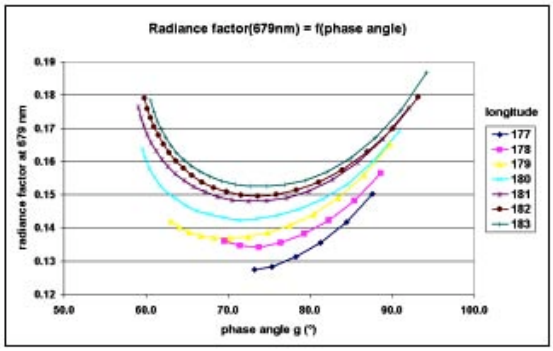
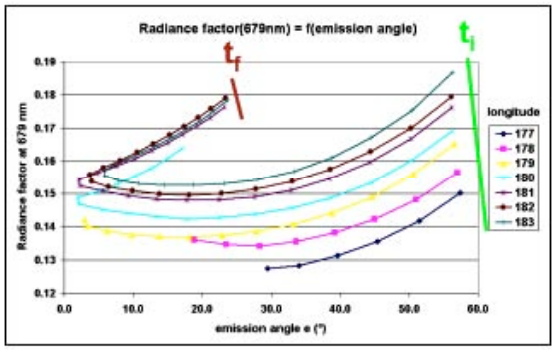
**DERIVATION OF MARS SURFACE SCATTERING PROPERTIES FROM OMEGA SPOT POINTING OBSERVATIONS.** P.C. Pinet [1], Y. Daydou [1], A. Cord [1,2], S. Chevrel [1], F. Poulet [3], S. Erard [3] , J-P. Bibring [3],Y. Langevin [3] , R. Melchiorri, G.C. Bellucci [5], F. Altieri [5], R. Arvidson[6], and OMEGA Co-I Team. [1]UMR 5562 / CNRS / GRGS, Observatoire Midi-Pyrénées, Toulouse, France, Patrick.Pinet@cnes.fr, [2]European Space Agency (ESA), European Space & Technology Centre (ESTEC), P.O.Box 299, 2200 AG Noordwijk, The Netherlands, acord@rssd.esa.int, [3]IAS, Orsay University, Orsay, France ; [4]LESIA, Observatoire de Meudon, Paris, France, riccardo.melchiorri@obspm.fr, [5] IFSI-INAF, Rome, Italy, giancarlo.bellucci@ifsi.rm.cnr.it, [6]McDonnell Center for the Space Sciences, Washington University, St Louis, USA, arvidson@wunder.wustl.edu.

**Introduction:** Emission phase function (EPF) observations have been carried out by Viking IRTM and Mars Global Surveyor TES instruments (e.g., [1,2]). With the generation of extensive angular coverage of emission phase function sequences, one can in principle assess and separate the contribution from surface and aerosol scattering phase functions. These observations, namely the TES EPF seasonal and spatial coverage, produced with large emission angles, have significantly improved the understanding of aerosols properties. Conversely, observations made under low to intermediate emission angles are most sensitive to the surface optical behavior, particularly when the atmosphere is experiencing low dust loading conditions. During Orbit 604 on July 10th 2004, the Mars Express spacecraft was rotated to allow the OMEGA instrument to obtain data at varying emission angles to derive an Emission Phase Function (EPF). We have explored the possibility of deriving surface photometric properties from these EPF observations, with the objective of comparing the outputs with thermophysical measurements from TES and THEMIS instruments, and from in situ data.

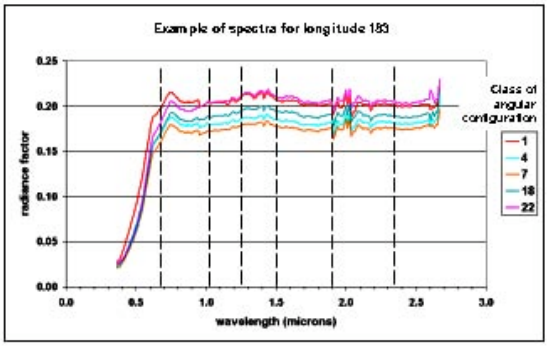
**Dataset and methodology:** A first regional survey of the martian photometric properties has been carried out over the equatorial region at 177-183° longitude, located in Medusae Fossae, south of Amazonis / Cerberus and chosen given its surface homogeneity for implementing the EPF observation.
For this purpose, an inverse method optimizing the determination of the global set of Hapke parameters, developed and tested on experimental data produced with a laboratory wide-field multispectral imaging facility, has been utilized to reduce the OMEGA EPF data [3, 4]. In this approach, the local variations of incidence and emission angles induced by the topographic variations are not taken into account but should not be critical given the overall flatness of the area, its reduced topographic roughness and the considered spatial scale of analysis. As a first investigation, the analysis derives photometric products for geographic cells, with 1° longitude bins and 0.5° latitude slice, each corresponding to an area on the order of 60x30km. The geometry of observation is such that illumination conditions are controlled by an oblique incidence out of the orbital plane (i= 60-67°) (morning situation) and emission angle variations in the orbital plane induce forward / backward geometry configurations (e < 58°), with a resulting phase angle coverage comprised between 60 and 95°,and binned in 22 classes of angular configurations, generating a dense and well-documented photometric dataset as displayed hereafter, where the I/F quantity is plotted as a function of phase angle and emission angle, for the different cells.



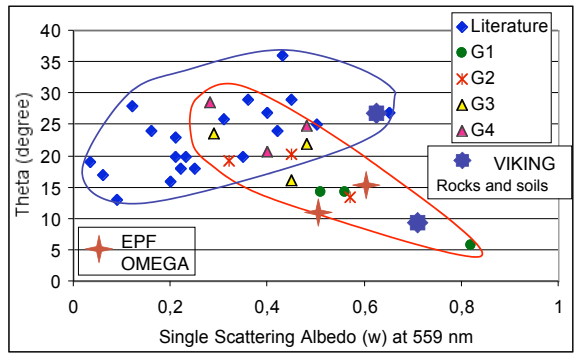




For the cell corresponding to the 183° longitude bin, the intensity changes in the spectra over a same zone, are also displayed for different angular classes and demonstrate both the OMEGA data sensitiveness and quality, essential for applying the photometric inversion. However, given the phase angle coverage, we cannot retrieve the parameters related to the opposition effect as they are unconstrained. Conversely, parameters *b, c,* describing the material properties through the particle phase function

approximated by the double Henyey-Greenstein function, the surface roughness $\theta$ parameter and the single scattering albedo $w$ appear to be well determined.




**Results:** First results characterizing the spectrophotometric behavior of the martian surface/atmosphere system through its optical scattering properties are produced. For the surveyed area (Medusae fossae, south of Amazonis / Cerberus), with intermediate albedo, topographic roughness and thermal inertia (70-90 S.I.) terrain properties, the regional photometric properties derived from VNIR (0.35 to 1.07 µm) and IRC (0.9 to 2.6µm) OMEGA detectors are as follows:
b = 0.45 +/- 0.05, without marked variability; c varies within 0.55-0.75, in favor of a prevailing backscattering behavior. An increase of variability on parameter c is noted toward the infrared; w (679nm) varies within 0.52-0.62; w(2340 nm) varies within 0.54-0.67; θ appears to range between 10-14° at 679 nm, with a possible 20% increase toward the near-infrared (12-17° in the spectral domain: 1000-2340 nm) ; θ increases slightly with w (θ = 11° for w = 0.52; θ = 15° for w = 0.62).
These results are analyzed in the context of laboratory results [3, 5], and with a compilation of telescopic and spaceborne observations of whole disk and disk-resolved photometric properties (surface roughness versus single scattering albedo) at regional scale of planetary regolith surfaces (Moon, Mercury, asteroids…) (referred to in the figure herafter as 'literature' (see also [3]) and in situ measurements made for martian rocks and soils by the Viking Landers [6,7]. G1, G2, G3, G4 refer to experimental measurements made for 4 different classes of grain size (G1<75 µm; 75µm<G2<250µm; 250µm<G3<500µm; 500µm<G4 <2mm) on targets composed of 3 materials, respectively fresh basalt, palagonite, oxidized basaltic tephra [3]. Particular emphasis is put here on the surface roughness θ versus single scattering albedo w results which appear quite consistent with both the case of Viking soils and simulated basaltic regolith surfaces with texture classes comprising grains ranging from less than 75 to 250/500 microns.




**Conclusion:** MGS-TES showed that spectral information attributable to surface emissivity is apparent without performing a surface-atmosphere separation [8]. The same conclusion is reached here with OMEGA EPF spectrophotometric information monitoring surface scattering properties through the atmosphere, showing that one may access from orbit to geology-driven surface photometric properties such as surface roughness. Indeed, results from Omega are quite consistent with in situ Viking and Mars Pathfinder soils / rocks photometric observation [6,7,9]. This is also demonstrated over Gusev crater from HRSC multi-angular observations [10]. It has implications for spectroscopic interpretation, as it is recognized that particle size and surface roughness have significant influence on granular mixture spectral properties [11, 12, 13] and for preparation of CRISM/MRO observations to come. Orbital access to these photometric quantities by EPF dedicated observations can alleviate limitations in the modeling methods which rely on the calculation of optical constants from reflectance spectra of pure samples both characterized in composition and particle size.

**References:** [1] Clancy R.T. and S.W. Lee (1991), *Icarus, 93,* 135. [2] Clancy R.T. et al. (2003), *JGR, 108,* 5098. [3] Cord A.M. et al. (2003), *Icarus , 165*, 414. [4] Pinet P.C. et al. (2004), *Proc. Ischia Mars Conf.* [5] McGuire A.F. and B.W. Hapke (1995), *Icarus , 113*, 134. [6] Arvidson R.E. et al. (1989), *JGR, 94,* 1573. [7] Guinness E.A. et al. (1997), *JGR, 102,* 687. [8] Ruff S.W. and P.R. Christensen (2002), *JGR, 107,* 5127. [9] Johnson J.R. et al. (1999), *JGR, 104,* 8809. [10] Pinet et al.(2005), *LPS XXXVI*, this issue. [11] Harloff J. and G. Arnold (2001), *Planet. Space Sci., 49,* 191. [12] Poulet F. and S. Erard (2004), *JGR, 109,* E02009. [13] Cord A.M. et al. (2005), *Icarus,* in press.