Asteroid (4) Vesta

• Vesta was the fourth asteroid discovered
  ◦ Triaxial ellipsoid, mean radius of 258 ± 12 km
  ◦ Radii of 289 km x 280 km x 229 km (± 5 km)
  ◦ Discovered by H. W. Olbers in 1807
  ◦ a = 2.36 AU, P_{orb} = 3.6 yr, P_{rot} = 5.3 hrs

• What is Vesta composed of?
  ◦ Vesta is a V type asteroid or protoplanet
  ◦ Spectra indicates basaltic minerals (e.g., low-Ca pyroxene, mixtures of plagioclase and pyroxene, Ca-rich augite)
  ◦ Spectra correlates with HED family of meteorites (Howardite-Eucrite-Diogenite), basaltic achondrites
  ◦ Basaltic minerals => Volcanic activity once existed
  ◦ Internal heat => a differentiated body
  ◦ Mass = 2.75-2.99 \times 10^{20} \text{ kg}; volume = 7.19 \times 10^{7} \text{ km}^3
  ◦ Density = 3.5-3.9 \text{ g/cc}
  ◦ Low porosity, thought to be solid body
  ◦ Spectra indicates no H$_2$O on surface

• Vesta was imaged by Hubble
• *Dawn* orbited Vesta from July 16, 2011 – Sept. 5, 2012
HEDs: Meteorites from Vesta?

Chemistry of the HEDs

- *Dawn’s* GRaND instrument can distinguish HED whole-rock compositions

![Diagram showing Mg vs Fe percentages for different types of HEDs](image)
• Objective: What is the role of size and water in determining the evolution of the planets?
  - Ceres is large & wet
  - Vesta is smaller & dry

• Three principal scientific drivers for mission:
  - *Dawn* captures the earliest moments in the origin of the solar system, to understand the conditions under which these objects formed
  - *Dawn* determines the nature of the building blocks from which the terrestrial planets formed
  - *Dawn* contrasts the formation and evolution of two small planets that followed very different evolutionary paths so that we understand what controls that evolution
Dwarf Planet (Ceres)

Protoplanet (Vesta)

Asteroids

- 21 Lutetia
- 253 Mathilde
- 243 Ida / 1 Dactyl
- 433 Eros
- 951 Gaspra
- 2867 Steins
- 5535 Annefrank
- 9969 Braille
- 25143 Itokawa
Approach (Rotation Characterization)
The topography to radius relation on Vesta amounts to $\Delta R_{\text{topo}} / R \sim 30\%$ (Moon and Mars yield 1%) This makes Vesta a hilly and slope-intensive environment.
Impact craters named after Vestal Virgins & famous Roman women
Other features named for Roman holidays
Key Geology Results:

- Impact cratering is the dominant geologic process that has modified Vesta’s surface.
- Vesta’s extensive steep slopes result in many mass wasting deposits, & ‘bimodal crater’ (sharp rim upslope, subdumed rim downslope).
- Any evidence of Vesta’s ancient volcanism has been destroyed. 
This slide compares in absolute units the height and width of the south pole mountain with Mars’ Olympus Mons, the solar system’s largest volcano.

- This mountain is comparable in height to Olympus Mons.
- It dwarfs any mountain on Earth.
- It is the central peak of the 505-km diameter Rheasilvia basin.
Rheasilvia Basin
500 km diameter

Veneneia Basin
400 km diameter
Vesta’s troughs are a tectonic response to impact basin formation.
Formation through devolatilization of subsurface or cometary ice
Vesta’s Geologic Map & Time Scale
Williams et al. (2014)