

SLOPE MORPHOLOGIES OF THE HELLAS MENSÆ CONSTRUCTS, EASTERN HELLAS PLANITIA, MARS. S. van Gasselt¹, E. Hauber², D. Reiss², F. Scholten², G. Neukum¹, and the HRSC Co-Investigator Team. ¹Freie Universitaet Berlin, Institute for Geosciences, D-12249 Berlin, Germany, ²German Aerospace Center, Institute of Planetary Research, D-12489 Berlin, Germany (vgasselt@zedat.fu-berlin.de).

Introduction: In 2004, the High Resolution Stereo Camera (HRSC) onboard Mars Express has obtained about a dozen of large-area image strips with a resolution of 12 to 25 metres per pixel that cover the Eastern Hellas Planitia region - a region which is characterised by large constructs of remnant hills and adjacent debris aprons. Although lobate debris aprons (LDA) in general have been interpreted to consist of rock debris and interstitial ice in varying proportions [1] image data from the Mars Orbiter Camera (MOC), THEMIS instruments and HRSC unequivocally show that these landforms are morphologically complex and that a variety of slope processes have to be taken into account when interpreting these features. We found further evidence for a retreat of a mantling deposit [2] and substantial changes in the water/ice-balance of that region.

Region of Interest (ROI): The Hellas Mensae construct is centred at 38°S and 98°E and is composed of several irregularly shaped remnants which are genetically connected to the Hellas impact event. The ROI (s. fig. 1) is located between 97°-100°E and 36.5°-39.5°S. This area has been selected as a type location as it provides a copiousness of characteristic landforms of slope morphologies that are based upon surficial flow and mass movement [e.g., 3,4] in connection with volcano-ground ice interaction in adjacent areas. For detailed analyses we have mapped the area in high resolution with a focus on (a) geologic units derived from topographic and image data, and (b) slope morphologies derived from image data of HRSC, MOC and THEMIS.

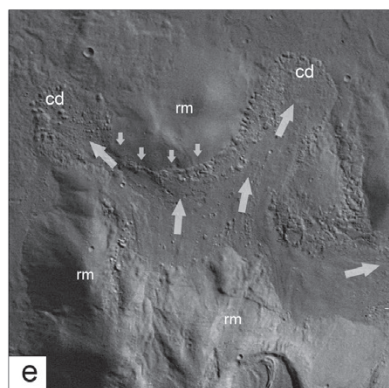
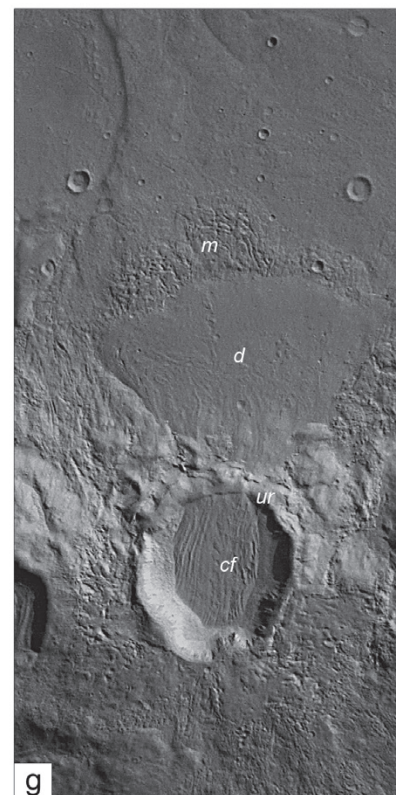
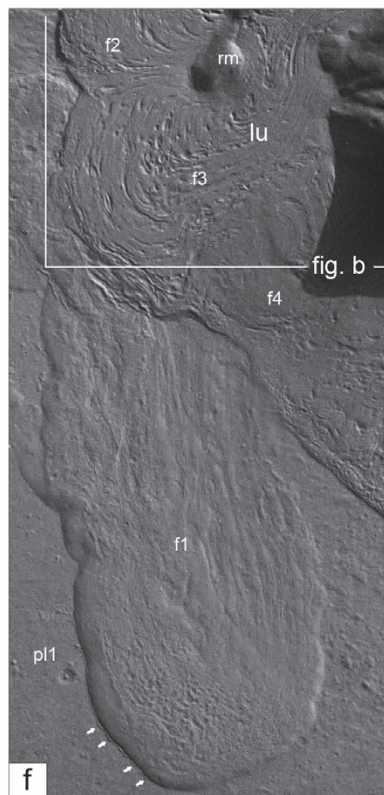
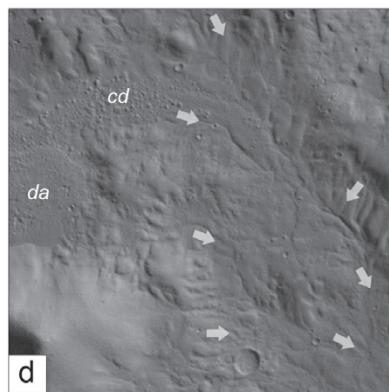
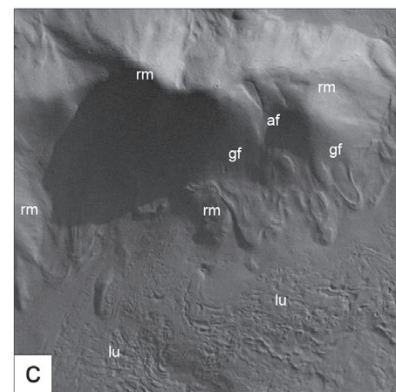
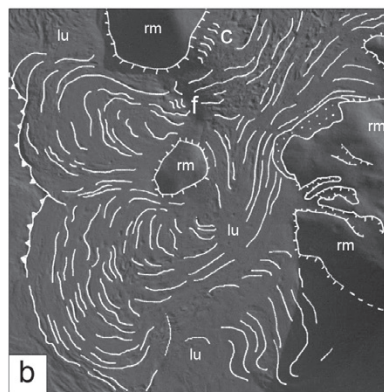
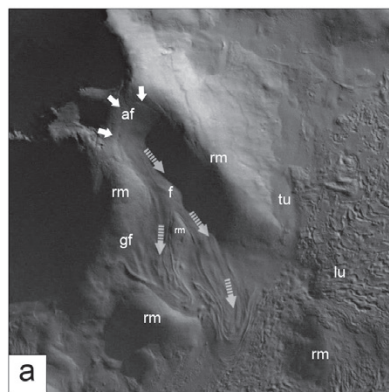
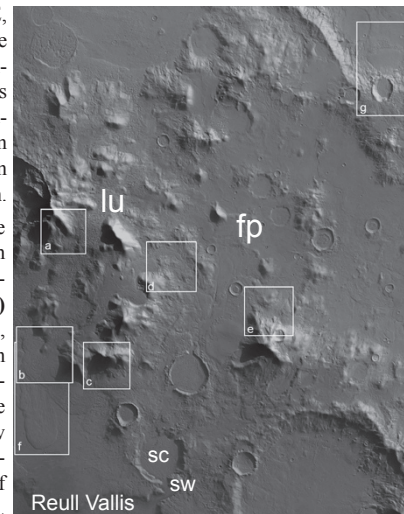
Characterisation of Terrain: The ROI (fig. 1) is mainly characterised by four units: (1) a large and complex lobate flow unit in the western part (lu in figs. 1 and 2), (2) a floodplain unit in the central and eastern parts (fp in fig. 1), (3) a variety of crater units comprising dissected crater rims, crater rim flows, crater fill units, and extensive ejecta blankets, and (4) several remnant units (rm in fig. 2). The lobate flows (lu) unit is punctured by several smooth-textured conical-shaped remnant hills (rm) and is fed by a variety of slope-related mass-wasting processes and small surficial flows emerging from remnant alcoves (af). The central parts of the lobate flow construct are characterised by a rough surface texture composed of several elongated and irregular depressions and ridges. These patterns have been interpreted as being remains of glacial advance, stagnation, and retreat [5]. It seems probable that these landforms are still subject to viscous deformation. This is suggested by their typical tongue-shaped to spatulate appearance, known from terrestrial periglacial creep processes. Their distinct steep flow fronts and arrangement of compressional ridges, lateral crevasses-like

features (e.g., c in 2b) and extensional furrows (f in 2b) resemble a slow flow process known from (peri-)glacial flows. In the southern parts of the ROI the large spatulate lobes (f2-f4 in fig. 2f) coalesce and are superimposed on an older flow (f1 in fig. 2f) which has a more elongated shape. Several surface-texture characteristics suggests that it is composed of the same material as the younger flows (f2-f4) but the elongated shape suggests a different rheology (i.e. lower viscosity) which is connected to varying amounts of debris or ice and therefore documents changes in the water/ice balance of that area towards a dry environment. The steep terminus of flow f1 is comparable to flows f2-f4 and suggests viscous deformation as well, which is in contrast to [6]. The overall concave profile supports the idea that the flow must be considered as being fossil or relict [e.g., 7]. The inventory of slope-related mass movements is heterogeneous. One set consists of fast-moving and possibly dry avalanche-like features (fig. 2e) that are characterised by accumulations of large boulders at their termini. Their superposition on older units suggests that they are relatively young. As another set, a large number of remnants show tongue-shaped surface flows with steep flow fronts (fig. 2a). These flows commence in remnant alcoves (af) or are part of multiple spatulate flow lobes (figs. 2a and 2c) that flow down remnant slopes. The latter are in correspondance with terrestrial periglacial processes known as gelifluction. The flows that originate in alcoves are derived from remnant talus material or from a mantling deposit [2] that covered parts of the remnants. Fig. 2a shows the retreat or surficial removal of that mantling deposit (af). The small-scale landforms that are connected to ice-assisted creep of talus material and terminate as steep walled spatulate flow lobes can be addressed as rock glaciers in general or gelifluction-debris rock glaciers [8]. The retreat of material subjected to creep is also documented at a crater in the NE of the ROI (fig. 2g). Lineations in the crater fill (cf) and the fan north of the crater (d) suggest removal of a former mass of moving debris which eroded parts of the crater rim (ur).

Conclusions: Large-scaled flow features known as LDA in the Eastern Hellas region show a variety of adjacent landforms that contributed to their formation such as gelifluction processes, dry avalanches, and a subset of different surface expressions of rock glacier phenomena. The LDA constructs cannot be considered solely as a large homogeneous mass of ice assisted creep of rock material. Through time, varying amounts of available water or ice caused retreat and movement of surficial deposits with varying rheologic behaviours.

Figure 1 (right): ROI of the Hellas Mensae area, centered at 98.5°E, 38°S, extending from 97°E, 39.5°S to 100°E, 36.5°S. Projection is sinusoidal. Boxes refer to image samples in Figure 1. The western part is characterized by an extensive and massive lobate flow construct (lf) which is composed of several individual flows emerging from alcoves and tops of remnants. The central parts show an abundance of dendritic fluvial patterns and resurfaced floodplains (fp). The fluvial patterns emerge from the termini of the western lobate flows. The flows point towards the southern crater (sc) which is filled by a thick deposit. The northern part of the Reull Vallis system has been fed with the crater fill material through a spillway (sw) that cuts through the southern crater rim.

Figure 2 (down): Terrain samples from the Hellas Mensae and adjacent areas. Image widths are 24 km for each image. **(a)** Elongated tongue-shaped flows with steep flow termini emerging from an alcove (af) that is partially filled with a mantling deposit. Spatulate flow emerge from the surface of remnants (rm), resembling gelifluction (gf). **(b)** Complex spatulate flow lobes (see 1f). **(c)** Multiple short elongated flows at south-exposed slopes. **(d)** Pattern of small debris apron (da), coarse debris accumulation (cd) and dendritic fluvial pattern that originates in the accumulation zone of the central debris construct and hill slopes in the north and east. **(e)** High-velocity landslides with coarse debris accumulations at the termini (cd), debris has been transported onto the slopes of a northern remnant (small arrows). **(f)** Flow lobes f2-f4 (see b) and older elongated flow lobe (f1) which shows a characteristic steep front and boulders accumulated at the terminus (arrows). **(g)** Retreated crater fill (cf) which overflowed the northern crater rim (ur) and left traces of fan deposits (d) and highly dissected moraine-like accumulations of boulders (m) at the terminus.



References: [1] Squyres, S. (1978) *Icarus* 34, 600-613; [2] Carr, M. H. (2001) *J. Geophys. Res.* 106, 23571-23594; [3] Pierce, T. and Crown, D. (2003) *Icarus* 163, 46-65; [4] Crown, D. et al. (2002) *LPS XXXIII*, Abstr. #1642; [5] Head, J. W. et al., (2005) submitted; [6] Baratoux, D. et al. (2002) *Geophys. Res. Lett.* 29, 60-1; [7] Haeberli, W. (1985) Mitt. Vers. Anst. Wasserbau, ETH Zuerich; [8] Corte, A. in Giardino J., Boston, 1987.