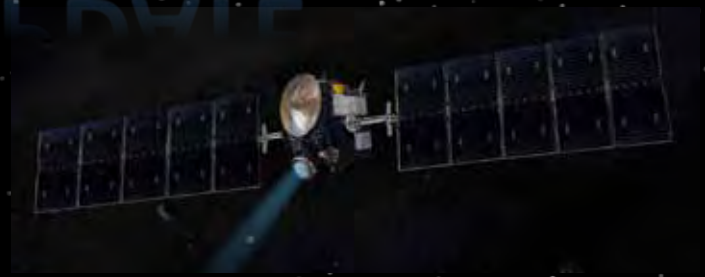
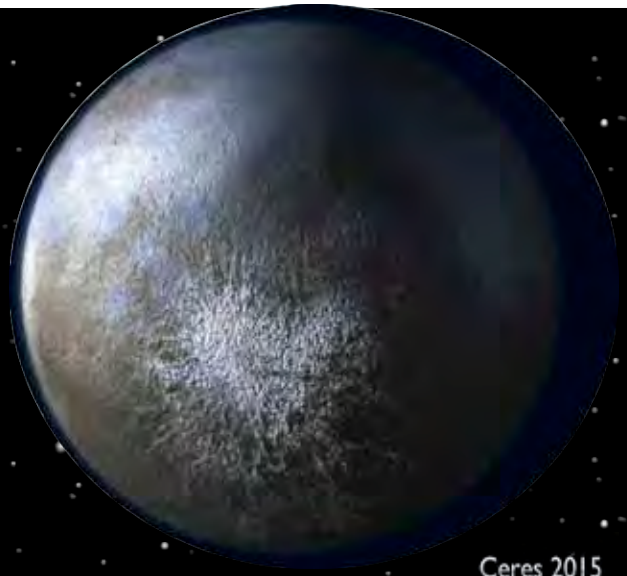
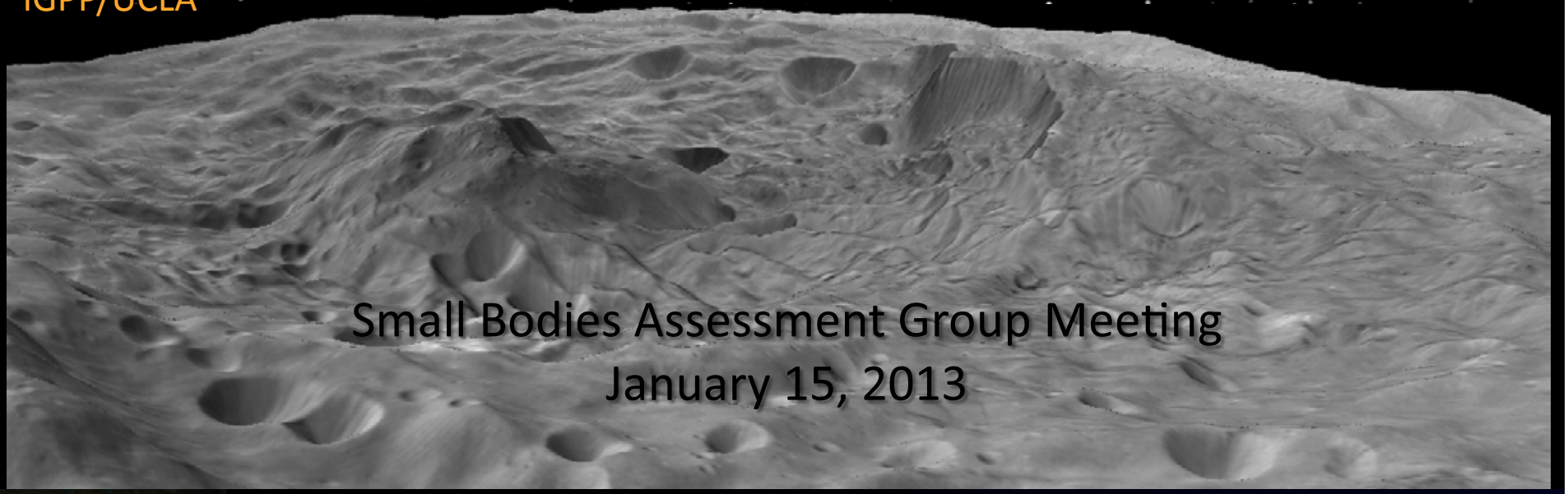
DAWN UPDATE





C. A. Raymond
JPL/Caltech
C. T. Russell
IGPP/UCLA



Small Bodies Assessment Group Meeting
January 15, 2013

Initial Observations

- As inferred from the meteoritic record, Vesta has an iron core and a basaltic crust, and formed within 1-2 Ma of the very beginning of the solar system.
- Cratering record
  - Southern hemisphere suffered two large crater forming events.
  - The amount of cratering is consistent with theoretical models of the dynamical evolution of main belt.
  - Craters occur mainly on steep slopes unlike on the Moon and Mars.
- Albedo
  - Vesta is bright, probably due to extensive nearly pristine pyroxene.
  - Vesta has dark patches in the surface and crust due to transport from carbonaceous asteroids and comets.

Dawn Data Sets

Global Topography

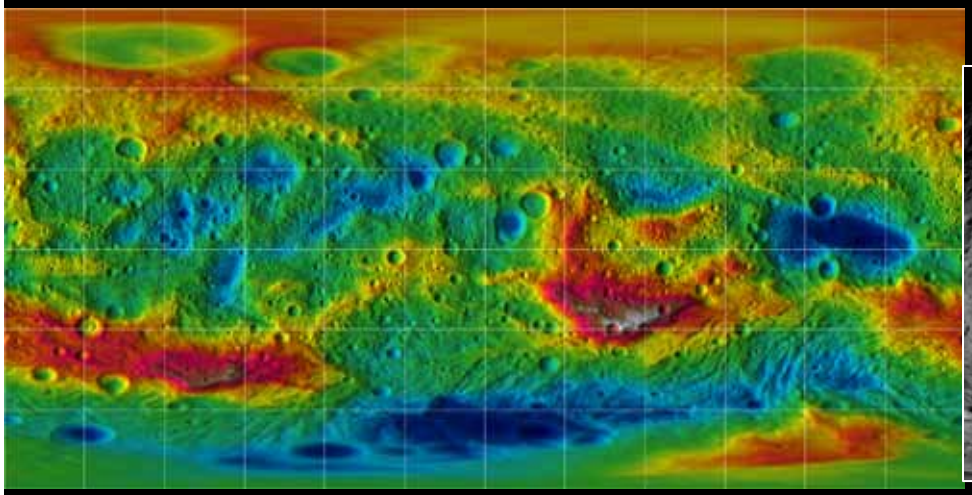
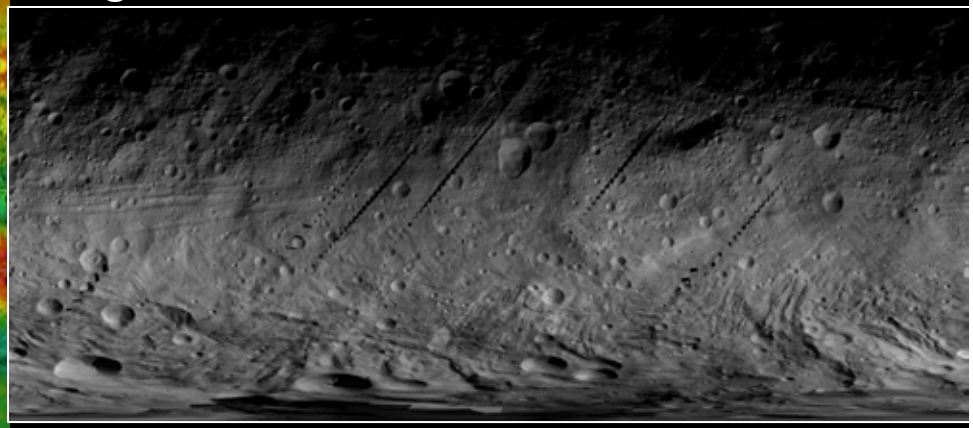
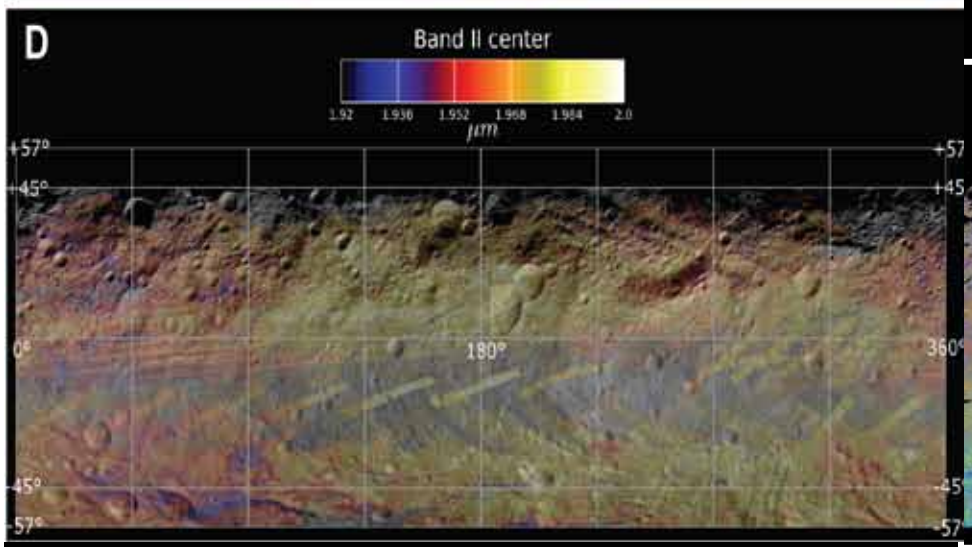


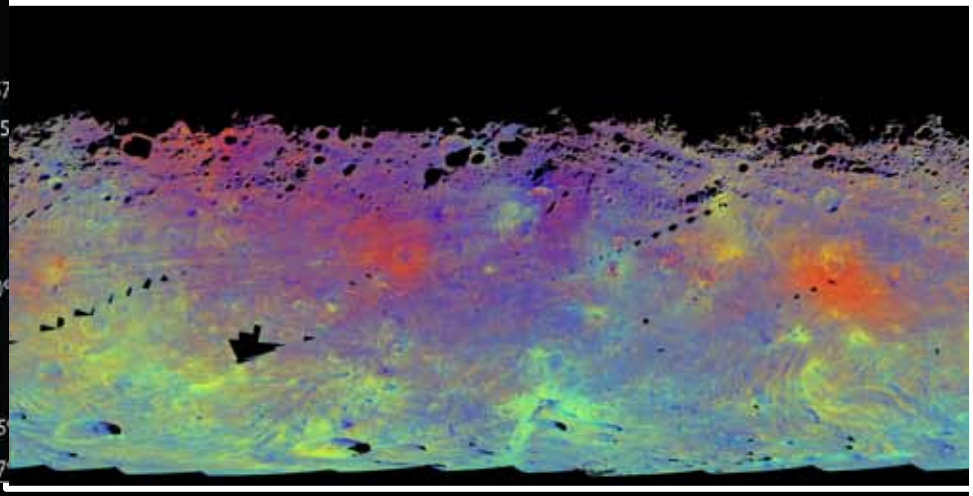
Image Mosaics



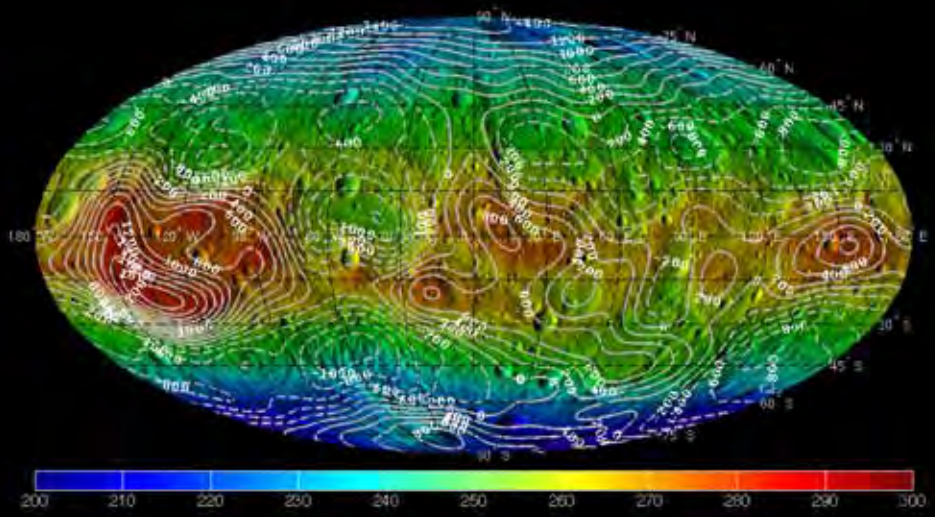
Vis-IR Spectral Maps



Camera Color Filter Data

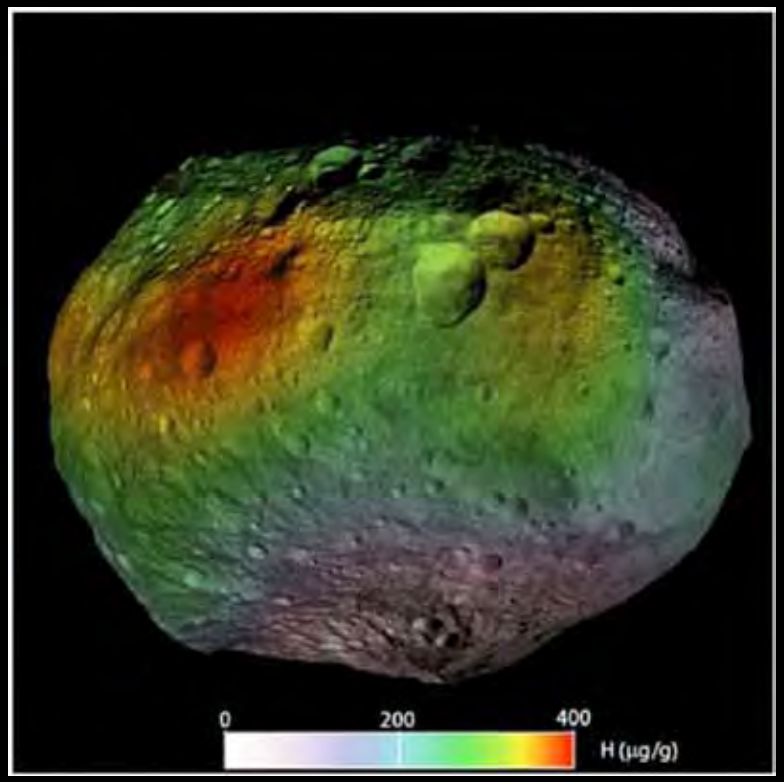


Dawn Data Sets

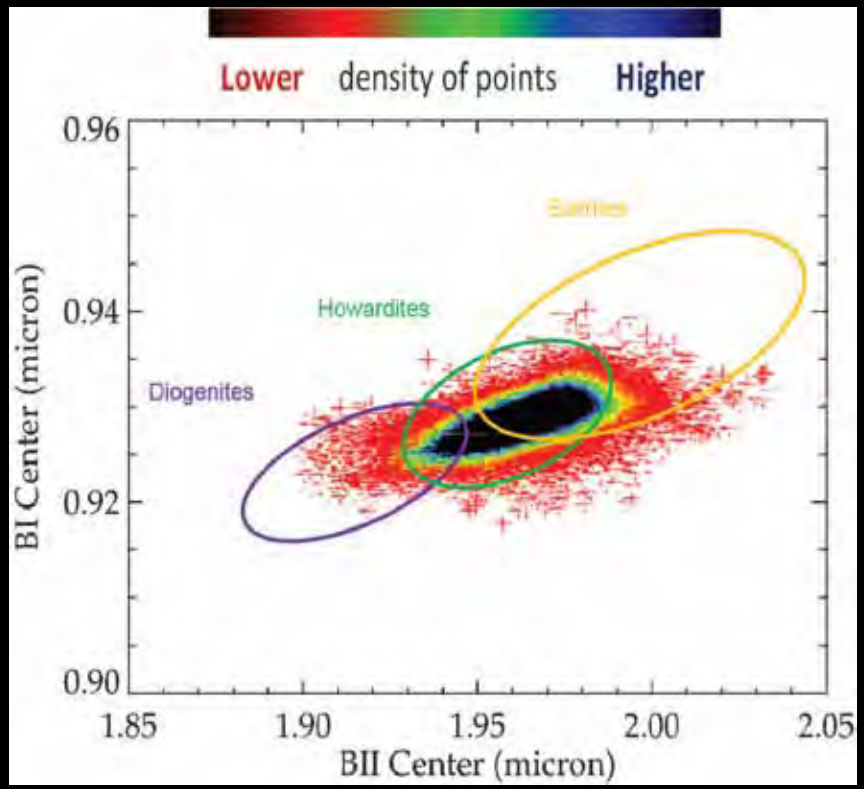


Gravity from coherent doppler tracking

Elemental Maps from GRaND

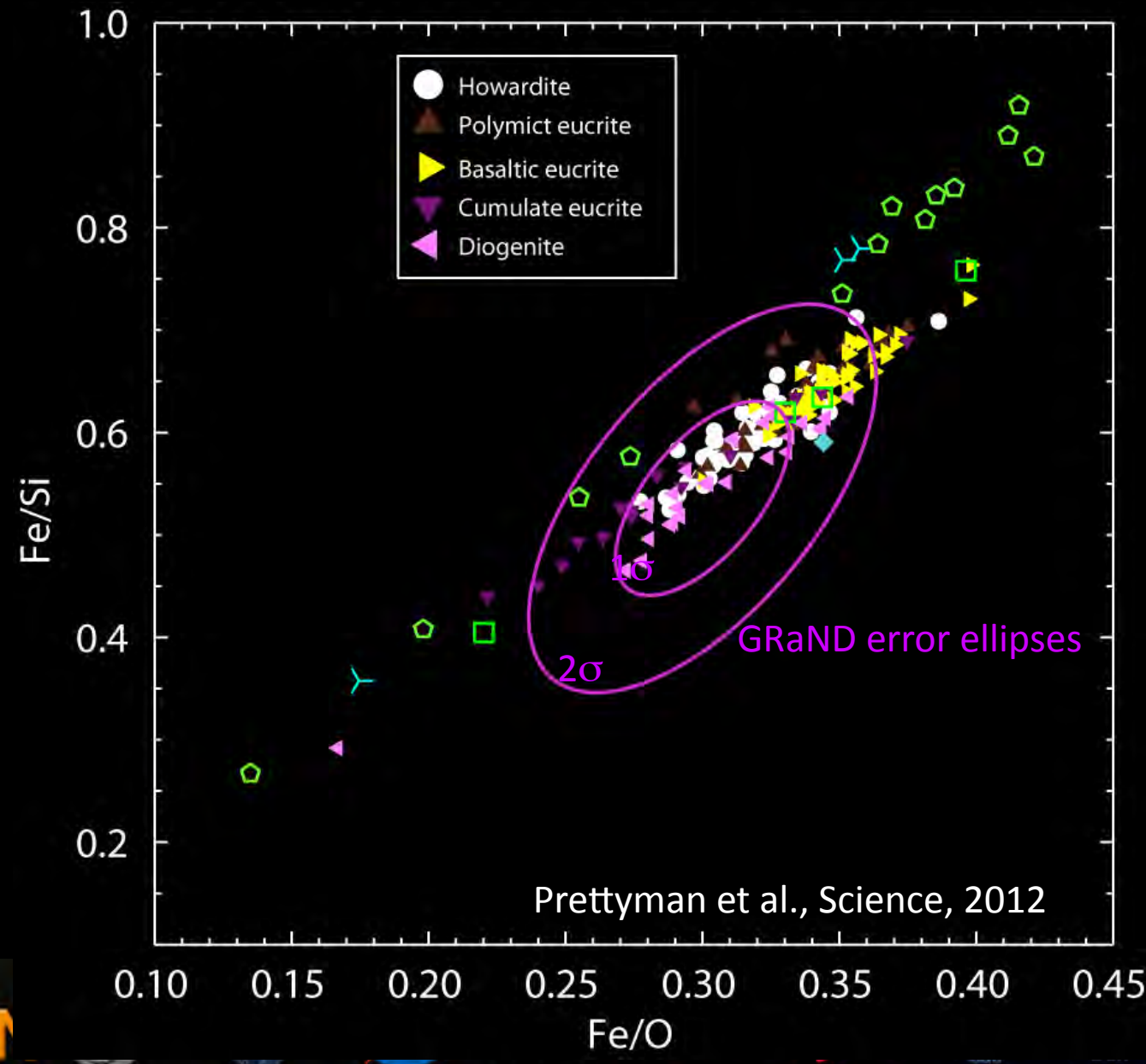


Vesta HED Connection Confirmed



- The scatter plot represents the distribution of the VIR BI and BII centers acquired during the Survey phase.
- Vesta Band centers plot in the HED range of band centers

GRaND Confirms HED Elemental Ratios



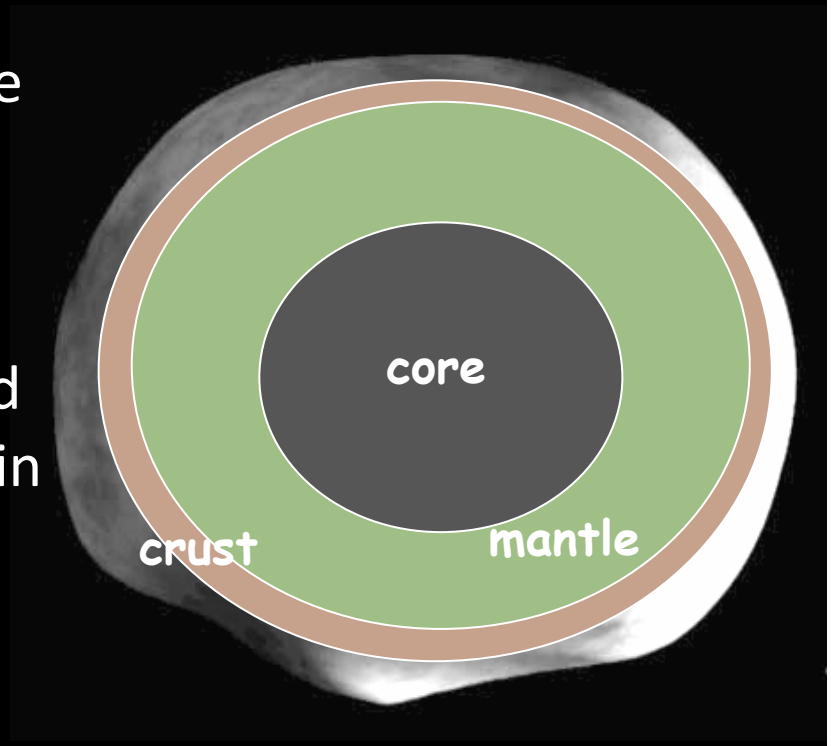
Prettyman et al., Science, 2012

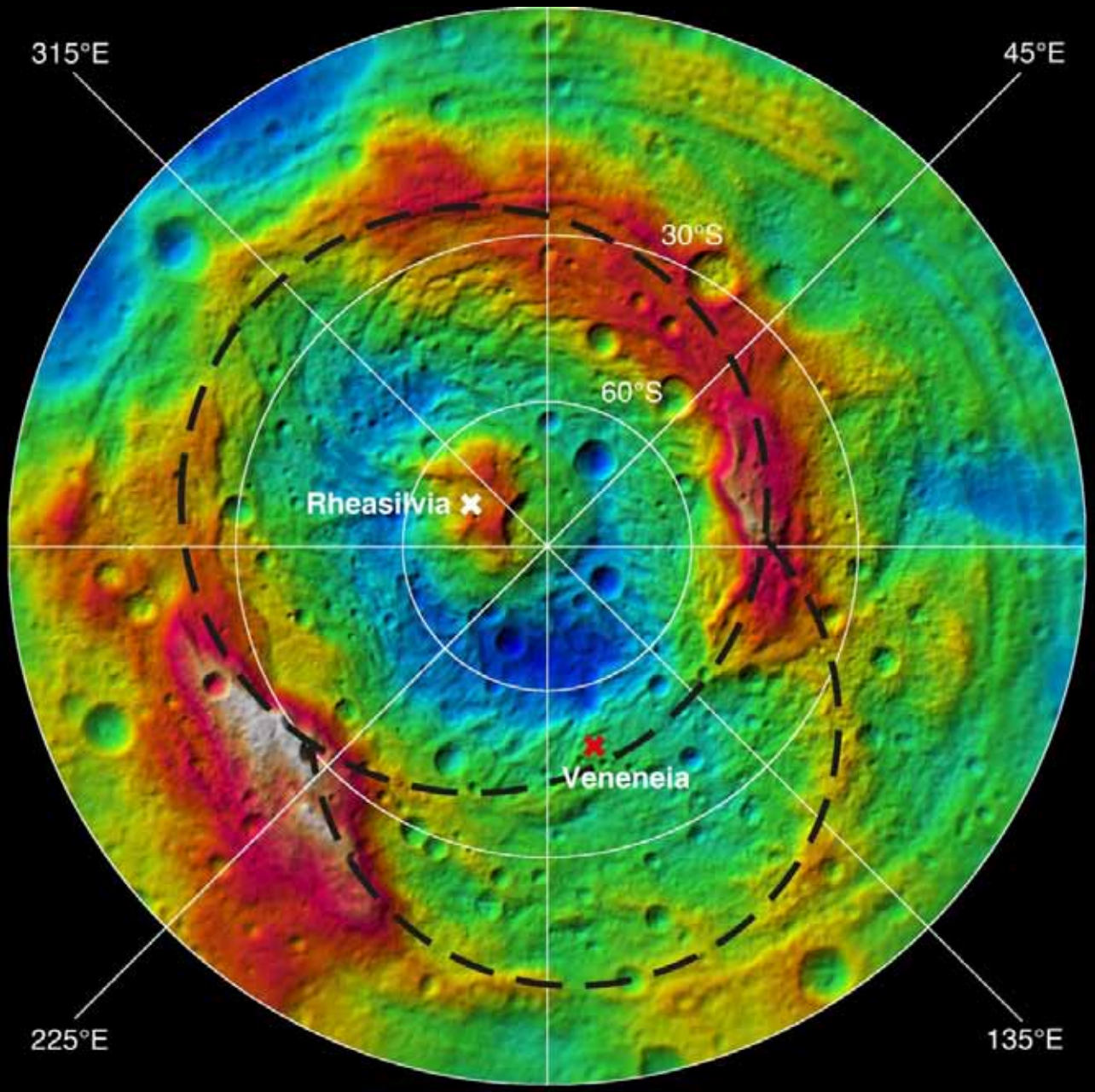
Vesta Interior Structure

Mass balance models are calculated using an assumed core density to derive the core size and bulk silicate density ranges that match J_2

Assumption of an iron core is supported by siderophile element depletion seen in the HED meteorites

- Iron meteorite density range of ~7100-7800 kg/m^3
- Low concentrations of sulfur in iron meteorites





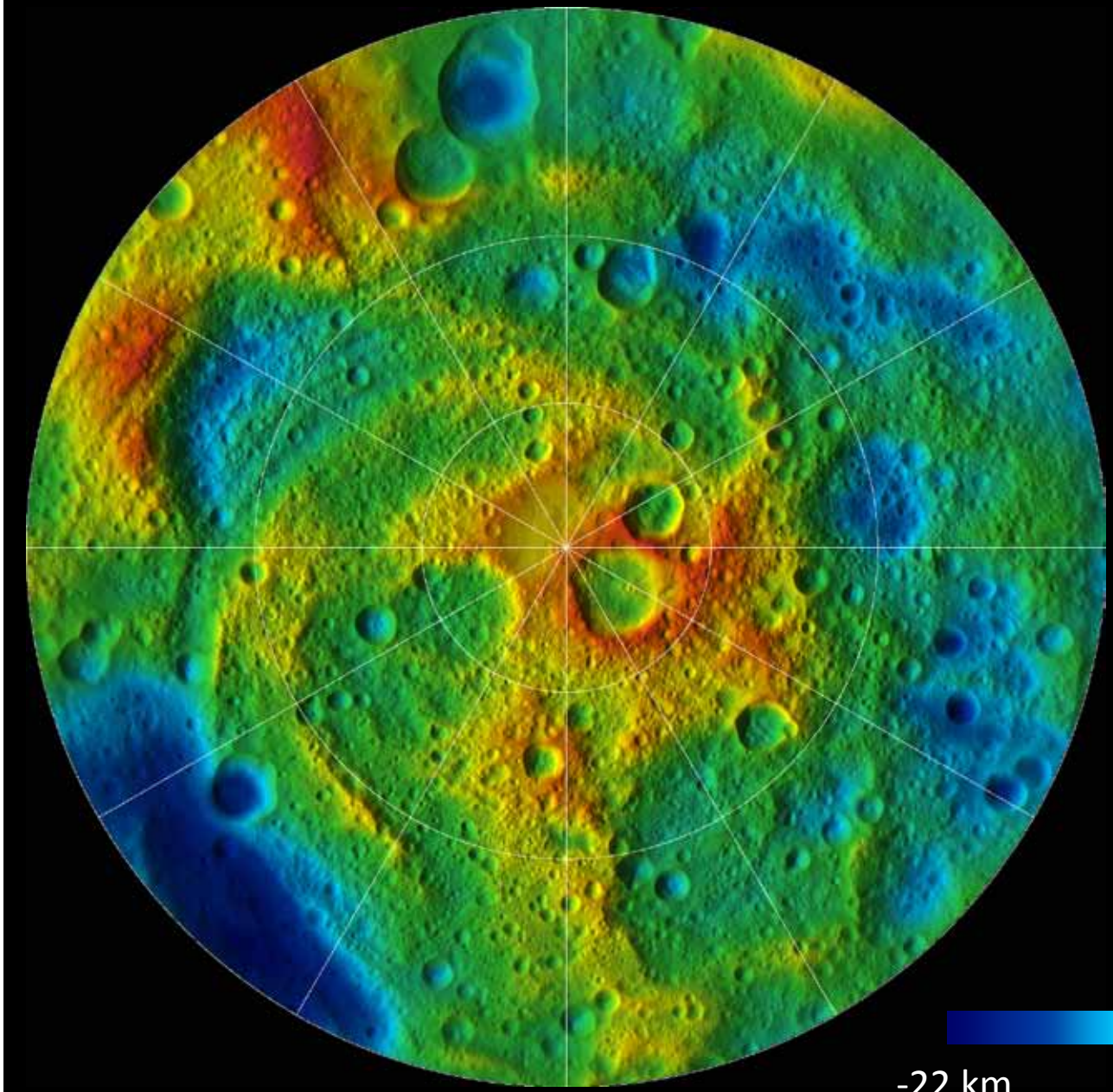
Southern Hemisphere Topography

Highest topography at Vestalia Terra

Lowest in the Rheasilvia Basin

Smooth with relatively few craters

19.5 km



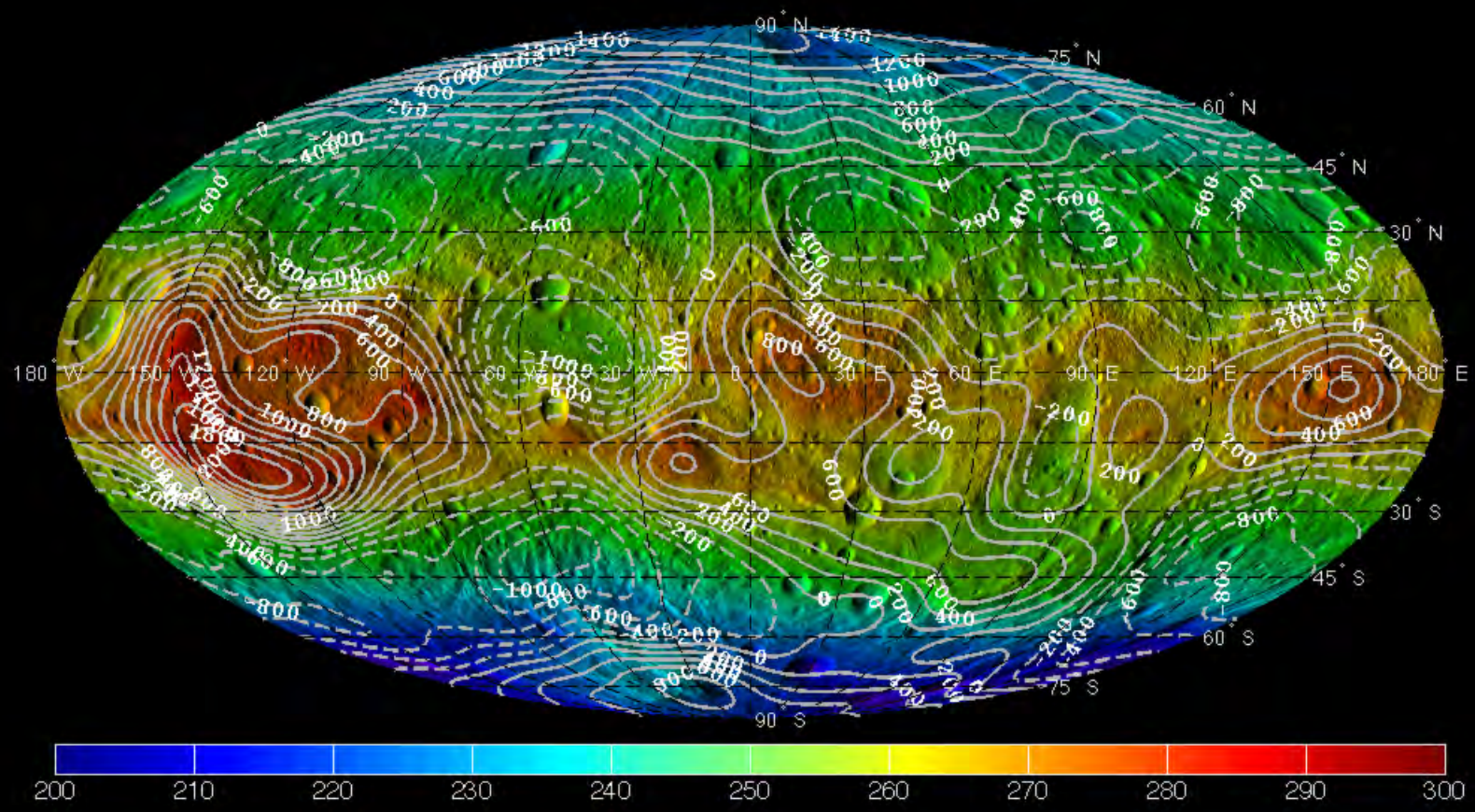
Northern Hemisphere Topography

Much lower than the southern hemisphere

No obvious topographic features antipodal to the giant impact basins

Densely cratered

Vesta surface gravity



High correlation of gravity and topography

Mantle and Crust Density

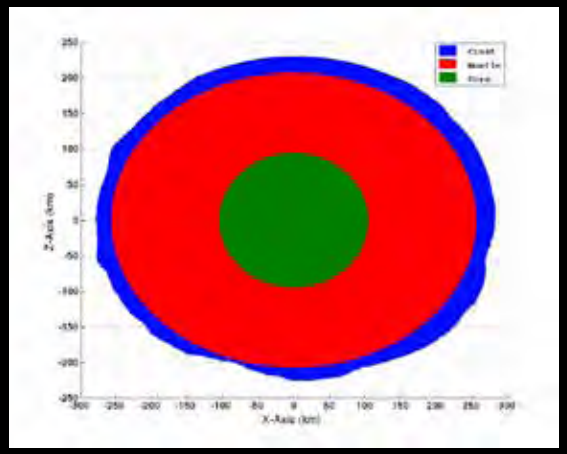
- Derived bulk silicate density of ~3100 is low compared to predictions that neglect porosity
  - range of 3500-3900 predicted based on pre-Dawn mass and volume (Thomas et al., 1997)
  - range of 3320-3630 kg m^{-3} predicted based on HED analyses (Ruzicka et al., 1997)

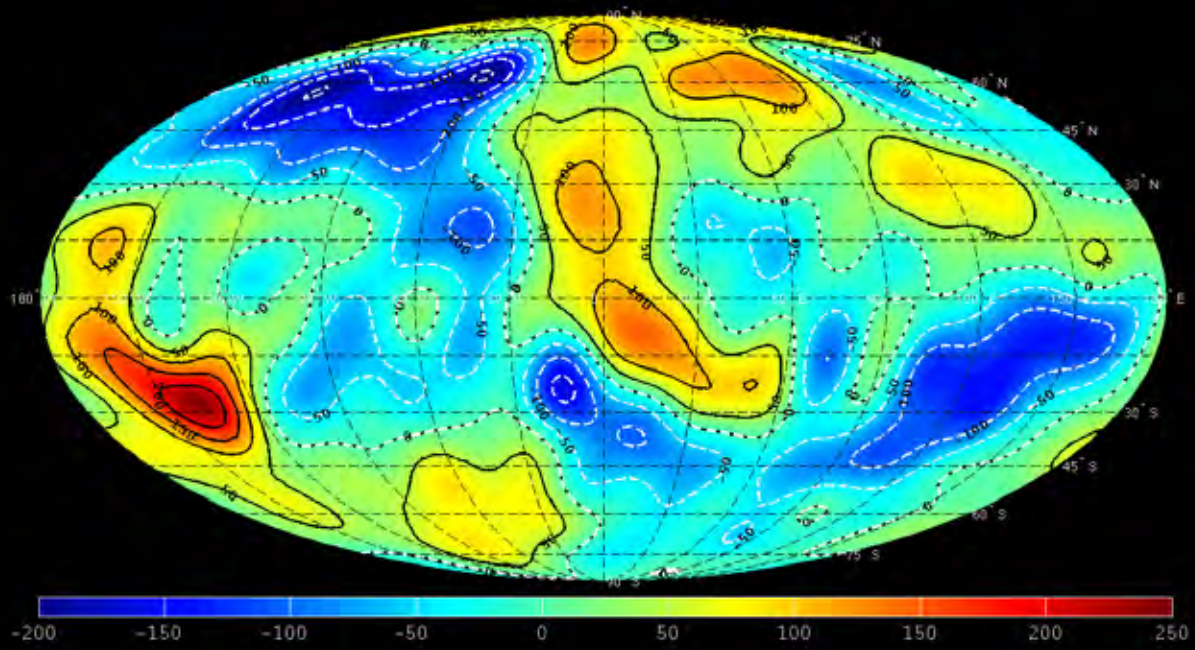
- Indicates porosity on order 5-15% in the crust and mantle, consistent with Vesta's impact history

- Examine Bouguer gravity field to understand crustal and mantle density variations

Bouguer Gravity

- Bouguer gravity is calculated for three layer core-mantle-crust models derived from mass balance models that match J2
- Crustal layer has variable thickness of average ~19 km thick with zero thickness in deepest part of the Rheasilvia Basin





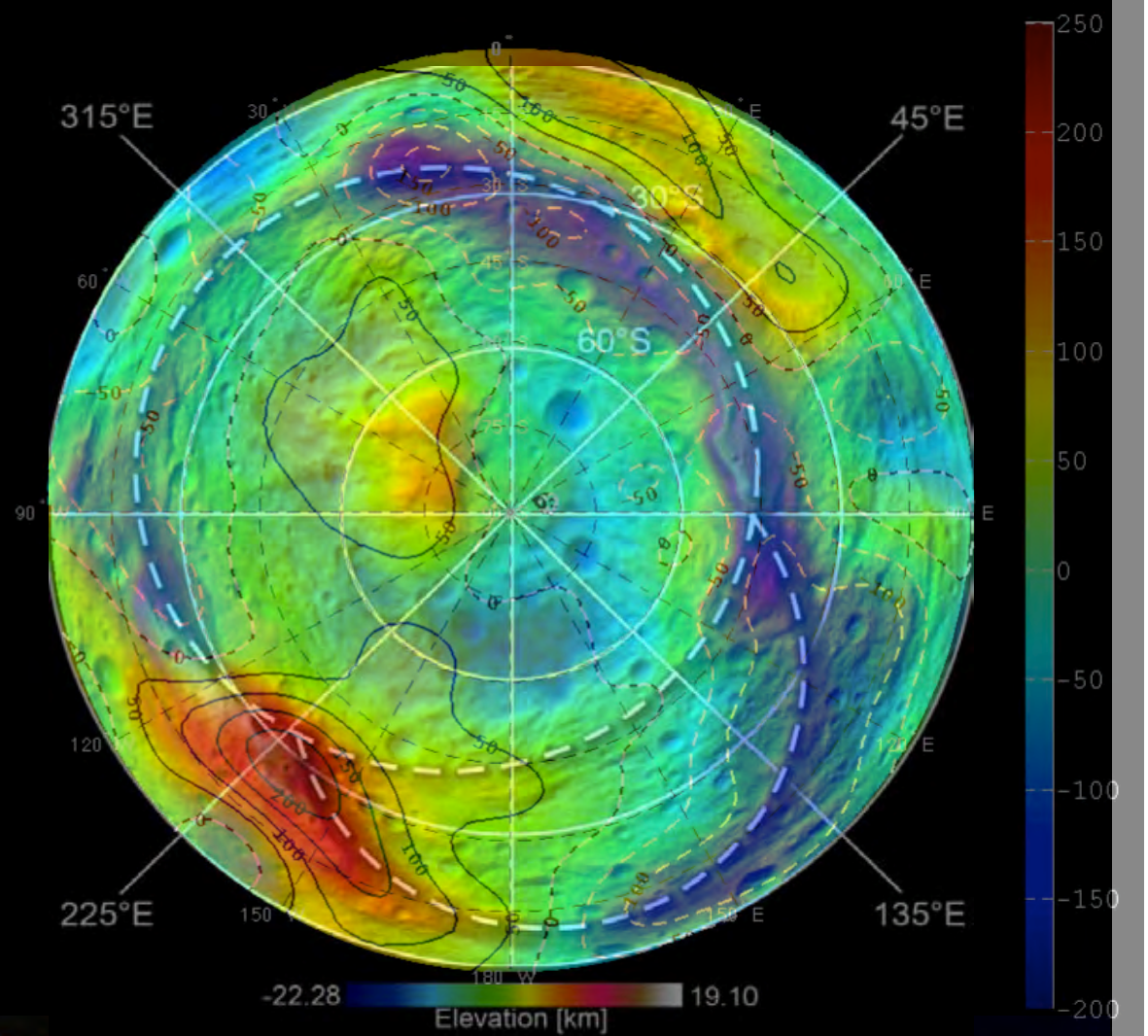
2990 kg/m^3 crust, 3170 kg/m^3 mantle, 7400 kg/m^3 core

Density Structure

High Correlation of low gravity and high topography along rims of basins (purple) implies porous ejecta of lower density that average crust

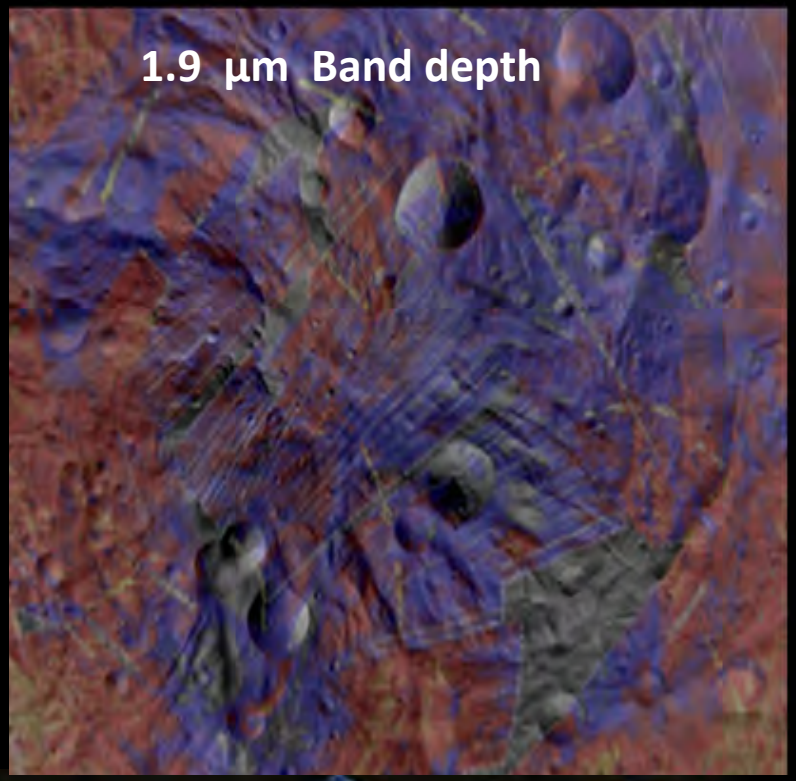
Central mound has higher density than average, but is at the edge of a broader positive density anomaly in the RS basin

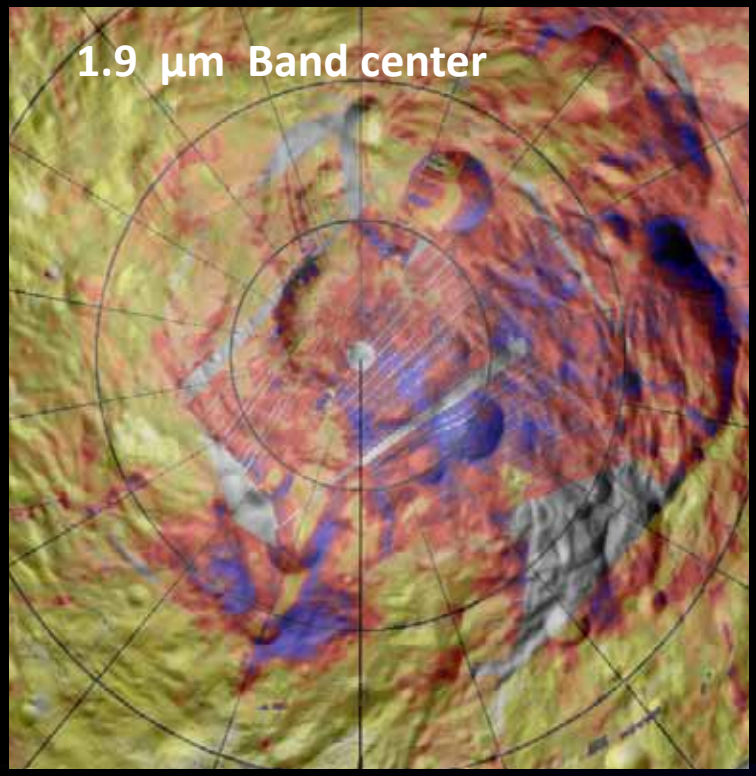
Vestalia Terra is very high and has a very strong positive density anomaly



Spectral Data in Rheasilvia

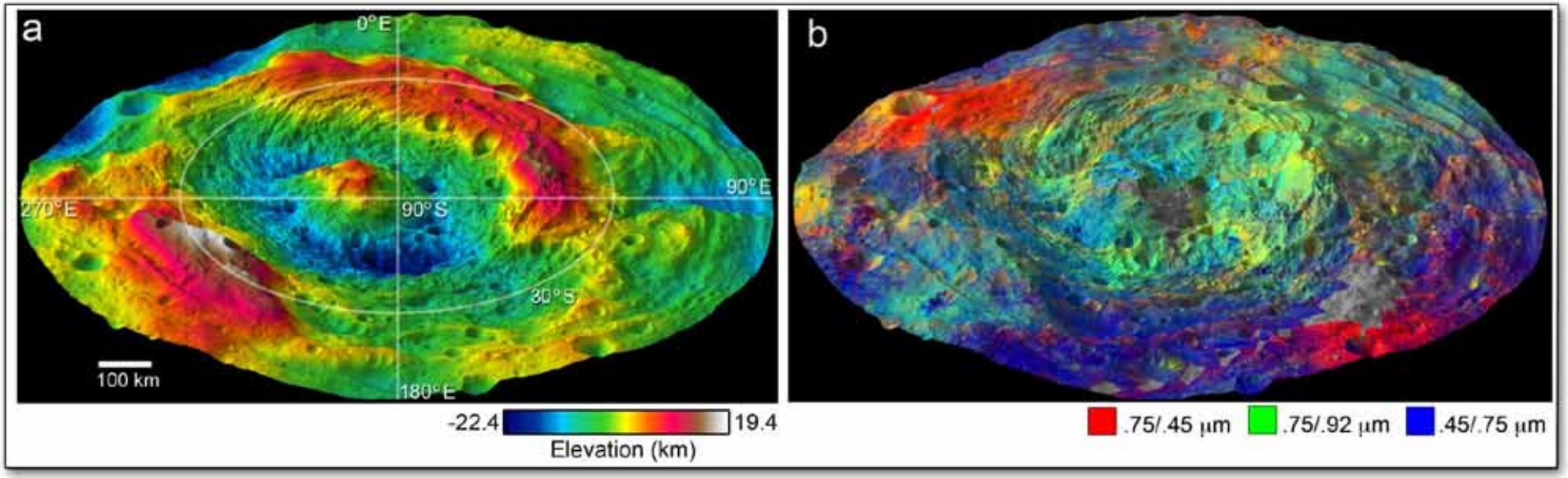
- The central mound of the Rheasilvia basin shows a diogenitic spectrum indicating exposures of the deep crust
- The signature is stronger on one side of the basin





Topography and Framing Camera Map

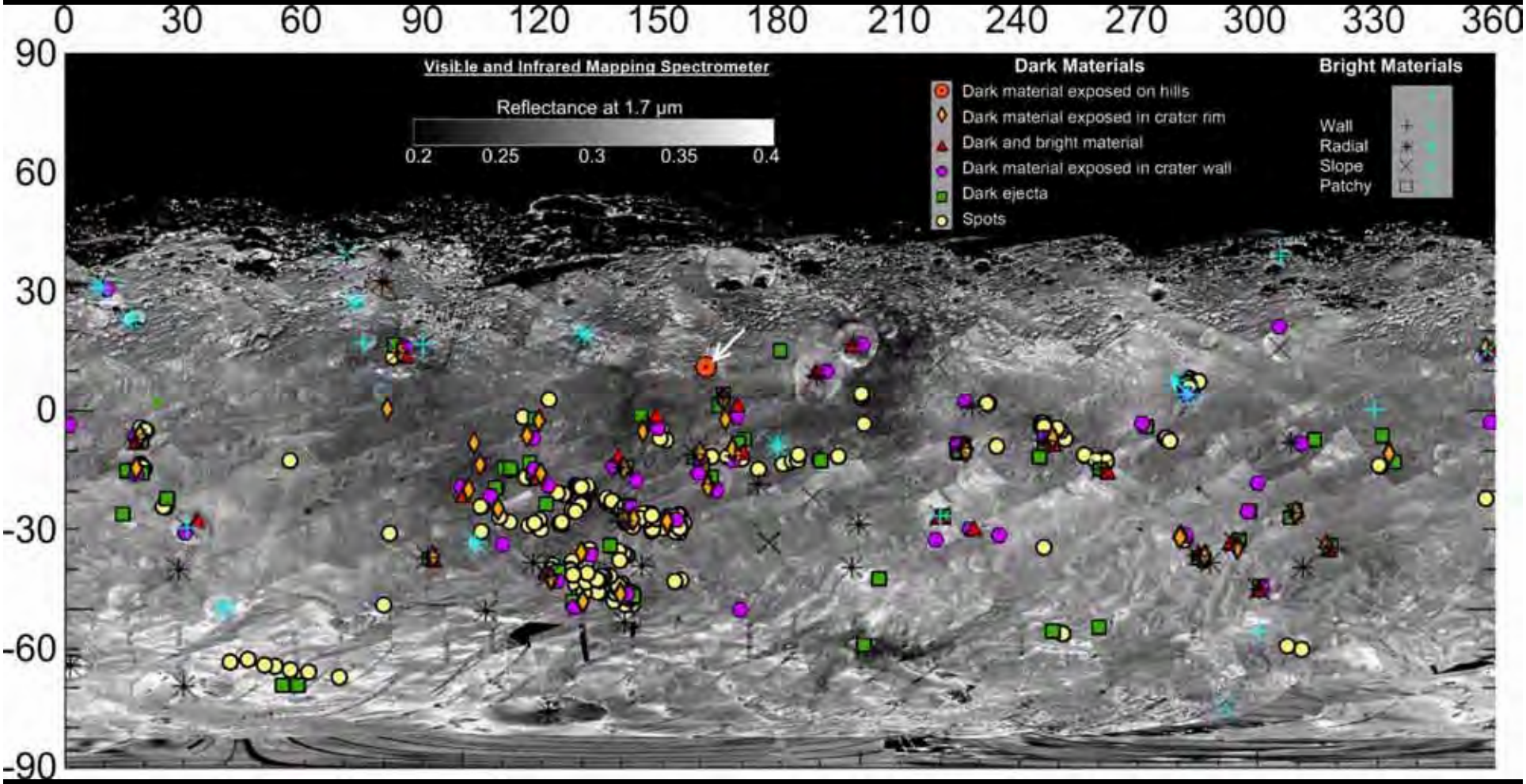
Topography | Color Ratios



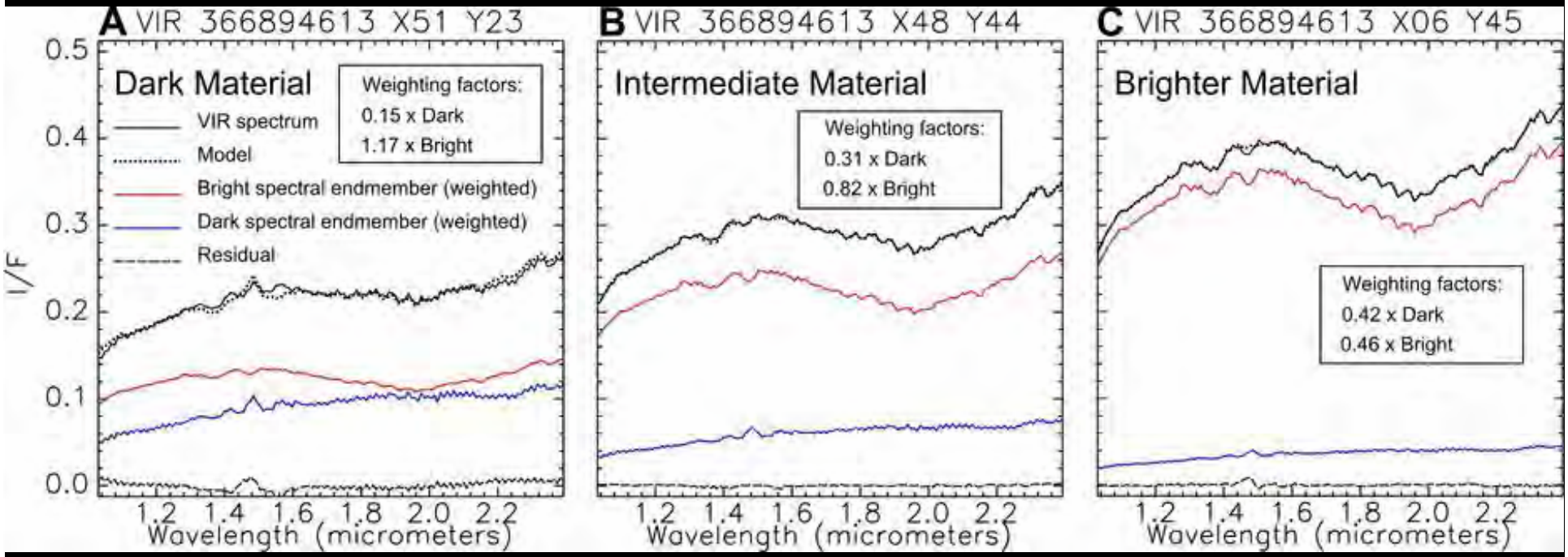
Deeply excavated (-20 to 22 km) areas at base of central uplift, and portions of basin wall, have strong 0.75/0.92 μm ratios (green), indicating high concentrations of diogenite

Distribution of Dark and Bright Material

McCord et al., Nature, 2012

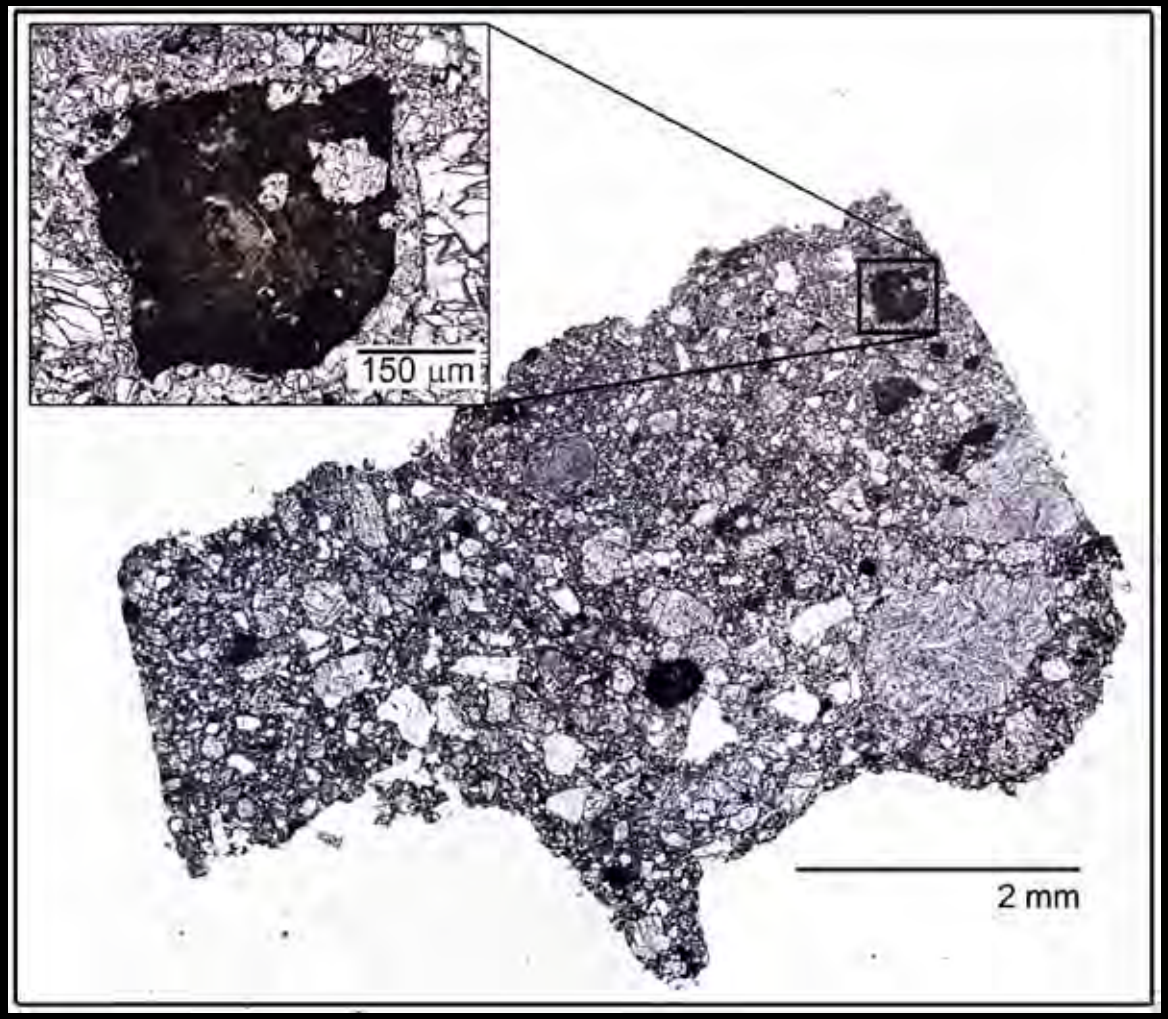


Spectral Endmembers



McCord et al., Nature, 2012

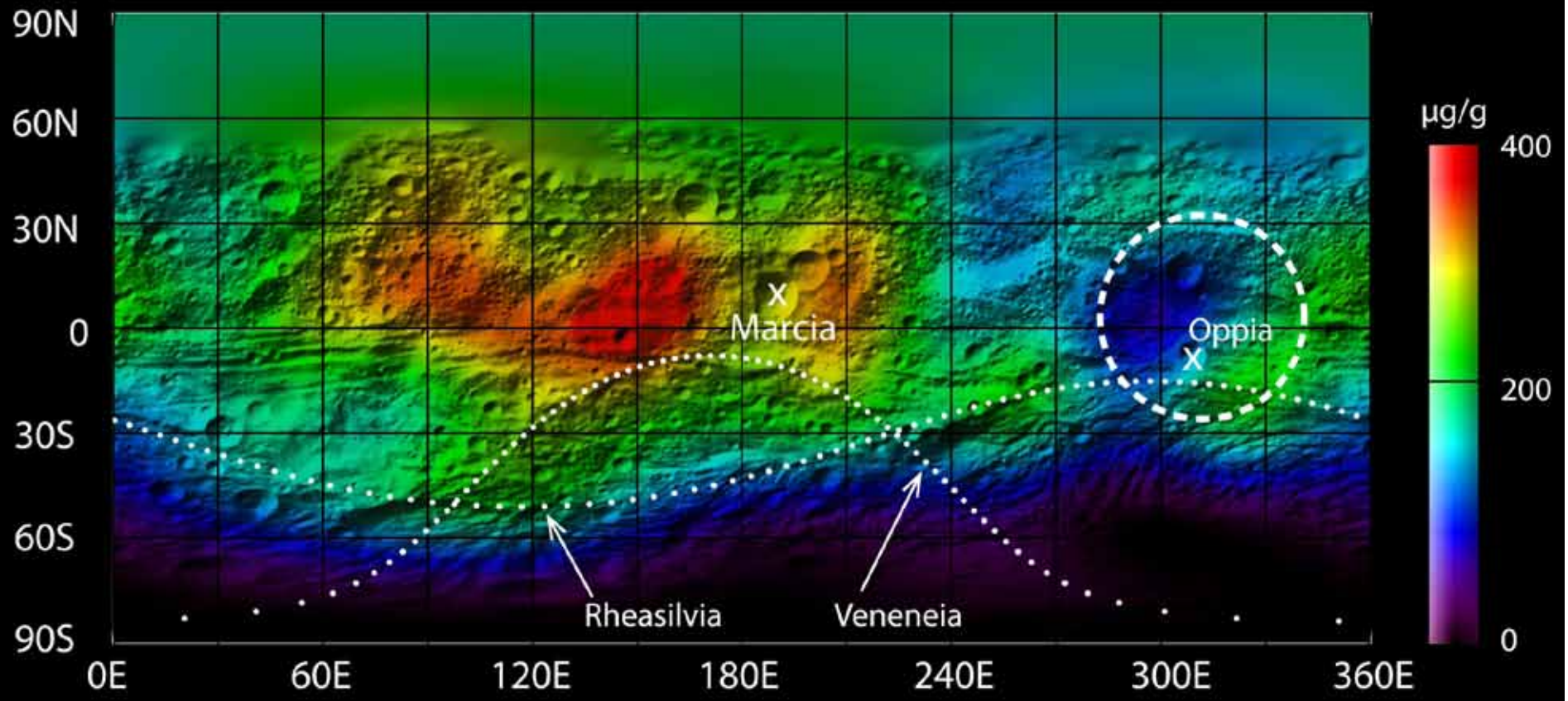
CM Clasts in Howardites



- About 400 µg/g H in howardite contained in carbonaceous clasts (Prettyman et al., Space Science Reviews, 2011)

A thin section of the Jodzie howardite in plane-polarized light highlighting a ~300 mm hydrated carbonaceous chondrite clast (inset). This thin section contains ~3 vol% carbonaceous chondritic clasts (Prettyman et al., Science, 2012)

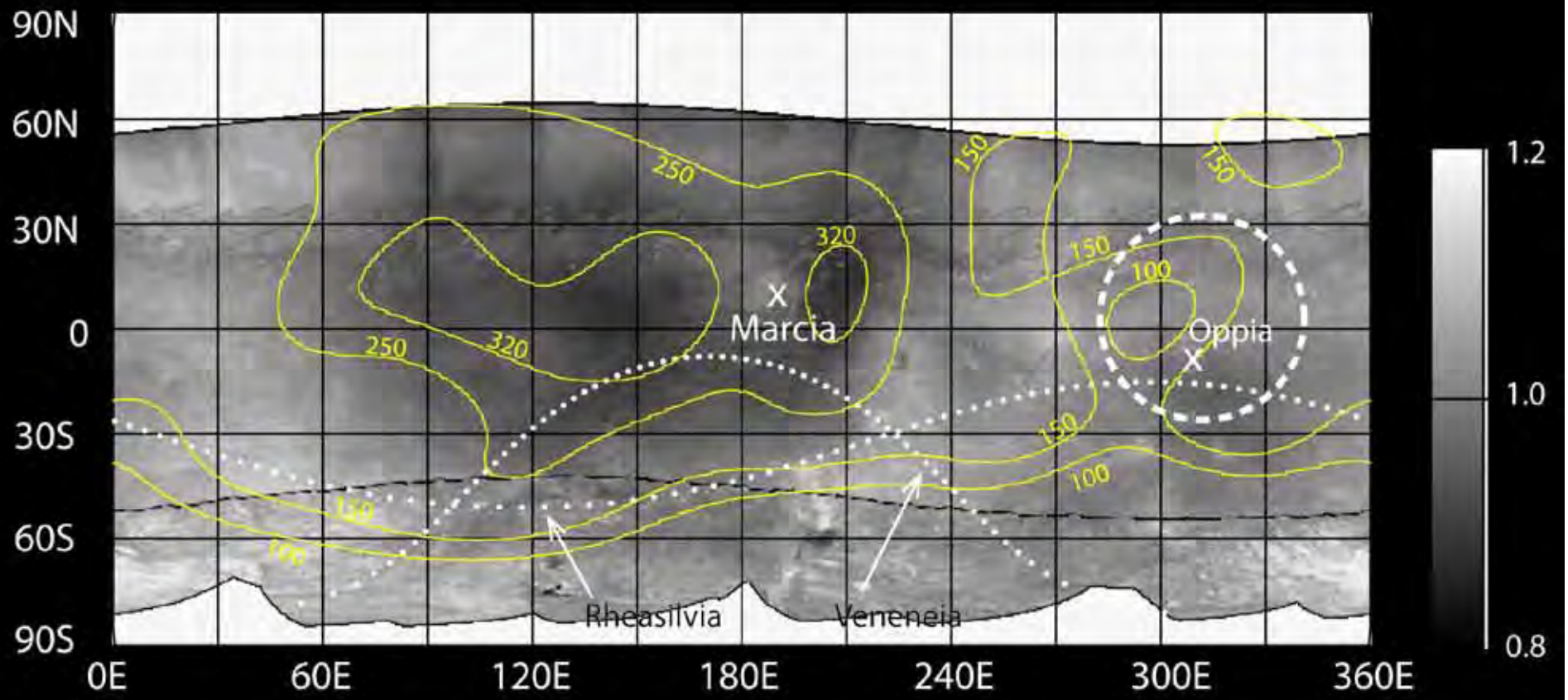
Map of Hydrogen



- Highest abundances of H are in regions where water ice is not stable
- Abundances are far in excess of that expected from solar wind (<100 ppm)

Prettyman et al., *Science*, 2012

Hydrogen contours superimposed on albedo (merged HST & Dawn FC)



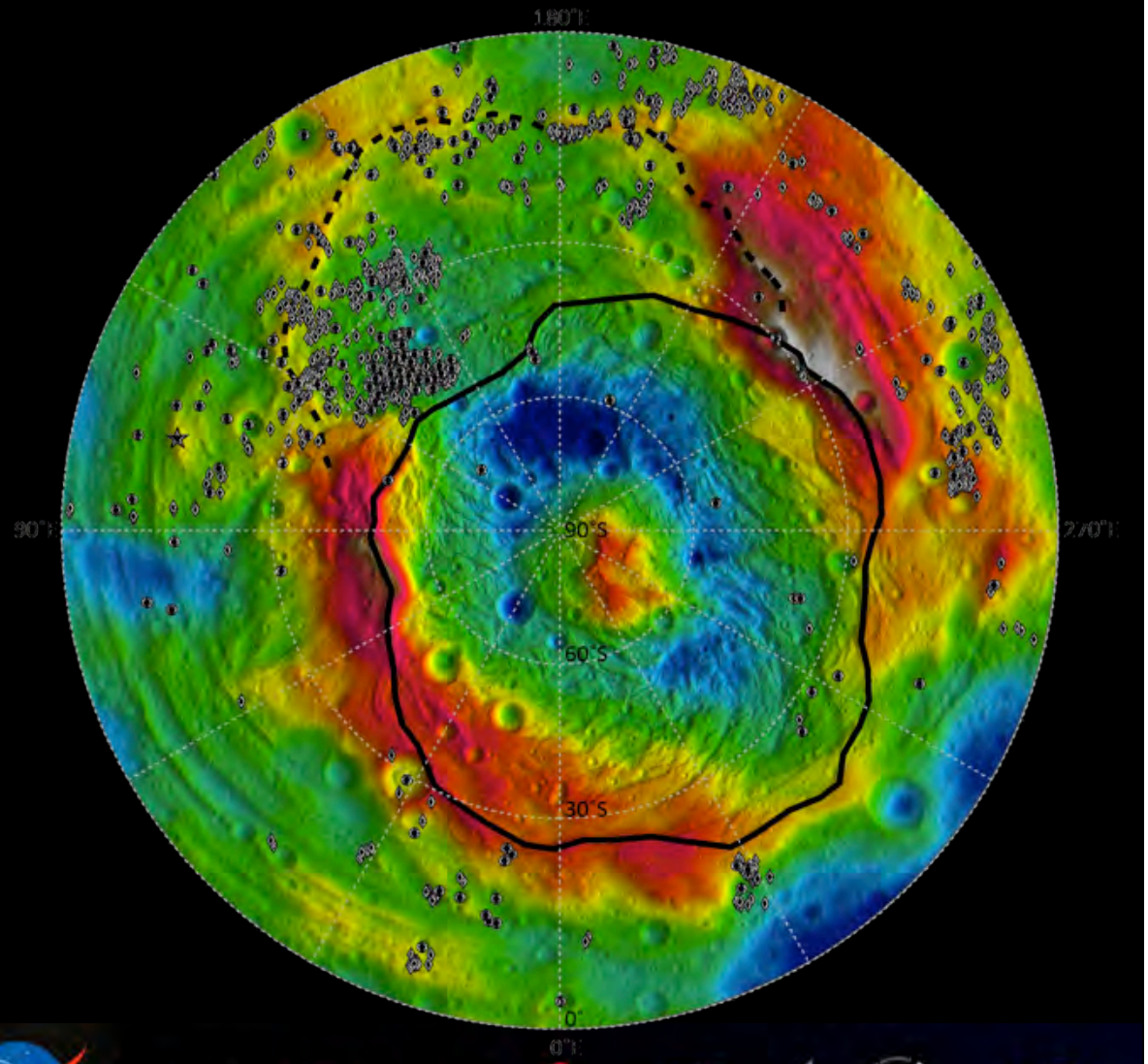
Highest H abundances are in association with low albedo regions on Vesta.

Prettyman et al., *Science*, 2012

Dark Impactor Preserved on Vesta?

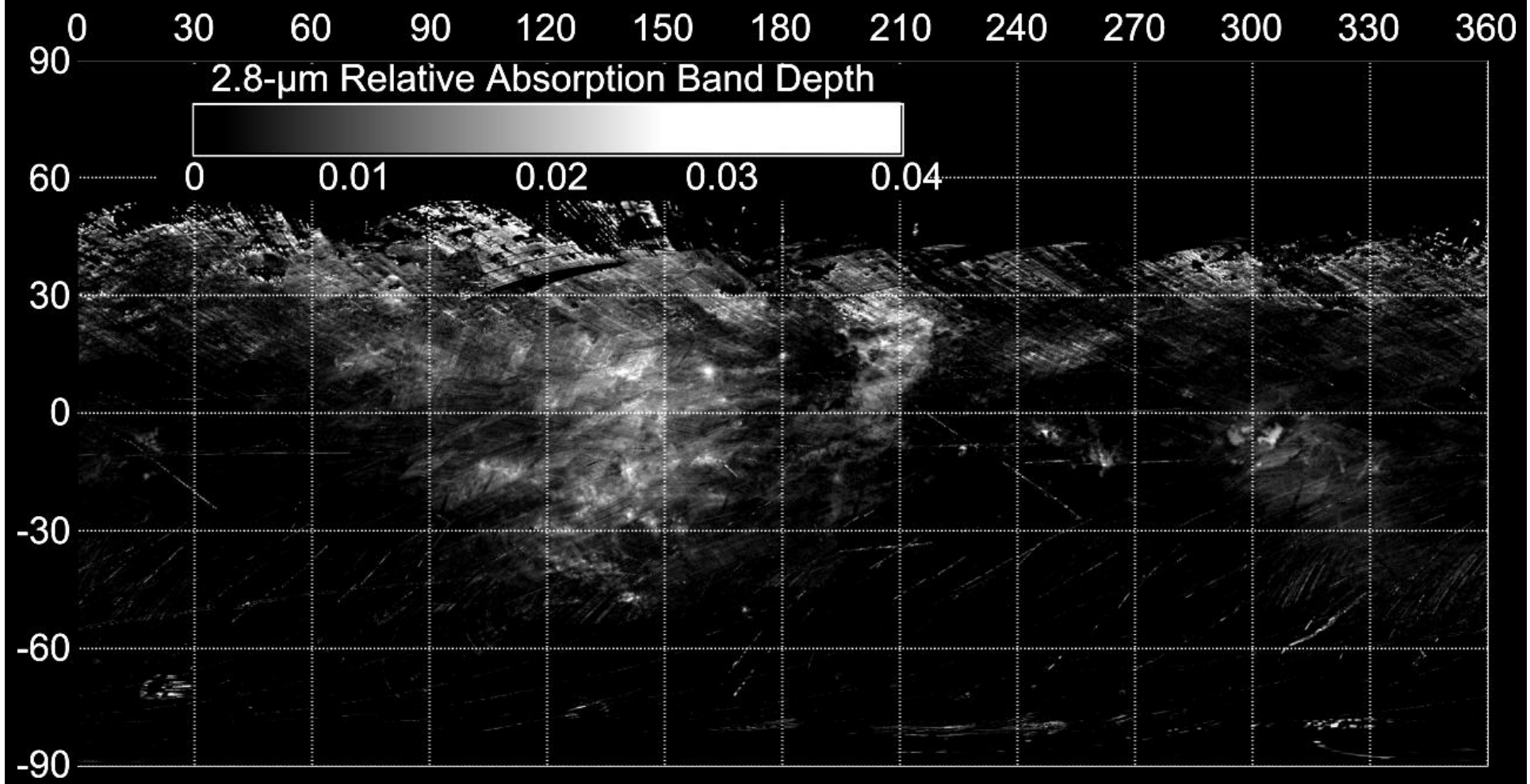
The Veneneia basin outlined in the dashed line hosts a preponderance of dark material deposits, leading to the hypothesis that the basin ejecta may preserve some of the original dark impactor material

Reddy et al., Icarus, 2012

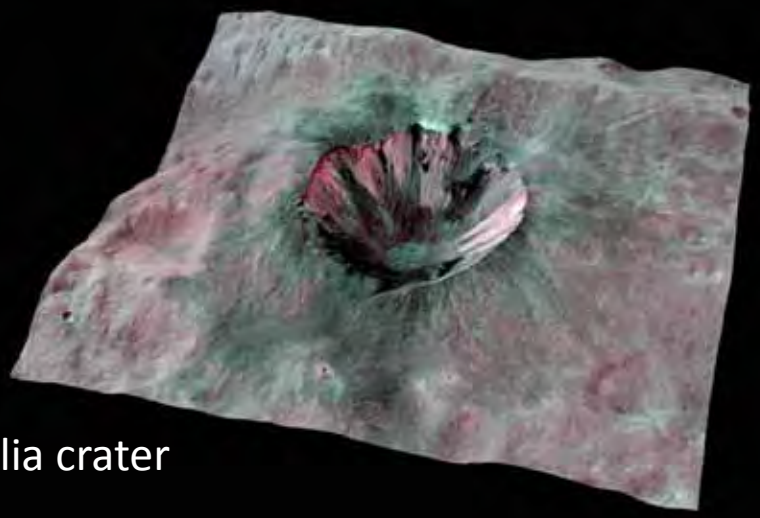


2.8 micron global distribution

De Sanctis et al., ApJ., 2012

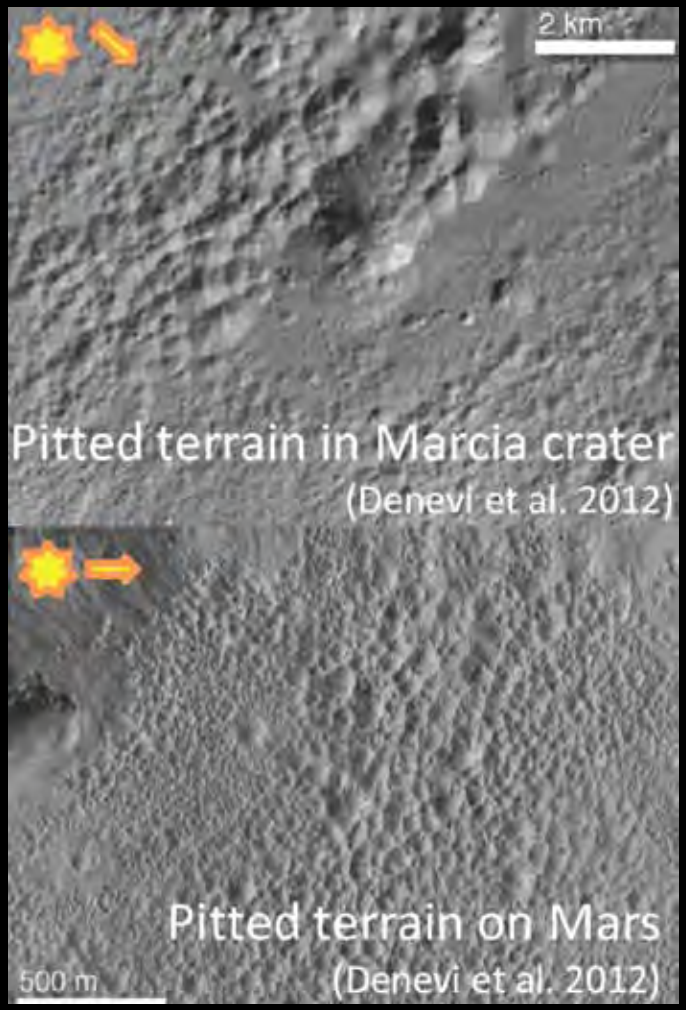


Devolatilization in Crater Bottoms

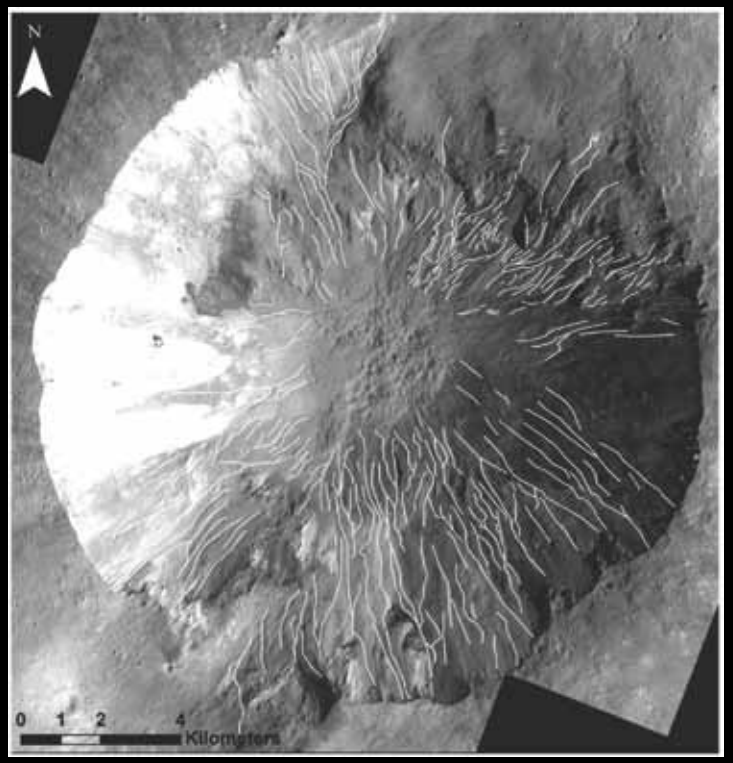


Cornelia crater

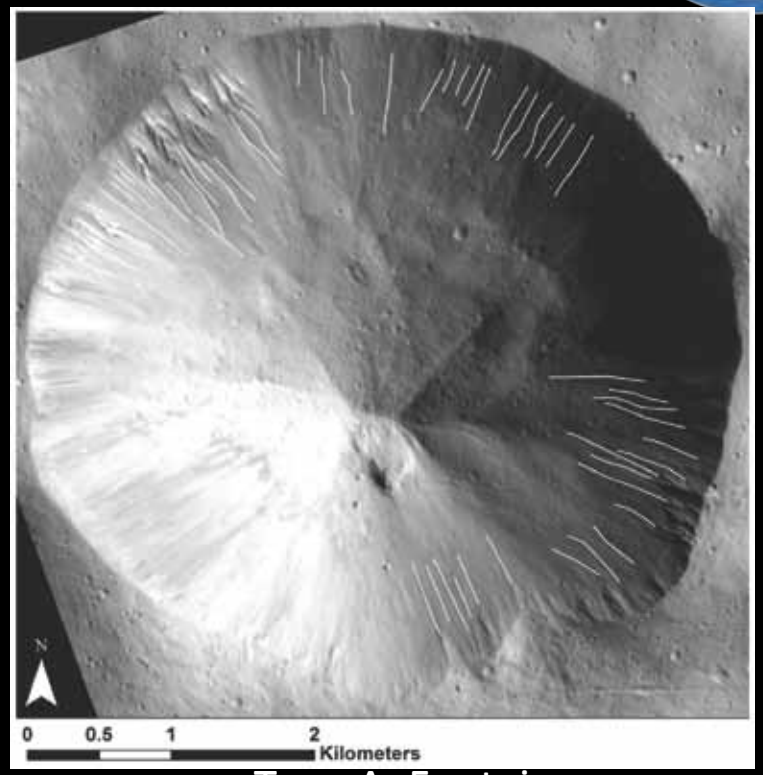
- In the bottom of a number of vestan craters are rimless pits that are similar to pits on Mars that have been attributed to the drying out (devolatilization) of the crater floor
- The most abundant solar system liquid that could do this is water
  - Liberation from the dark carbonaceous material we see everywhere?
  - Subsurface ice melted by impacts?
- Additional clues can be found in the crater walls



Different Styles of Gullies in Vestan Craters



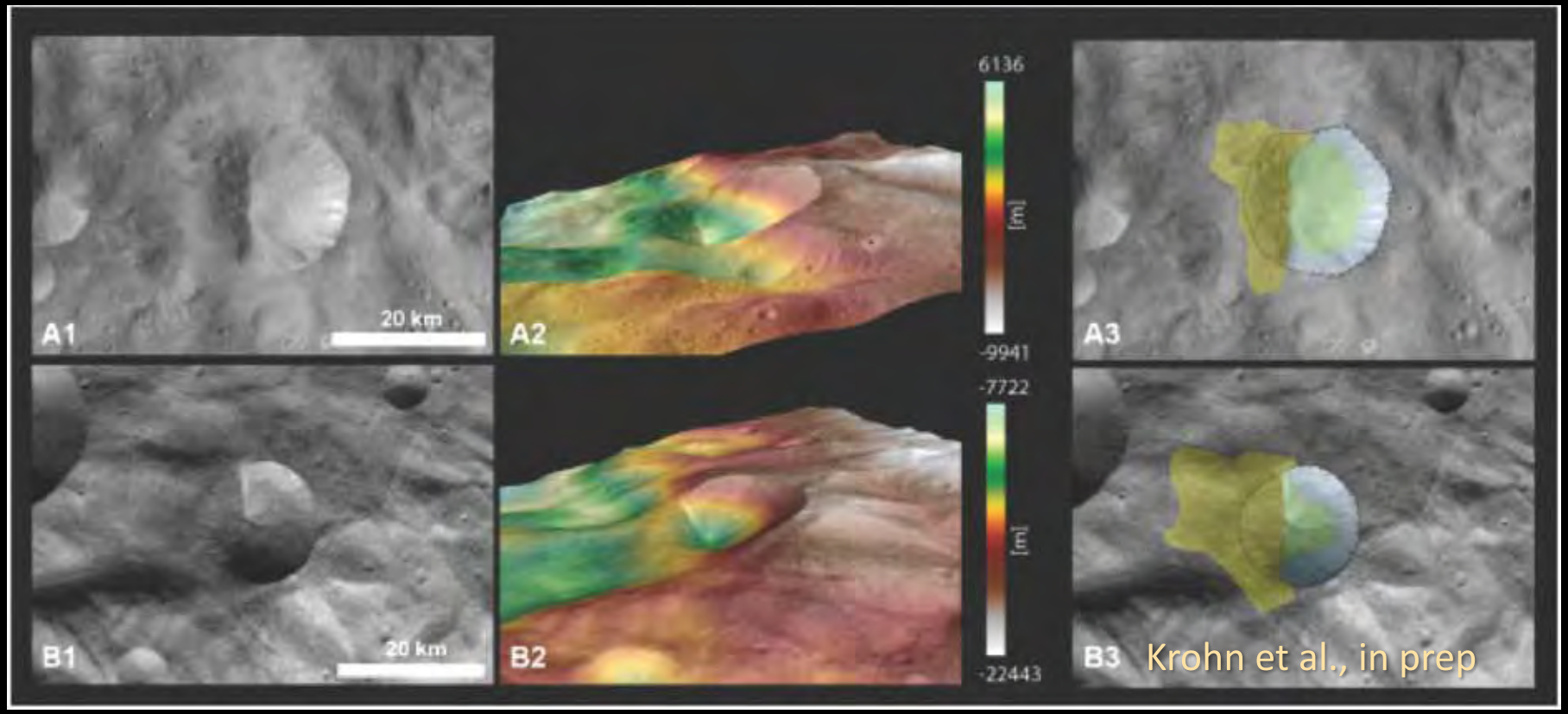
Type B: Cornelia



Type A: Fonteia

- Mass wasting is evident in the walls of many vestan craters. If there is a source of liquid, it could also flow out of the walls and erode gullies.
- Two distinct types of gullies are seen on Mars, Earth, and Vesta. One type has straight, wide, short paths; the other type has long, narrow, sinuous, merging channels.

Bimodal Craters

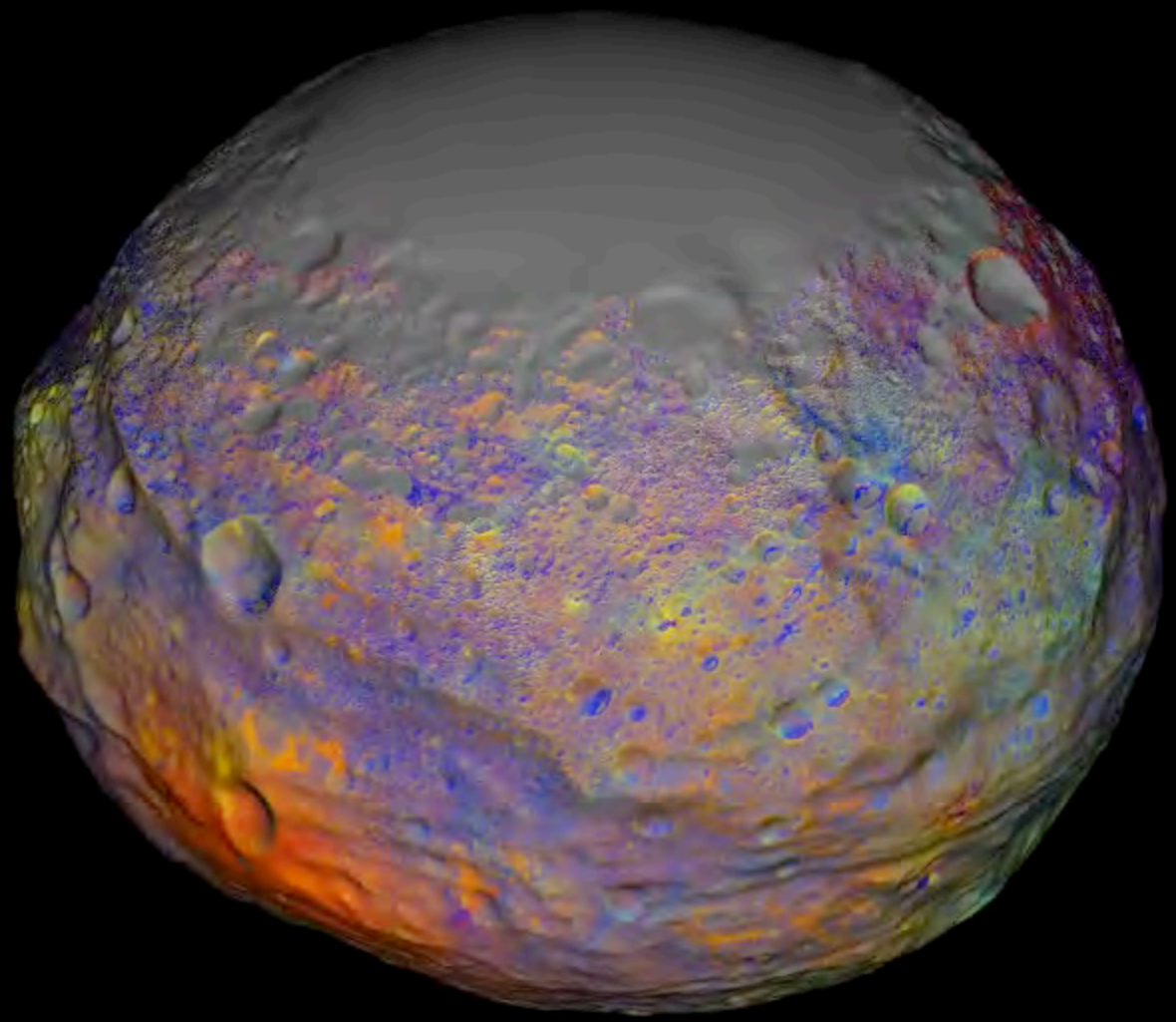


- Most craters form on slopes
- Craters that are much smaller than sloped surface preferentially eject material downslope
- This process sometimes creates bimodal craters with a dividing line across their centers.

Summary

- Vesta formed and differentiated within 1 Ma of condensation of the first solar system solids, and has witnessed nearly all of solar system history
- Vesta is the parent body of the HED meteorites and their source is the Vesta dynamical family of smaller Vestoids that were lthe result of the Rheasilvia impact, and possibly others
- Vesta has a compositional and mineralogical diversity at every scale and is a geologically active body
- Vesta supports the theoretical models of early solar system impactor flux driven by planet formation and migration
- Volatile-rich material has been delivered to and preserved on the surface of Vesta at concentrations that were unexpected

FC Color Data on Shape Model



Courtesy A. Nathues, L. Le Corre, Max Planck Inst. and D. O'Brien, PSI