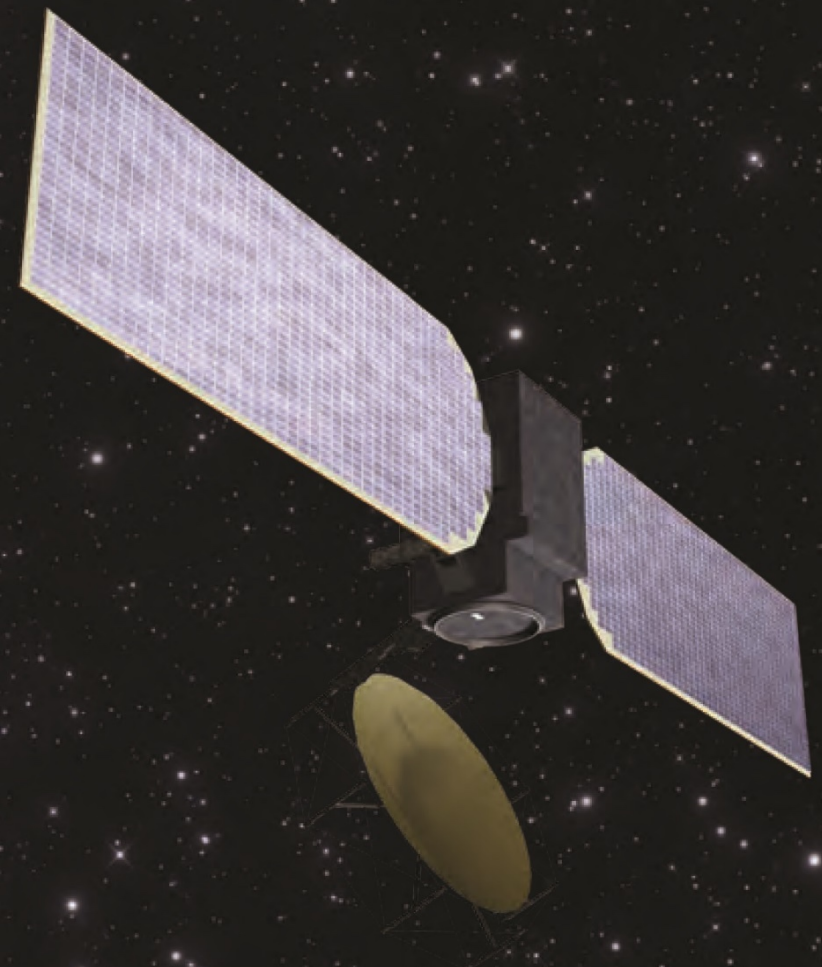
Athena

First encounter of (2) Pallas with a SmallSat

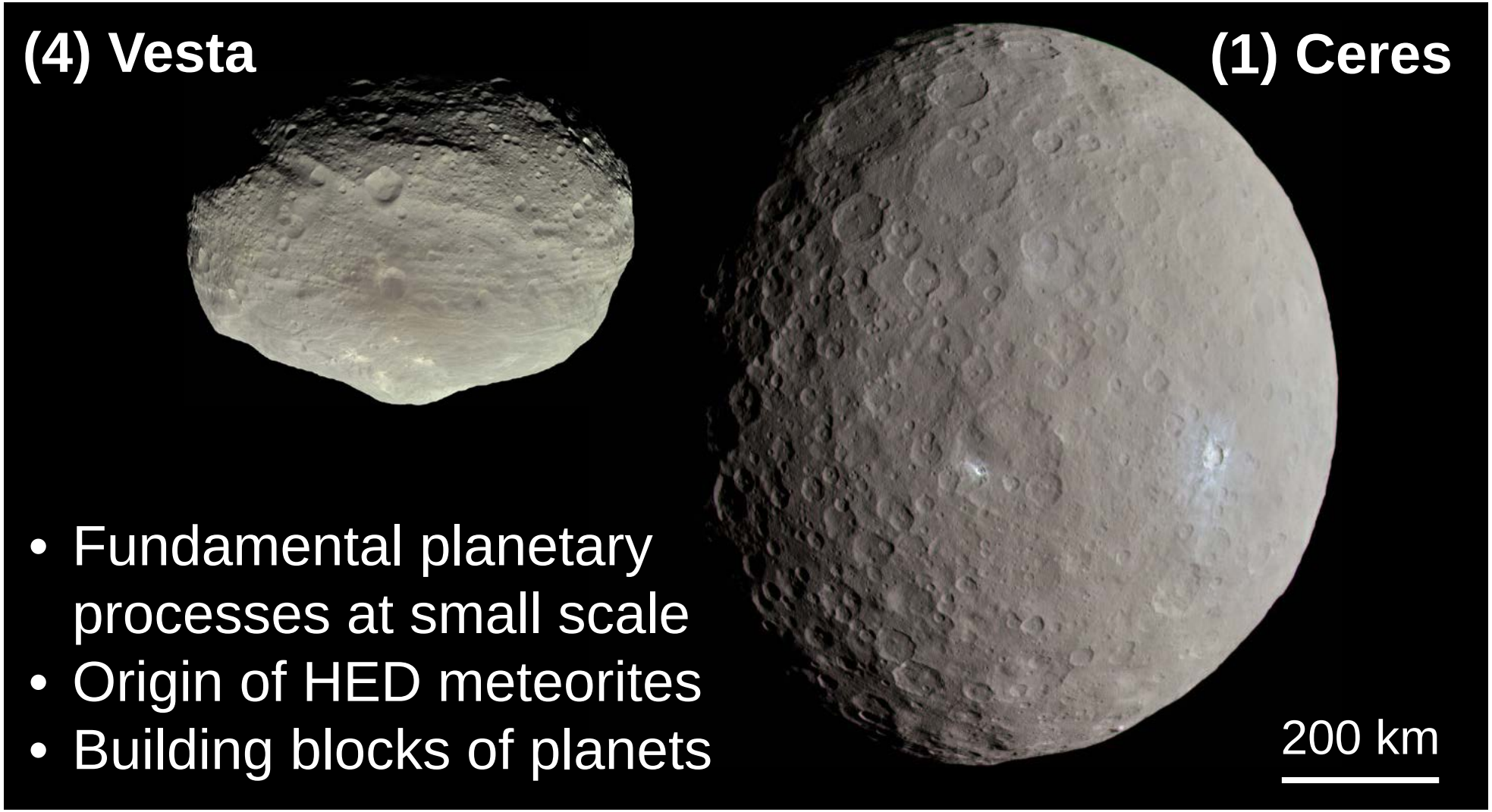


Joseph O'Rourke (*PI, ASU*)

Calina Seybold (*PM*), Julie Castillo-Rogez (*PS*)

Co-Is: L. Elkins-Tanton, R. Fu, T. Harrison, S. Marchi, R. Park, B. Schmidt, D. Williams

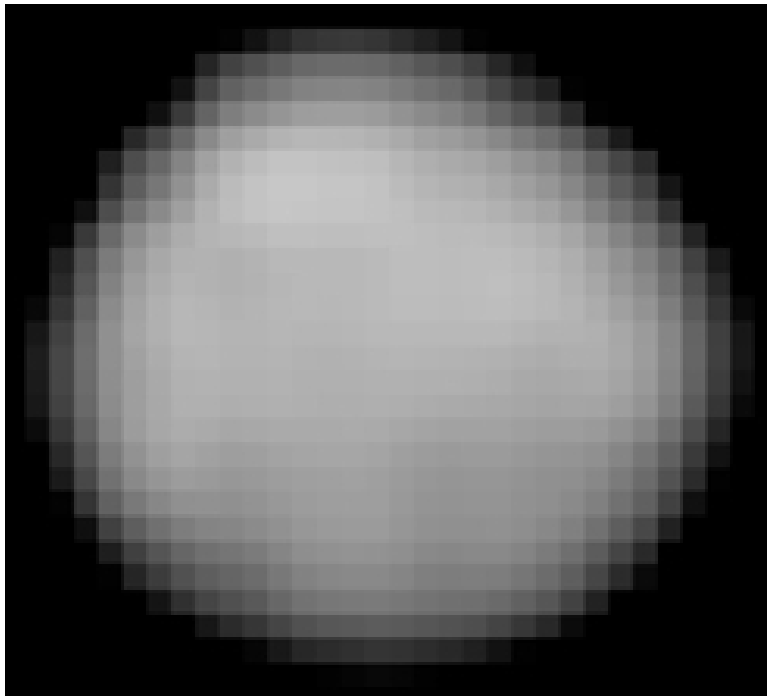
NASA Dawn: Two Protoplanets



- Fundamental planetary processes at small scale
- Origin of HED meteorites
- Building blocks of planets

Pallas Awaits Exploration

- Missing link between (1) Ceres and (4) Vesta in terms of water content and surface geology
- Largest unexplored object inside Neptune's orbit
- Parent of near-Earth asteroids including (3200) Phaethon
- Extreme *i* (>35º) and *e* indicates unique dynamical history



HST | Schmidt et al. 2009

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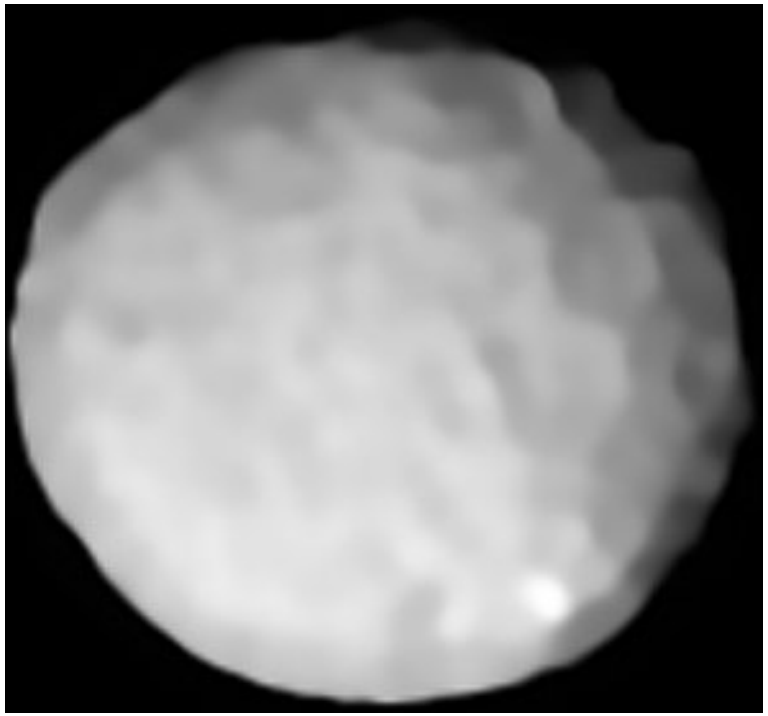
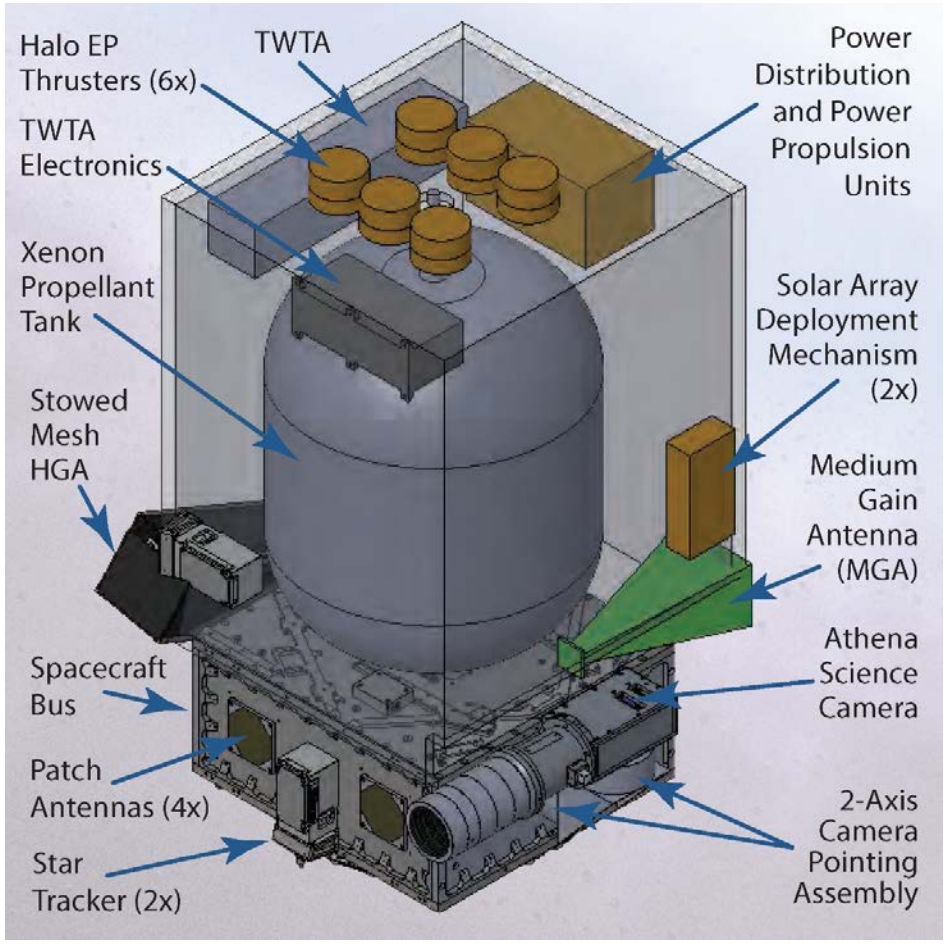
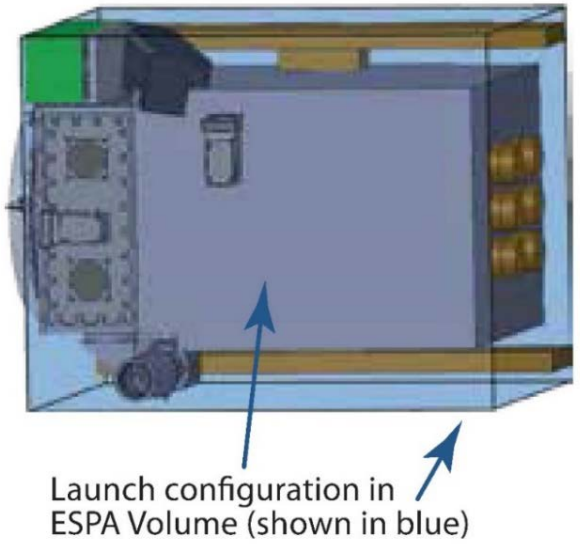


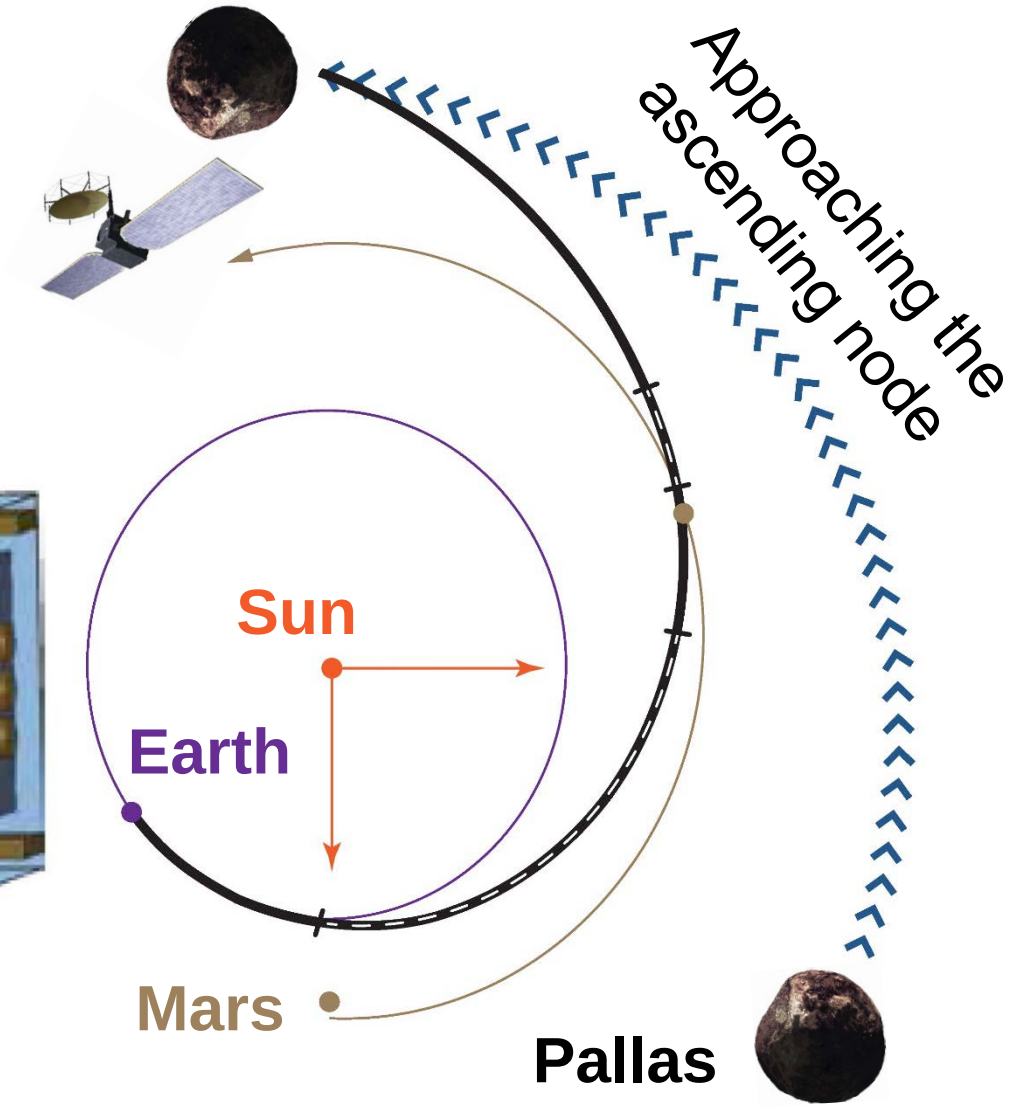
ESO/VLT-SPHERE

Athena: Catch Pallas at the Ecliptic



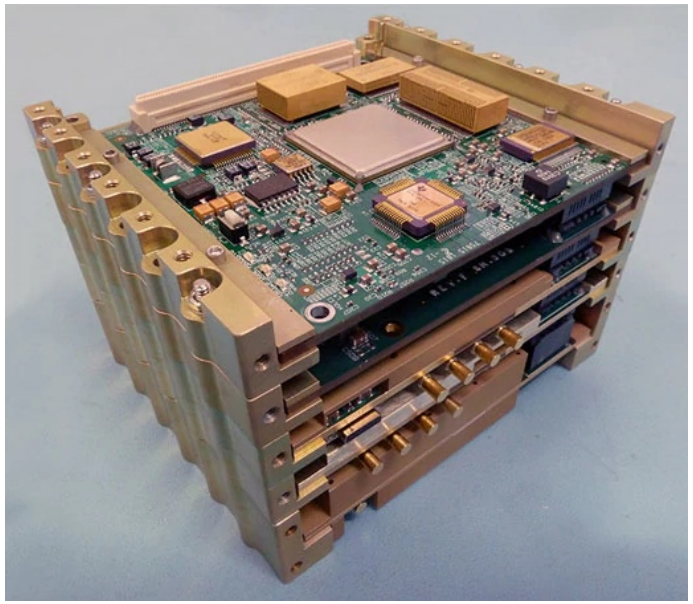
Pallas encounter
Radio science
(2 days)
RGB imaging
(8 hours)





Payload: High Heritage, Low Cost

Athena Science Camera
Panchromatic & RGB color
Geologic mapping & topo.



Radio science
Iris X-band radio
Mass measurement

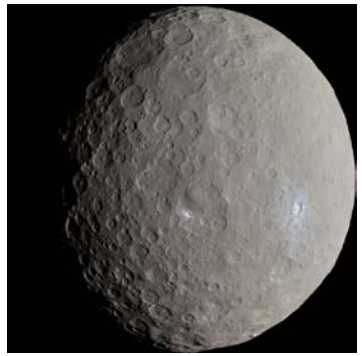
Athena: Decadal-Priority Science

Science Goals	Science Objectives
1. Understand the role of water in the evolution of Pallas	A. Determine the average density.
	B. Determine the rheology and geology of the near surface.
2. Constrain the origin and evolution of Pallas & its impact family.	C. Determine the history and effects of impacts on Pallas.

Imaging (Encounter Hemisphere)	
Panchromatic *SNR > 50* *<0.5 pix. blur*	<150 m GSD
	<300 m (≥3x stereo)
Color (RGB) *SNR > 80*	<500 m GSD

Radio Science (2-way Doppler)
Gravity field to degree 0 (total mass) Performance simulation predicts <0.1% precision

Objective A: Bulk Water Content



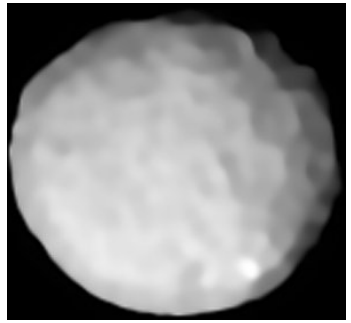
Ceres

~30% H_2O

2161 kg/m^3

Schmidt & Castillo-Rogez 2012

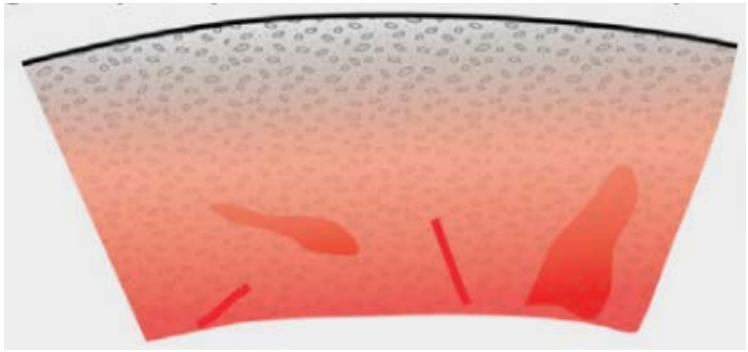
???



Pallas

2400 ± 250 kg/m^3

3400 ± 900 kg/m^3



Fu & Elkins-Tanton 2014

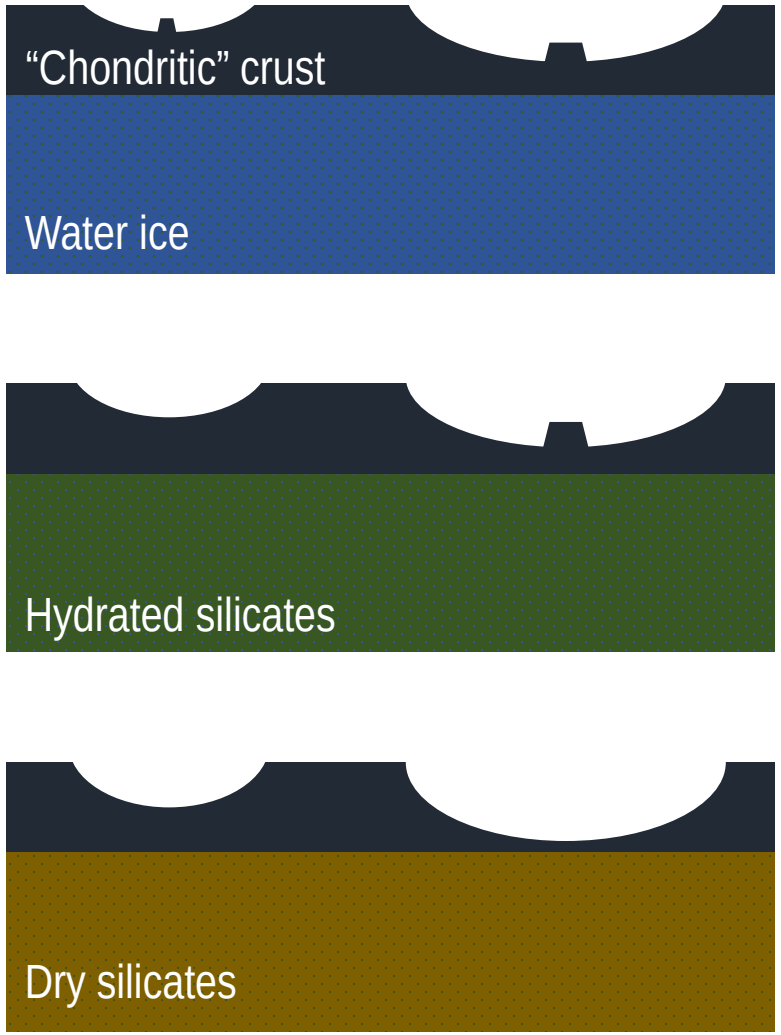
Vesta

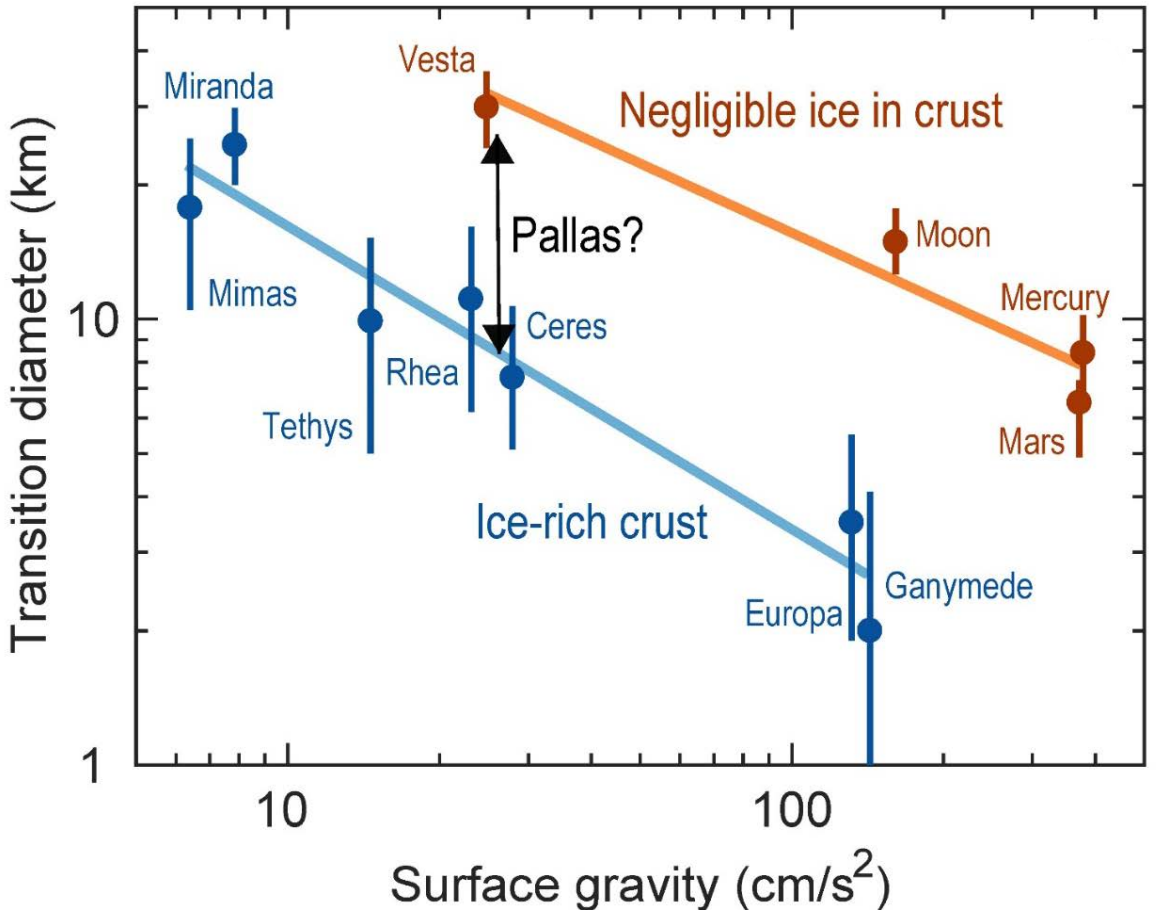
~0% H_2O

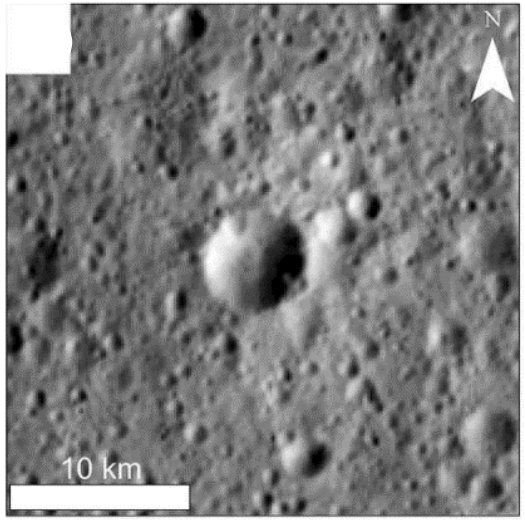
3456 kg/m^3

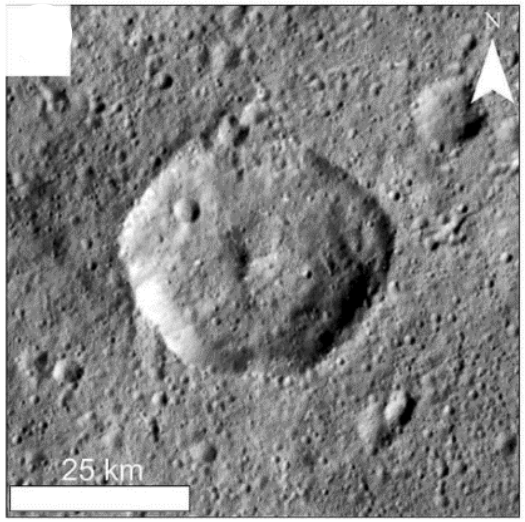
Does aqueous alteration on the surface signal that Pallas is water-rich?

Objective B: Internal Structure



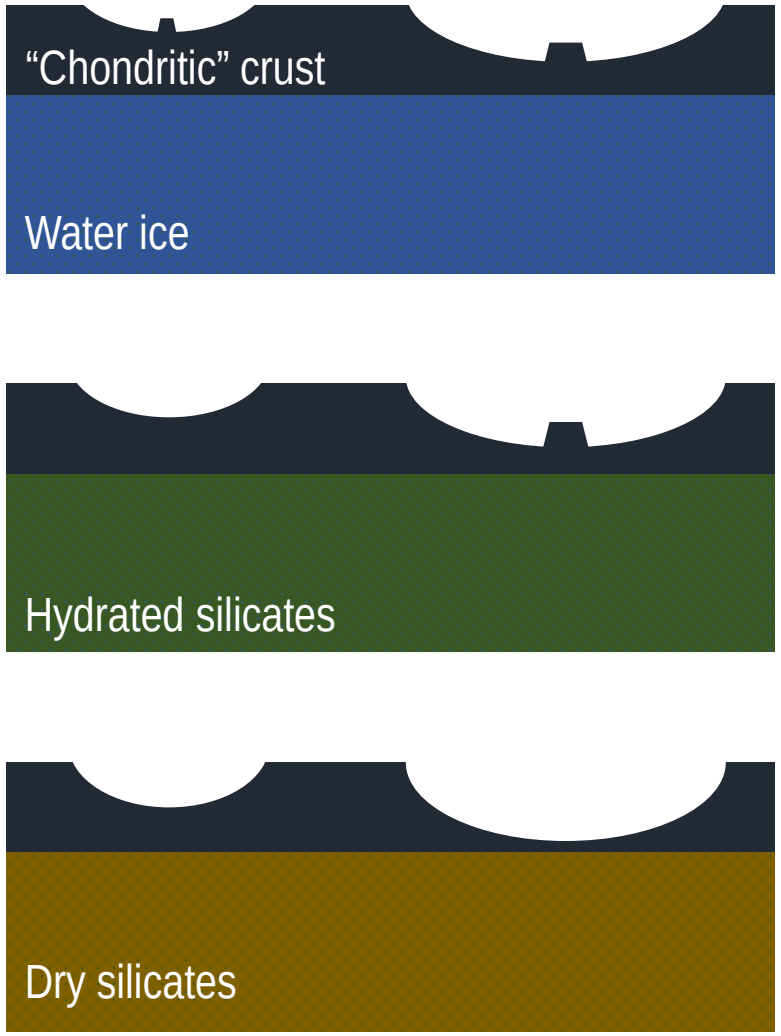


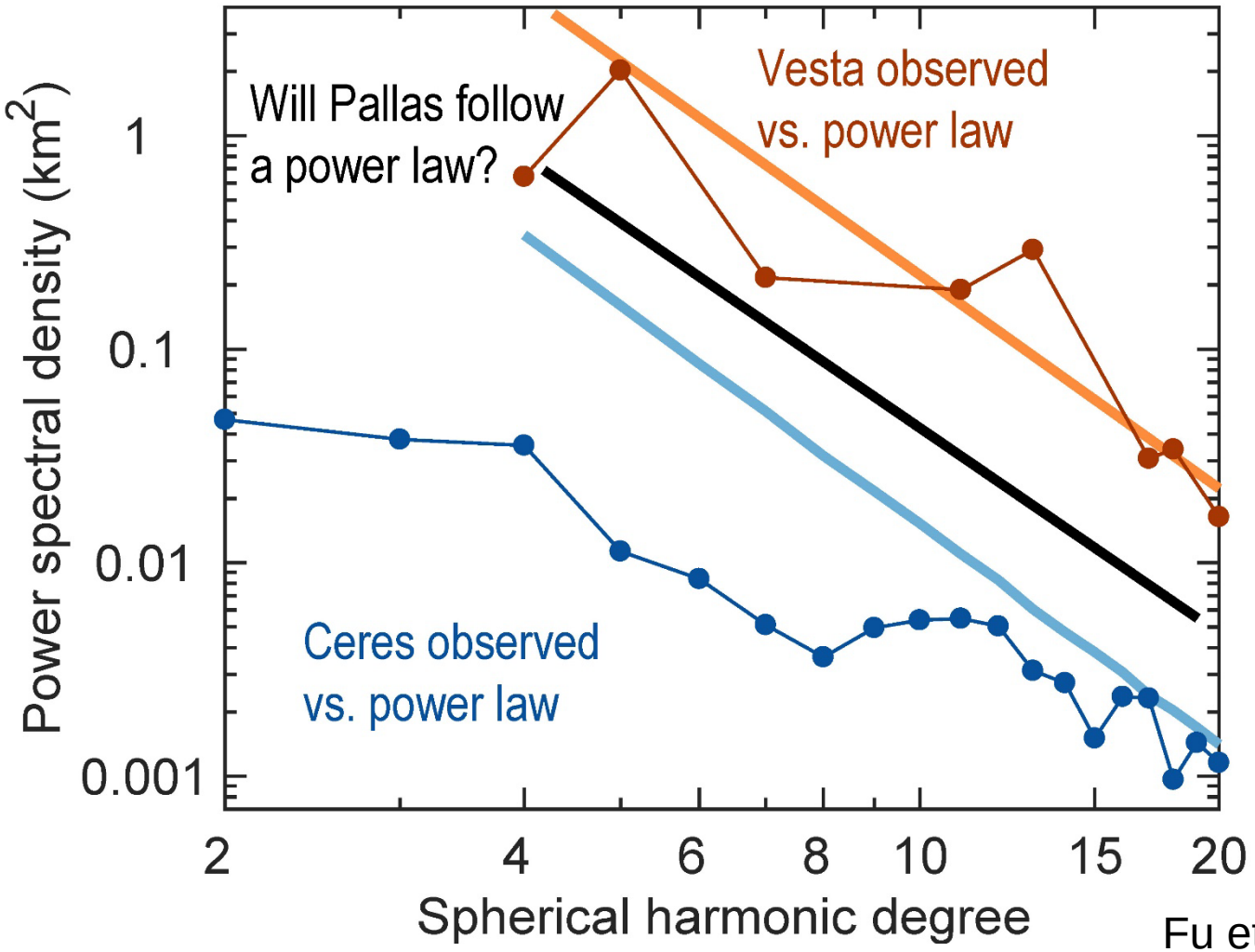




Hiesinger et al. 2016

Objective B: Internal Structure

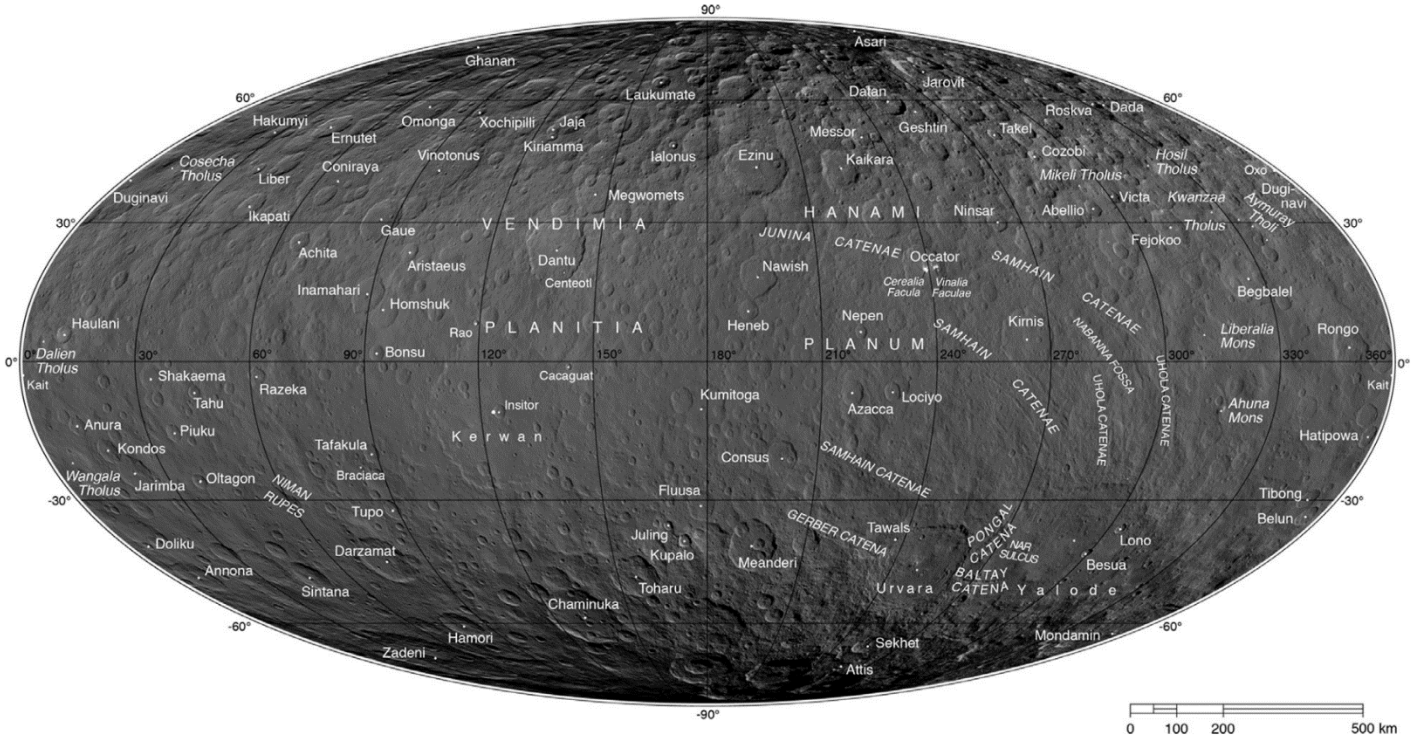


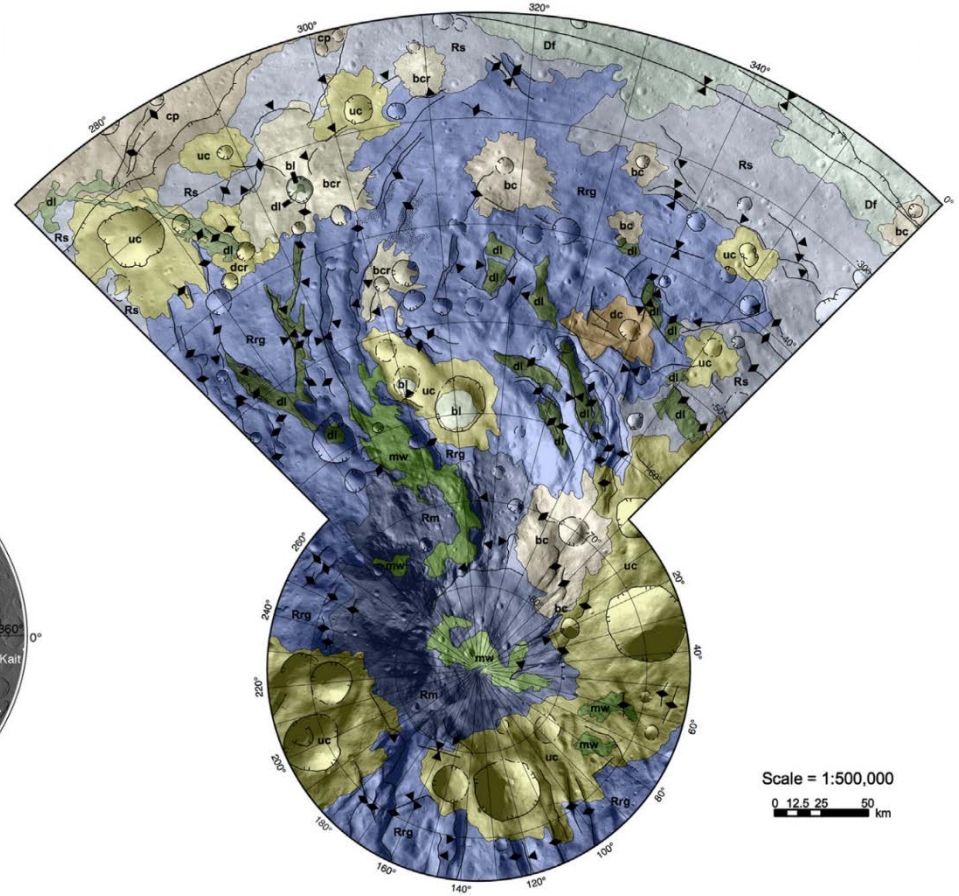


Fu et al. 2017

Objective B: Geologic Mapping

Geologic maps reveal a variety of features regardless of whether water ice or dry silicates dominate surface rheology

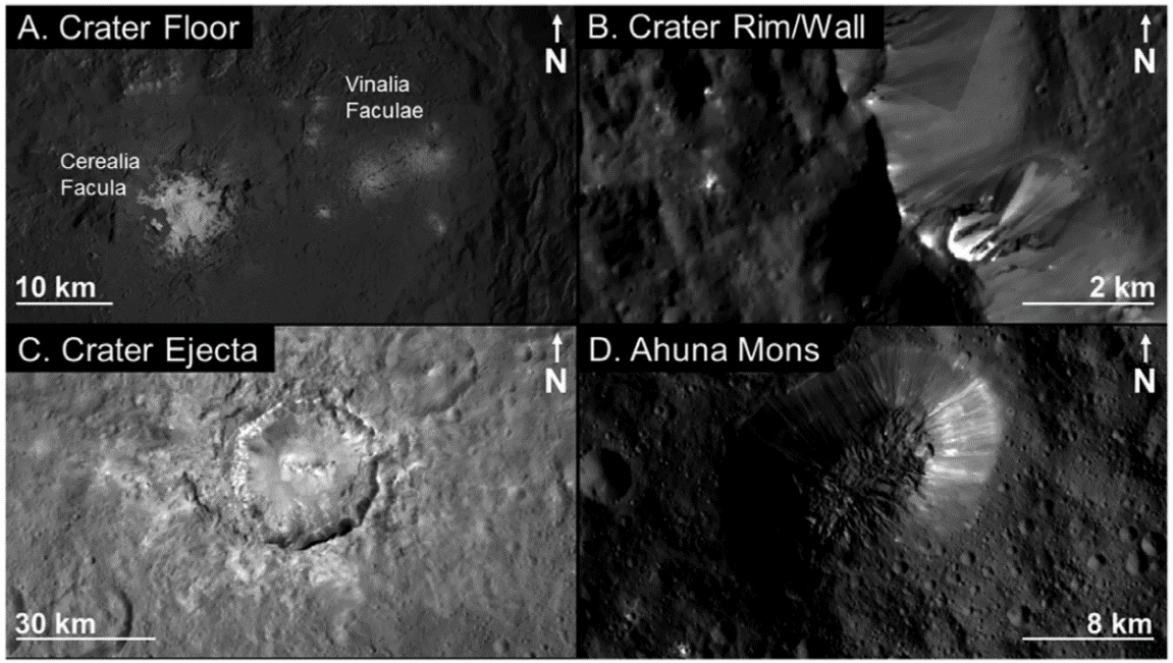


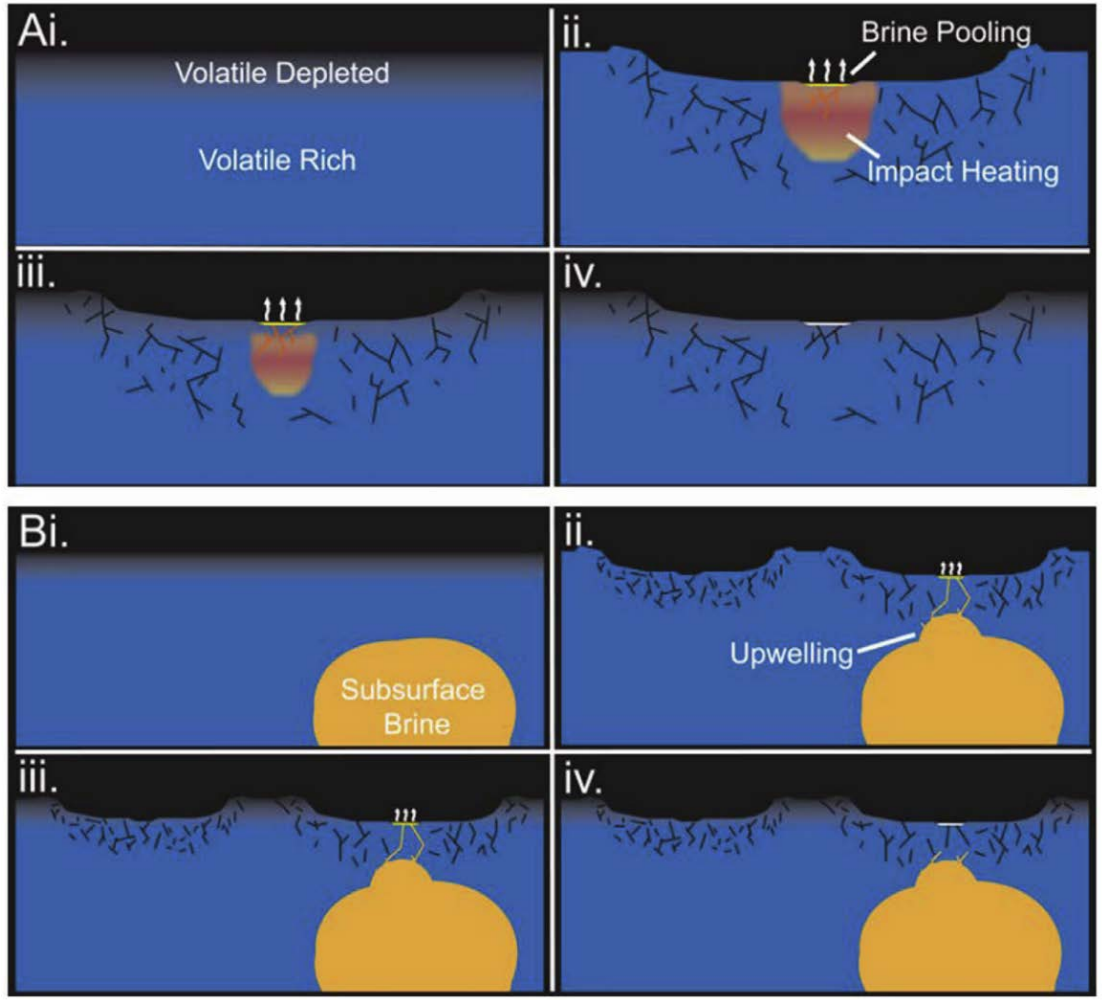


Williams et al. 2014, 2018

Objective C: Impact Velocities

Widespread bright spots are expected on a Ceres-like surface for Pallas (Stein et al. 2019)





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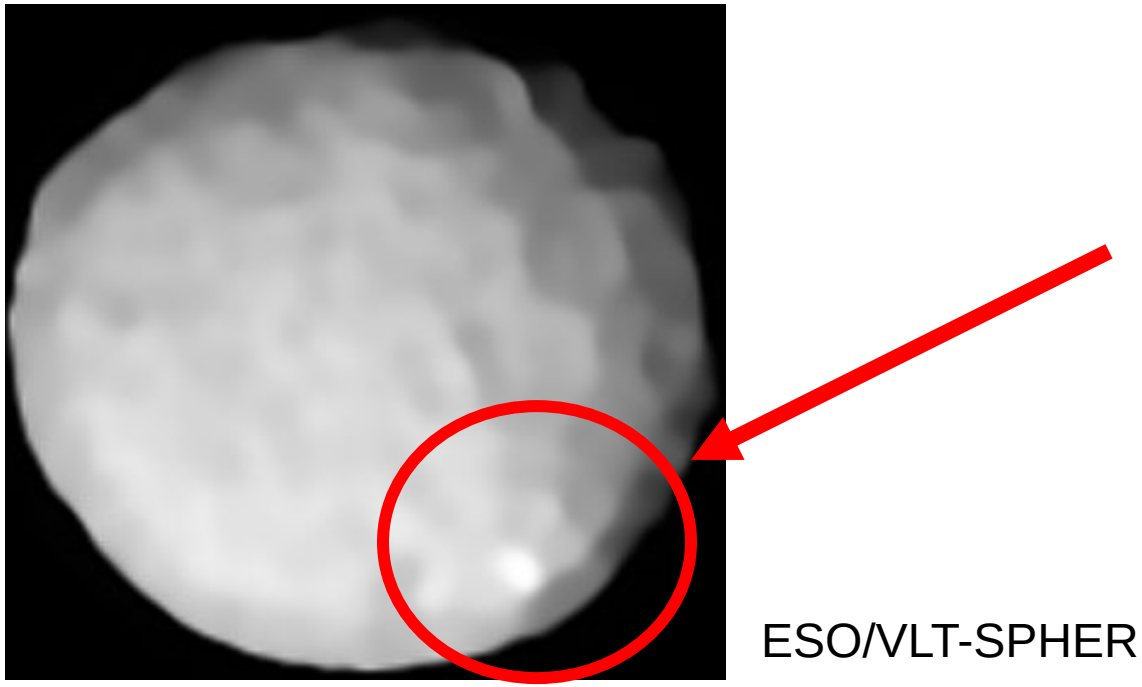
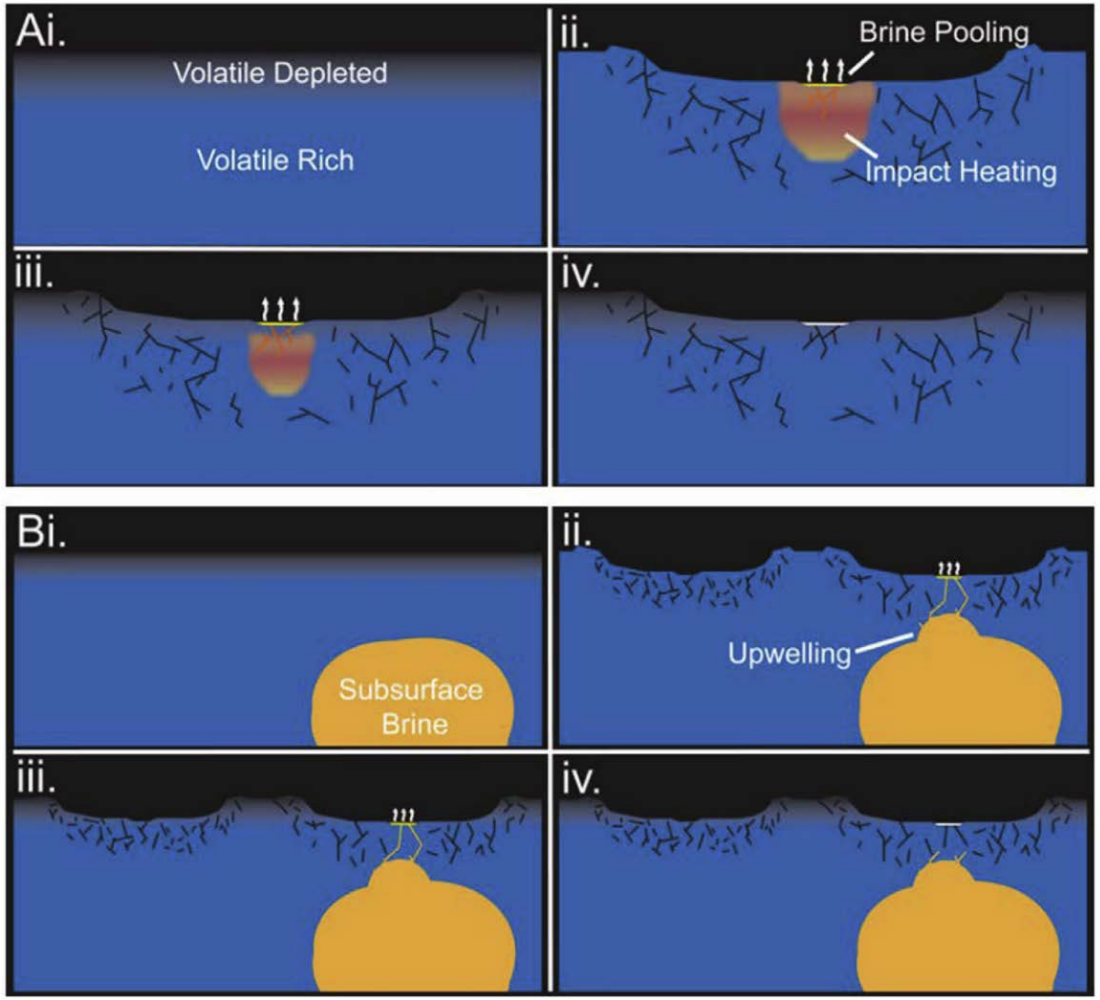
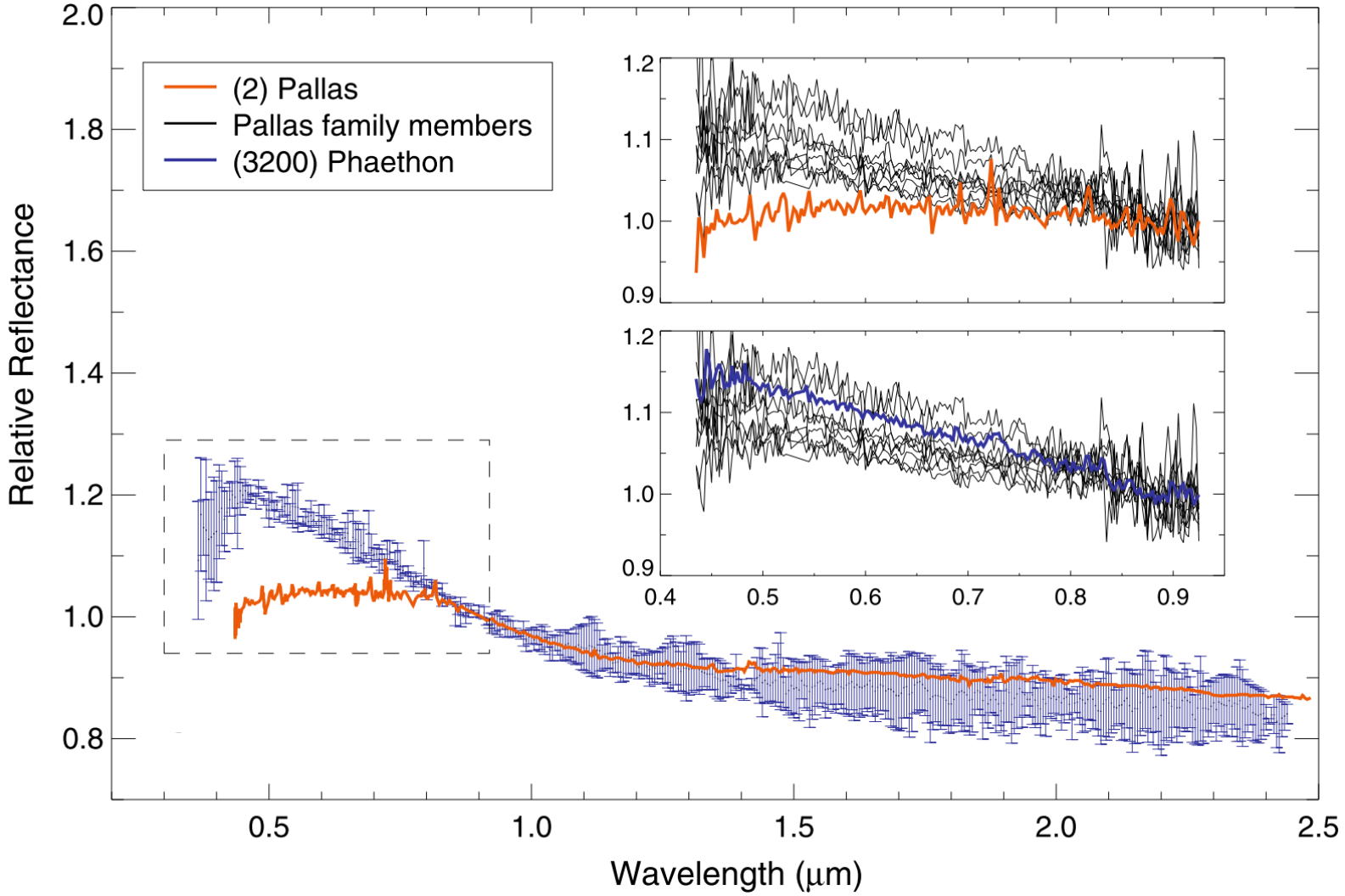


ESO/VLT-SPHERE



Objective C: Origin of Phaethon



Athena resolves the color difference (visible) between Pallas & Phaethon at ~5 km scale

Synergy with DESTINY+ mission

de León et al. 2010

Conclusions

- Pallas is a compelling protoplanet
  - Fundamental processes at small scale
  - Missing link between Ceres and Vesta
  - Unique dynamical history and cratering
  - Parent of NEAs including (3200) Phaethon
- Athena targets decadal-priority science
  - 2018 proposal centered on bulk composition, internal structure, and geologic mapping
  - Desire many instruments (dust detector, IR & neutron spectrometers, magnetometer, etc.)