Mountainous units in the Martian Gusev Highland region: volcanic, tectonic, or impact related? T.E. Zegers[1], M. van Kan[1], B., Foing[1], R. Pischel[1], K. Gwinner[2], F. Scholten[2], S. Werner[5], G. Neukum[5] and the HRSC Co-Investigator Team,
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Introduction: Gusev crater is situated at the boundary between the southern Noachian Highland terrains and the northern Lowlands. Geological mapping of this region was carried out, combining THEMIS and HRSC image data and HRSC digital terrain models (DTM), based on HRSC stereo capabilities.

Three major geological units can be distinguished in the Southern Highlands. These units, their relationships, and the structural elements, provide a record of the earliest part of Martian geological evolution.

Gusev Highlands: A typical Highland terrain is well preserved to the south and east of Gusev Crater. The larger region was previously geologically mapped by Kuzmin et al. [1] based on Viking data. The Highlands form a heavily cratered plateau at an elevation of approximately –1500 m (DTM HRSC referenced to Mars ellipsoid). The plateau is transected by the Ma'adim Vallis river system cutting approximately 1500 m into the highland plateau. The majority of the surface outcrop is formed by the Gusev Highland Unit. The surface of this unit is typically irregular on a 100m scale and shows a large number of craters and erosional features such as channels and grooves. Crater count statistics suggest an age of ~4.04 Ga for this unit, based on the algorithm by Hartmann and Neukum [2]. Although the details of crater-retention ages are controversial, the crater-count statistic ages presented here were obtained using a uniform data set and can therefore be used as absolute ages within this dataset.

In local, relatively low lying areas, the Gusev Highland Unit is covered by a younger and relatively smooth unit called the Modified Gusev Highland Unit. The crater count age of this unit is ~ 3.73 Ga. Since most erosional features are absent in the Modified Gusev Highland Unit, the erosional activity in the highlands is largely constrained between 3.73 and 4.04 Ga. Although there is no layering visible in the (Modified) Gusev Highland Units, it is likely that the two units have remained in their original position and orientation. There is no indication for tectonic disruption or tilting.

The oldest unit of the highlands occurs in three relatively small (<30 km diameter) areas. In these areas the "mountainous" unit surfaces through the Gusev Highland Units as mountainous terrains of higher topography. Figure 1 shows the HRSC based anaglyph of one of these mountainous terrains.

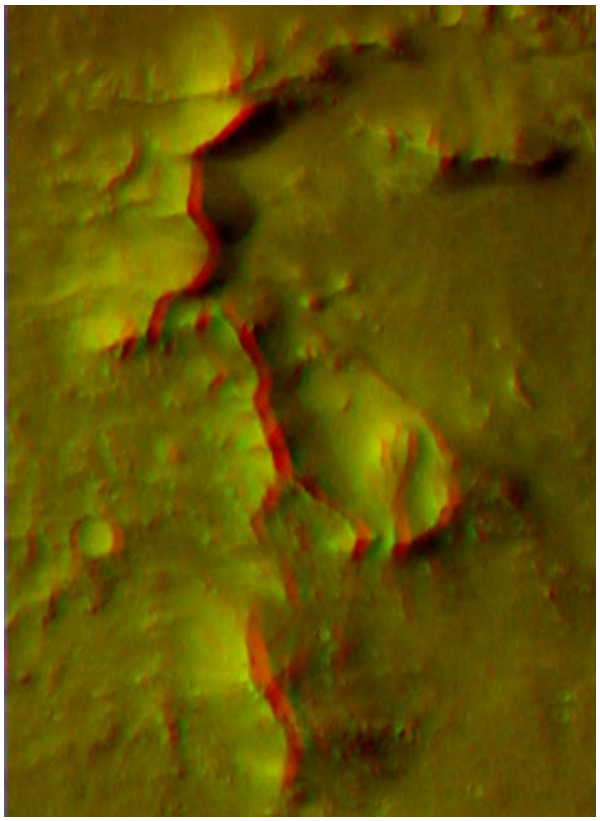

Figure 1. Anaglyph of mountainous terrain, based on HRSC nadir and stereo channel (orbit 283). This terrain occurs approximately 50 km southeast of Gusev Crater. North is to the left of the image.

Mountainous units: Topographic profiles based on HRSC DTM's through these mountainous terrains show that these terrains rise up to 2500 m above the surrounding Highland plateau. The topography is irregular with ENE-WSW oriented ridges. Images show that the mountainous units are embayed by the Gusev Highland Units, indicating that the mountainous units may have a more extended volume in the subsurface. This age relationship also indicates that the Mountainous Unit is older than 4.04 Ga, the crater count age of the Gusev Highland Unit. Images show no fine recognizable layered structure. Topographic profiles perpendicular to the ridges typically show a rugged and irregular northern slope, and a smooth planar southern

slope. In the northern slope morphological changes coincide with slope breaks, suggesting large scale (100-m) compositional/textural variation .

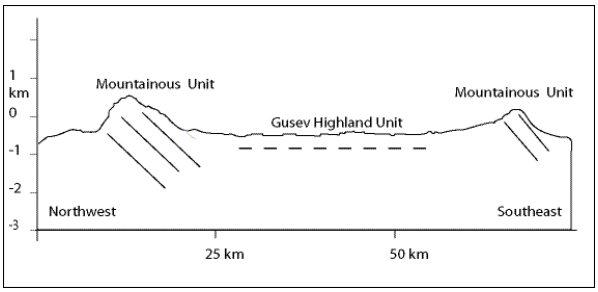

Figure 2. Topographic profile through two regions of Mountainous units to the southeast of Gusev Crater. Note exaggerated vertical scale.

Origin of Mountainous Units: The topography and correlating image analysis is at odds with an interpretation in terms of volcanic origin. The cone shape expected for a volcanic edifice is not present in these terrains. The large scale structure is consistent with a thick sequence, with large scale stratification, which has been tilted to the southeast. The smooth 6-10º SE dipping slopes can in that case be interpreted to be dip slopes. The irregular northwestern slopes would in that case be face slopes, showing signs of the large scale internal layering.

This would suggest that these Mountainous Units not only formed prior to 4.04 Ga, but were also tilted and partly eroded before being partially covered by Gusev Highland Unit deposits. Tilting of Mountainous Unit stratigraphy may have been related to major impacts. Block tilting associated with extensional faulting typically occurs around large impact structures. The size of such an impact crater must have been considerably larger than Gusev Crater to explain the scale and trend of tilting. Alternatively, the tilted mountainous terrains may be one of the few relicts of a dynamically more active early Mars evolution. Models of the thermal evolution of Mars indicate that during the earliest stages of Martian evolution processes similar to plate tectonics on Earth may have been possible [3, 4]. Large scale tilting of units, with a persistent strike over large distances (100-1000 km) is one of the geological expressions of plate tectonics. With the current dataset it is not possible to distinguish between tilting caused by plate tectonics and tilting caused by ancient large scale impact basins.

References

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