Composition from IR Spectra: Comets, Asteroids, Meteorites, and the Moon

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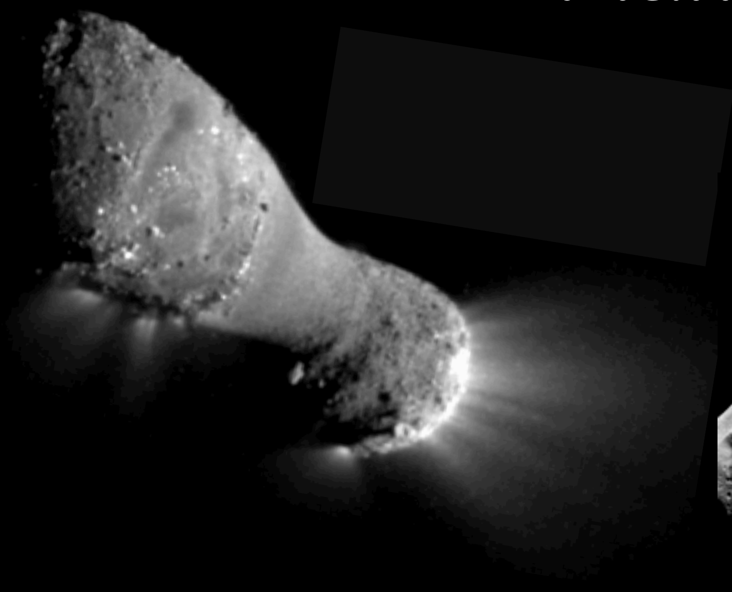
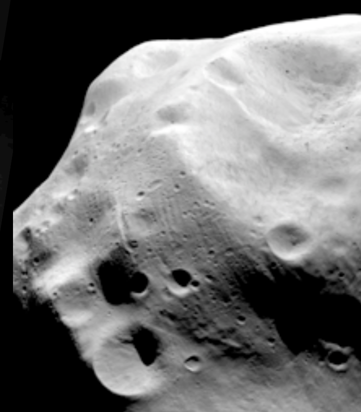
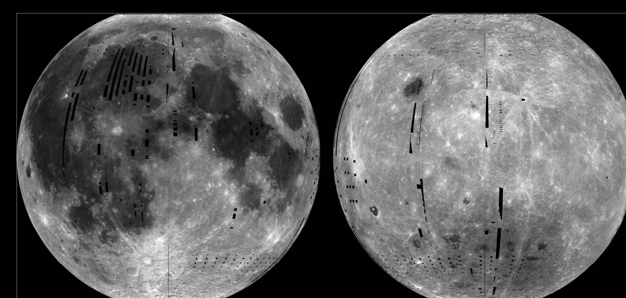
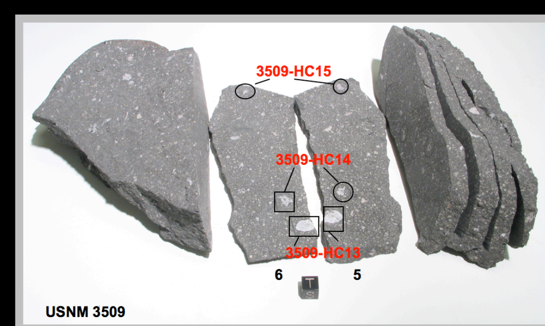






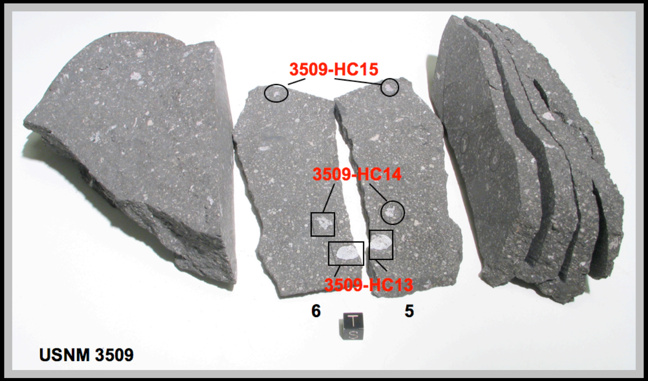


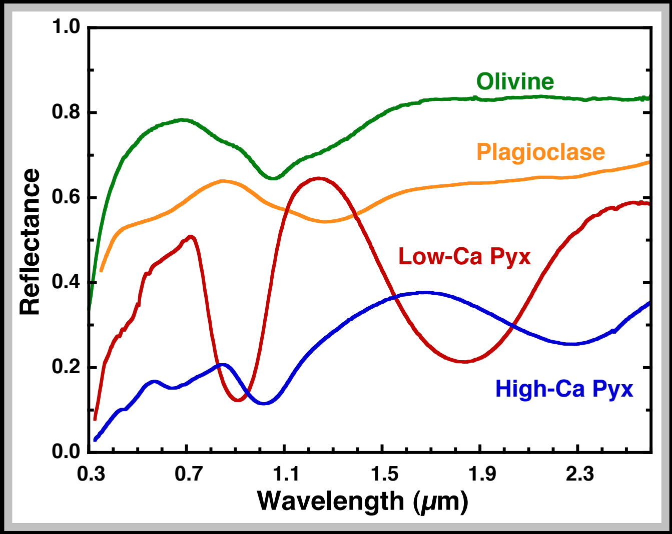
History & Evolution of the Early Solar System

Study of the least processed surfaces w/ Spectroscopy

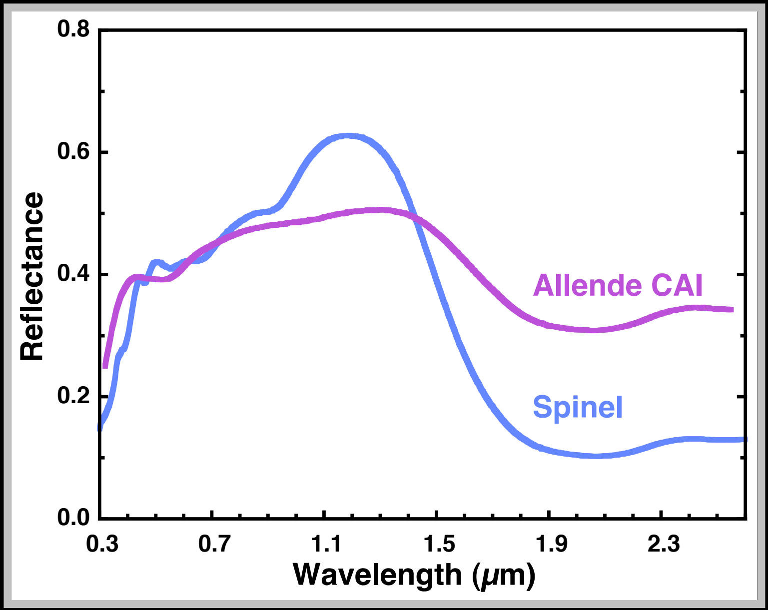
- **Comets**
  - » Composition: primordial vs. evolutionary mixing within early Solar System
    - continued analysis of Deep Impact (ice, solids, surface)
    - extended mission (DIXI) to Hartley 2 (Nov. 2010)
- **Asteroids and Meteorites**
  - » Composition: timing and nature of accretion and alteration (igneous, aqueous, metamorphic, impact)
    - laboratory analysis (Smithsonian)
    - asteroid surveys (telescopic, SPEX)
    - DAWN mission to mainbelt Asteroid 4 Vesta
- **The Moon**
  - » Composition in a geologic context. Formation and relation to Earth and subsequent igneous and impact evolution; H_20/OH !!
    - Moon Mineralogy Mapper (M^3) on-board Chandrayaan-1

Calcium Aluminum-Rich Inclusions: CAIs



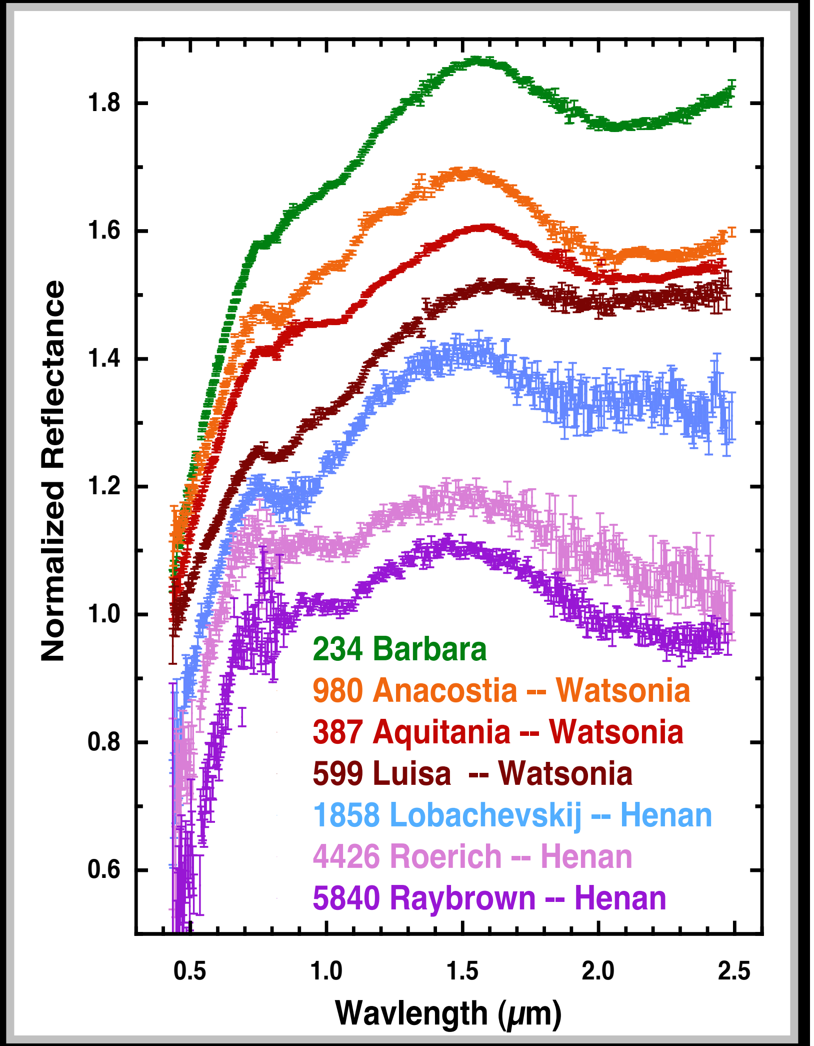


- **Oldest known rocks**
  - » mineralogy predicted for first nebular condensates
  - » date the start of the Solar System
  - » occur in all classes of chondrites
- **Spectrally dominated by spinel hercynite: [Fe,Mg]Al_2O_4**
  - » strong 2 μm absorption
  - » absent or weak 1 μm bands



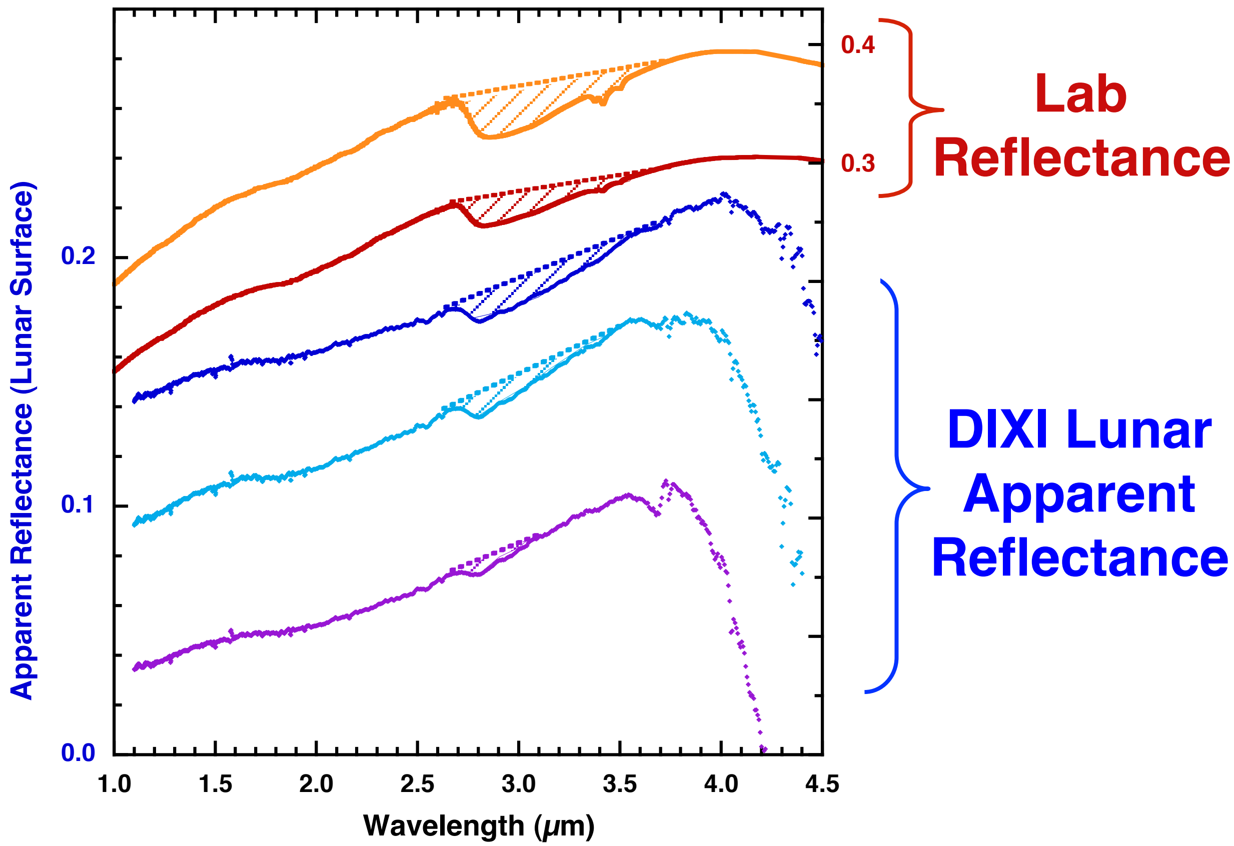
Calcium-Aluminum-Rich Asteroids

- **3 distinct parent bodies**
  - 234 Barbara;
    Watsonia and Henan Families
- **Spectral models: 2x-3x > CAIs then any known meteorite**
  - implies very ancient
  - early accretion
- **Survived as large bodies**
  - d = 50-100 km
- **if Al-rich why didn't the melt?**
  - perhaps, pre-date Al^{26} injection into solar system ?

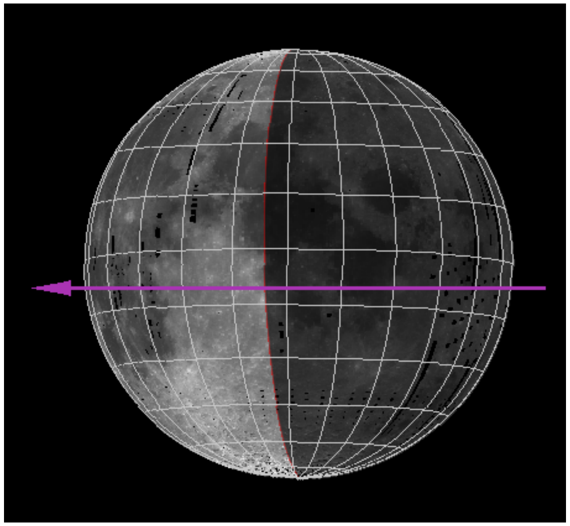


Water on the Lunar Surface

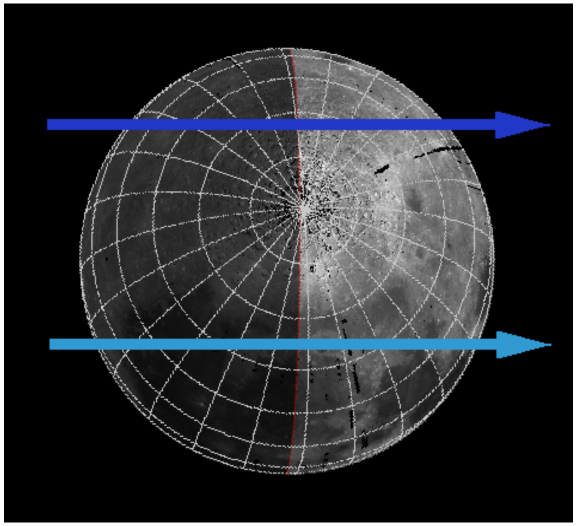
Adsorbed OH and H_2O



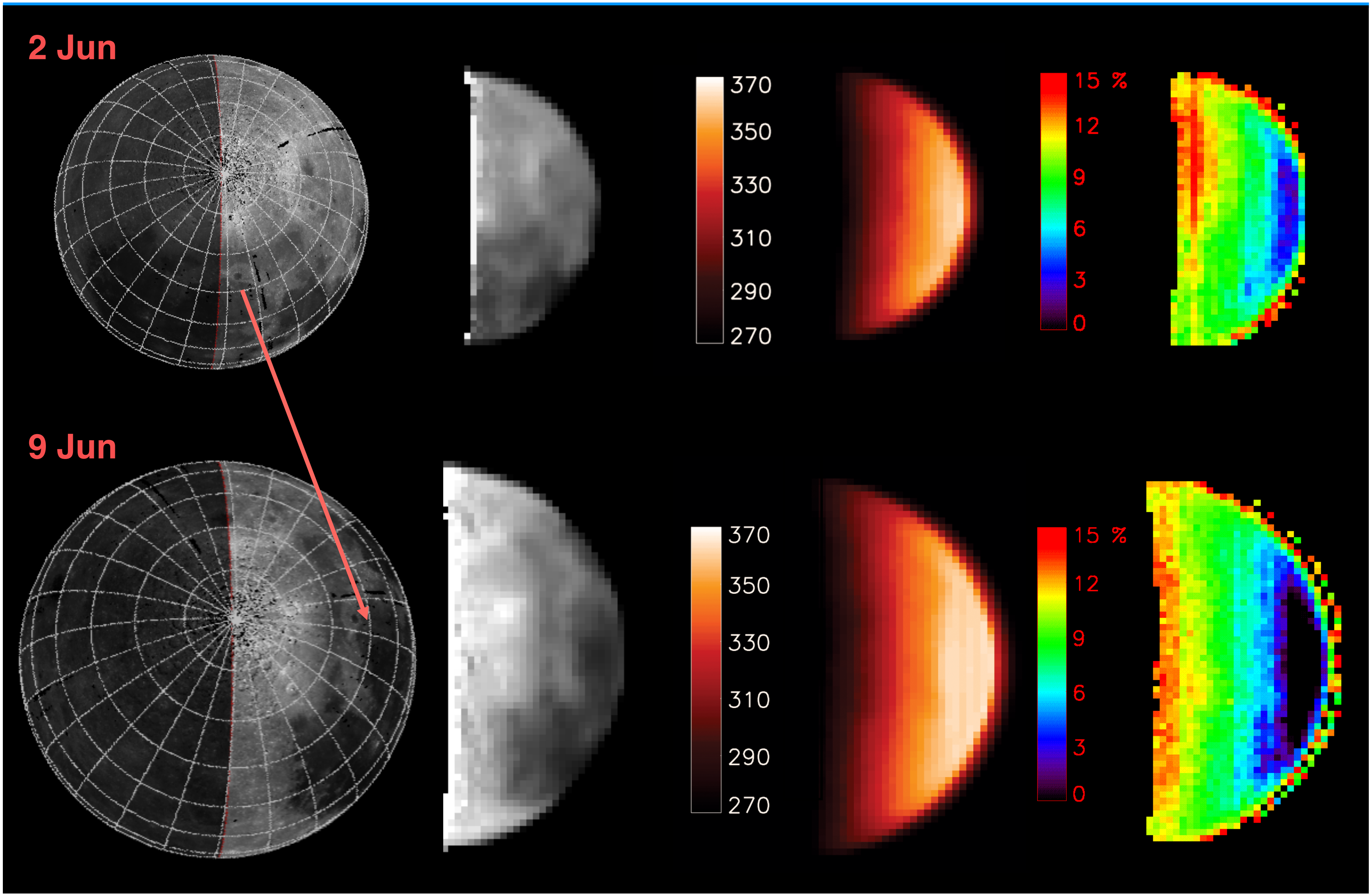
Dec 2007



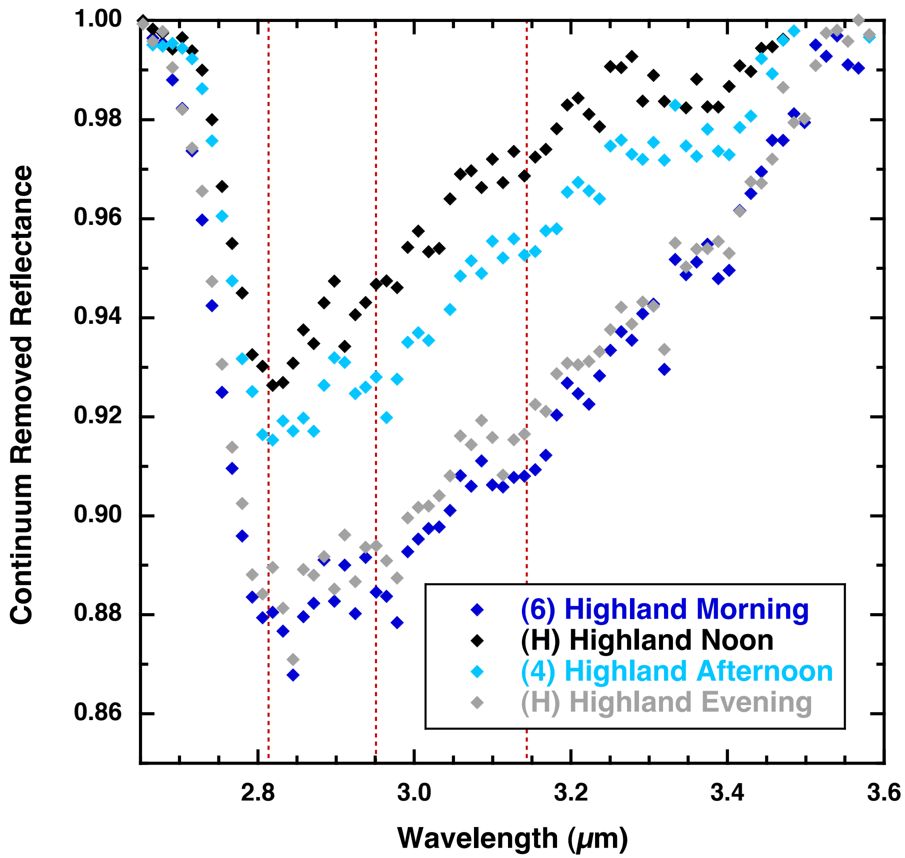
June 2009

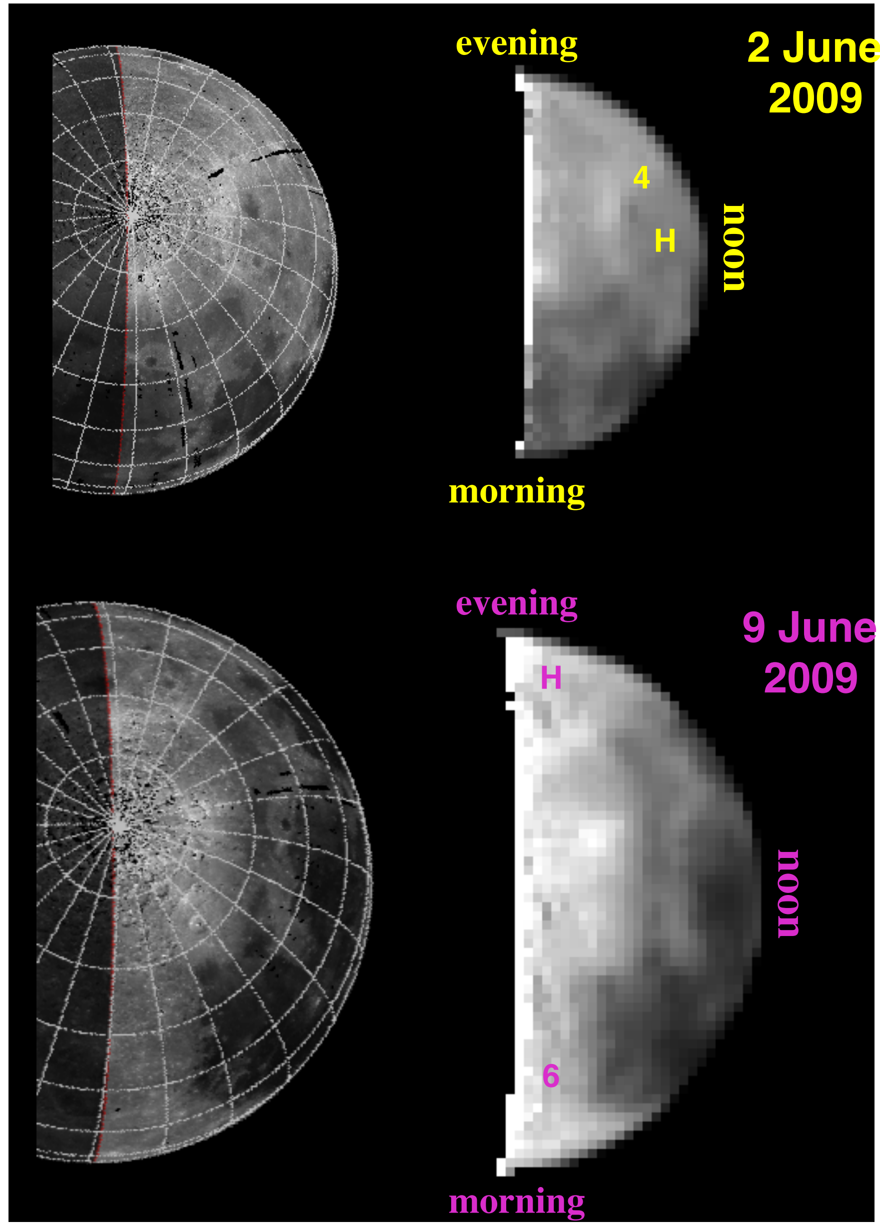


North Pole: 2nd & 9th Jun '09



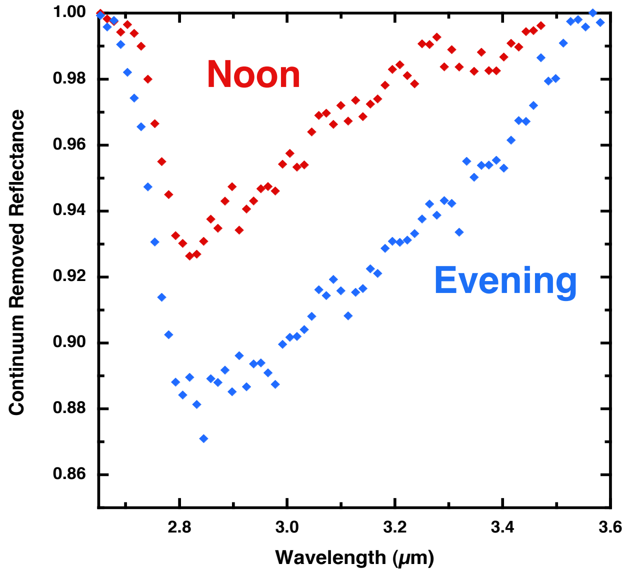
Change with Time of Day

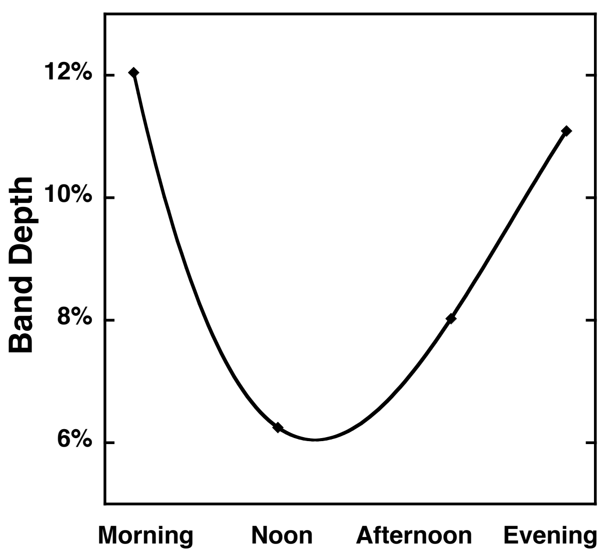




Comparing highland units
- morning equals evening
- noon/afternoon weaker and shape change

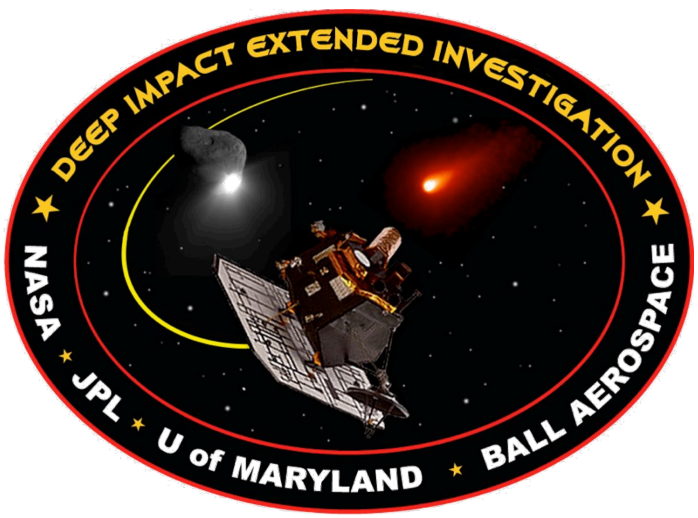
Daytime Cycle

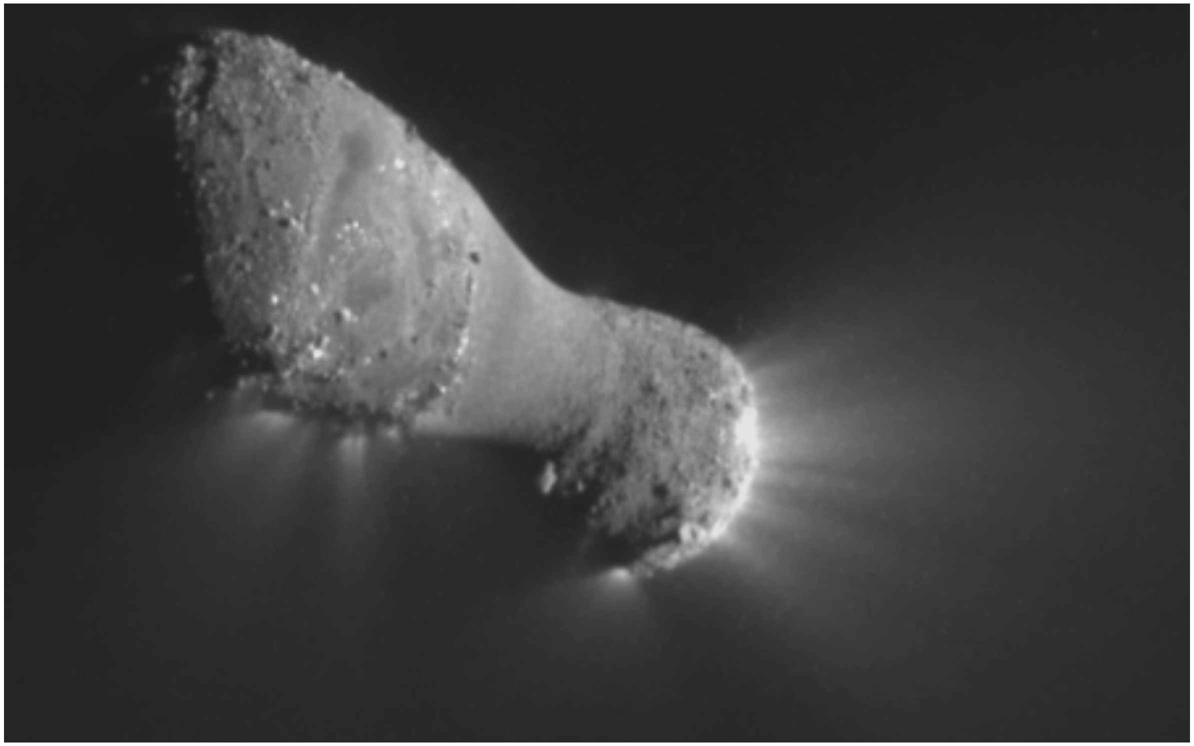




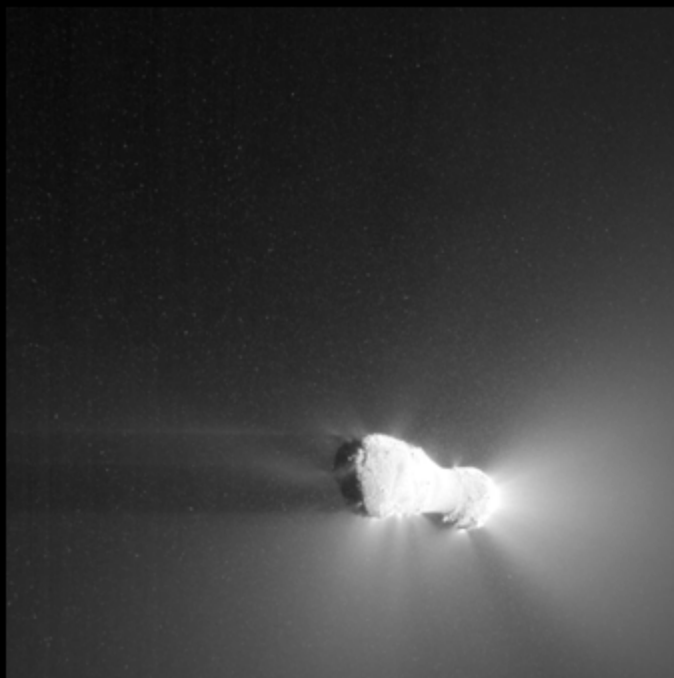
- **Diurnal change**
  - » **suggests surface effect**
- **Entire surface is hydrated**
  - » **during at some part of the lunar day**
- **Change in shape of absorption**
  - » **preferential loss of H_2O vs. OH**
- **Loss toward noon, recovery back to morning values by evening**
  - » **entirely in daylight**
  - » **not condensation**
  - » **rapid photodissociation of H_2O ?**
  - » **short term migration?**
  - » **ready source?**
- **Consistent with Solar Wind**
  - » **H^+ reacts with O in lunar soil**

Deep Impact eXtended Investigation to Comet Hartley 2



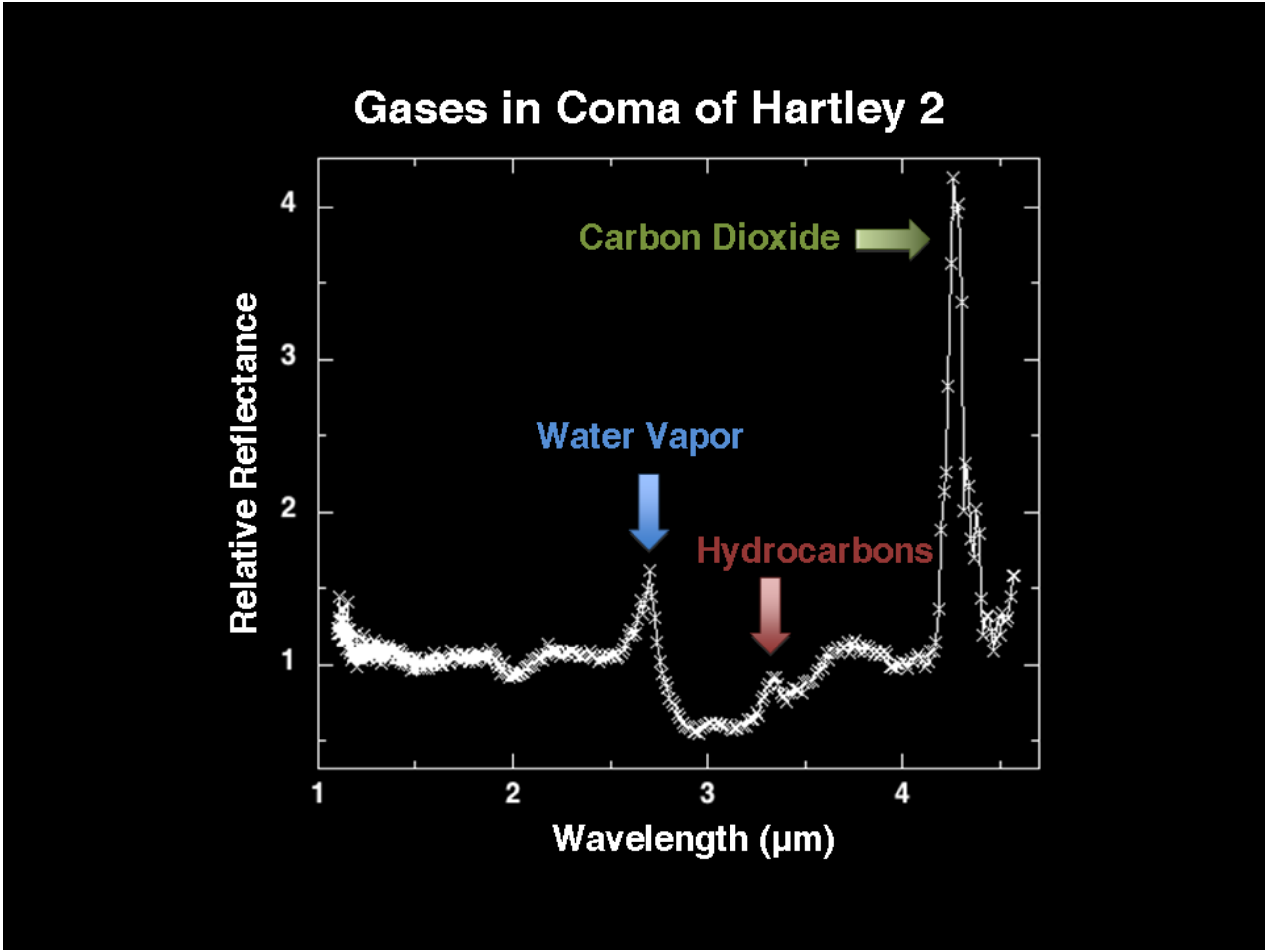


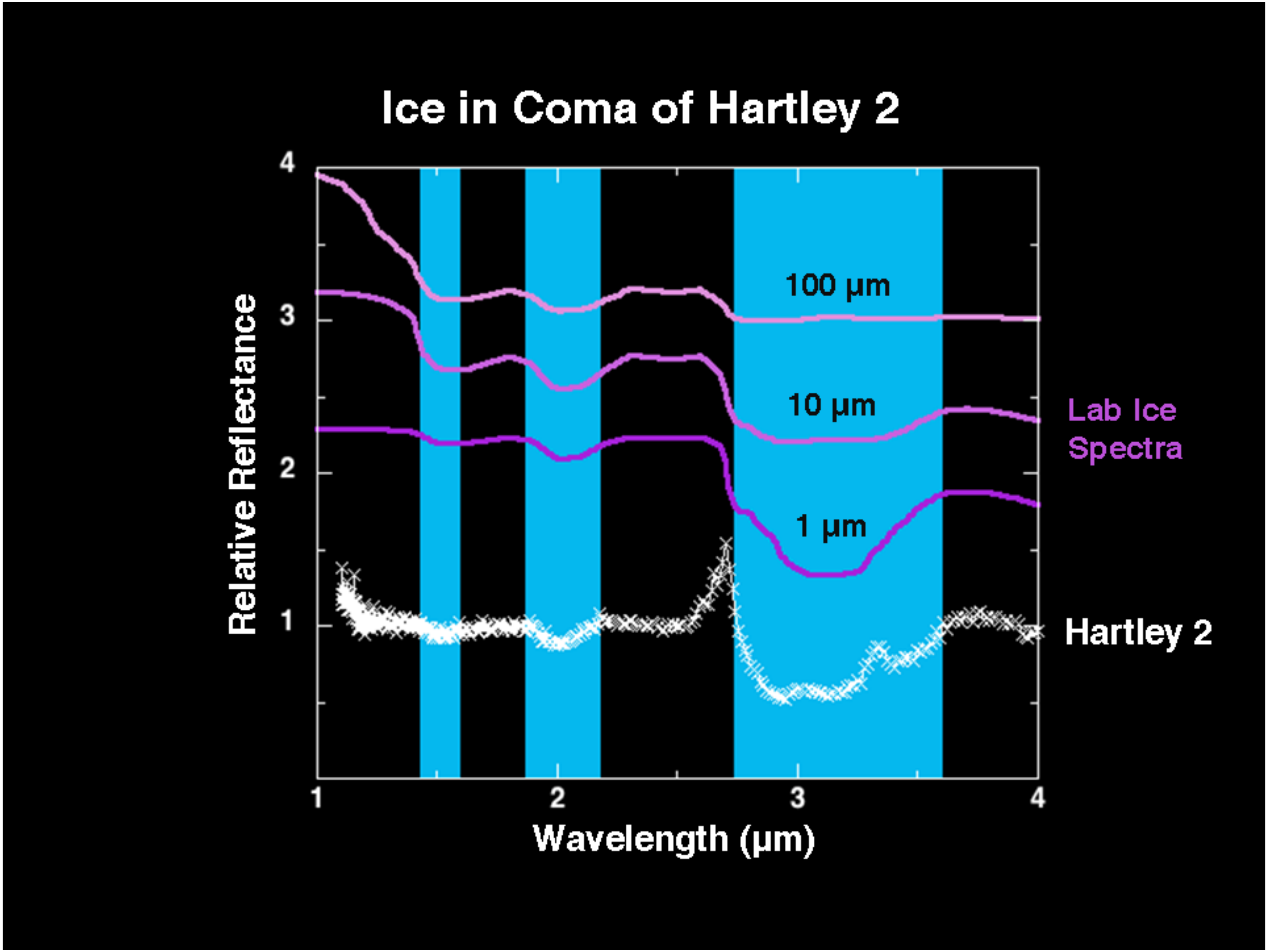
MRI Camera View of Nucleus and Inner Coma



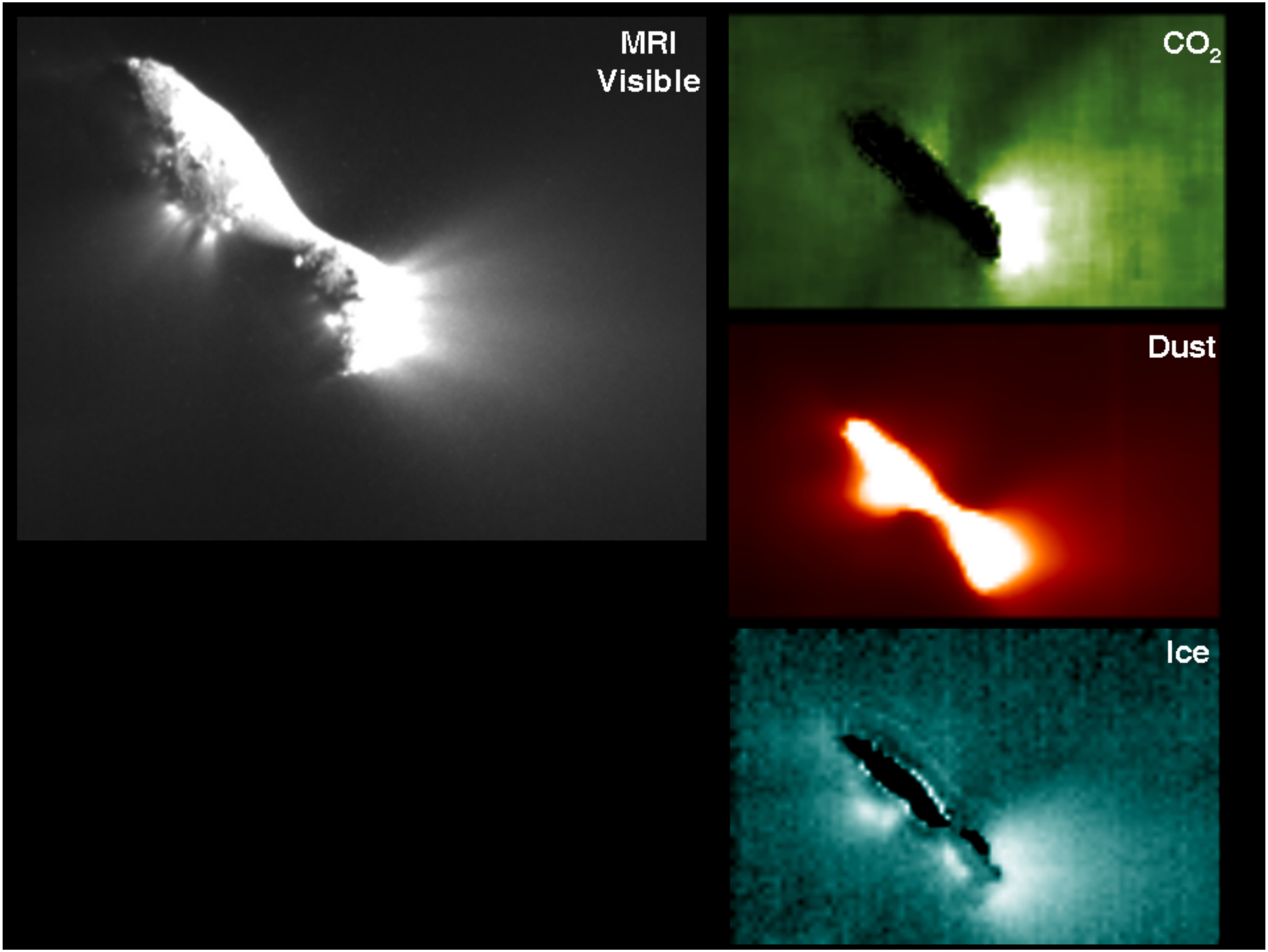
context view

enlarged view

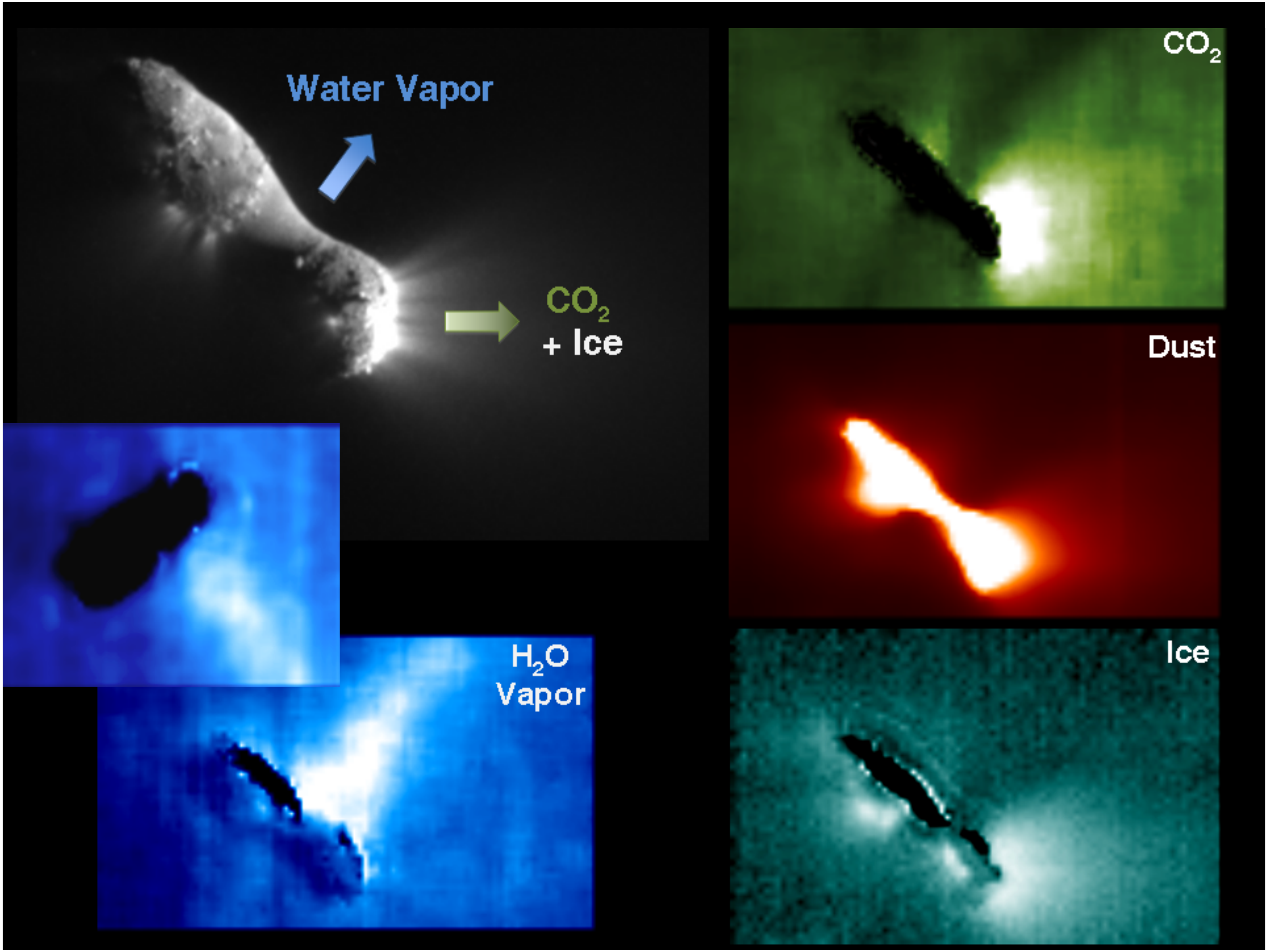

Gases in Coma of Hartley 2
Carbon Dioxide
Water Vapor
Hydrocarbons
Relative Reflectance
4
3
2
1
1
2
3
4
Wavelength (µm)



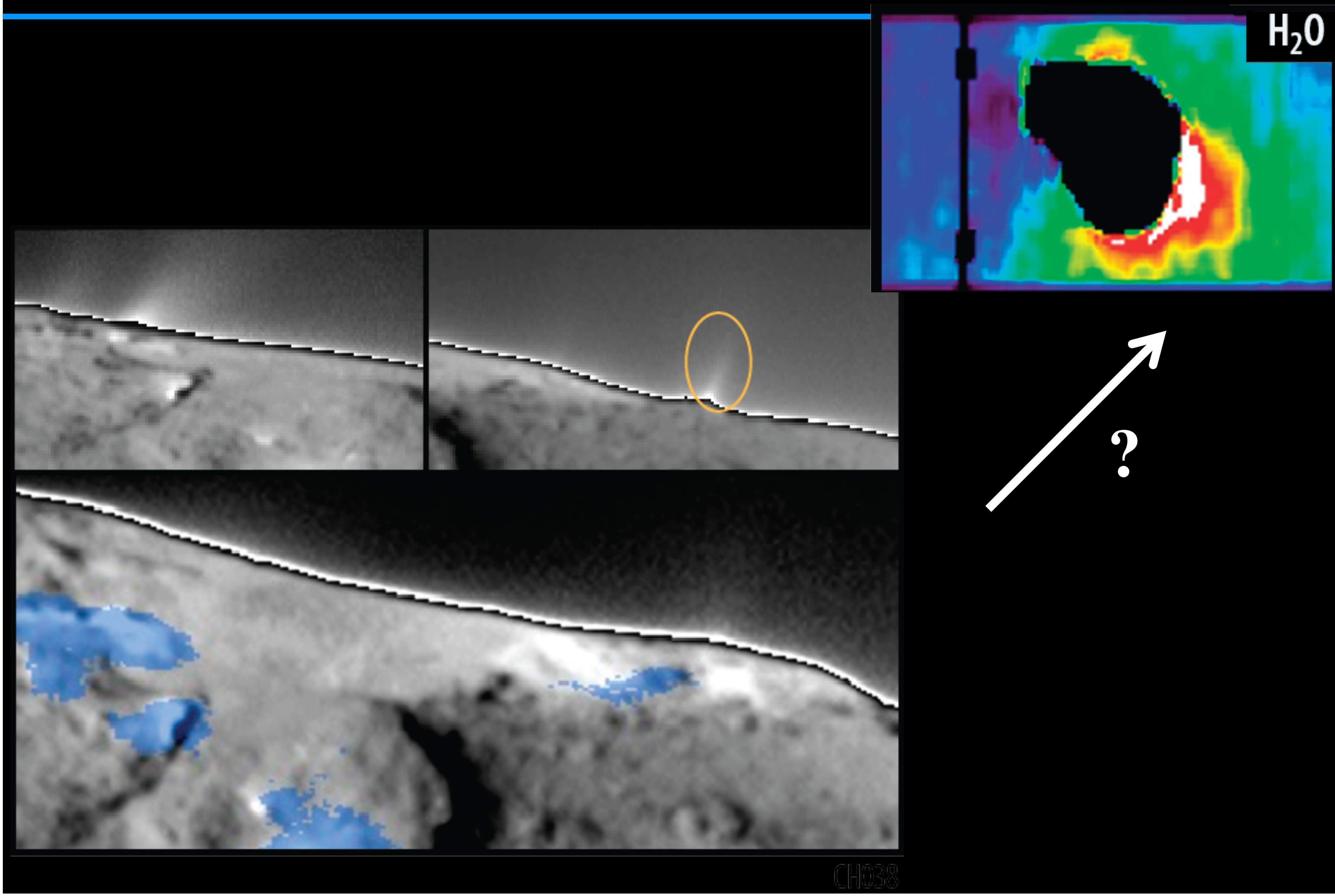
Ice in Coma of Hartley 2
Relative Reflectance
Wavelength (µm)
100 µm
10 µm
1 µm
Lab Ice Spectra
Hartley 2
4
3
2
1
1
2
3
4



MRI
Visible
CO_2
Dust
Ice

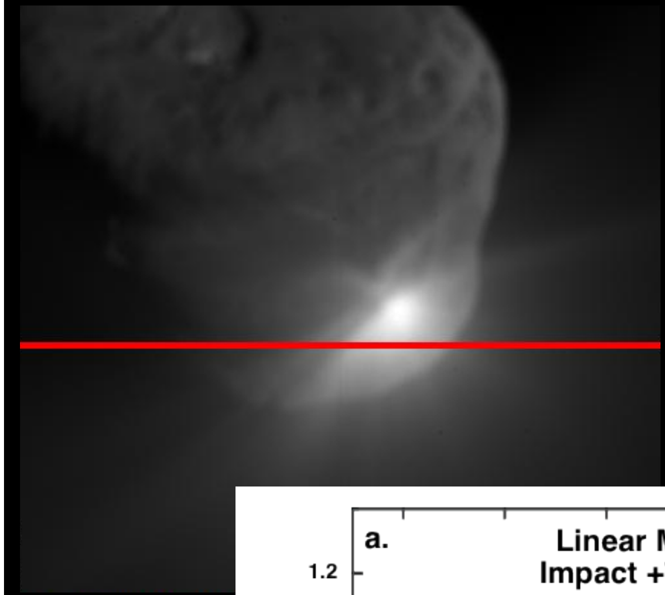

Water Vapor
CO_2
+ Ice
CO_2
Dust
Ice
H_2O
Vapor

Water Ice on Tempel 1



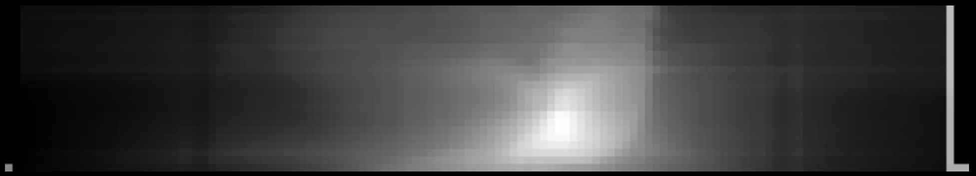
Water Ice in Tempel 1 Ejecta

Visible Image

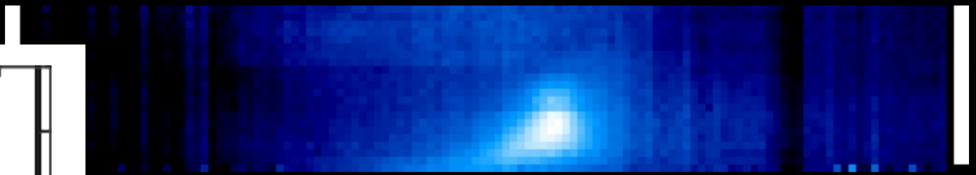


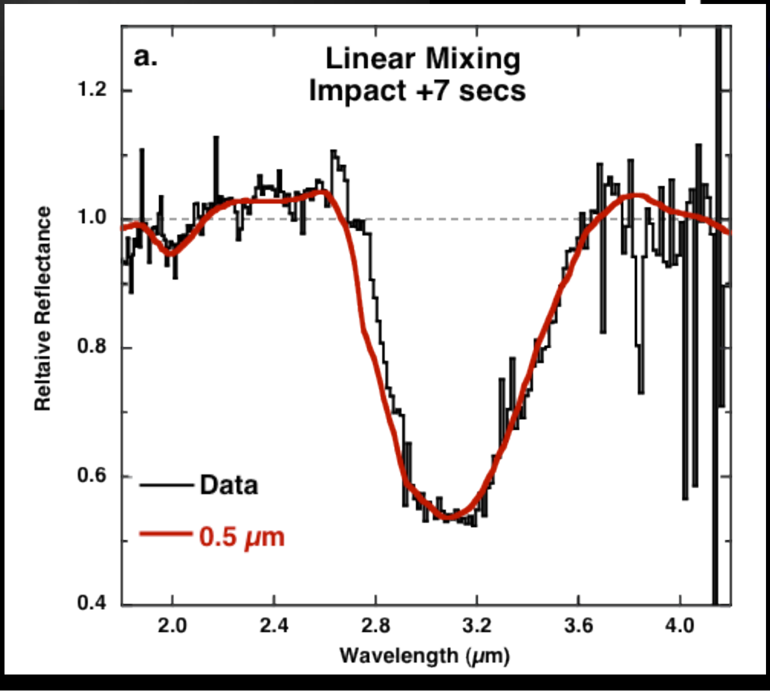
Impact +50 to 80 sec

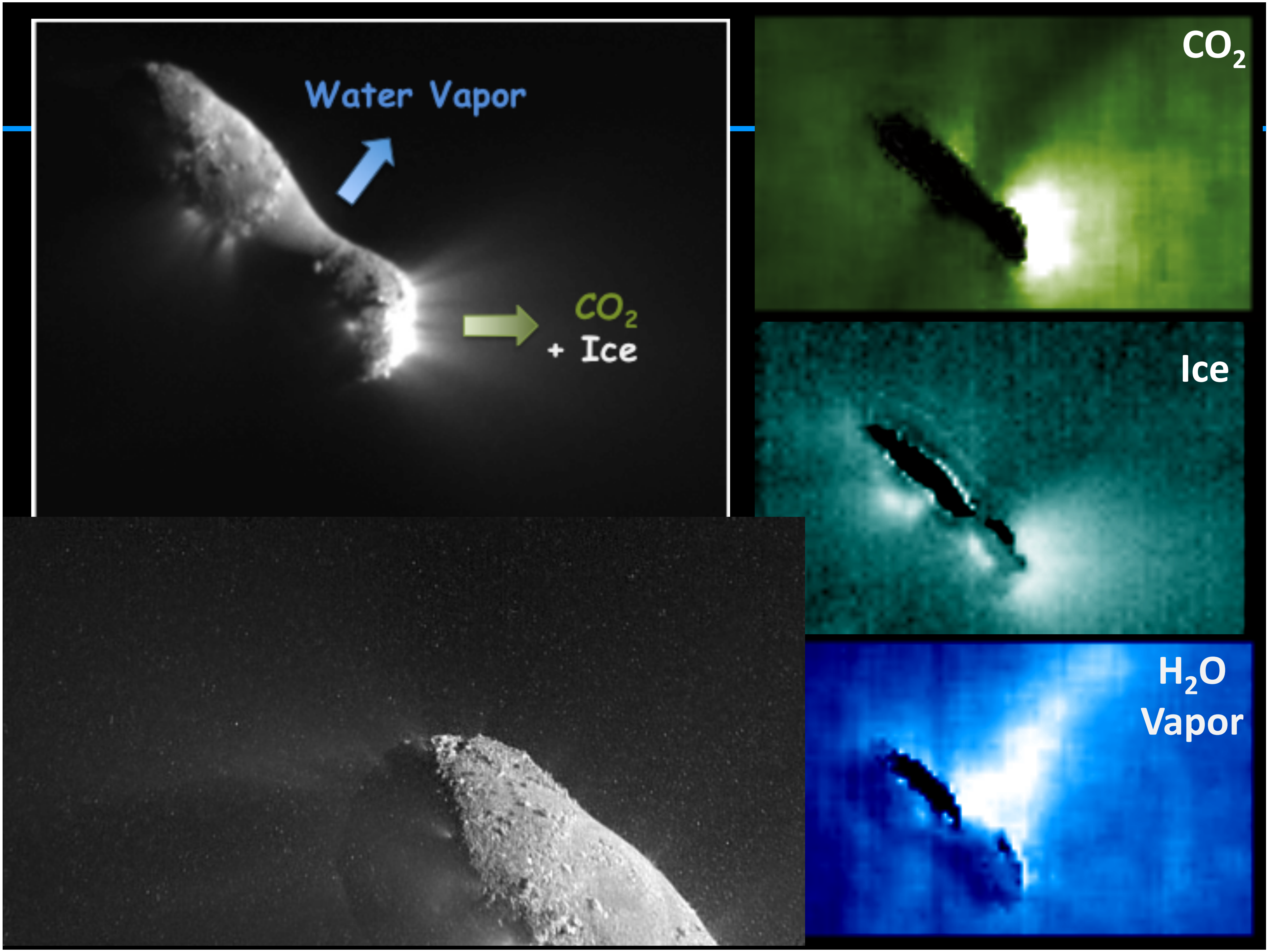
IR (1.5 μm) Image



Depth of 3 μm Ice Absorption







Water Vapor
CO_2
+ Ice
CO_2
Ice
H_2O
Vapor

Colorizing the Solar System