Huang et al. (2007) Science 317, 650. [2] Cerda, K et al. (2002) Nature 419, 579 [3] Phillips et al. Science (2001) 291, 2587 [4] Lemoine et. al., (2001) JGR., 106(E10), 23359.

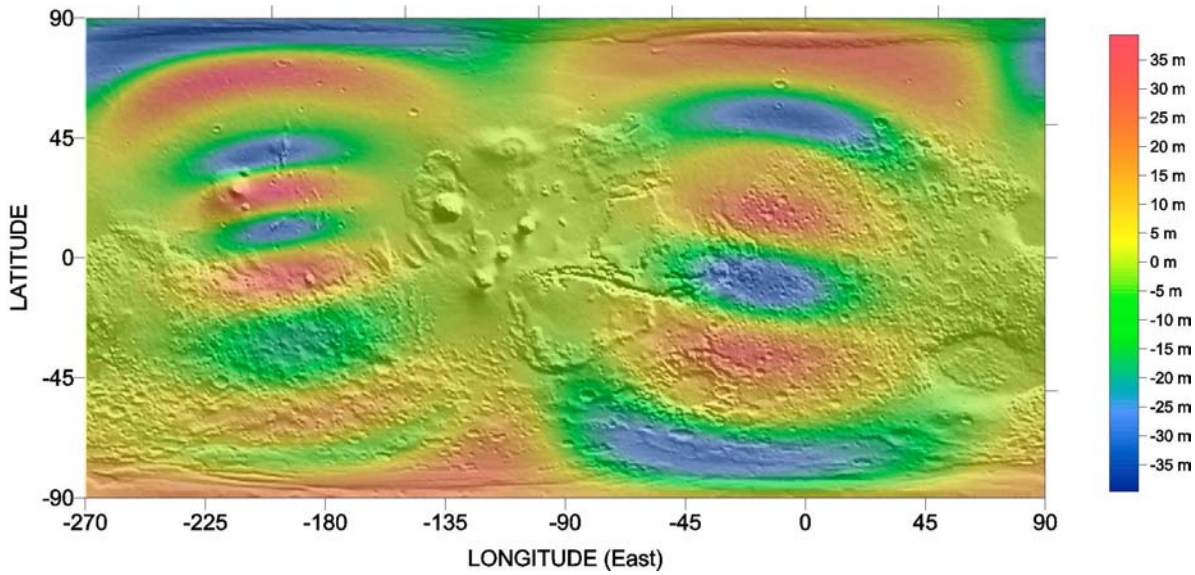

Figure 2. Wrinkles in the martian geoid as revealed by tessoral spherical harmonics centered on Tharsis.