LITHOSPHERIC FLEXURE AS A CONSEQUENCE OF POSSIBLE EROSION IN ARABIA TERRA, MARS. Alexander J. Evans[1], Jeffrey C. Andrews-Hanna[1], and Maria T. Zuber[1] ([1]Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139-4307, xan@mit.edu)

Introduction: The Arabia Terra region, an area of ~1x10^7 km^2 [1], lies on Mars' dichotomy boundary and is centered at (25E, 5N). Unlike other areas of the dichotomy boundary, Arabia provides a more gradual transition from the southern highlands to the northern lowlands of Mars in both topography [2] and crustal thickness [3]. While Arabia Terra has traditionally been considered to be part of the ancient southern highlands, it possesses topography and crustal thickness that are arguably more similar to the northern lowlands [3]. While the geological processes leading to the formation of the region have not been clearly identified [2, 3], Arabia Terra appears to contain many high-elevation inliers that have been interpreted as evidence for extensive erosion in the region [1]. The topographic difference between Arabia Terra and the highlands would require as much as 5 km of erosion in certain areas to yield the current elevation of Arabia, neglecting the effects of subsequent flexure. However, substantially more erosion would be required in order to reproduce the crustal thickness difference between Arabia Terra and the highlands [3]. Such a large amount of erosion would result in flexural effects and gravitational signatures due to load removal [4]. To determine the viability of erosion as a mechanism for the formation of Arabia Terra, we consider simplified erosion scenarios and examine the resultant flexural response.

Modeling: To examine possible erosion scenarios of Arabia Terra, we use a forward modeling approach. The erosion is represented as a topographic load with a uniform density of 2900 kg m^{-3} [3, 5] in a thin elastic lithospheric shell model [4]. The supposition of erosion as the primary mechanism responsible for the current state requires the original (pre-erosion) topography to be coincident with the southern highlands at an elevation of ~2 km.

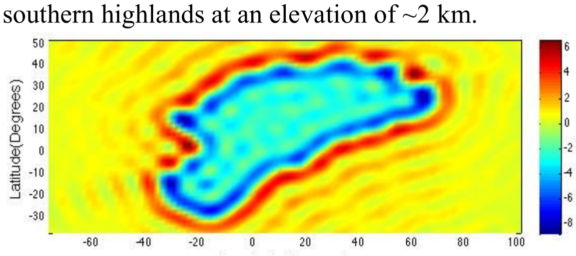

Figure 1: Gravity anomaly (in mGal) resulting from a uniform erosive load of -450 meters.

Results and Discussion: Incorporating flexural effects into the erosion scenarios allows for the identification of the resultant gravitational anomaly and deflection, which can be evaluated against the observed structure of Arabia. Among the many variables, the flexural response is most sensitive to the poorly-constrained elastic lithosphere thickness [3]. Though estimates of the effective elastic thickness of the Martian lithosphere vary over a wide range (up to 200 km [3]), the Arabia elastic thickness in early Martian history has been constrained to be <40 km [3, 5]. We assume a 20-km elastic lithosphere thickness with an initial elevation of 2 km.

Uniform Erosion: Investigating the amount of erosion consistent with [1] yields 450 m of eroded material distributed uniformly over Arabia Terra. This results in a uniform uplift of ~200 m interior to the region. This small uplift may be explained by an original surface elevated 250 m above the present-day topography. The resultant gravity anomaly, shown in Figure 1, has less than a 10 milliGal (mGal) difference between the interior and exterior of Arabia Terra. Though there is no observable resemblance to this difference in the gravity anomaly map of Arabia, the large gravity anomalies could mask resultant gravity anomalies of a few tens of mGals.

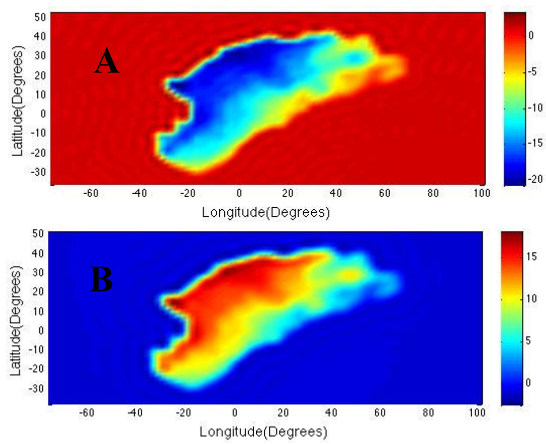

Figure 2: (A) Model load. Amount (in km) of erosion required to generate current topography. (B) Flexural response (in km) corresponding to best-fit topographic load.

Erosion - Topographic Difference: Another scenario is to describe the topographic difference between the highlands and Arabia as due to erosion. This yields a gravity anomaly with a ~20 mgal difference between the interior and exterior of Arabia. Though this difference could be masked, this scenario remains unlikely as it does not reproduce the regional topography. Explaining the topographic difference as a consequence of erosion effectively ignores flexure of the region, and yields a topographic trend shallower than observed.

Minimum Misfit for Topography: Incorporating flexure into reconstruction of the current surface requires erosion of a greater amount than calculated from the topography difference. Iterating our model to attain the best-fit erosion amount and distribution yields the erosion model load in Figure 2A. For a 20-km elastic thickness, our solution erodes up to ~22 km in the most extreme areas; in certain areas the elastic lithosphere is completely eroded.

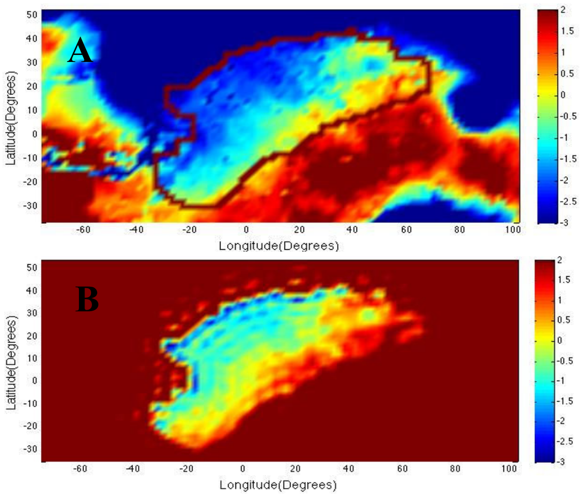

Figure 3: (A) Outline of Arabia Terra in elevation map (in km). (B) Best-fit topography solution (in km) for region.

Figure 2B and 3B show the resulting flexural response and the final state of the region. Topographically, this scenario is consistent with the crustal deficit of Arabia Terra with respect to the southern highlands **[3].** As seen in Figure 2, such a large amount of erosion would induce topographic uplift of as much as 1 km exterior to Arabia. The observed topography is inconsistent with this result.

The large amount of erosion required to reproduce the current state of Arabia would also induce large gravity anomalies in the region (Figure 4) along with observable differences and trends**.** As the large gravity anomalies in the region of ~-65 mGal are mostly continuous across its boundary, it is unlikely that these are directly related to its formation. Therefore, we compare the differences and trends of the resultant gravity anomaly to that of Arabia Terra.

Contrary to observations, our model predicts a large positive gravity anomaly immediately beyond the northern edge, instead of the ~-150 mGal anomaly shown in Figure 4A. Also, we predict a gravity anomaly difference of ~100 mGal between Arabia and its surroundings. This trend is not observed in the gravity anomaly map and is too large to be masked by regional gravity anomalies. Thus, this scenario does not conform to the observed gravity signature of Arabia.

Conclusion: In order for erosion to be a viable candidate for modification of Arabia Terra, an erosional model must reproduce the topography and gravity anomaly both within and exterior to the area. Although the best-fit erosion scenario we examined can reproduce the observed topography, it fails to reproduce suitable gravity anomalies or topographic trends immediately exterior to the region. Thus, it is not likely that erosion represents the primary explanation for the current physiographic expression of Arabia Terra. To explain both the gravity and topography of the region in the context of erosion, the erosion would have to have occurred in concert with viscous relaxation or sub-crustal erosion [6] or have acted at a time when the lithosphere was of negligible thickness. However, uniform erosion on the order of 450 m, as suggested by [1], conceivably could have occurred in Arabia. Further study will be conducted using the resultant flexure and gravity anomalies to place limits on the maximum amount of erosion within the region.

References: [1] Hynek B. M. and Phillips R. J. (2001) *Geology*, *29*, 407-410. [2] Kiefer W. S. (2005) *GRL*, *32*, 22201. [3] Zuber M. T. et al. (2000) *Science*, 287, 1788-1793. [4] Johnson, C. L. et al. (2000) *Icarus*, *144,* 313-328. [5] McGovern P. J. et al., (2004) *JGR,* 109, DOI 10.1029/2004JE002286. [6] Nimmo F. and Stevenson D. J., (2001) *JGR, 106* (E3), DOI 10.1029/2000JE001331.

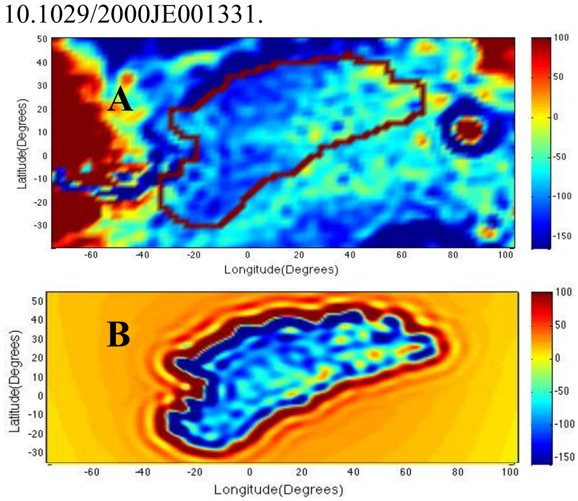

Figure 4: (A) Gravity (in mGal) of Arabia Terra with an offset incorporated into a degree and order 1 term of the spherical harmonics to compensate for the long-wavelength deformation and center-of-mass offset induced by Tharsis. (B) Resultant gravity anomaly (mGal) for best-fit topography.