IMPROVED SURFACE PHOTOMETRIC MAPPING ACROSS GUSEV AND APOLLINARIS FROM AN HRSC/ MARS EXPRESS INTEGRATED MULTI-ORBIT DATASET: IMPLICATION ON HAPKE PARAMETERS DETERMINATION. A. Jehl[1], P. C. Pinet[1], A. Cord[1,2], Y.D. Daydou[1], D. Baratoux[1], S.C. Chevrel[1], N. Manaud[1], R. Greeley[3], M.A. Kreslavsky[4,5], J. Raitala[6], H. Hoffmann[4], K. Gwinner[4], F. Scholten[4], T. Roatsch[4], R. Jaumann[4], G. Neukum[7], and The Mars Express HRSC Co-Investigator Team.
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Introduction: In the past, reflectance measurements of selected rocks and soils over a wide range of illumination geometries have been obtained by the Viking Lander, Mars Pathfinder and MER multispectral imaging facilities and provide local constraints on the interpretations of the physical and mineralogical nature of the Martian surface materials.

With the *High Resolution Stereo Camera (HRSC)* on board *Mars Express (MEx)*, multi-angular datasets are generated with the nadir-looking, stereo and photometric channels (i.e., 5 geometries acquired at 679nm), which can be used for deriving the surface photometric characteristics in view of mapping the variation of the soil/bedrock optical properties of Mars. In order to compensate the limited number of observational geometries associated with one HRSC acquisition, observations from two or more overlapping strips acquired at different times along the mission are combined in order to span as much as possible the phase angle domain. Then, an inverse method, optimizing the determination of the global set of Hapke parameters, developed and tested on experimental data is implemented on the HRSC orbital dataset [1,2].

Regional survey of Gusev Crater and Apollinaris south flank: The region under study is the Gusev crater and south flank of Apollinaris Patera (cf. Fig. 2a) for which 4 overlapping strips have been obtained, 2 orbits (24 and 72) at low phase angle (g<50°;i~30°) and 2 orbits (637 and 648) at high phase angle (g>60°; associated with dawn illumination conditions i~80°)) (cf. Fig. 1). The previous study presented in [2] was carried out only with orbits 24 and 72.

HRSC data are binned at 1.6km / pixel and orthorectified with HRSC DTM October 2005 version and Vicar tools [4, 5] to correct for mis-registration and minimize compression effects. However, DTM residual noise causes yet some imperfection and advanced DTM products should be implemented for addressing studies at higher spatial resolution. With very oblique illumination conditions, observational limitations are the shadow caused by the local relief and correlative decreased S/N ratio. Pixels poorly or not illuminated have been discarded.

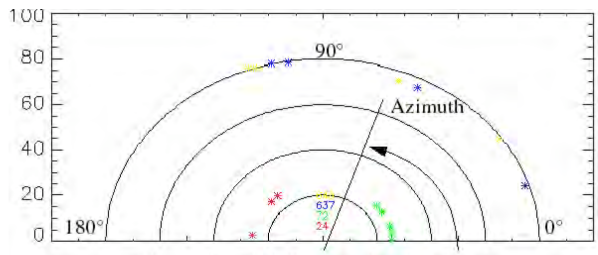

***Figure.1** Radial distance gives incidence. Polar angle gives azimuth.*

Results and Interpretation: Taking advantage of this extended phase domain ranging from 25 to 95° associated with a diversity of illumination conditions (cf. Fig. 1), the Hapke inversion procedure using a double Henyey-Greenstein function has been repeated [2] and an improved global photometric mapping based on a PCA analysis of the derived photometric parameters is produced, with the results shown hereafter. The variance of the photometric information appears to be distributed in the first 3 principal axes, respectively taking 52, 34 and 13% of the total variance. The scatter plots are displayed on figure 3 and the variability is explored by means of a cluster analysis. As pointed out earlier [2], significant photometric changes are revealed between the different units across the crater. The surface properties associated with the dark wind streaks regions, in the low albedo (LA) region where *Spirit* has landed [2, 3, 8] are displayed in yellow. It is confirmed (cf. Fig. 2d) that units such as A, B, C patches [2] present a low surface roughness ($2 < \theta < 8°$), which is combined with a pronounced but lower c (0.4-0.45) value than previously estimated [2], suggesting a microscale texture indicative of a rather smooth and packed granular surface [2, 8]. A clear photometric contrast is noted in the northern part of the crater (displayed in red and pink), revealing that the surface texture clearly varies between the PL (Plains) and WR (wrinkled) units [2, 6], the PL unit (displayed in green) behaving very much the same as the A, B, C patches (LA), with a variation in the phase function form b, while the WR one may be rougher and relatively more backscattering. Outside of Gusev, on the south flank of Apollinaris Patera 2 types of photometric behaviors are observed, mainly a very rough textured terrain (in pink, 17 $<\theta<$ 27°), with locally smooth patches (in dark blue). In light blue, is represented a quite distinct photometric type (cf. figures 2d and 3) combining low *b,* pronounced *c* (0.5-0.65) and high θ (25-30°) values. Its distribution appears limited and actually this photometric type is better recognized at a higher spatial resolution on the order of 100m /pixel [7] . It maps some localized hill tops in the Columbia hills complex and local topographic highs in the south of Gusev. This observation hints at a possible stratigraphic relationship.

Conclusions:
This improved HRSC multi-orbit multi-angular data analysis, relying on level 4 photogrammetric products, demonstrates their usefulness for the photometric characterization of the martian surface scattering properties.

These results also establish how critical is the need of a wide phase domain for spectrophotometric studies, in particular when carried out from the orbit and it has implications for the forthcoming CRISM observations. It calls for more fundamental and experimental studies for assessing what are the requirements to derive well-constrained photometric products [9].

References: [1] Cord A.M. et al. (2003), *Icarus , 165*, 414. [2] Pinet et al. (2005), LPSC 36th, # 1721. [3] Arvidson R.E. et al. (2004), *Science, 305,* 821. [4] Gwinner K. et al. (2005) *Mars-Express meeting* , ESTEC; Scholten F. et al. (2005), *in Photogram. Engineer. & Rem. Sens,* 71 (10). [5] Albertz et al. (2004), *Int. Arch. Photog. Rem. Sens.*,35, B4, 869 [6] Martinez-Alonzo S. et al. (2005), JGR, E1, E002327. [7] Pinet et al. (2006), LPSC XXXVII, this volume. [8] Greeley R. et al.(2005), *JGR 110*, E002403. [9] Baratoux et al., *this volume*; Kaydash et al., *this volume.*

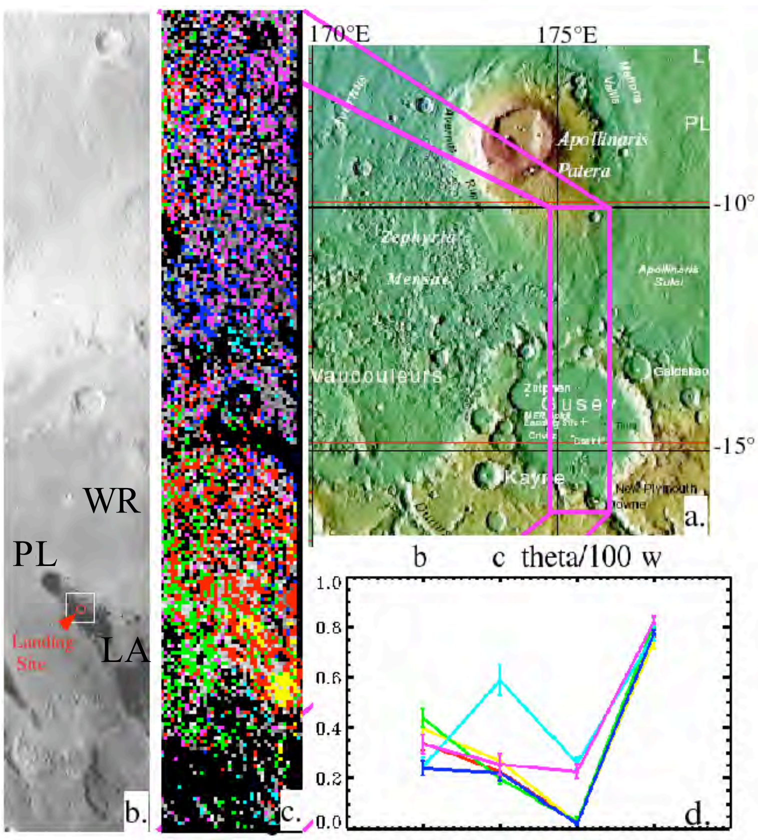

Figure.2 a. Geographic location of the studied area . b.Subset of HRSC 24Nadir (white frame refers to the zone discussed in [6] . c.Clustering from PCA d.Hapke's parameters associate with clustering

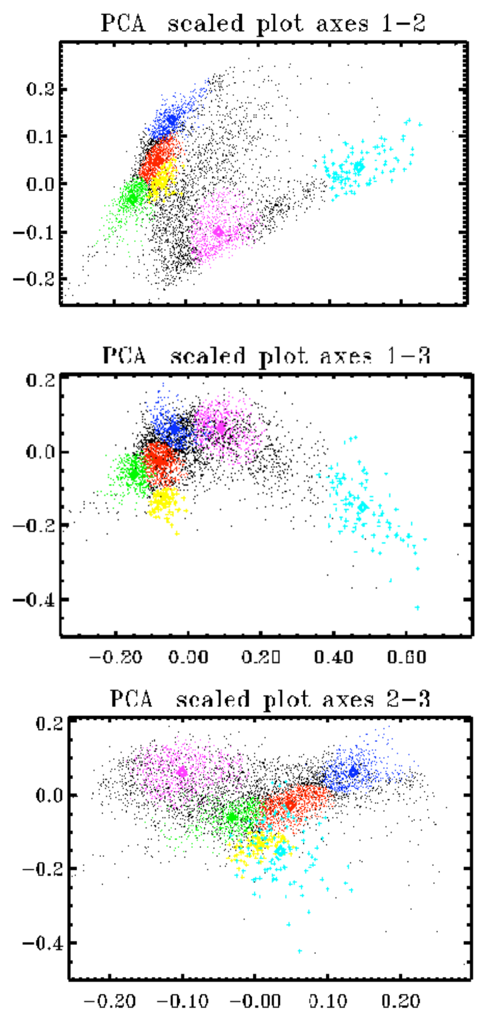

Figure 3. Distribution in the PCA space. Colored clusters are associated with figures 2c and 2d.