DETAILED STUDY OF SPUR AND GULLY TOPOGRAPHY WITHIN EASTERN VALLES MARINERIS, MARS

L. Vargas <lv15vb@brocku.ca>, F. Fueten <ffueten@brocku.ca>, R. Stesky, and E. Hauber

Introduction:

We present the results of a detailed study of the walls of Valles Marineris, which also examines structural features (e.g. grabens) visible on the plateau. We suggested that features in the plateau can be linked to spurs and gullies (SG) in the walls. The expression of SG varies in different tectonic settings.

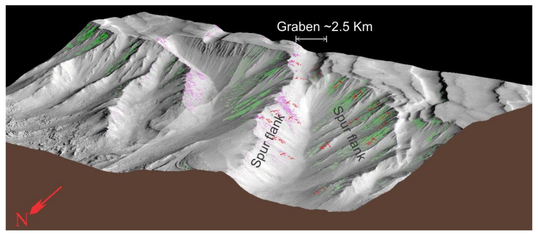
The results are presented as four cases in which a structural influence is suggested for the development of the wall geometry: (I) Wall development which is influenced by the presence of a graben intersecting a wall at a high angle; (II) V-shaped channels with planar walls; (III) The structural influence of grabens on the formation of headwalls, and (IV) Identification of multiple anomalous planes within the walls of Valles Marineris.

The documented cases indicate that wall development is influenced by different structural settings. Further work will explore the geometrical properties and geomorphology of the identified features in order to characterize them and to understand their formation.

Case (I): Wall development and Graben intersection

Grabens at Ophir planum [12,13] intersect the walls of Valles Marineris at different angles (**Fig. B**). In this case a graben crosses at a relative high angle the wall of East Candor (**Fig. 1**). It is suggested that the graben extends through in the wall as the flanks of the spurs. Attitude measurements [1] of the walls of the graben and the flanks of the spurs provide insights into a possible connection (**Fig. 2**).

The extension of the walls of the graben form the flanks of the spurs, and later erosional processes and wall retreat [8,9] widen the graben in the Chasma wall.



Planar Color Scheme
Strike: 140-170
Dip: 30-40
Strike: 285-315
Dip: 30-40

Figure 1: 3D Model of East Candor wall showing a graben crossing the Chasma wall and aligns with the flanks of the spurs. A planar color scheme is projected over a CTX-DRG 6m/px.

The dip of the graben walls differ (**Fig. 2**) resulting in asymmetry. The graben floor is tilted as the result of the asymmetry [14,15,16].

Figure 2: Stereonet of attitude measurements. The cluster are attitudes for each side of the wall of the graben and flanks of the spurs

This agrees with a new model for planetary grabens [14,15,16] which proposed an hourglass shape (**Fig. 3**).

Measured graben walls are shallower than depicted in the schematic **Fig 3** due to erosion.

Figure 3: Hourglass model for surface breaking planetary grabens. [14,15,16]

Case (III): Structural influenced triangular headwall from grabens

Triangular headwalls (TH), in sections of wall devoid of graben have curved rims and smooth interior surfaces as the result of erosional processes (**Fig. 6**) [3,8]. An example of smooth TH is located at East Candor (**Fig. 6 and C**). TH is as expected [3] in the absence of obvious structural features in the plateau [5].

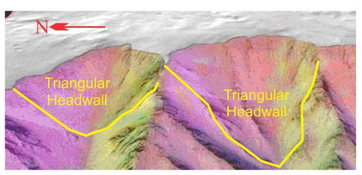


Figure 6: East Candor wall shows a curved rim with a triangular headwall exposing a smooth surface, and no structural features near the plateau.

Grabens crossing with a low intersection angle to the north wall of West Coprates chasma (**Fig. 7**) [12,13] are associated with wall retreat that involves spur and gully (SG) formation [9] over the TH (**Fig. 7B**) [8]. SG are formed near the rim [3] and have developed a branched pattern downslope [3, 8], indicating wall retreat [9]. This suggests that spur facets (**Fig. 7**) [8] are an expression of structural control [10].

SG are found in one of the curved rims that contains grabens crossing it (**Fig. 7A**).

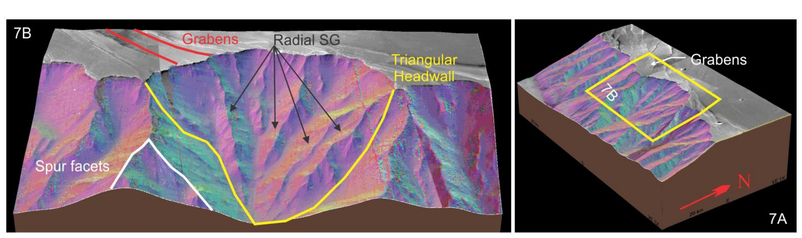
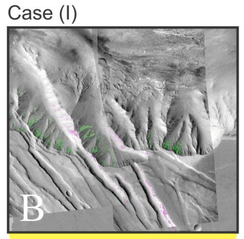
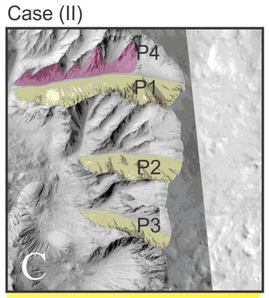


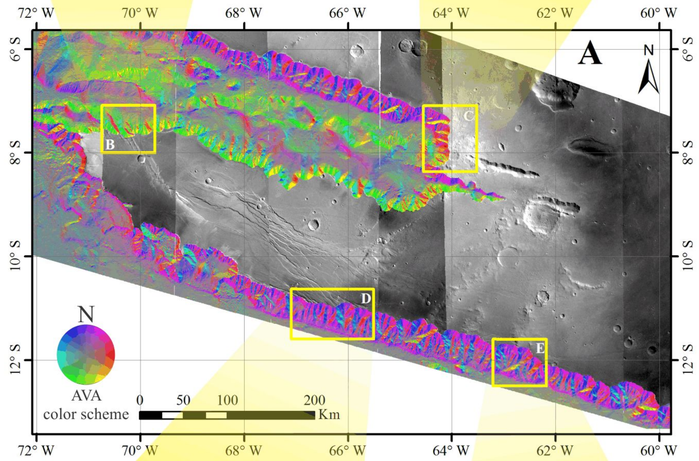
Figure 7: (7A) Shows a set of grabens crossing the wall of West Coprates at the curved rim with a low intersection angle. (7B) The wall shows within the curved rim a triangular headwall that contains radial spurs and gullies concentric downslope and near spur facets.

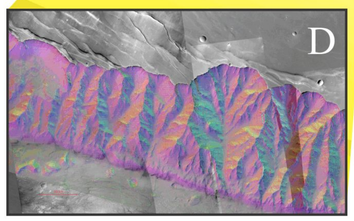
Case (I)



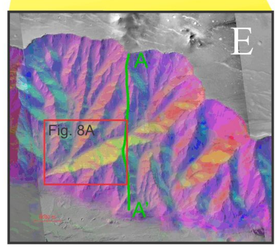
Case (II)







Case (III)



Case (IV)

It is suggested that structural control [10] in the TH is due to the presence of visible grabens and the faults associated with them (**Fig. 7**). The structural control led to the development of radial SG during the wall retreat [9] as the result of later erosional processes [8].

We suggested a timeline in which spur facets of the main Valles Marineris wall formed during wall retreat [6, 9]. Late Hesperian graben formed in the planum [12,13], followed by the formation of radial SG at the TH [3, 8, 11].

Case (II): V-Shaped channel

Three planes were identified within East Candor walls (**Fig. C**) using the AVA color tool [1]. They extend over the east wall of East Candor Chasma.

P1 crosses the north wall and dips towards the north wall (**Fig. B**), which is one of the characteristics of observed anomalous planes throughout the walls of Valles Marineris (**Case IV**). P2 and P3 are planes with ridges that extend from the east wall of East Candor Chasma.

It appears that P1 crosses with a plane (P4) that stands out at the north wall of East Candor (**Fig. 4**) and they form a V-shaped structure sub-parallel to the equator.

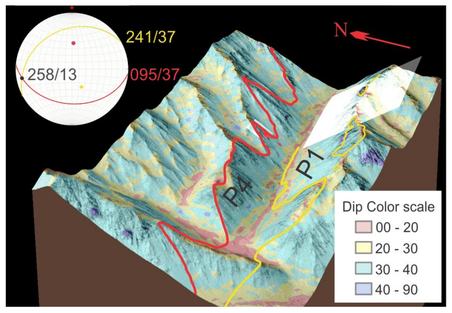
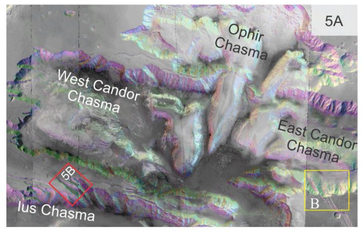


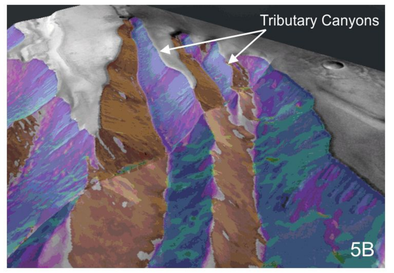
Figure 4: Dip color scheme over CTX-DRG 6 m/px [10,11], and planar models of P1 and P4 from Orion measurements on HRSC-DTM 50 m/px. Stereonet shows the attitude from each planar features and determines the trend and plunge of the intersection between them.

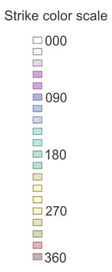
Attitude measurements proved that P1 and P4 possesses stable wallslopes [2]. Results for dip values are within the range of 30-40 (**Fig. 4**). Dip results suggest consistency of the planar extension of P1 and P4. We determined that strike ranges for P1 and P4 of 240-270 and 080-110 (**Fig. 5C**) respectively.

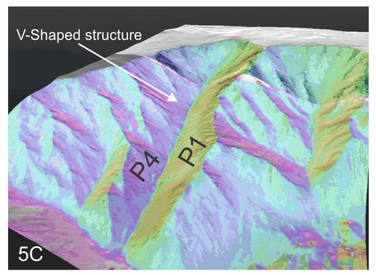


Note that dips are constant for most of the planar faces. Measurements using Orion yielded attitudes of 095/37 and 241/37 for P1 and P4 respectively (**Fig. 4**), which is approximately 10° steeper that general wallslopes within Valles Marineris.

Figure 5: (5A) Valles Marineris Chasmas (e.g. Ius, Candor and Ophir) AVA imagery [1] at 70% transparency over HRSC-DRG resolution 12.5 m/px; (5B) Parallel tributary canyons at East Ius Chasma with a Strike color scheme showing the undulating walls; (5C) V-shaped structure at East Candor Chasma with a Strike color scheme showing the consistency in planarity.







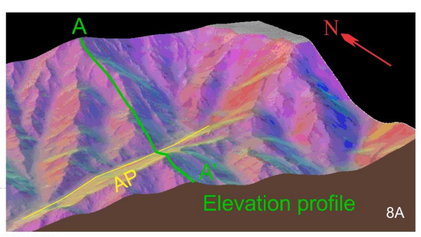
The V-shaped structure is compared to tributary canyons which have similar smooth surfaces due to talus in filling (**Fig. 5B**). The walls of tributary canyons and those of the V-shaped structure have similar dip values. There are however differences in the consistency of strike values (**Fig. 5B-5C**).

Walls of the V-shaped structure are more planar with less variation in strike values than the more undulating tributary canyons (**Fig. 5B-5C**). Other differences include the presence of coarse ribs at the upper part of the V shaped planes.

Case (IV): Anomalous planes crossing Spurs and Gullies

Anomalous planes (AP) were found at different locations of Valles Marineris. They share similarities such as: dip towards the wall (**Fig. 8**), a constant stable wallslope [2], and the presence of orthogonal small spurs and gullies (SG) (**Fig. 9**) [8] on their surface. The origin of these AP structures is unknown.

Location (E) shows an AP that possesses these features (**Fig. E, 8 and 9**). An elevation profile (green line) (**Fig. 8B**) indicates that the elevation of the SG above and below the AP differ. The study of these AP is still under development and considers the involvement of possible tectonic [4] and erosional processes [3,8].



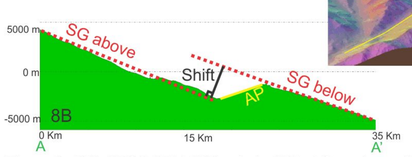


Figure 8: (8A) HRSC DTM (150 m/px) of West Coprates wall showing a set of SG with different trends and an anomalous plane (AP) that dips towards the wall (yellow plane). (8B) The green line represents the elevation profile (A-A').

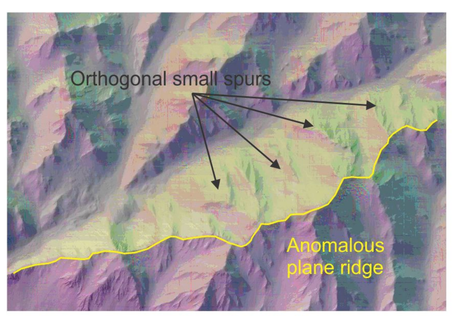


Figure 9: Close-up of the anomalous plane showing the orthogonal small spurs.

CONCLUSIONS

(I) The documented cases indicate structural control of the geometry of Valles Marineris walls.

(II) Martian grabens have the characteristics of the hourglass model for Planetary grabens (**Fig. 3**) [16]. In some cases these grabens can be linked to spur and gully formations.

(III) Spurs and gullies cover a large part of the walls of Valles Marineris. We considered that they are not simply erosional features but can provide more information about the processes involved in the formation of Valles Marineris.

(IV) Anomalous planes are found throughout Valles Marineris. Further work will explore the geometrical properties and geomorphology of these planes with the aim to characterize them and explain their origin.

REFERENCES

[1] Minin, M. et al. (2015), LPS XLVI, abstract #1577. [2] Schultz, R. A. (1988), Planet. Space. Sci., 45, 827-834. [3] Lucchitta, B. K. (1978), JGR 6(5), p651-662. [4] Andrews-Hanna, J. C. (2012), JGR, 117, doi:10.1029/2012JE004059. [5] Schultz, R. A. and Lin, J. (2001) JGR, 106(B8), p16549-16566. [6] Andrews-Hanna, J. C. (2012), JGR, 117, doi:10.1029/2011JE003953. [7] Wilkins, S. J. et al., (2002), Geo. Res. Lett., 29(18), doi:10.1029/2002GL015391. [8] Wallace, R. E. (1978), JGR, 6(5), p637-650. [9] Peulvast, J. P. et al. (1999), Geomorphology, 37, 329-352. [10] Blasius, K. R. et al. (1977), J. Geophy. Res., 82, 4067-4091. [11] Davis, P.A. and Golombek, M. P. (1990), J. Geophy. Res., 95, 14231-14248. [12] Schultz, R. A. (1991) JGR, 96, 22777-22792. [13] Hauber, E. et al. (2007), LPS XXXVIII, abstract #1670. [14] Schultz, R. A. et al. (2000), LPS XXXI, abstract #1175. [15] Schultz, R. A. (2000) LPS XXXI, abstract #1176. [16] Chapman, M. (2007), Mars Tectonics, in: The Geology of Mars, R. A. Schultz, et al. (Eds.), pp. 371-399, Cam-bridge Univ. Press. [17] Moratto, Z. M. et al. (2010), LPS XLI, abstract #2364. [18] Broxton, M. J. and Edwards, L. J. (2008), LPS XXXIX, abstract #2419.