EROSIONAL FEATURES ON TESSERA TERRAINS, VENUS S. Khawja[1], R. E. Ernst[1,2], C. Samson[1,3], P. K. Byrne[4] and R.C. Ghail[5] [1]Department of Earth Sciences, Carleton University, Ottawa, Canada, [2]Faculty of Geology and Geography, Tomsk State University, Tomsk, Russia, [3]Department of Construction Engineering, École de Technologie Supérieure, Montréal, Canada, [4]Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, USA, [5]Department of Earth Sciences, Royal Holloway University of London, Egham, United Kingdom

Introduction: Tesserae, also known as complex ridge terrains, occupy approximately 8% of Venus' surface, forming continent-like units (crustal plateaus) embayed by adjacent volcanic plains [1]. Tesserae consist of at least two sets of intersecting lineaments (e.g. ridges and grooves) and are a result of tectonic deformation of a precursor terrain [2]. However, the nature of that precursor terrain, as well as the causes and mechanisms of deformation are still under debate [3,4]. Recent models [5] suggest Earth-like conditions on Venus prior to a major period of flood volcanism and associated extreme global warming. A key test of this model is to investigate the tessera terrains in detail before the period of flood volcanism and search for evidence of erosion which would be indicative of pre-global warming conditions.

Erosion on Tesserae: There are two major reasons to expect erosional features in tessera terrains:

1) Climate models suggest that Venus could have had Earth-like habitable conditions until at least ca. 0.72 Ga, therefore the occurrence of water erosion would be expected before that time [5].
2) Some present-day topographic variations observed in tesserae are potentially consistent with erosion [6] although other causes should be considered.

The present research concentrates on the second point by assessing the causes of observed topographic variations in tesserae. It focuses on the implications of erosion via water. The possibility of wind or glacial erosion are also addressed.

Topographic Models: We consider three models to explain topographic variations in tesserae (Fig. 1). The first two models (Figs. 1a, 1b/1b') address whether the topography can be explained as primary, caused by folding or faulting, without any subsequent erosion. The third model requires erosion (Fig. 1c).

Methodology: All the SAR (synthetic aperture radar) images and topography data used in this research are from NASA's 1990-1994 Magellan mission. Topographic data have poor vertical and horizontal resolutions of 100 m and 10 km, respectively. Higher resolution stereo topographic maps recently produced from combining Cycle 1 and 3 Magellan SAR data [7] have a vertical resolution of 50-100 m and a horizontal resolution of 1-2 km. However, even this improved resolution is not sufficient because the uncertainties are of comparable scale to the observed topographic variations.

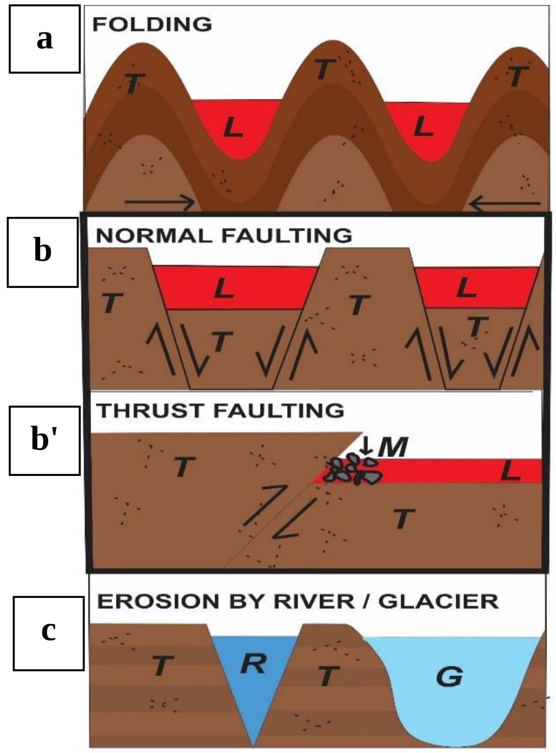

***Figure 1**: Schematic diagrams of three-models to explain topographic variations: folding (a), faulting (normal (b)/thrust (b')), and erosion by river/glacier (c). T = tessera, L = lava flooding, M = mass wasting, R = river erosion, G = glacial erosion.*

To circumvent the topographic uncertainty problem, we are mapping tesserae that are partially flooded by lava flows (Fig. 2). We assume that lavas have flooded these areas to approximately the same level, and thus reveal the spatial distribution of topographic lows, such as valleys.

Results: We examine two Magellan images of tesserae (Figs. 3, 4) that are partially flooded and consider the topography against the three models (Fig. 1).

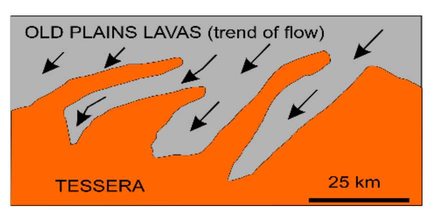

***Figure 2:** Schematic diagram of tessera terrain partially flooded by old plains lavas.*

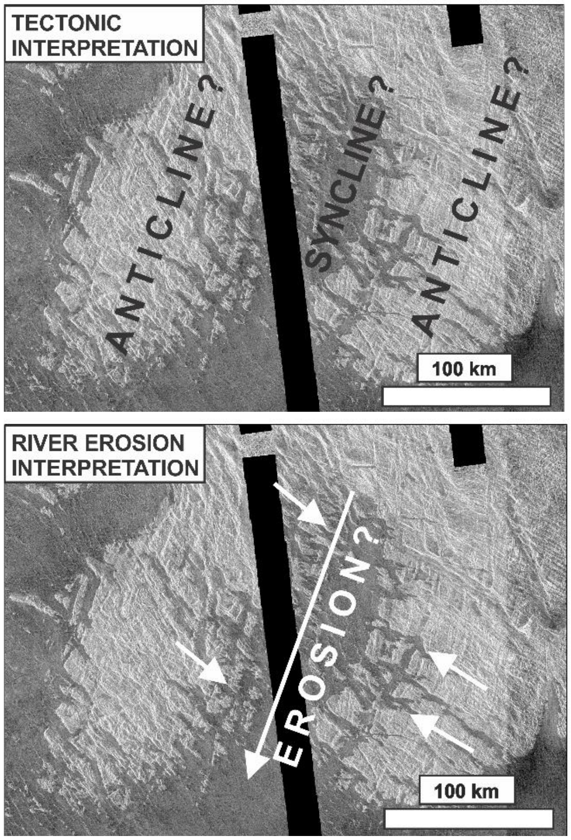

Figure 3: *Magellan SAR image (48.2E, 4.4S) from the southern part of Salus Tessera (light grey) showing alternative interpretations of the valley patterns (marked by younger plains lavas (dark grey)). Top: tectonic interpretation; bottom: river erosion interpretation. Modified from [6].*

Fig. 3 shows flooding in a re-entrant. The only alternative to an erosional origin for this structure is a primary syncline [6]. However, in such a folding model, the adjacent anticlinal portions should exhibit no structures (or perhaps only minor parasitic folds and secondary structures) in the absence of erosion (Fig. 1a) which seems at odds with their apparent tectonic complexity. Fig. 4 shows an irregular pattern of tesserae high ground and valleys (marked by lava flooding). In this case, the linear structures on the tesserae tend to be oblique to the trend of possible grabens and horsts, and erosion may offer a simpler interpretation.

Discussion: In the areas displayed in Figs. 3 and 4, there is weak evidence for the pattern of elevated topography being related to anticlines or domes, or to thrust fault uplift or normal faulting. Therefore, erosion is a viable alternative for explaining the observed topography.

Wind erosion on Earth produces aeolian features such as terrestrial dunes, yardangs, and similar features have been observed on Venus [8]. However, wind erosion will not cause topographic variations on the scale of tens to hundreds of meters that we observe in tesserae [9].

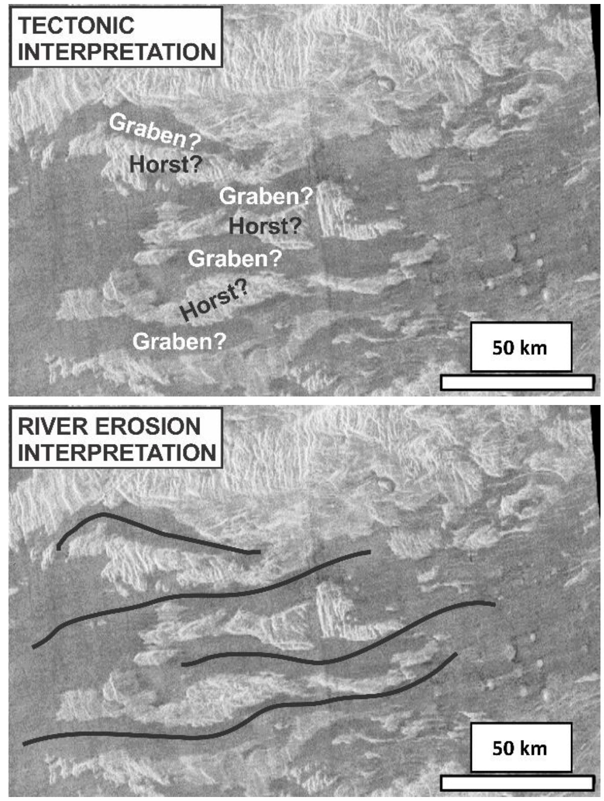

Figure 4: *Magellan SAR image (61.7E, 6.5S) showing segments of tesserae (light grey) surrounded by plains unit (dark grey). Top: tectonic interpretation; bottom: river erosion interpretation (black lines represent interpreted river valleys).*

If primary folding and faulting, and wind erosion are ruled out, then the cause of the topographic variations in tesserae could be liquid water or ice erosion. Preliminary mapping of approximately 10 tesserae margins embayed by plains lavas reveals matches with terrestrial stream patterns [10, 11] suggesting that erosion of tesserae may be widespread.

References: [1] Bindschadler D.L. & Head J.W. (1991) JGR, 96.B4, 5889-5907. [2] Basilevsky A.T. & Head J.W. (1998) JGR, 103.E4, 8531-8544. [3] Hansen V.L. & Willis J.A. (1996) Icarus, 123.2, 296- 312. [4] Gilmore M.S. & Head J.W. (2018) PSS, 154, 5-20. [5] Way et al. (2018) GRL, 43, 8376–8383. [6] Ernst et al. (2019) LPSC 50, #2382. [7] Herrick et al. (2012) TAG, 93(12), 125-126. [8] Greeley et al. (1997) JGR, 97(E8), 13319-13345. [9] Khawja S. et al. (2019) LPSC 50 #1967. [10] Howard A.D. et al. (1967) *AAPG Bulletin*, 51 (11), 2246. [11] Bridge J. & Demicco R. (2008) Cambridge University Press.