GULLIES, FLOW FEATURES AND SPIDER ARMS FOR CLIMATE RECONSTRUCTION ON MARS – PROPOSAL FOR COMPLEX MAP GENERATION. A. Kereszturi[1,2,3,4] ([1]Collegium Budapest Institute for Advanced Study, H-1014, Szentharomsag u. 2., Hungary, [2]Hungarian Astronomical Association, [3]Nagy Karoly Astronomical Foundation, [4]Planetary Science Research Group at Eotvos University. E-mail: akos@colbud.hu)

Introduction: We started to build up a framework called climatic planetomorphology [1] in 2007, resembling to climatic geomorphology on Earth, to use surface features as climate and environmental condition indicators on Mars. This system was used not only for research but also for educational purposes at university level, together with analog field works [2,3], student probe design [4], and student research [5,6] on climate and atmosphere related issues. Here we review some surface features, which may help to reconstruct the polar climate of the last million years.

Methods: To connect surface features to past climates we used published data on possibly liquid water related surface features, climate models, and realized own measurements [7, 8]. For morphometric calculations MRO HiRISE images, for topographic analysis shadow length measurements were used.

Various **linear erosional features** on Mars may formed in connection with liquid water or brine. Here we review some recent features, without superimposed craters. The best known of them are middle and high latitude gullies, formed probably by the melting of snow packs, which fit into the general view of surface evolution governed by mantling sedimentary layers [9]. Other climate related features are probably also there, with their size proportional to the mass of deposited and melted water ice. Their four possible categories (details in Table 1.) are:

- *"Classical" gullies* in the middle and high latitude region, formed in the last million years by melting of snow packs deposited under different climate.
- A special group is the *gullies on dunes*, with best examples from Russel crater (see Fig. 2. later).
- Small *meandering, curving trenches* (Fig. 1.) on gently sloping dune surfaces, which show the same depth (10-20 cm) as the dune ripples they cut through.
- *Spider arms* are possibly formed by insolation induced sublimation of CO_2 ice below a translucent layer - although other models involve the effect of liquid water [10]. The size of arms (width, depth, length) may be related to the erodibility of surface material, but also may reflect the volume/speed of subsurface gas currents or brines. The rate of sublimation/melting may correlate to the transparency, thickness, crystal structure and dust content of the ice – all of them are climate related.
- Ephemeral flow-like features, recently named *VLF-flows* [11] on steep dune slopes were observed in spring [12], which could be connected to the movement of interfacial water or brine lubricated dune grains [13].

Table 1. Possible recent polar flow features on Mars

Feature	Location	Characteristics
"Classical" gullies [14]	On steep slopes, width: 10-100 m, length <2 km	Components: alcove, erosional trench, accumulated fan
Gullies on dunes [15, 16, 17]	On dunes, width 10-30 m, length 100-1500 m	No alcove and accumulated fan, but have elevated levees
Small meandering, curving channels on dunes	Gently slopes of dunes, width 2-4 m, length 20-100 m	Meandering trench, with a track that is not influenced by topography
Dark VLF-flow features [12, 18]	On step dune slopes, width 2-5 m, length 1-200 m	Active in spring, in the top mm layer, track is determined by the topography of small dune ripples

All of the above-mentioned features are younger than the small-scale ripple-like pattern on the top of dunes, and based on the lack of superimposed craters may formed during recent climate changes.

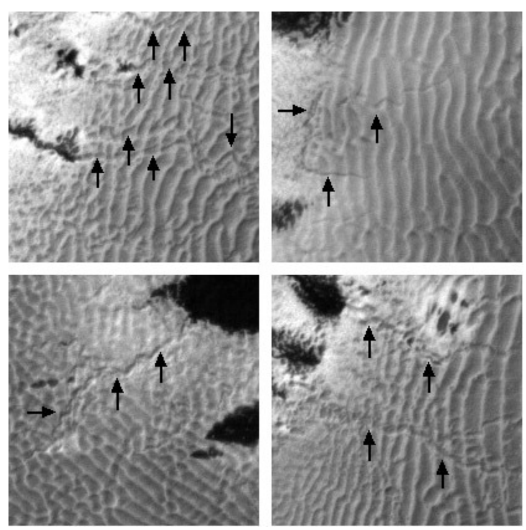

Fig. 1. Examples for small, meandering channels on dunes on 50x50 m inset images from Richardson crater

Classical gullies, gullies on dunes and VLF-flow features may be the manifestation of the same process working on different scale: the seasonal accumulated ice feds springtime flow – while during long period climatic changes greater amount of accumulated ice in shadowed alcoves may give rise to the larger gullies. Despite spiders and some curvilinear erosional features may have formed by the action of CO_2 gas currents below translucent ice, they are still good candidates for climate reconstruction – with parameters related to the CO_2 once covered the surface. But there is possibility that liquid brines may contributed in their formation.

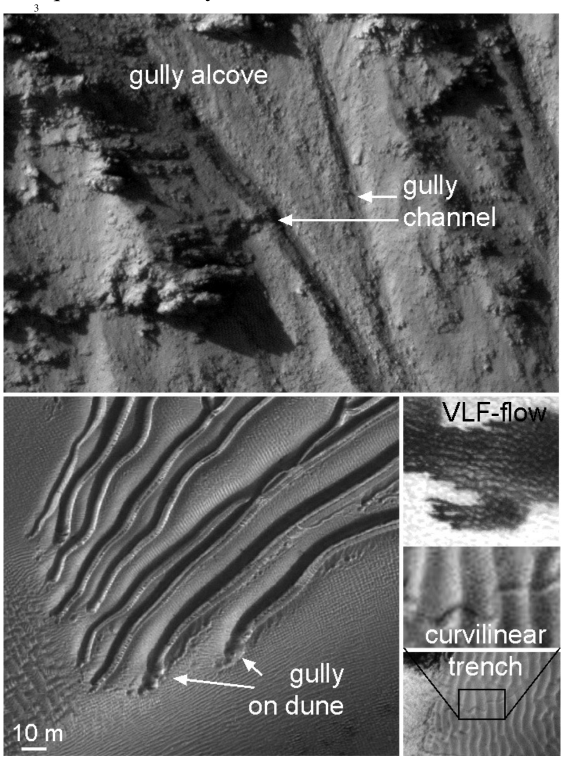

Fig.2. Possibly flow-related erosional features on same scale images. Gullies, alcoves (top), gullies on a dune (Russel crater, bottom left), springtime flow feature (Jeans crater, middle right), and a curvilinear trenches on dunes (Jeans crater, bottom right)

Based on simple approach three main parameters should be analyzed regarding the possibilite surface melting produced them: 1. insolation (solar constant, length of daytime, solar elevation) 2. dust content and microscopic ice structure (albedo, heat absorption, conductivity), 3. mass of ice deposited and stayed on the surface (possibility of melting before sublimation). Orbital states relevant to these phases could be characterized in climate models, possibility of melting could be estimated by modeling ice microstructure and dust content. In the next step, the above mentioned surface signatures of melting sould be correlaterd to these climate and modeling parameters. Four simplified theoretical end-members phases regarding the variable insolation and water ice deposition are visible in Fig. 3.

Conclusion:. Various effects may cause climate changes in the last million years, like change in the tilt of rotational axis and change in atmospheric dust content. The above mentioned features could be correlated to these changes. Their locations and connections with other climate related structures, may hint into their formation.

Fig. 3. Possible theoretical endmember phases, to analyze the conditions favourable for melting

To elucidate what kind of connections are real, we suggest the mapping of these features together with climatic context and possible climatic changes, represented on the same map with thematic mapping tools as preliminary realized by [19], and it is suggested in the work of Hargitai [20].

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