Phobos photometric properties from Mars Express HRSC observations

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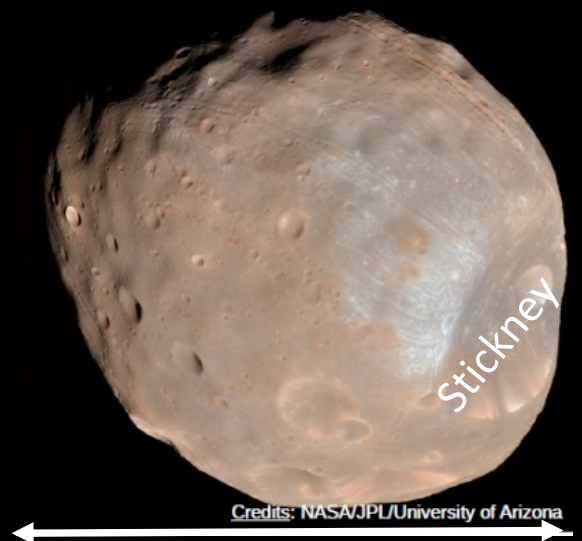
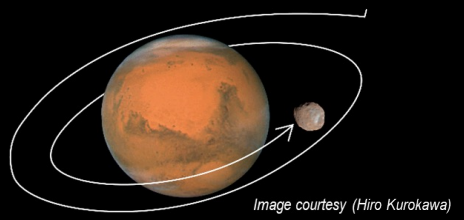
Context and motivation



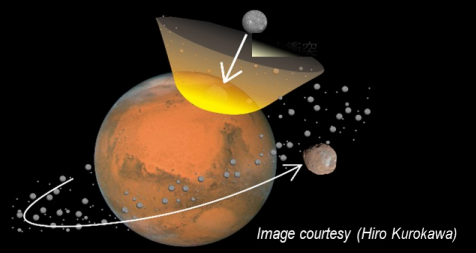
- **Blue and red units**
- **Complex geology**
- **Grooves**
- **Debated origin**

Capture of asteroid



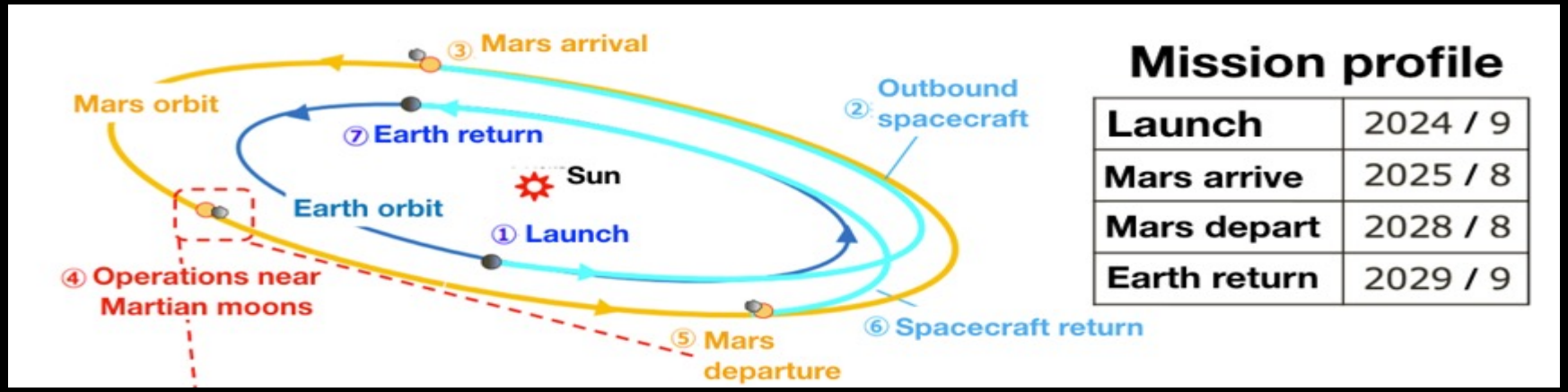
Consistent with D- or T-type IR spectra

***in situ* formation by an impact**



Consistent with low eccentricity & inclination

Better knowledge of **Phobos** properties in support of the JAXA sample return mission MMX - Martian Moons eXploration mission : in situ investigation of the martian system & samples return from Phobos to finally understand Phobos & Deimos origin

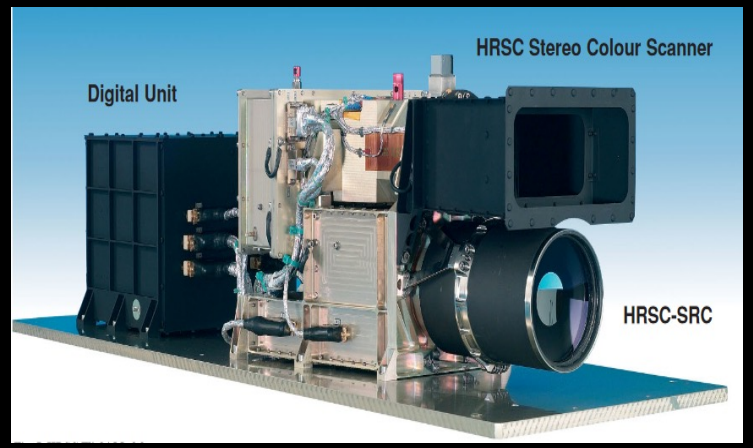


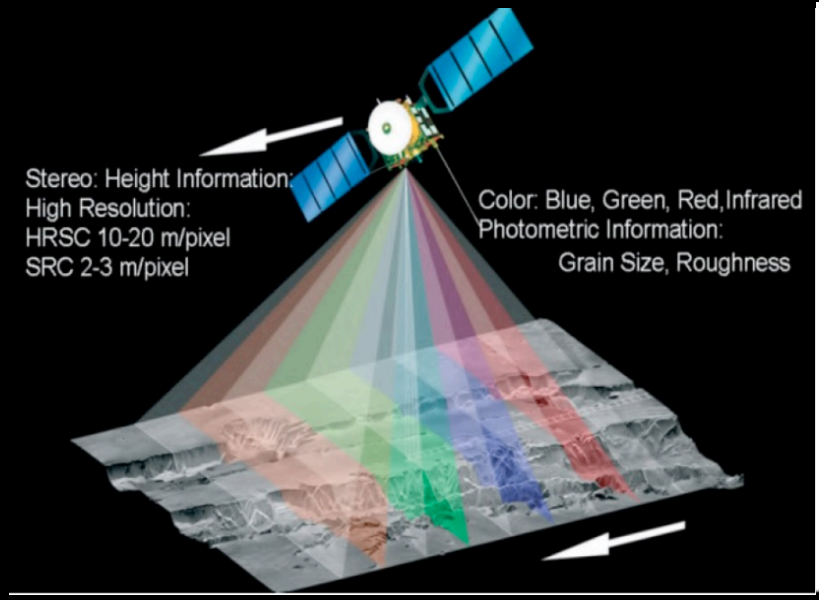
Mission profile

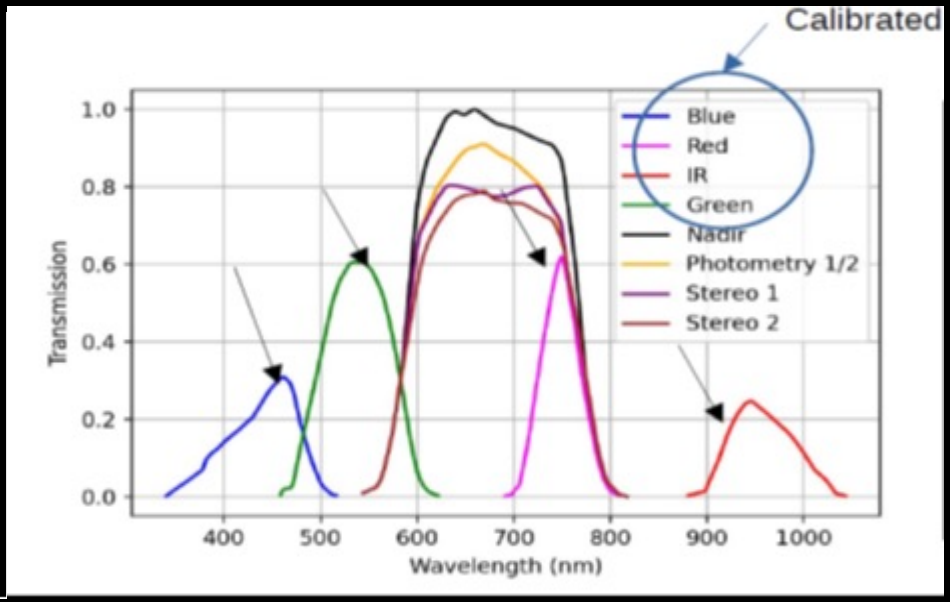
Launch	2024 / 9
Mars arrive	2025 / 8
Mars depart	2028 / 8
Earth return	2029 / 9

Mars Express (MEX) Observations

ESA-Planetary Science -→ unpublished data on Phobos photometry from MEX
MEX: launched in 2003, still operational, extended until 2027
HRSC camera: 9 filters + Super-Resolution Channel (SRC)







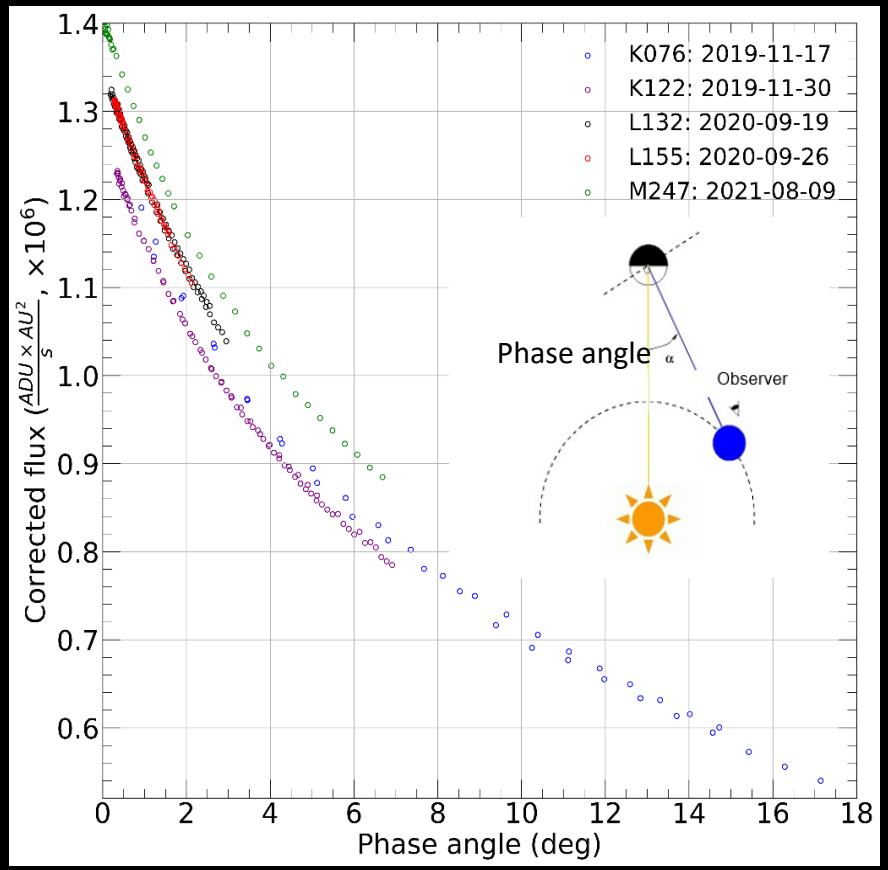
- Analysis of ~1200 images (up to 2021)
- Blue-Green-Red-IR filters: calibrated but with very few observations at α<10 degrees.
- SRC data: not absolutely calibrated but observations cover very small phase angles during 5 orbits

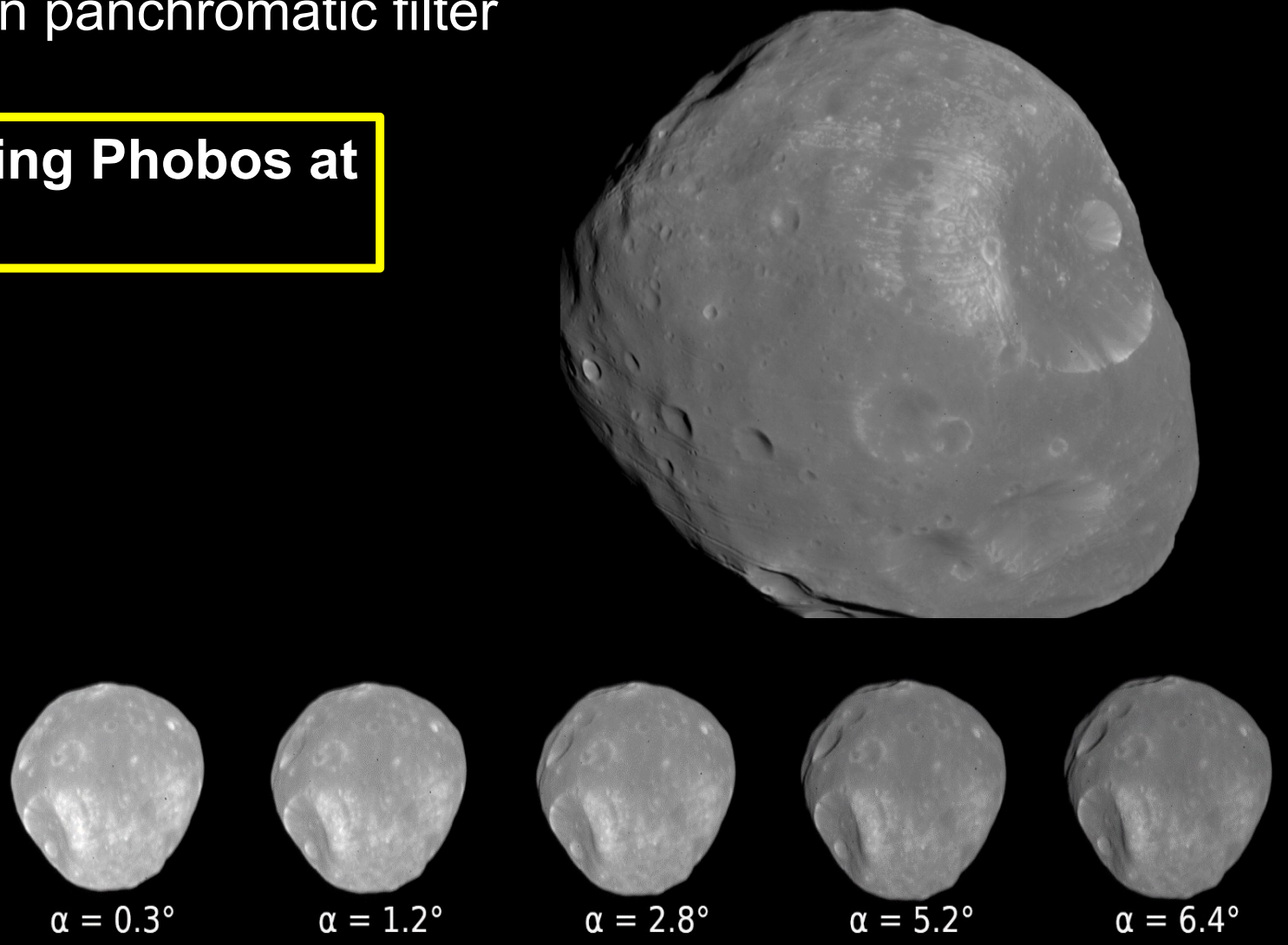
SRC data: Phobos opposition surge

K076: 2019-11-17

- Cover the 0-17 deg in phase in panchromatic filter (650±250)nm in 2019-2021

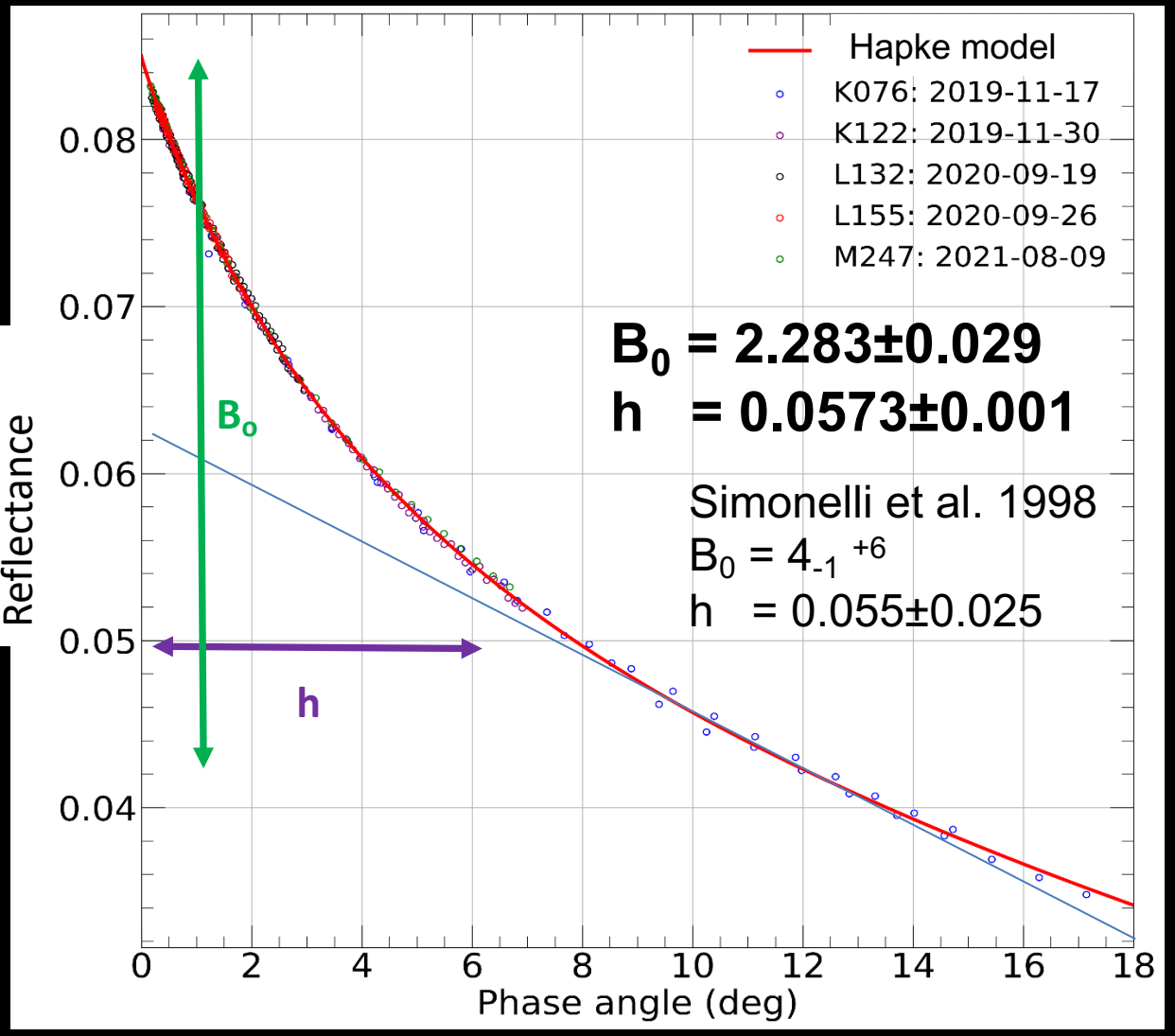
Unique observations covering Phobos at low phase angles



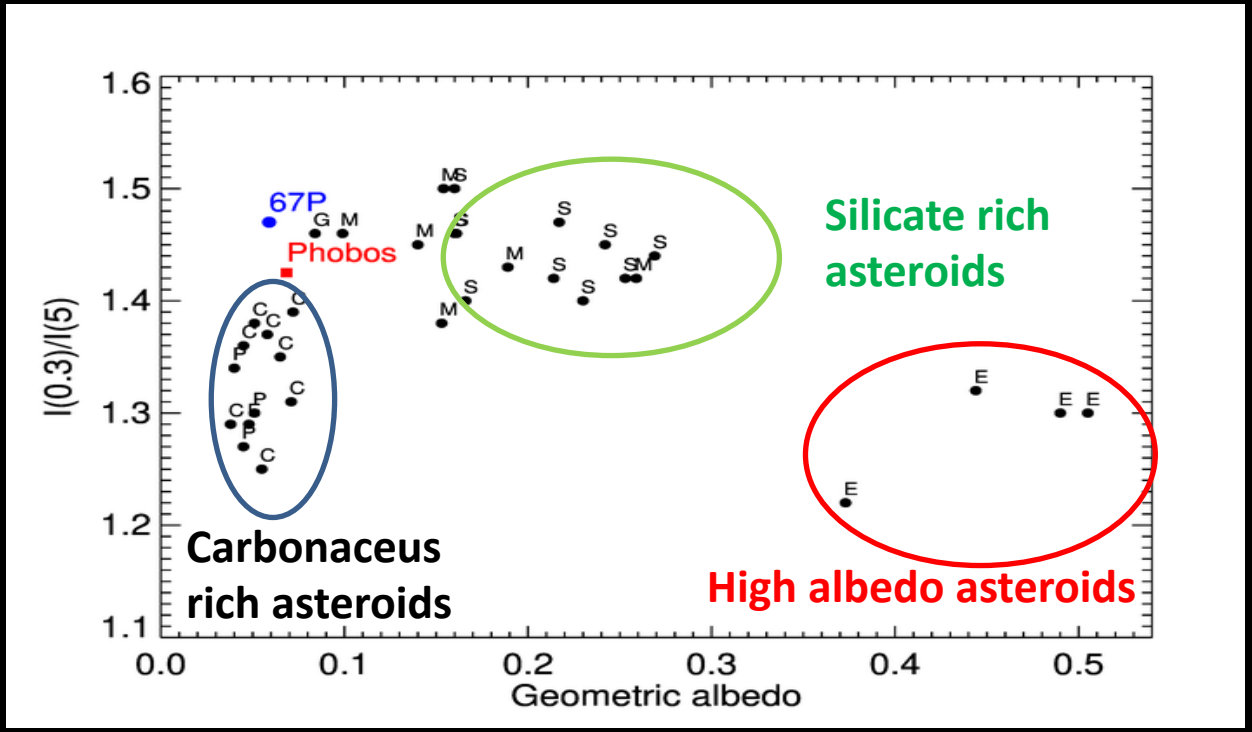


M247:2021-08-09

SRC data: Phobos opposition surge



- **strong opposition surge → thick dust layer, surface dominated by particles size bigger than tens of micron**
- **Phobos photometric properties** show analogies with **67P nucleus, and with moderate albedo primitive asteroids**

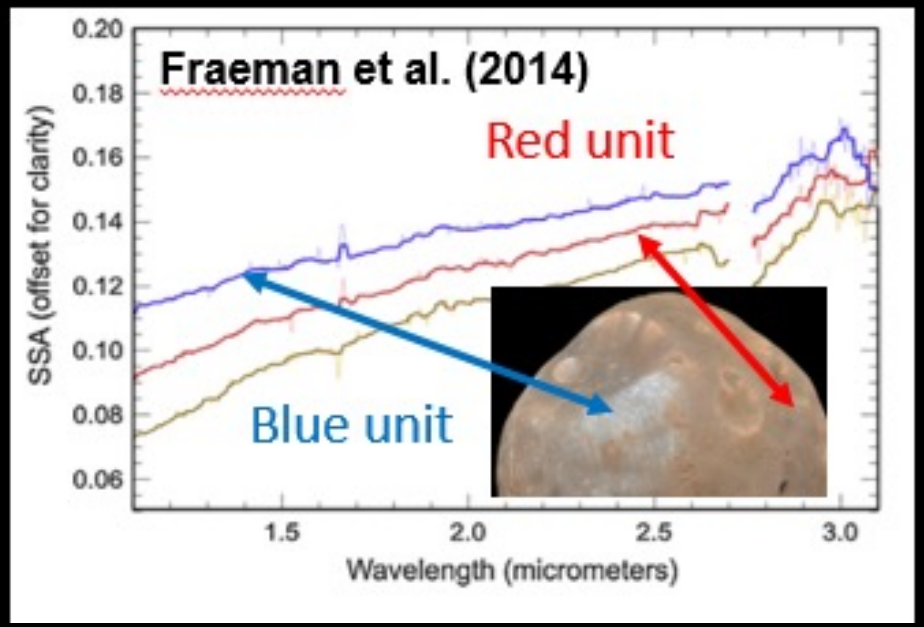


HRSC calibrated data

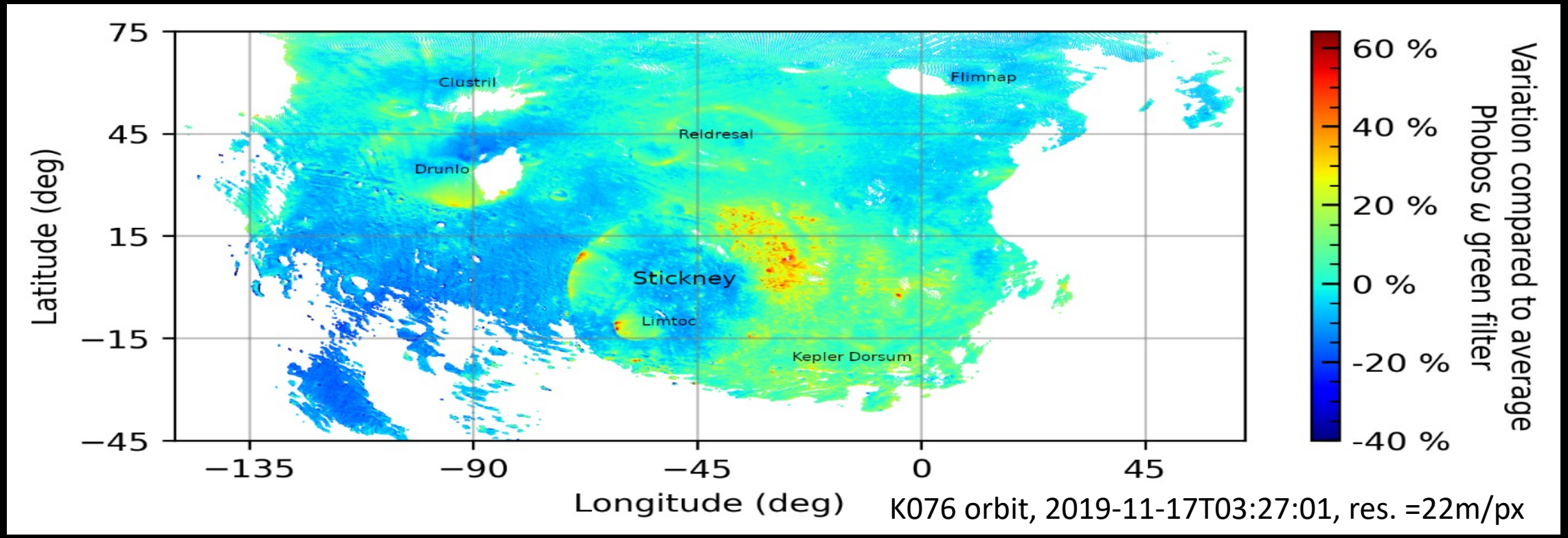
Filter	central wavelength (nm)	w
Blue	444	0.063
Green	538	0.071
Red	748	0.072
IR	956	0.082

w=single scattering albedo
Ceres : $0.07 < \omega < 0.11$
Bennu : $\omega = 0.043$
Ryugu : $\omega = 0.044$
67P : $\omega = 0.034$
Moon : $\omega = 0.21$

- Phobos has a relatively dark surface with albedo increasing with the wavelength
- Material is brighter than that typically observed in carbonaceous rich bodies like Bennu or Ryugu
- The brightest regions are associated with the blue unit
- High surface porosity (87%) → thick dust mantle and/or complex structure of surface grains



SRC- Relative albedo map



- The northeast Stickney rim, the grooves inside it, the west rim of Limtoc craters are the brightest areas on Phobos, all associated with the blue unit → crater “fresher” ejecta
- Stickney floor is about 10% darker than the average surface confirming literature results (Simonelli et al., 1998)
- The equatorial-West side of Stickney is also 15 % darker than average→ local variations in composition and/or surface structure (grain size, porosity,..)

Conclusions

- Unique MEX-SRC dataset →**best coverage of Phobos opposition effect so far**
- Phobos shows a **strong opposition effect and high surface porosity**→ presence of a thick dust mantle
- Albedo variations across the surface: blue unit is up to 50-65 % brighter than the average red terrain. The floor and the west side of Stickey are among the darkest regions on Phobos
- Phobos phase function shows analogies with moderate albedo **C-type asteroids, porosity and opposition parameters are very similar to those of 67P nucleus**

Important results in support of the sample return MMX –JAXA mission, which will study the Mars system and will sample Phobos in the blue and red units

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