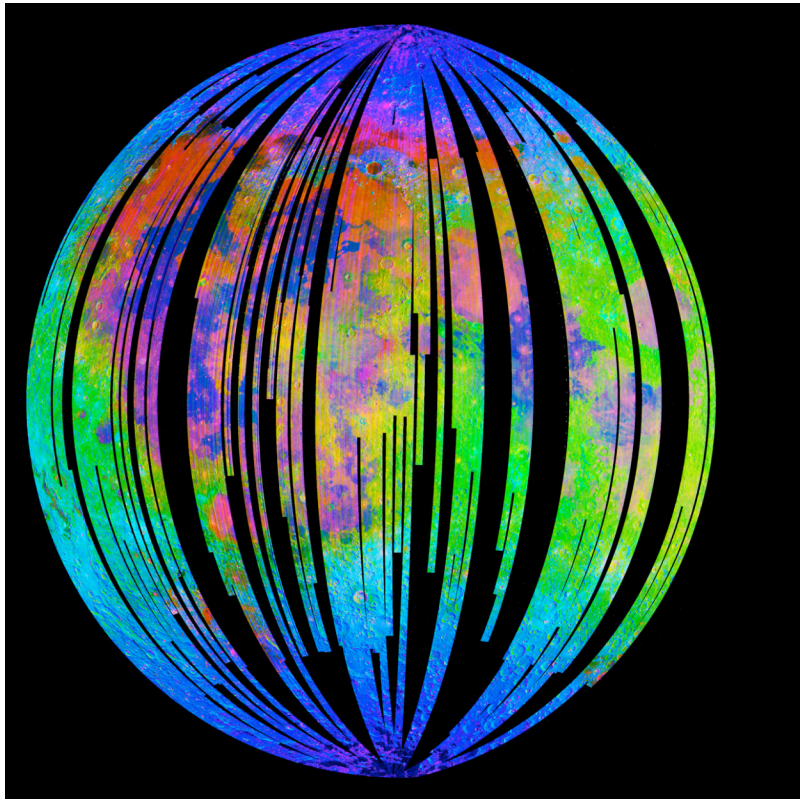
Water Found on the Moon

- Analysis of lunar rocks collected by Apollo astronauts did not reveal the presence of water on the Moon

- Four spacecraft recently reported small amounts of H_2O and/or OH at the Moon:
  - India's Chandrayaan mission
  - NASA's Cassini mission
  - NASA's EPOXI mission
  - NASA's LCROSS mission

  The first three measured the top few mm of the lunar surface. LCROSS measured plumes of lunar gas and soil ejected when a part of the spacecraft was crashed into a crater.

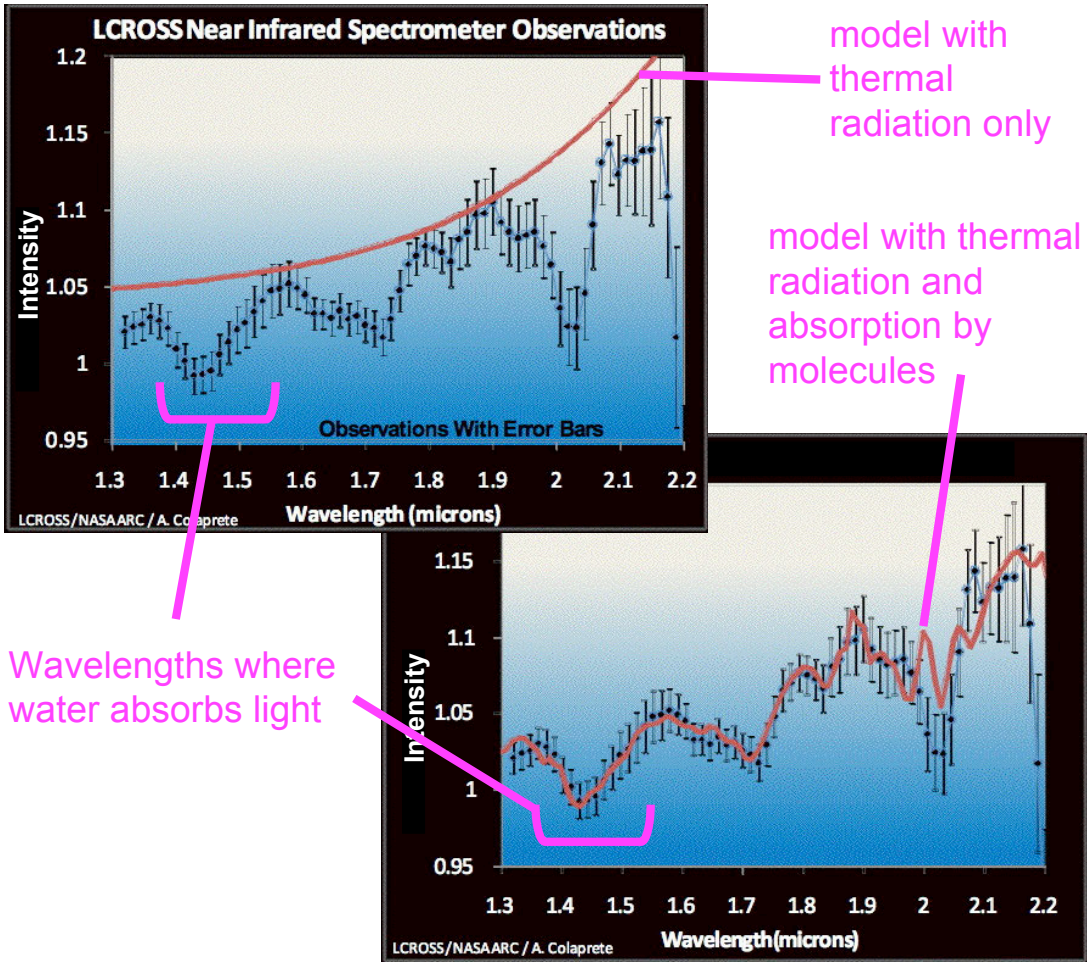
- *How much water?* Approximately 1 ton of lunar regolith will yield 1 liter of water.



This false-color map created from data taken by NASA's Moon Mineralogy Mapper (M3) on Chandrayaan is shaded blue where trace amounts of water (H_2O) and hydroxyl (OH) lie in the top few mm of the surface.

How was Water Detected?

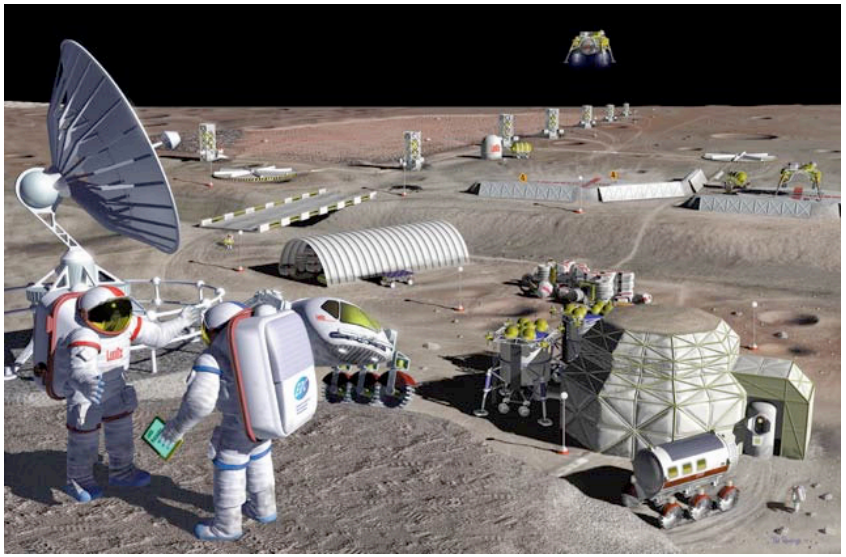
- Lunar soil emits infrared *thermal radiation*. The amount of emitted light at each wavelength varies smoothly according to the Moon's temperature.
- H_2O or OH molecules in the soil absorb some of the radiation, but only at specific wavelengths
- All four infrared spectrographs measure a deficit of thermal radiation at those wavelengths, implying water is present



An infrared spectrum measured by LCROSS (black data points) compared to models (red line)

The Big Picture

- Lunar water may come from ‘solar wind’ hydrogen striking the surface, combining with oxygen in the soil. It may also arrive via meteorite and comet impacts. Both processes are likely.
- Lunar water may be ‘bounced’ by small impacts to polar regions, forming ice in permanently shadowed craters
- Similar processes may occur on other airless bodies (e.g., Mercury, asteroids)
- Water-laden lunar regolith may be a valuable resource, possibly supporting future lunar exploration activities



Discovery of water on the moon may support future activities on the lunar surface and beyond. Artwork from NASA / Pat Rawlings.

For More Information…

Press Releases

- NASA – 9/24/09 - “NASA Instruments Reveal Water Molecules on Lunar Surface”
  http://www.nasa.gov/topics/moonmars/features/moon20090924.html
- Space.com – 09/23/09 - “It's Official: Water Found on the Moon”
  http://www.space.com/scienceastronomy/090923-moon-water-discovery.html
- NASA Ames – 11/13/09 - “LCROSS Impact Data Indicates Water on Moon”
  http://www.nasa.gov/mission_pages/LCROSS/main/prelim_water_results.html
- Space.com – 11/13/09 - “'Significant Amount' of Water Found on Moon”
  http://www.space.com/scienceastronomy/091113-lcross-moon-crash-water-discovery.html

Images

- Image from Slide 1 courtesy of [NASA/ISRO/BROWN University/R.N. Clark, USGS]
  http://www.nasa.gov/topics/moonmars/features/moonm3-images.html
- Images from Slide 2 courtesy NASA
  http://www.nasa.gov/mission_pages/LCROSS/main/LCROSS_results_images.html
- Image from Slide 3 from NASA / Pat Rawlings
  http://www.patrawlings.com/

Source Articles (on-campus login may be required to access journals)

- Pieters et al., ‘Character and Spatial Distribution of OH/H2O on the Surface of the Moon Seen by M^3 on Chandrayaan-1’, *Science*, **326**, p. 568, doi: 10.1126/science.1178658, 2009.
- Sunshine et al.., ‘Temporal and Spatial Variability of Lunar Hydration as Observed by the Deep Impact Spacecraft’, *Science*, **326**, p. 565, doi: 10.1126/science.1179788, 2009.
- Clark R.N., ‘Detection of Adsorbed Water and Hydroxyl on the Moon’, *Science*, **326**, p. 562, doi: 10.1126/science.1178105, 2009.

All articles available at http://www.sciencemag.org/content/vol326/issue5952/index.dtl

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