Interaction of Phobos' surface with the Solar Wind and Martian Environment

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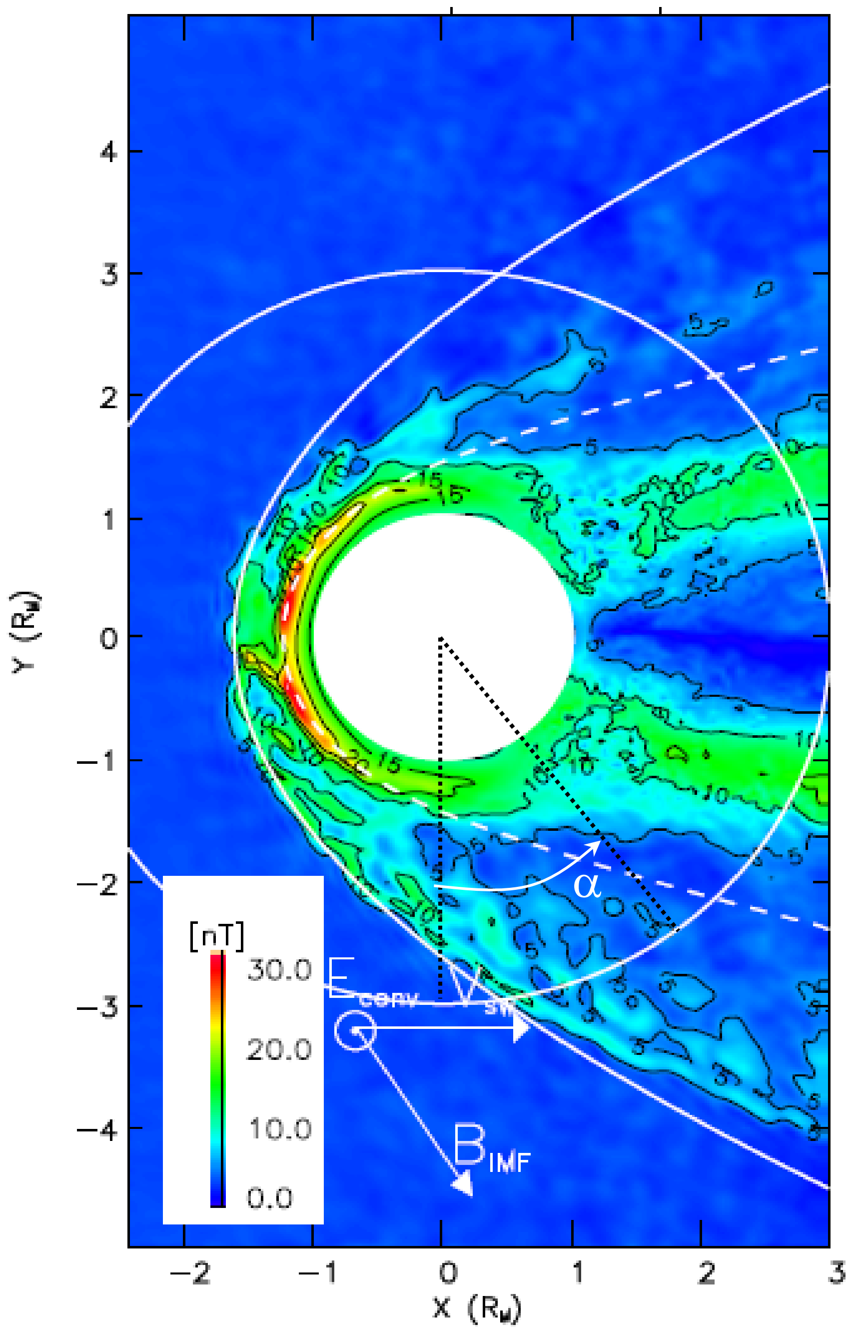
I- Phobos composition as seen from the ejecta cloud



Assumptions

→ 3D test-particle at Phobos (Cipriani et al, 2011)

→Sputtering of Phobos surface by Solar Wind Hydrogen and Helium ions as well as by Planetary protons

→ Micro-meteoritic bombardment of Phobos Surface

→Solar Minimum conditions

→Atomic ejecta (not molecular)

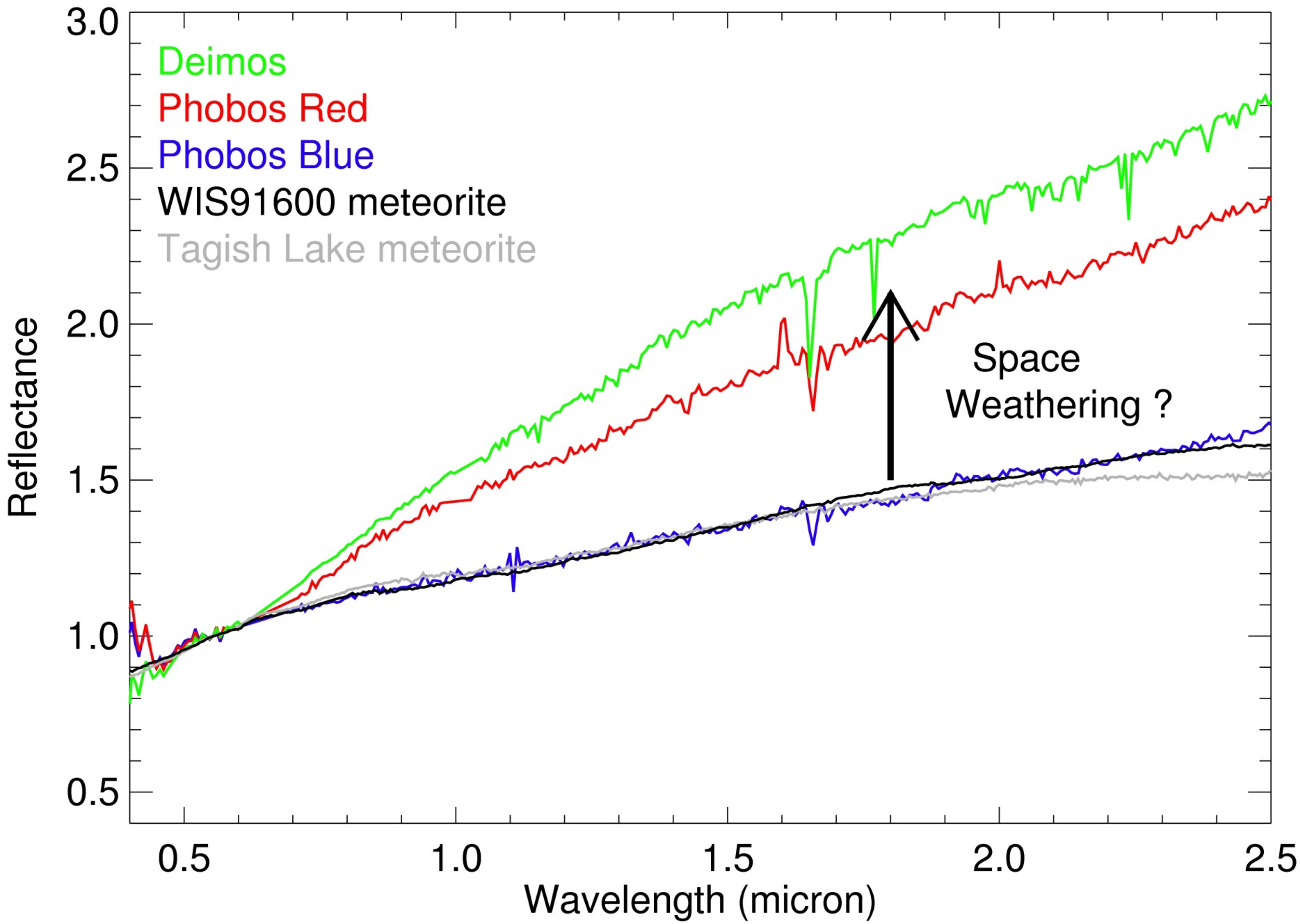
Phobos surface composition was abusively considered as close to that of D- type parents (e.g. Tagish Lake/WIS 91600 meteorites)

Table 1
Mass fraction of the main elements composing Phobos' regolith, used in this study.

Element	Fe	Si	O	Mg	Al	Na	Ca
Mass fraction	0.21	0.1300	0.4100	0.10	0.017	0.005	0.001

Table 2
Ejection rates of material due to micrometeoroid bombardment.

Element	Ejection rate (s^{-1})	Average ejecta speed (km s^{-1})
Fe	3.04×10^{16}	0.94
O	1.17×10^{17}	1.76
Mg	2.58×10^{16}	1.44
Al	2.89×10^{15}	1.36
Ca	2.89×10^{14}	1.11
Na	4.55×10^{14}	1.47



See P. Vernazza et al talk on Wednesday

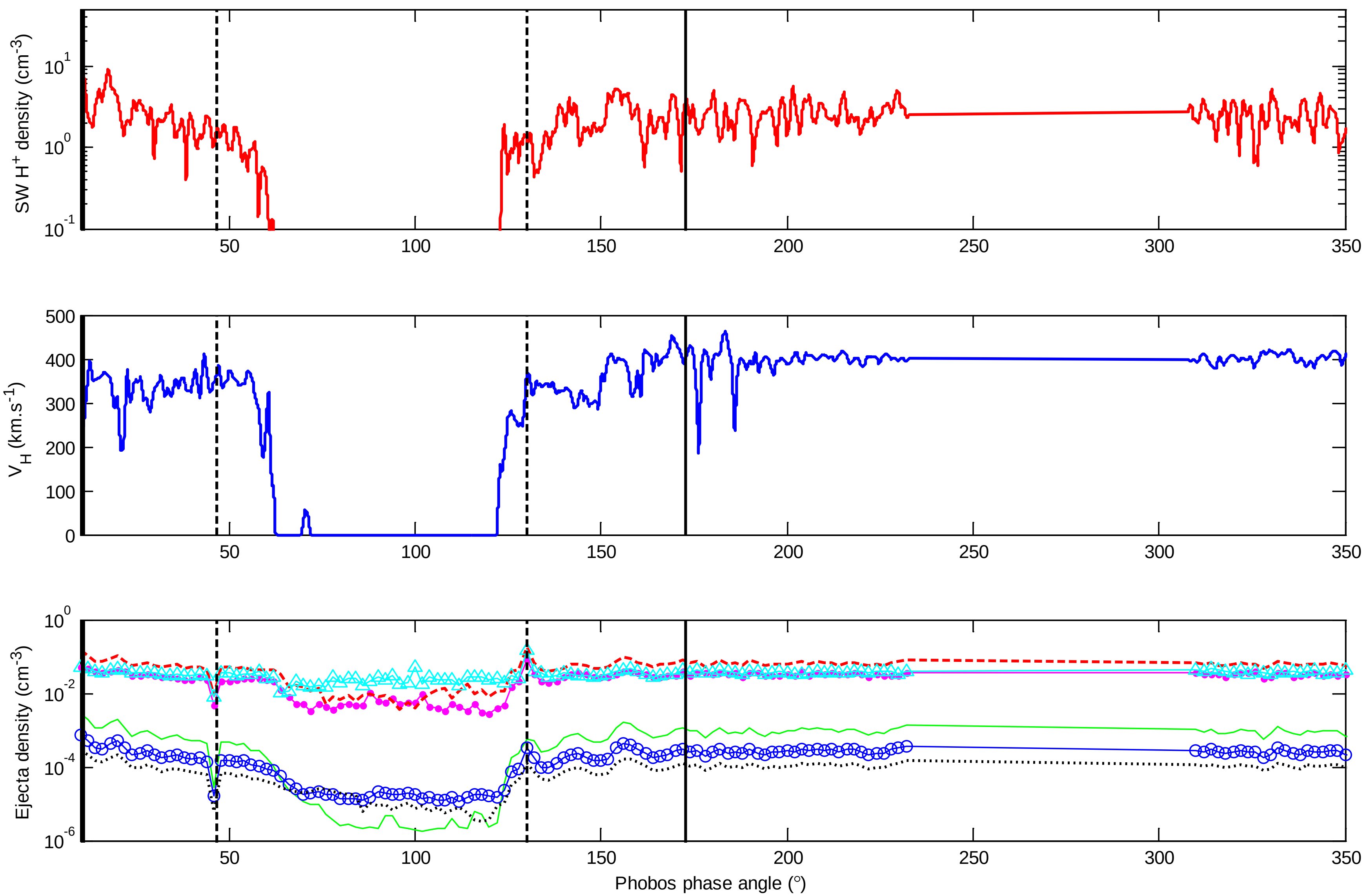


Fig. 2. Upper panel: solar wind protons density at Phobos' orbit. Middle panel: solar wind protons velocity component along the Sun–Mars axis. Lower panel: Evolution of average ejecta densities within 500 km from Phobos' surface as a function of Phobos' phase angle. Light blue line with triangles: Iron, red dashed line: Oxygen, magenta dash-dotted line: Magnesium, green solid line: Aluminium, blue line with circles: Sodium and black dotted line: Calcium. Black vertical lines (10° and 172.6°) indicate the average position of the Bow Shock in the hybrid simulation of Modolo et al. (2005), while black dashed lines (46.7° and 130°) indicate the average position of the Magnetic Piles-up Boundary crossed by Phobos.

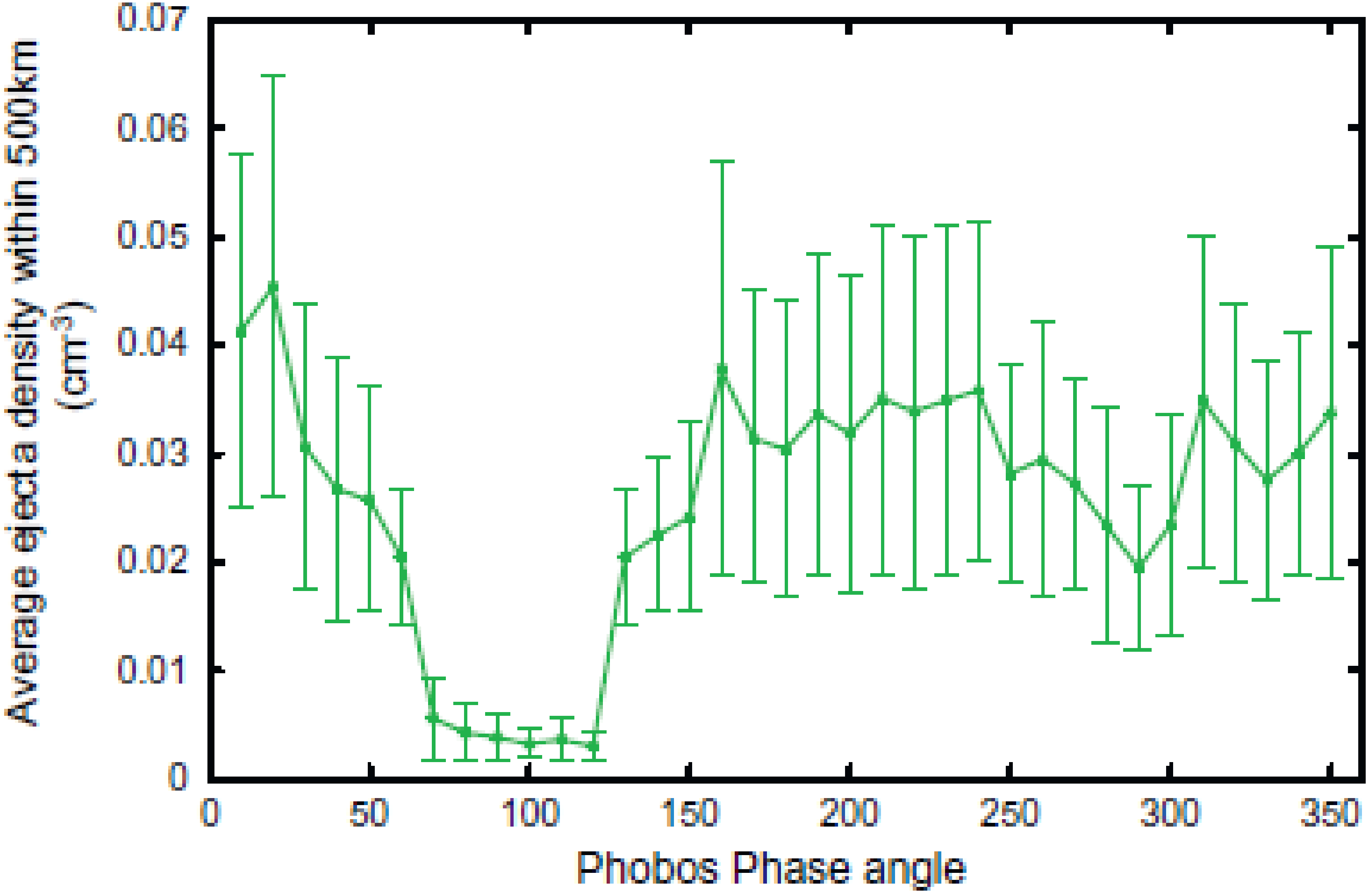


Fig. 3. Average density variations of Magnesium within 500 km of Phobos surface. Errorbars show the standard deviation of the density due to variation of the binding energy in the range (0.1–2 eV).

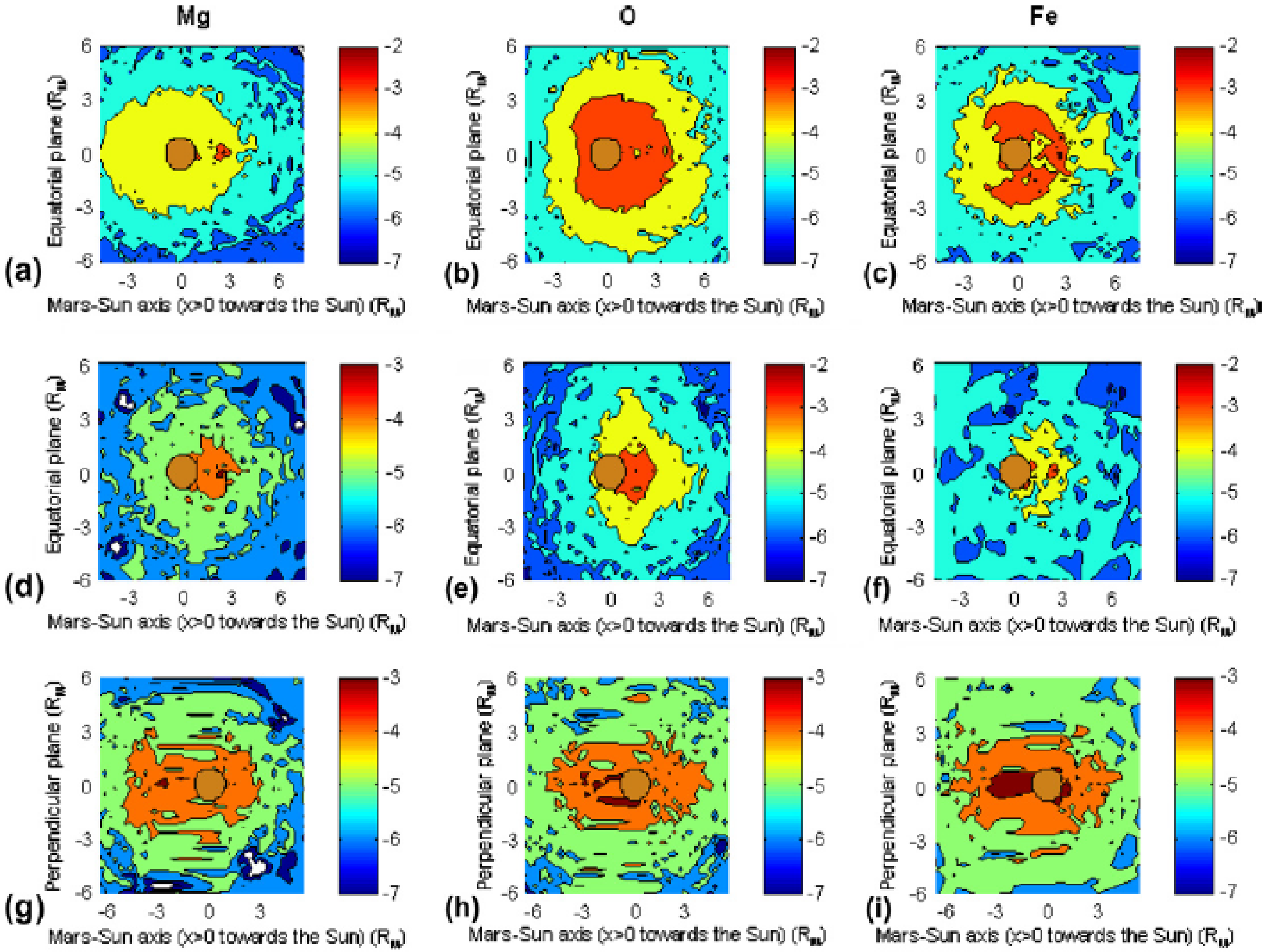


Fig. 4. Morphology of Phobos' ejecta disk for Mg, Fe, and O centered on Mars (distances are given in martian radius), in the equatorial plane (panels (a)–(c)), and in a plane perpendicular (panels (d)–(i)). The *Z* is oriented towards the North pole of Mars, while the *X* axis is aligned with the Mars–Sun direction. In panels (a)–(f), Phobos is at the subsolar point ($X = 2\ R_M$, $Y = 0\ R_M$), whereas its position is anti-solar in panels (g)–(i) ($X = -2\ R_M$, $Y = 0\ R_M$). The colorscale on the right of each panel gives the ejecta density in cm^{-3} (LOG SCALE).

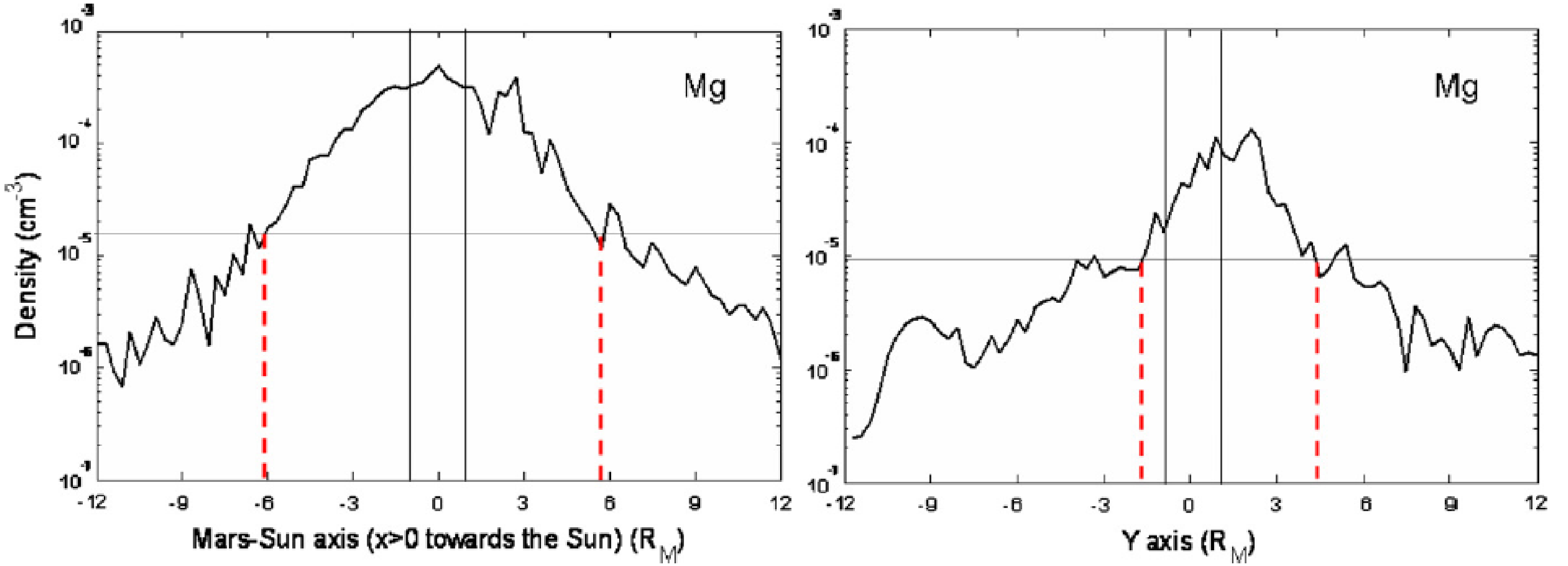


Fig. 5. Density of Magnesium along the Mars–Sun axis (left panel) and along a perpendicular axis (right panel). The disk extension (as defined in the text) along both directions is indicated by the red dashed lines. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

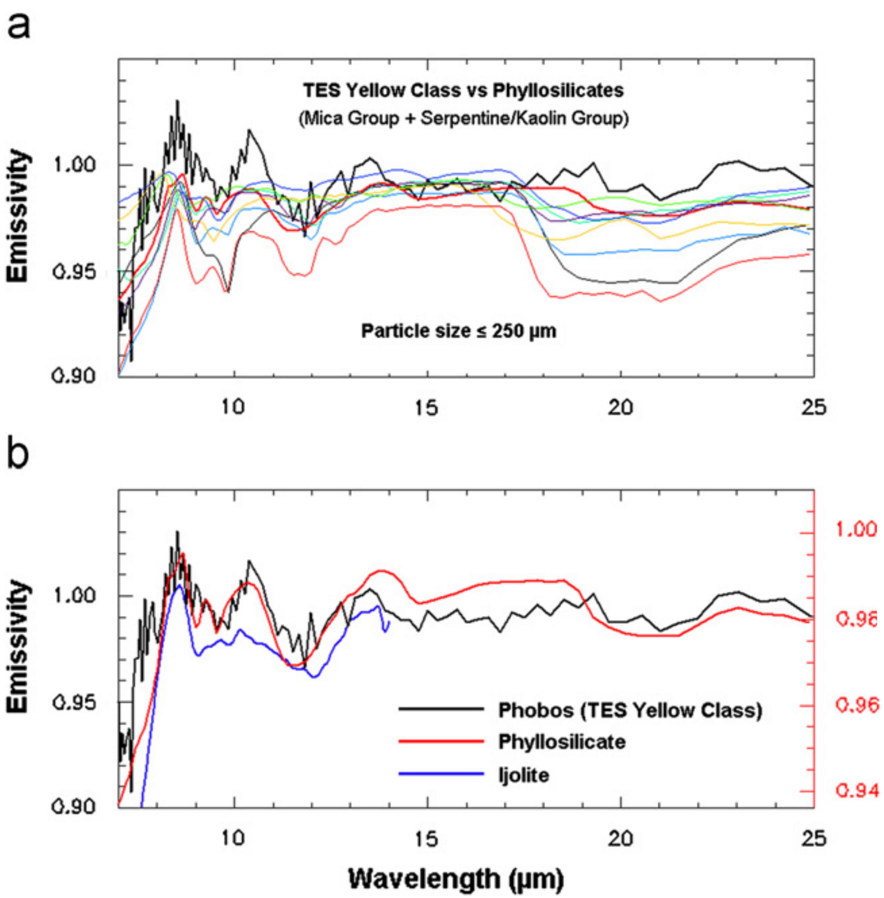
Table 3
Variabilities of solar scattering emission brightness in the vicinity of Phobos along Phobos orbit. Values for Fe and O are not shown because typically lower than 10^{-5} *R*.

Element	Wavelength (Å)	Min (R)	Max (R)	Avg (R)	g-factor (s^{-1})
Ca	4226.728	2.1×10^{-3}	2.7×10^{-2}	1.2×10^{-2}	0.66
Na	5895.924	1.5×10^{-3}	1.0×10^{-1}	7.3×10^{-3}	0.54
Al	3944.006	8.7×10^{-4}	9.5×10^{-3}	4.4×10^{-3}	4.25×10^{-2}
Mg	2852.9631	1.2	2.1	1.5	0.41

Outlook

- *Iron, Oxygen and Magnesium would dominate the ejecta cloud densities*
- *Magnesium would be the only potentially detectable species (emission brightness of 1.4×10^{-3}R/nm) in the UV range (HST/STIS limit sensitivity 4×10^{-3} R at 2852.9631A, S/N=10, 1h integration, resolution 30000)*
- *Molecular sputtered products (non reactive incident ions would produce O_2, H could recombine and give H_2O)*

Further Work : better assumption on surface composition



Giuranna et al, PSS, 2011

Table 3
Summary of hints for Phobos origin.

Data/model	Capture scenario	In-situ scenario
Spectral reflectance (previous works)	Likely[a] *carbonaceous chrondrites* *D-type asteroids*	Likely *Silicate material*
Spectral emissivity (this work)	Possible *achondrites?* *Shergotty?*	Likely *Silicate material*
Celestial mechanics	Unlikely	Likely
Bulk density	Unlikely *D-class material*	Likely *Silicate material*
Bulk porosity (Rosenblatt et al., 2010)	Unlikely *Anhydrous chondrites*	Very likely

→ **Investigate Phyllosilicates and feldspars**

→ **Relevant scattering emission signatures to help investigate the question of Phobos' surface composition ?**

II- Phobos response to the SW as backscattered Hydrogen

(Backscattered) hydrogen observations

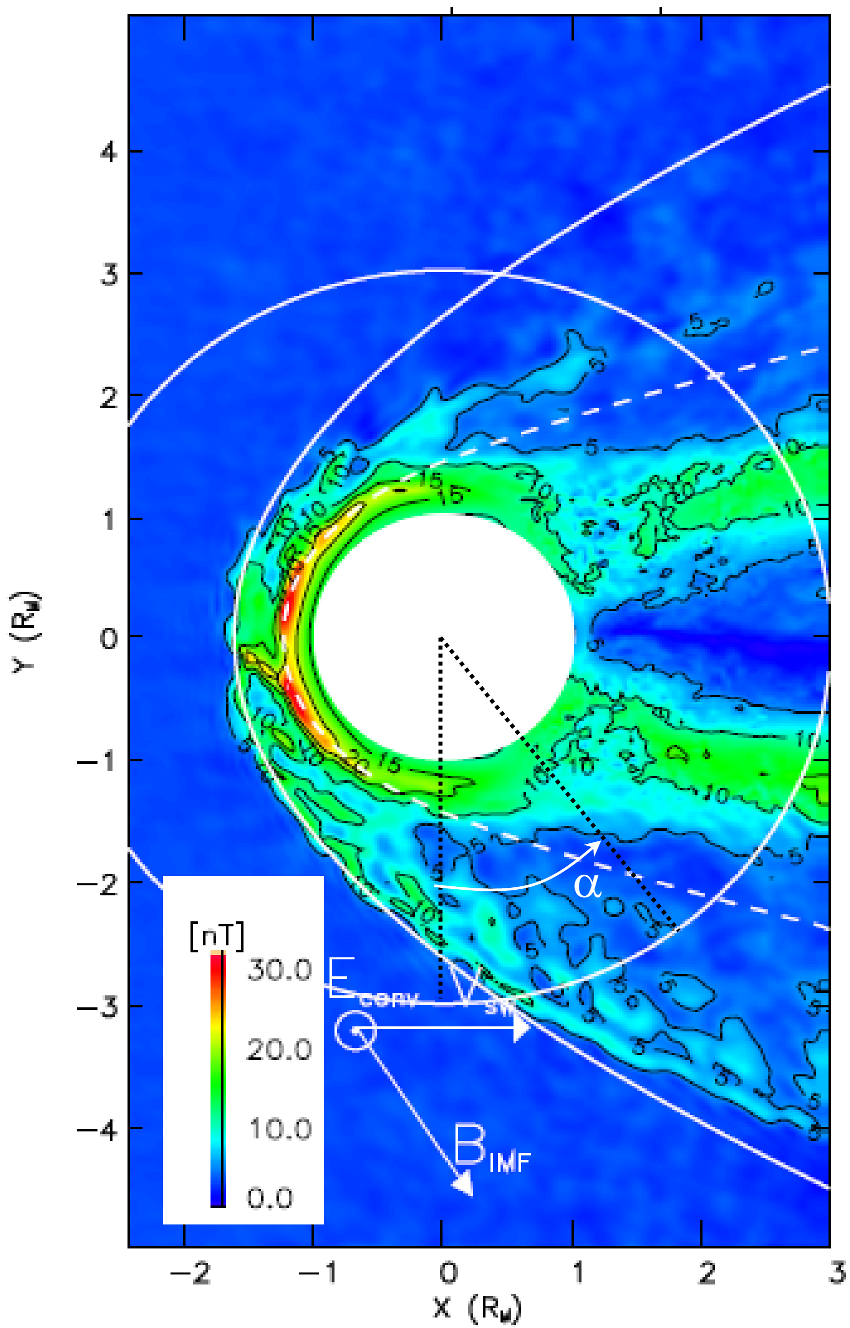
Impact of Solar Wind Protons on planetary regolith results in (re)emission of hydrogen as :

_ Neutrals : observed at the Moon (SARA/Chandrayann 1), not (yet) at Phobos

~ 10-20% of impacting flux (Wieser et al, 2009)

_ Protons : observed at Phobos (MEX/ASPERA3) and the Moon (SELENE and SARA/Chandrayann 1)

~ up to a few % (Saito at al, 2008, Holmström et al 2010, Futaana et al, 2010)



Assumptions

→ 3D test-particle at Phobos (Cipriani et al, 2011)

→Solar Wind Protons/Electrons, Electric Field, IMF input from Hybrid Code (Modolo et al 2004)

→ Planetary protons

→ Angle Vsw / IMF = 56°

→ Reflection coefficient for

-Neutrals : 15 %

-Protons : 5%

→ Non specular in a ~ 30° aperture cone

Questions

- ***Backscattering mechanism → not known***

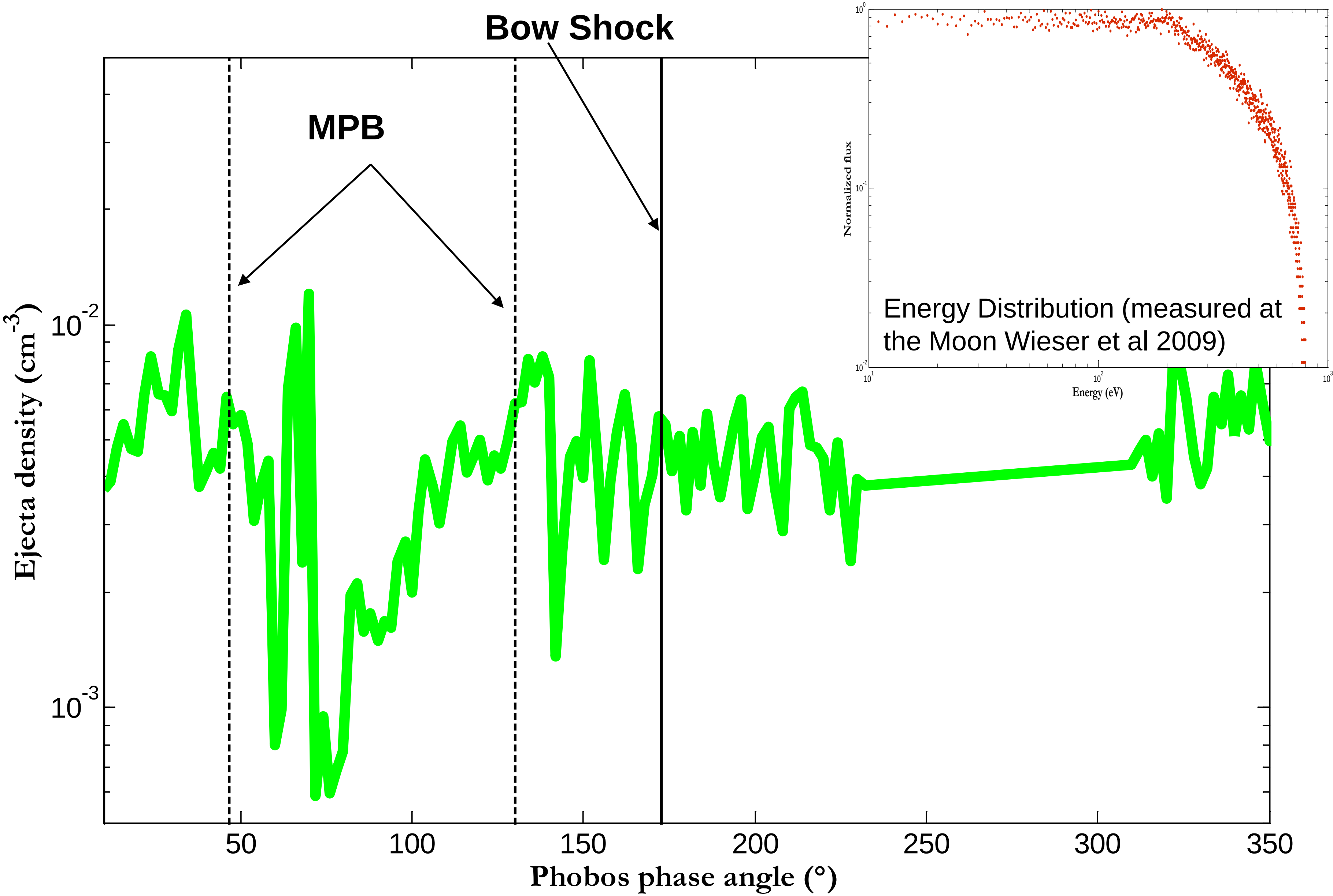
  - Role of surface microphysics: neutralization process ? collision – scattering ? <u>surface charge state</u> <u>and electrostatic potential</u> ?

- ***Refined picture of the Martian Environment :***

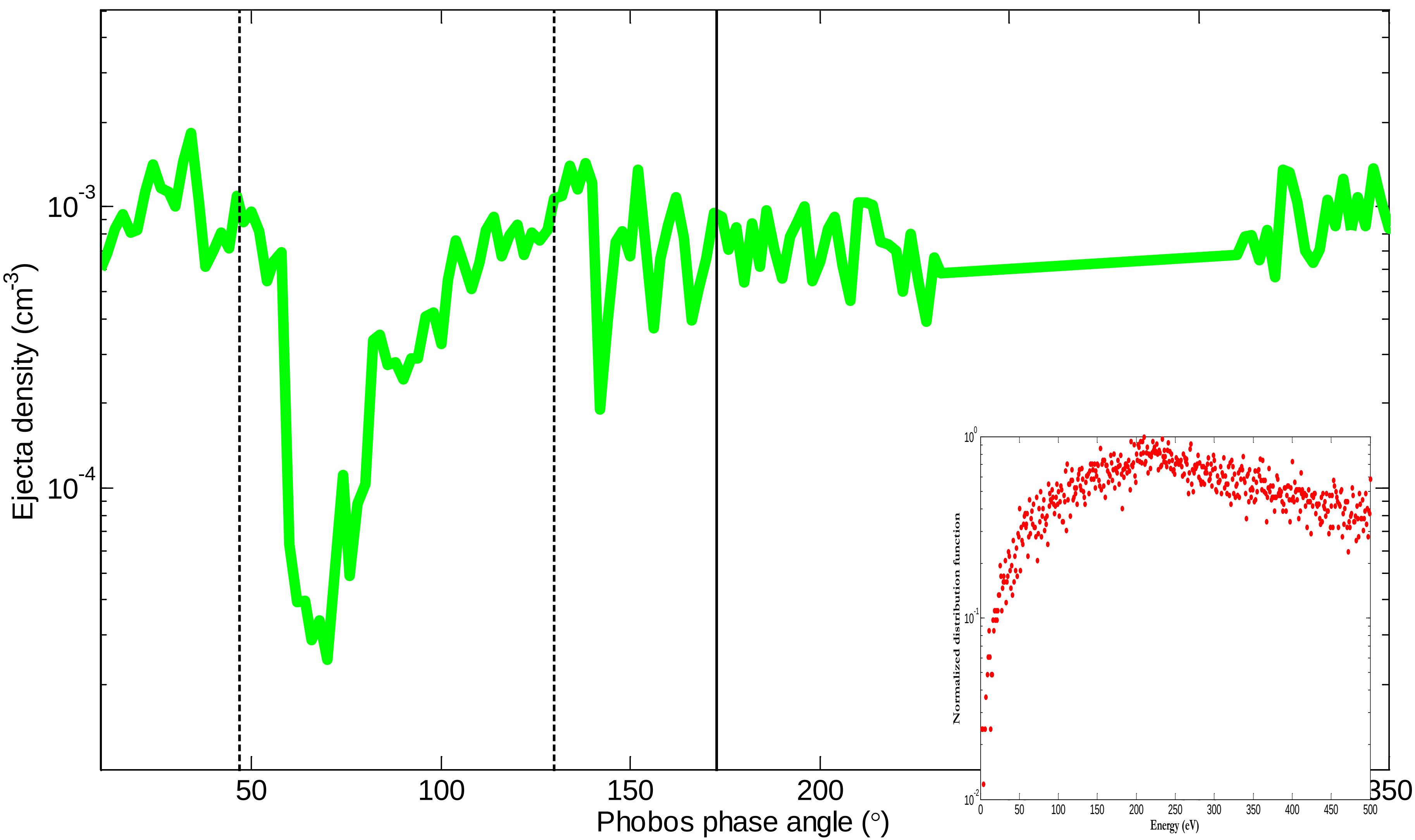
  - Influences classical SW / surface interaction with airless bodies (e.g. Holmström et al 2010)

  - Backscattered spatial distributions ?

Densities (non escaping) at Phobos Orbit



Backscattered Protons – Densities



Backscattered protons – Spatial Distribution