Imaging RADAR

Sriram Gopalakrishnan (EP16B005)

Based on: NASA ARSET webinar (https://arset.gsfc.nasa.gov/disasters/webinars/advanced-SAR-18)

Wave Parameters

- Wavelength
- Polarization
- Incidence angle

Wavelength

- P Band : 400 MHz - 1 GHz (~ 40 cm)
- L Band : 1 - 2 GHz (~ 20 cm)
- S Band : 2 - 4 GHz (~ 10 cm)
- C Band : 4 - 8 GHz (~ 5 cm)
- X Band : 8 - 12 GHz (~ 2 cm)

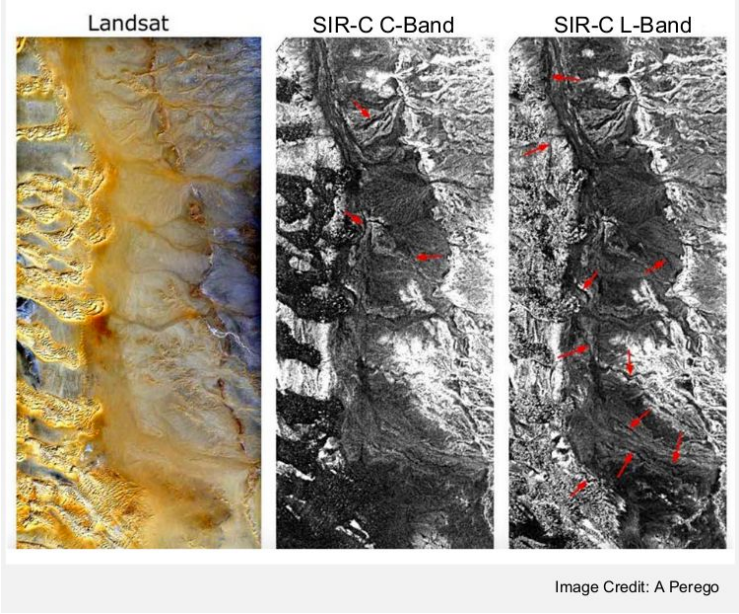
Choice of wavelength

There is a trade-off between **resolution** and **penetration depth**

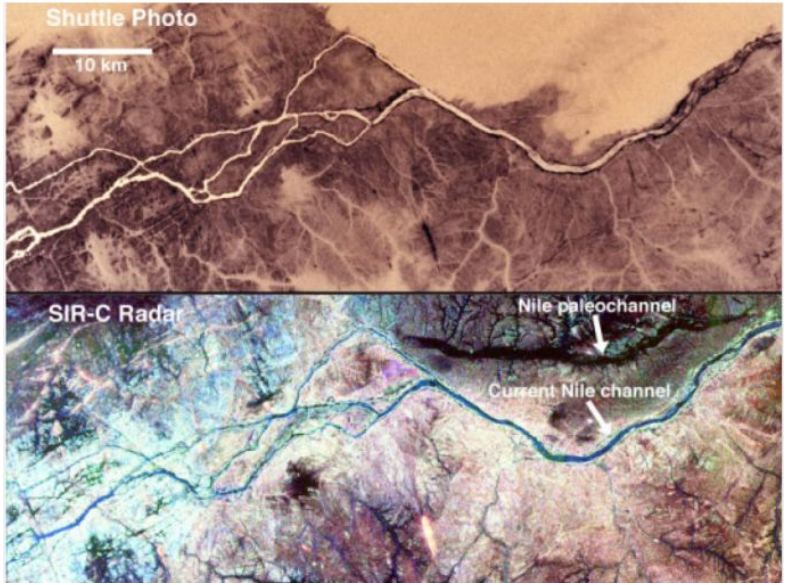
$$\delta \sim \sqrt{\lambda}$$

Latter is more important for **subsurface imaging**

Optical vs C band vs L band

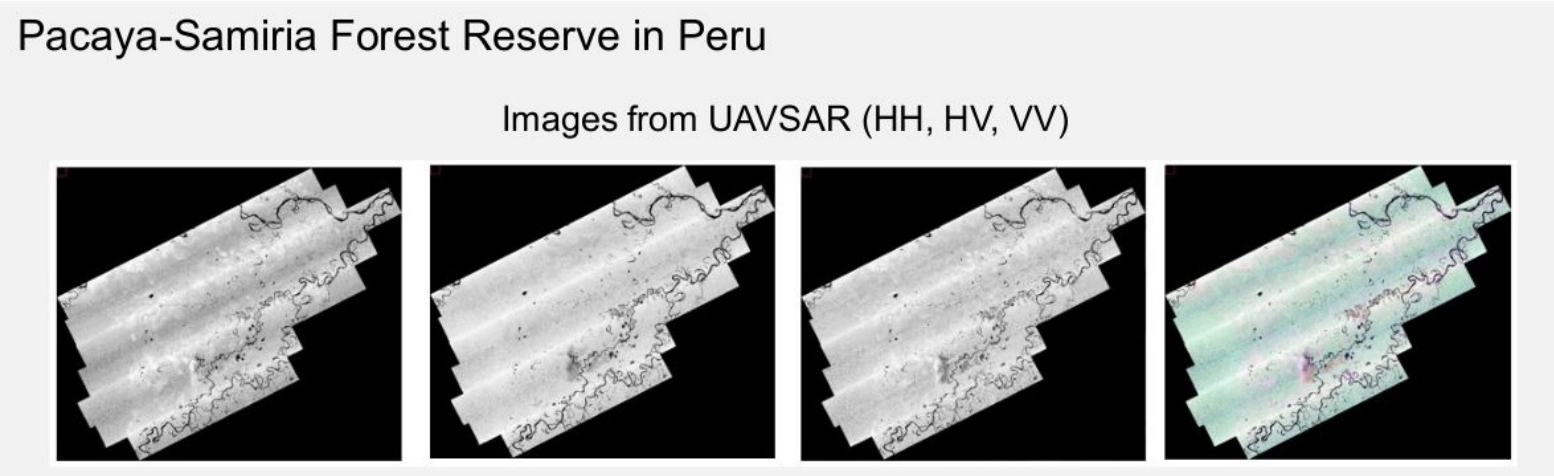


Visible, C-band and L-band images of Southwest Libya (Credit: NASA)



Visible and C-band images of the Nile river (Credit: NASA)

Polarization : Polarimetric SAR



False color RADAR image (rightmost) as an RGB mix of HH, HV and HV greyscales.
(Credit: NASA)

Ground Ice on Ceres

Sriram Gopalakrishnan (EP16B005)

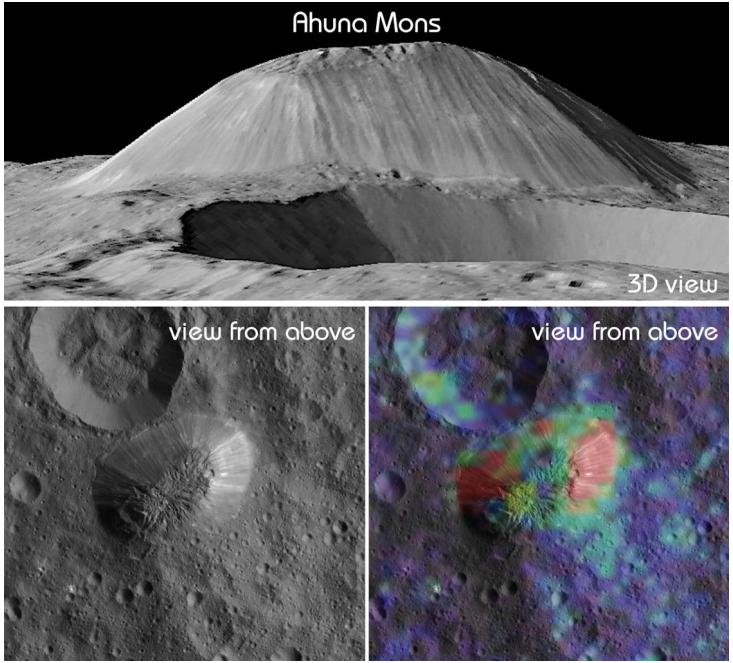
Based on: Geomorphological evidence for ground ice on dwarf planet Ceres (Nature Geoscience, 2017)

Ceres

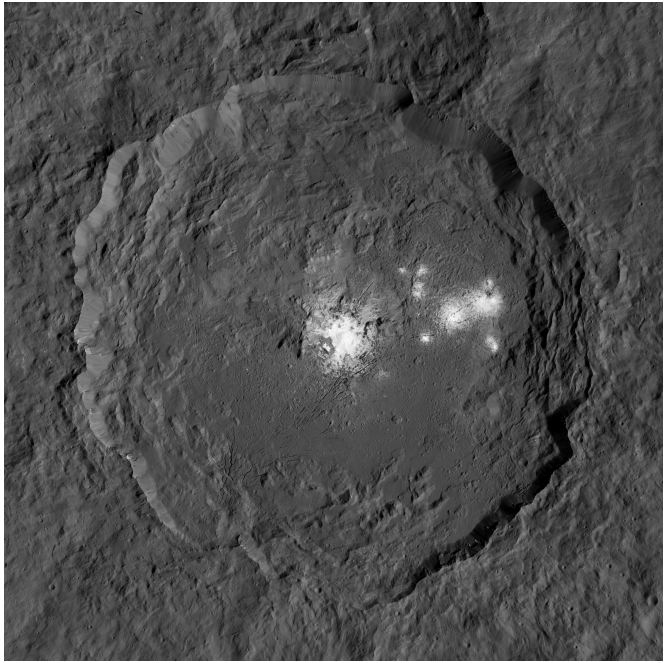
- Dwarf Planet, Largest object in the asteroid belt.
- Has been studied by NASA's Dawn spaceprobe (2007-2018)

Dawn Payload

- Framing Camera (Germany)
- Visible and IR spectrometer (Italy)
- Gamma Ray and Neutron Detector (GRaND, US, Los Alamos lab)



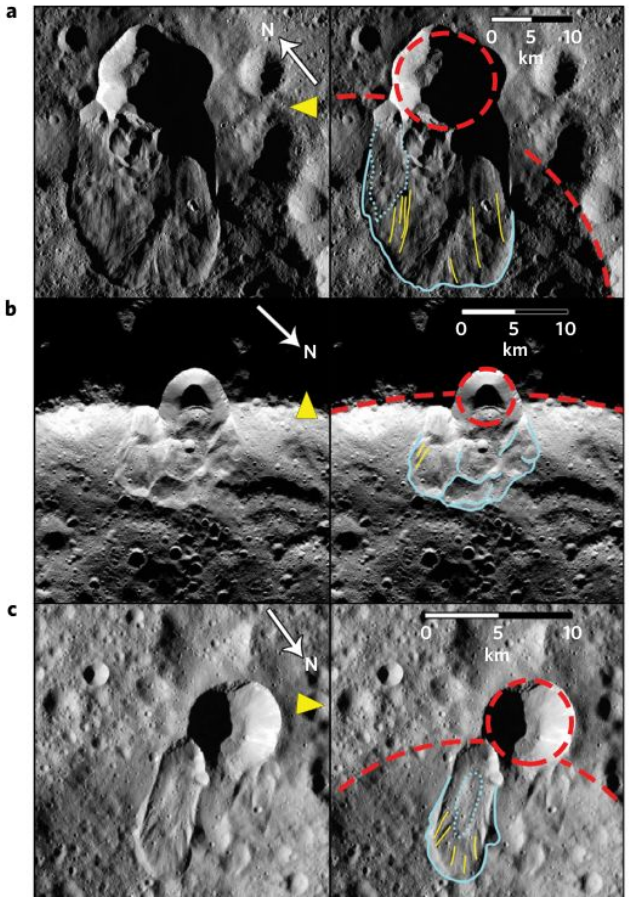
Ahuna Mons (Credit: Wikipedia)



Occator Crater (Credit: Wikipedia)

Objective and Method

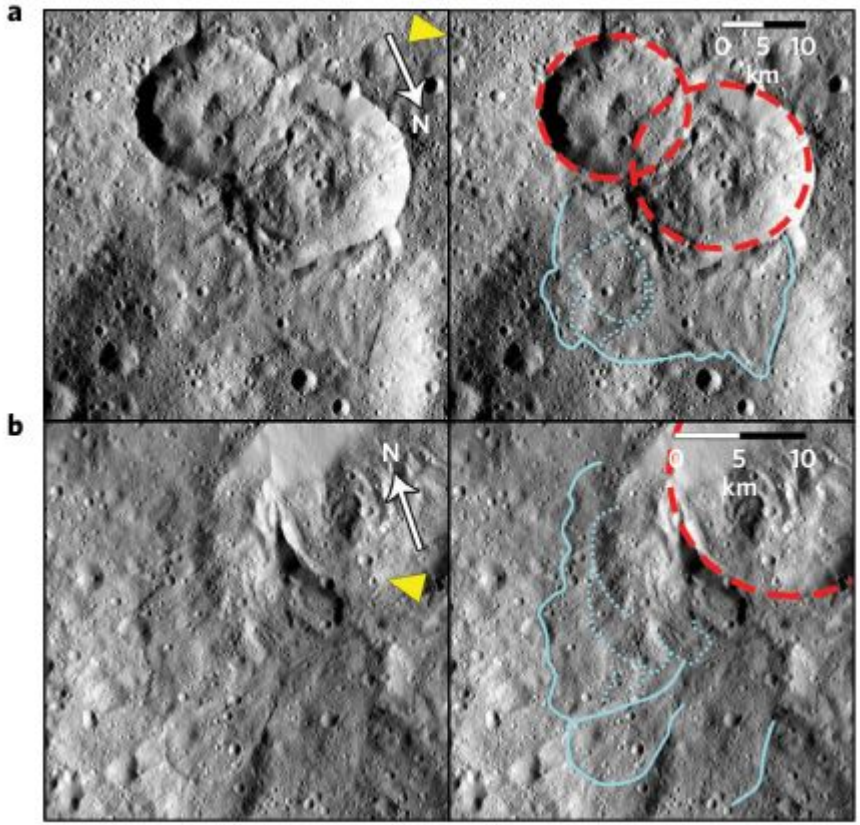
- What? Infer the presence of **Ground Ice** (Water ice + silicates) on Ceres.
- How? Comparing the nature of **surface flows** with those on Mars and Iapetus (moon of Saturn)



Type 1 flows on Ceres (Paper)

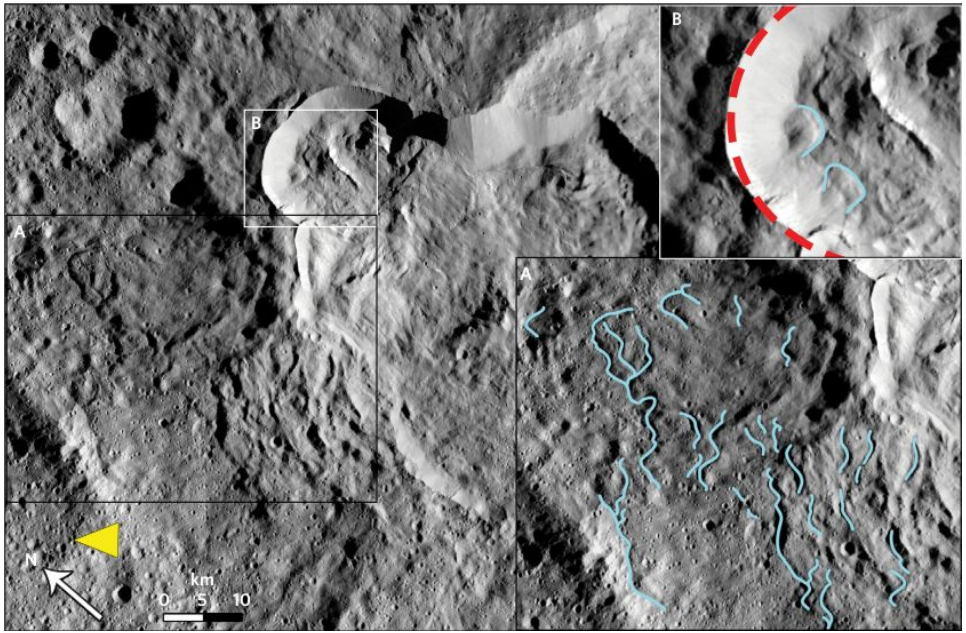
- Thick (>100m), short ranged flows
- Steep slopes.
- Flows into the crater.
- Slow flows, similar to **Martian rock glaciers**.

[The red dashes demarcate the crater and the central lobe. The blue curve represents the flow contour. The yellow lines represent directed flow along furrows. The yellow arrow represents the direction of incident light]



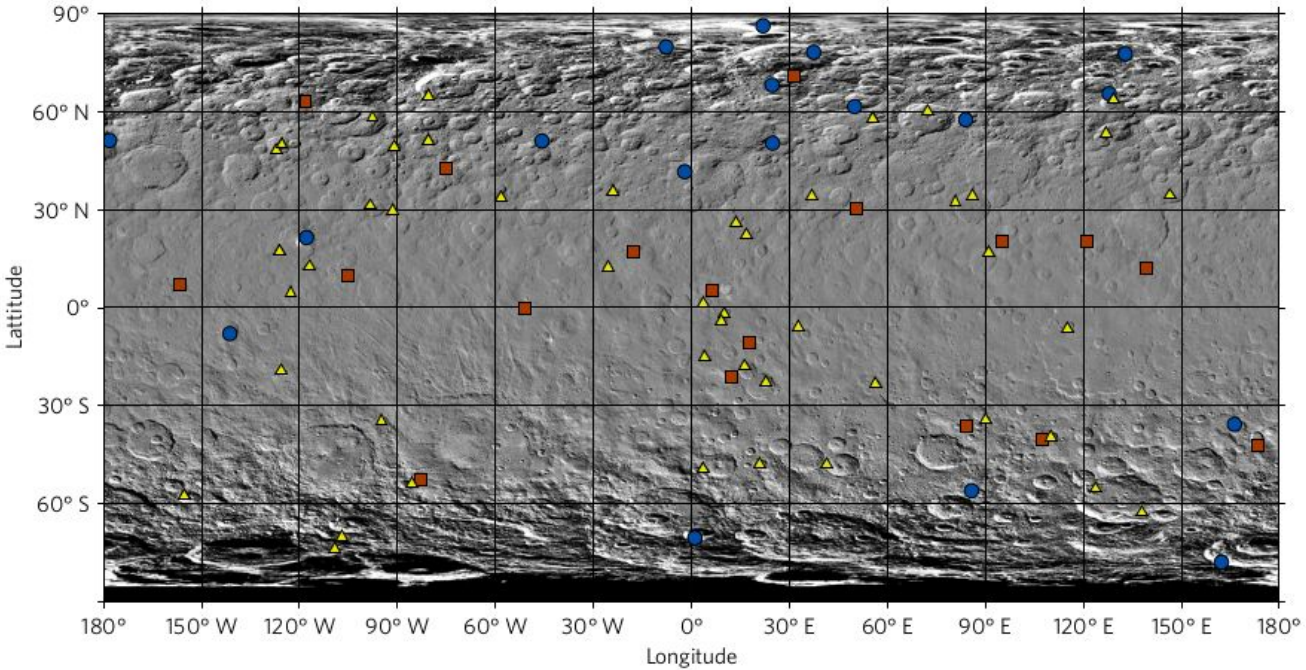
Type 2 flows on Ceres (Paper)

- Thin (~10m), long ranged flows.
- Shallow slopes.
- Flows out of the crater.
- Similar to **landslides on Iapetus.**



Type 3 flows (From paper)

- Rarest, equatorial.
- Very thin, Fluidized flow.
- Origin: Impact ejecta!
- Similar to flows observed on **rampart craters on Mars and Ganymede.**

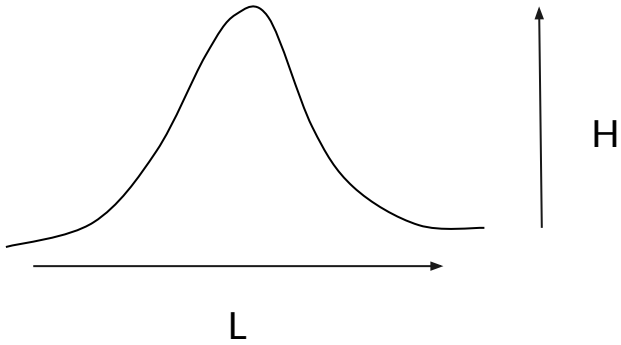


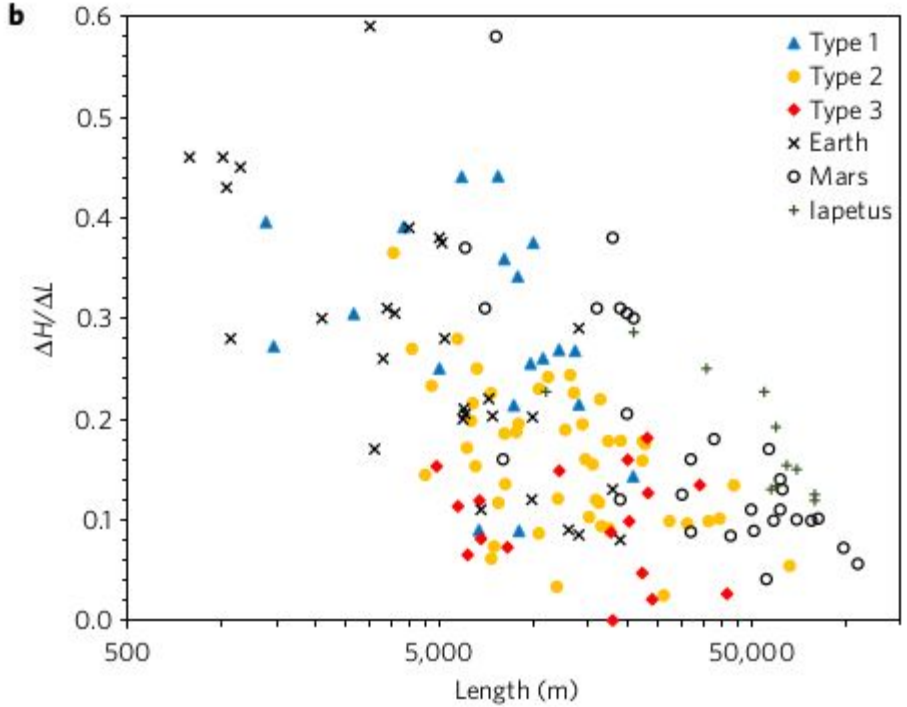
Global distribution of flow features (From Paper)
[Type 1: Blue circles, Type 2: Yellow triangles, Type 3: Red squares]

North-South asymmetry consistent with GRaND observations (latitude dependent ice depth)

A measure of internal friction

H/L : A crude measure of internal friction.





H/L vs L plot of all flow types, superposed flows observed on Earth, Mars and Iapetus

- Type 2 flows overlap with lobate flows on Iapetus.
- Slower flow, Larger H/L

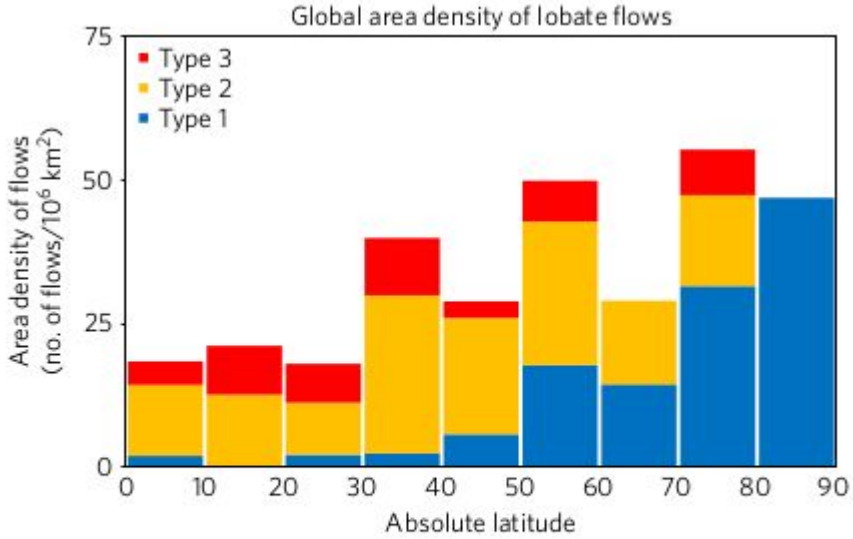


Figure 6 | Global area density of type 1 (blue bars), type 2 (yellow bars) and type 3 (red bars) flows. The areal density of surface flows on Ceres increases with increasing latitude, in particular for type 1 flows.

Area density of flow types as a function of absolute latitude (Paper)

With increasing latitude

- Type 1 density increases rapidly.
- Type 2 density is almost constant.
- Type 3 shows no correlation. (But not observed at poles, suggesting warmer temperature requirement)

Implications

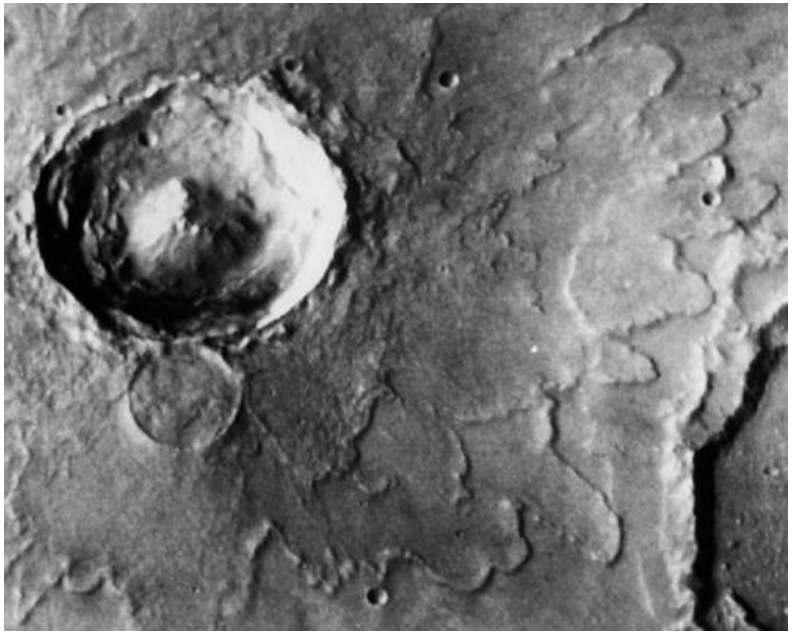
- Ceres is only the 3rd planetary body with widespread ground ice.
- The water ice in Ceres's crust might have been a source of Earth's primordial water.

Remark

Authors state that “Latitude dependent behaviour is not expected for salty or clay compositions, nor has spatial variation in such compounds been observed”

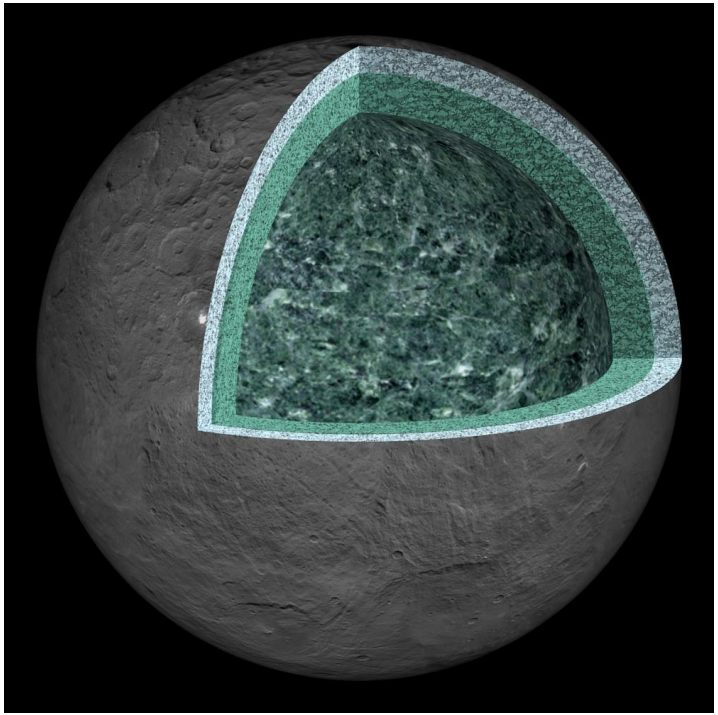
Thank You

Rampart Crater



A Rampart Crater on Mars (Credit: Wikipedia)

Internal Structure



Artist’s concept of the internal structure of Ceres. (Credit: Wikipedia)
40 km crust, 100 km mantle