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Abstract link:

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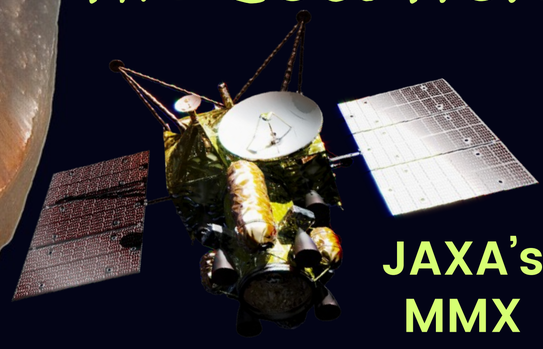
SPECTRAL-MINERALOGICAL CORRELATIONS IN METEORITE AND SIMULANT ANALOGUES FOR PHOBOS

THE QUESTION

Phobos' origin is unresolved: debris from a giant impact between Mars and an asteroid, or a **captured primitive asteroid.**
Remote spectra alone cannot distinguish these - there is no mineralogical ground-truth.

JAXA's MMX mission will return samples from **Phobos in 2031** to answer the question.

THE SOLUTION



JAXA's MMX

To interpret MMX's observations, we propose:
A spectral-mineralogical reference catalogue built from powdered meteorite analogues.
We link **FTIR reflectance spectra** to **XRD mineralogy** on the same powder aliquot.
This catalogue will inform sampling site choices and evaluate **returned sample spectra.**

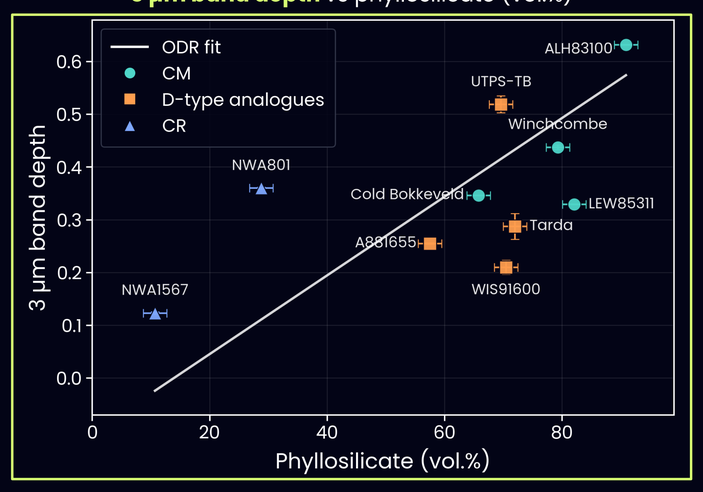
Methods:

We measured **diffuse FTIR reflectance spectra** (1.6-25 μm) and **PSD-XRD** on the same <40 μm particle-size powder of 23 meteorites and the UTPS-TB Phobos simulant, isolating the effect of mineralogy on the spectra.
Samples include CM, CR, and CO carbonaceous chondrites, ordinary chondrites, ureilites, and the Martian meteorites Nakhla and Tissint, for both the **captured-asteroid** and **giant-impact** hypotheses.
Linear relationships between spectral features and mineral abundance were fitted using orthogonal distance regression (ODR).

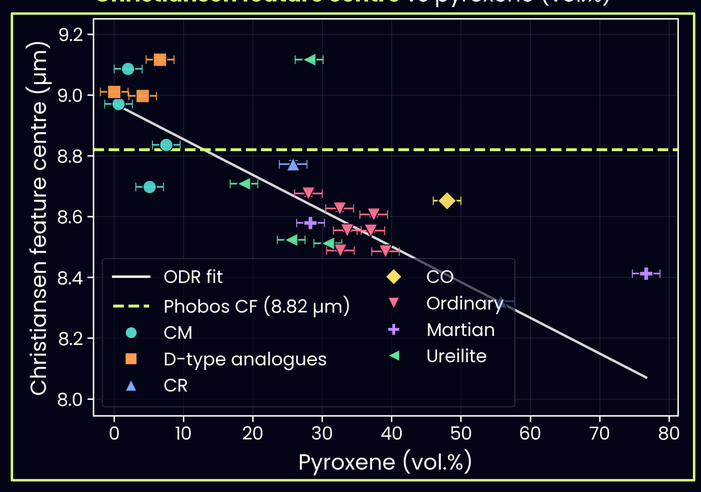
Results:

Spectral-mineralogical trends. Meteorite trends are used to predict Phobos's mineralogy.

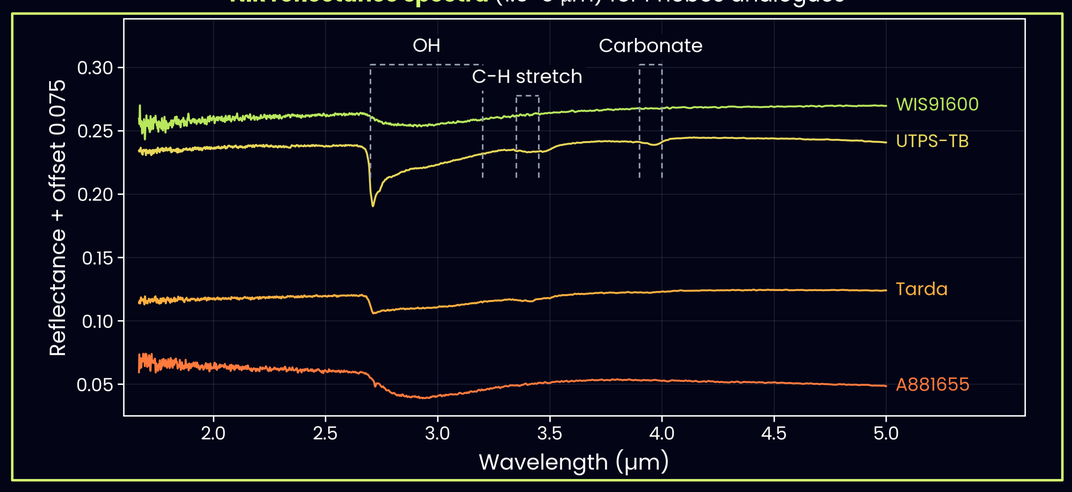
3 μm band depth vs phyllosilicate (vol.%)



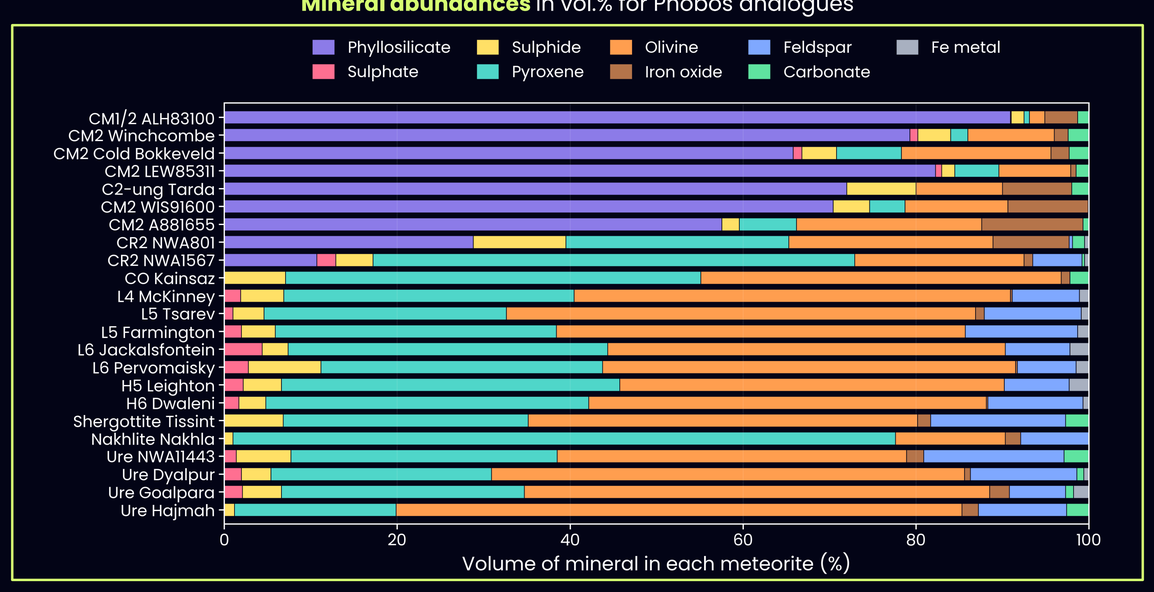
Christiansen feature centre vs pyroxene (vol.%)



NIR reflectance spectra (1.6-5 μm) for Phobos analogues



Mineral abundances in vol.% for Phobos analogues



Testing the formation hypotheses

- Phobos' CF (8.82 μm) implies **~13 vol.% pyroxene, ~10 vol.% olivine,** which are low anhydrous-silicate abundances matching carbonaceous chondrites.
- This rules against both the ordinary-chondrite mineralogy of inner-Solar-System capture and the pyroxene-plagioclase igneous mix expected from giant impact.
  - No 3 μm or carbonate feature is yet confirmed at Phobos; every hydrated meteorite here has a band depth far stronger than the published upper limit, **consistent with a space- weathered primitive surface.**

Conclusion:

1. Band depth of 3 μm feature varies with retained phyllosilicate; **CF position** varies with pyroxene abundance.

2. No 3 μm feature is confirmed at Phobos, and its CF (8.82 μm) matches the **carbonaceous chondrites** most closely.

3. Our results favour capture of a primitive, aqueously-altered outer Solar System body which is space-weathered.

These conclusions will be tested by MMX sample return...

References:
[1] Citron, R. et al. (2015) Icarus 252:334-338. [2] Pajola, M. et al. (2013) ApJ 777:127. [3] Kuramoto, K. et al. (2022) EPS 74:12. [4] Miyamoto, H. et al. (2021) EPS 73:1-17. [5] Bates, H. C. et al. (2023) M&PS 1-23. [6] Cressey, G. et al. (1996) Powder Diffr. 11:35-39. [7] Wargnier et al. (2024) Icarus 421 116216. [8] Barucci, M. et al. (2025) EPS 12:69. [9] Knollenberg, J. et al. (2025) EPS 12:53.