Bang, Zoom, Straight to the Moon

Lunar Science in a New Age of Exploration

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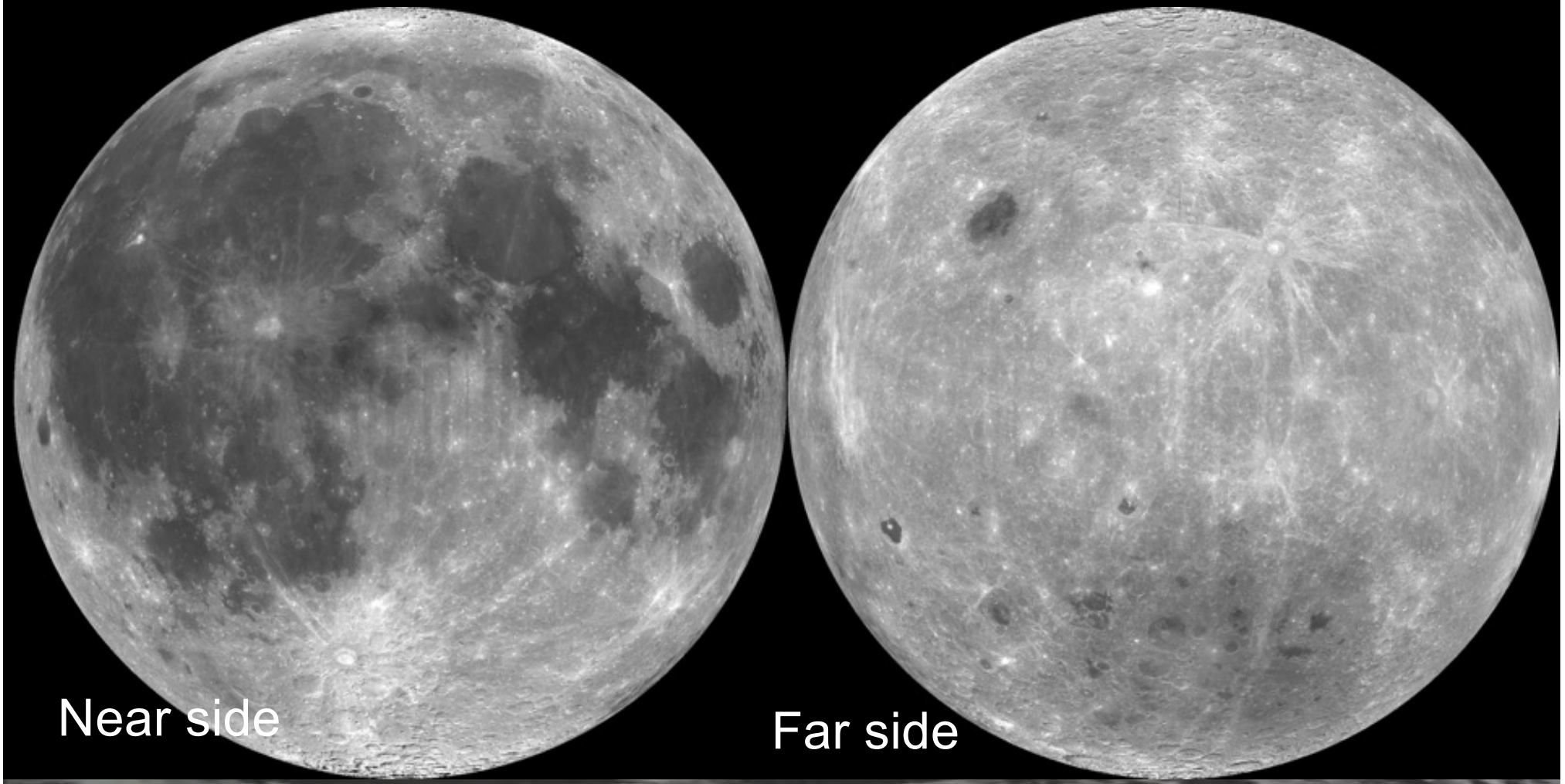
The Face of the Moon



The Face of the Moon

Highlands
feldspathic =
igneous

Near side

Far side

The Face of the Moon

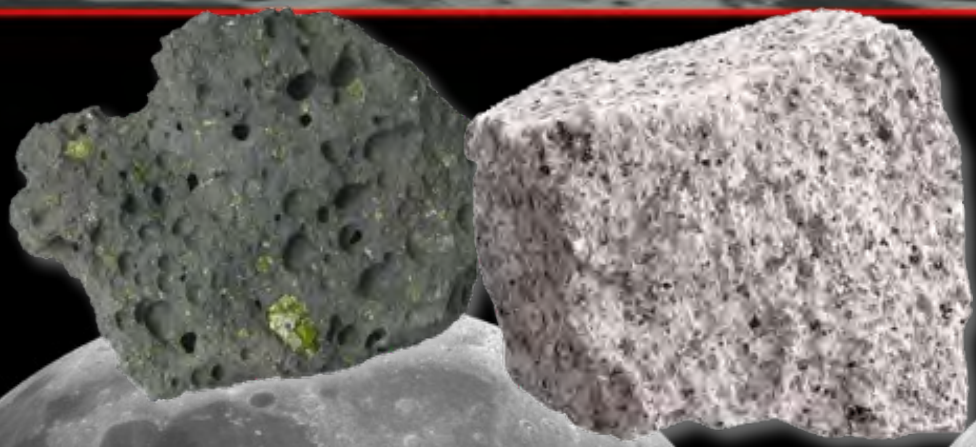
Highlands
feldspathic =
igneous

Craters and basins
=
impact

Near side

Far side

The Face of the Moon



Mare/maria=
lava flows

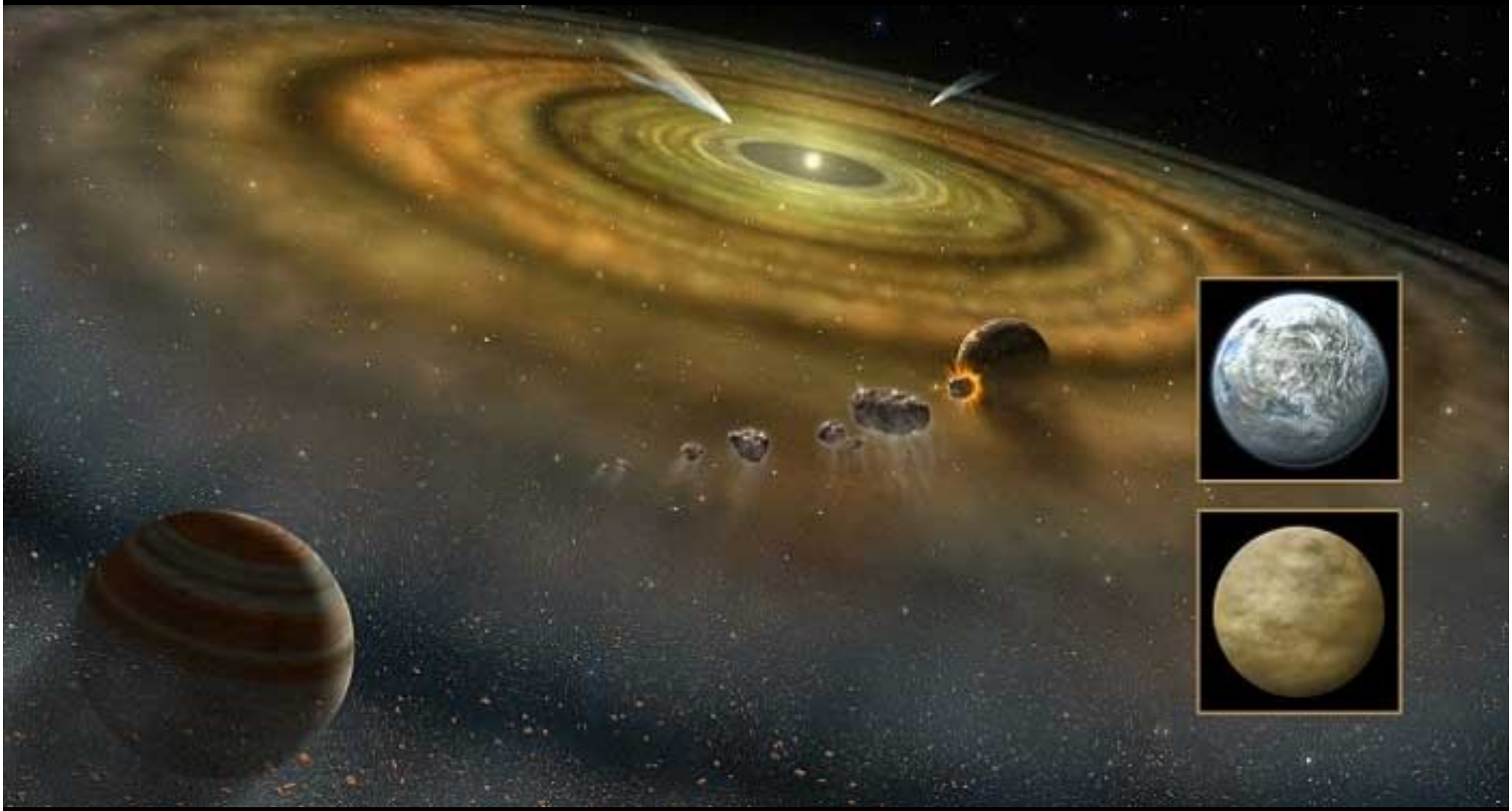
Highlands
feldspathic =
igneous

Craters and basins
=
impact

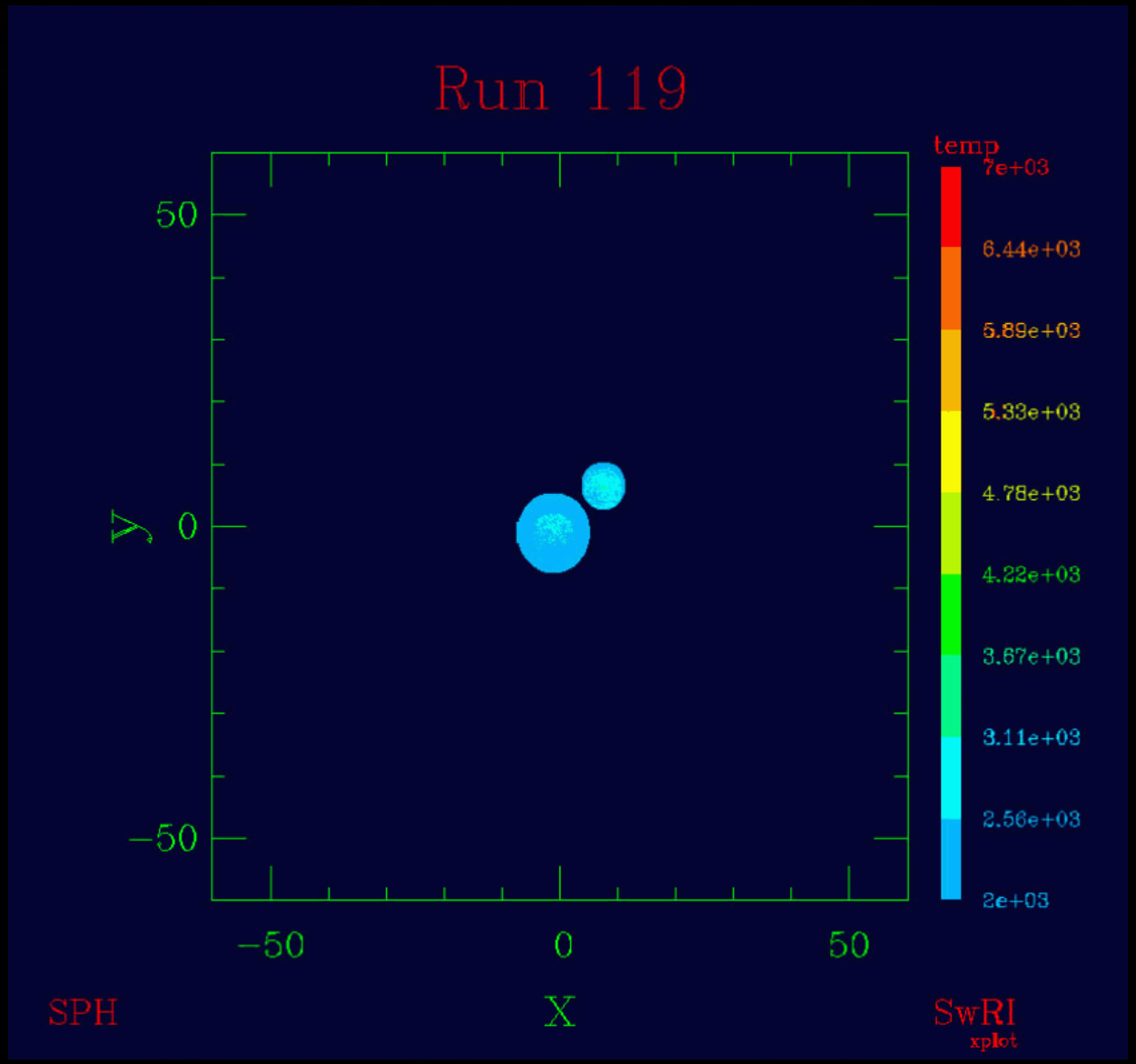
Near side

Far side

In the beginning ….



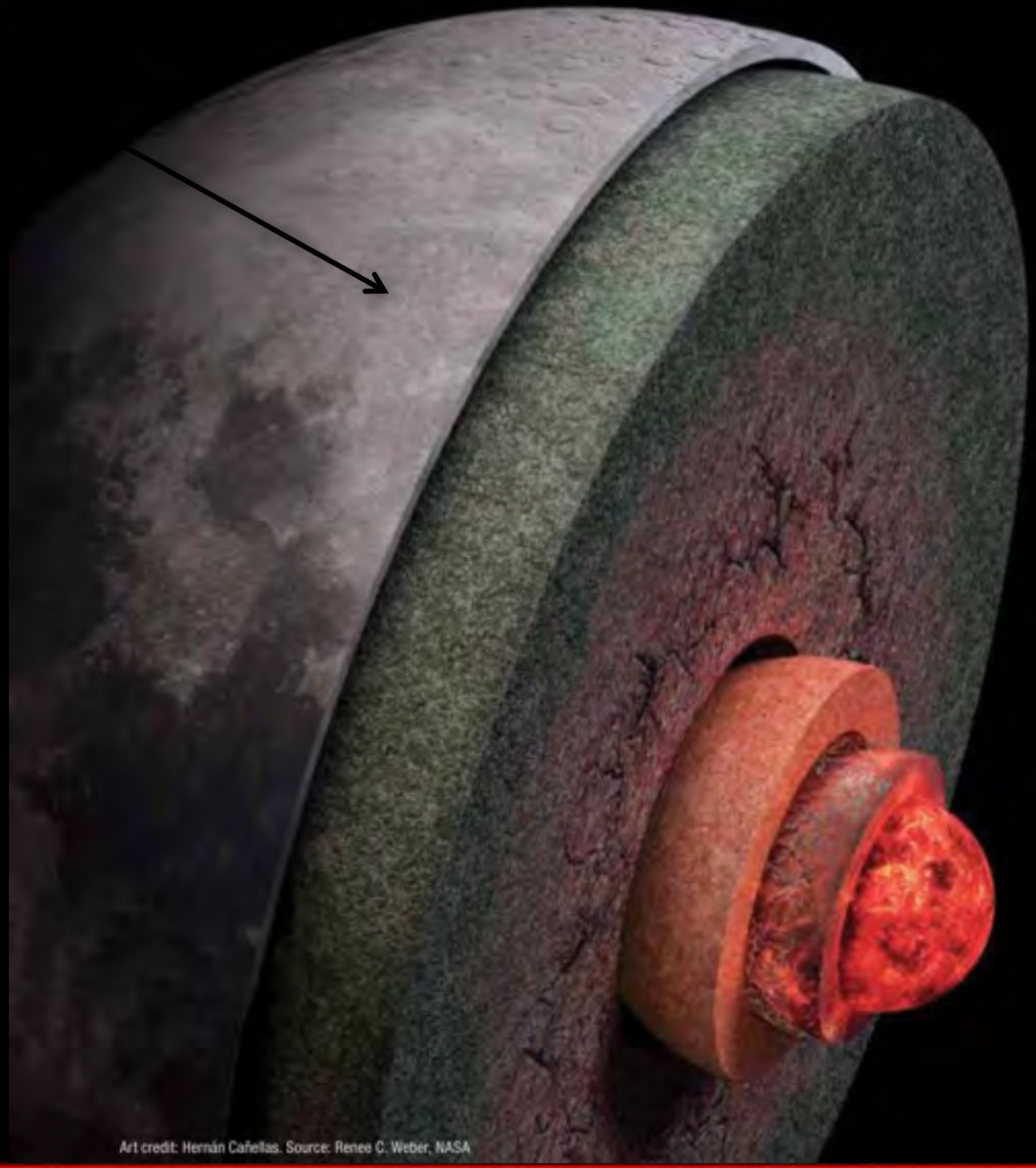
Origin of the Earth-Moon system



Canup (2004)

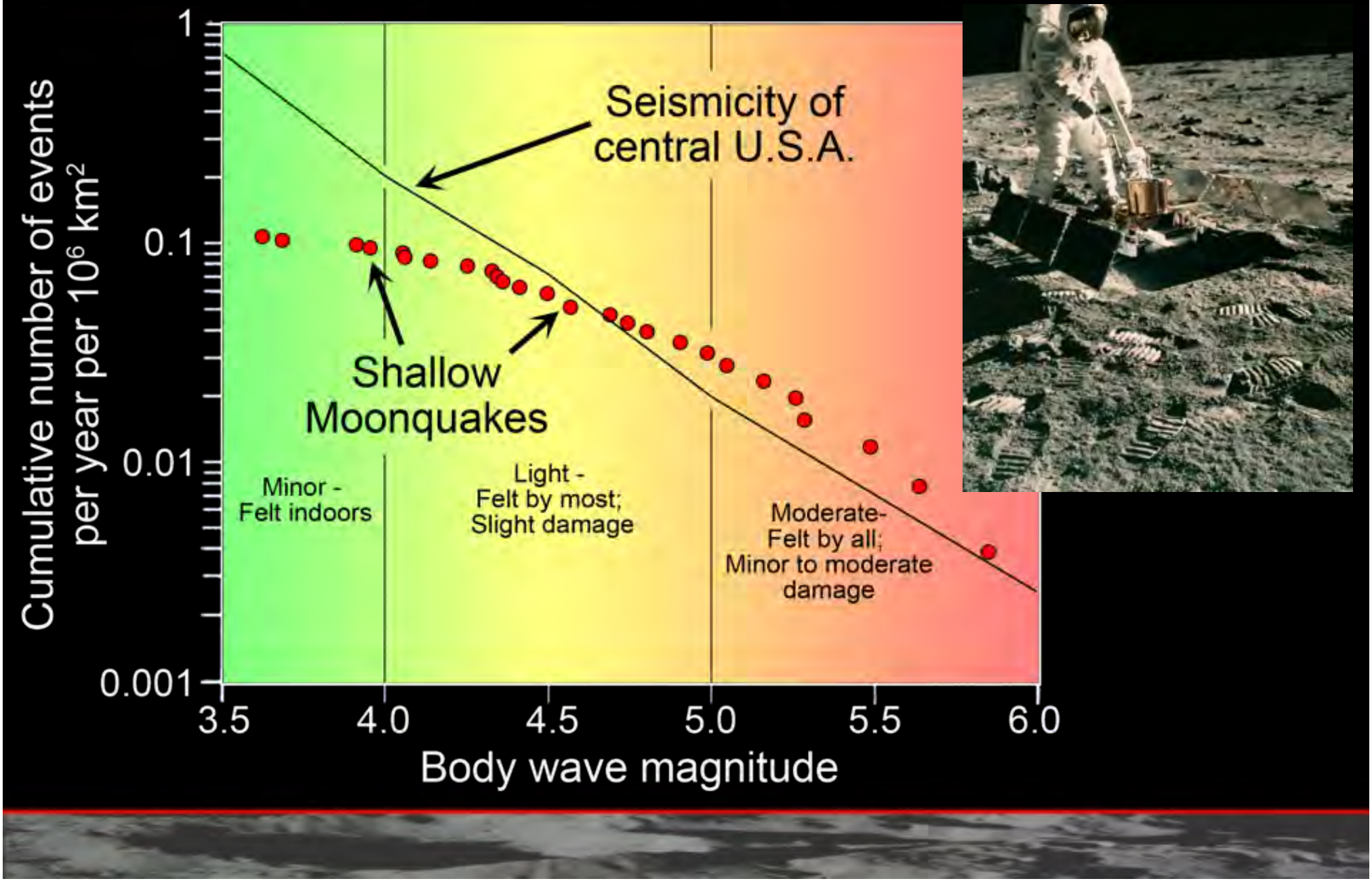
T scale:
2000-7000K

Crust, mantle, and core

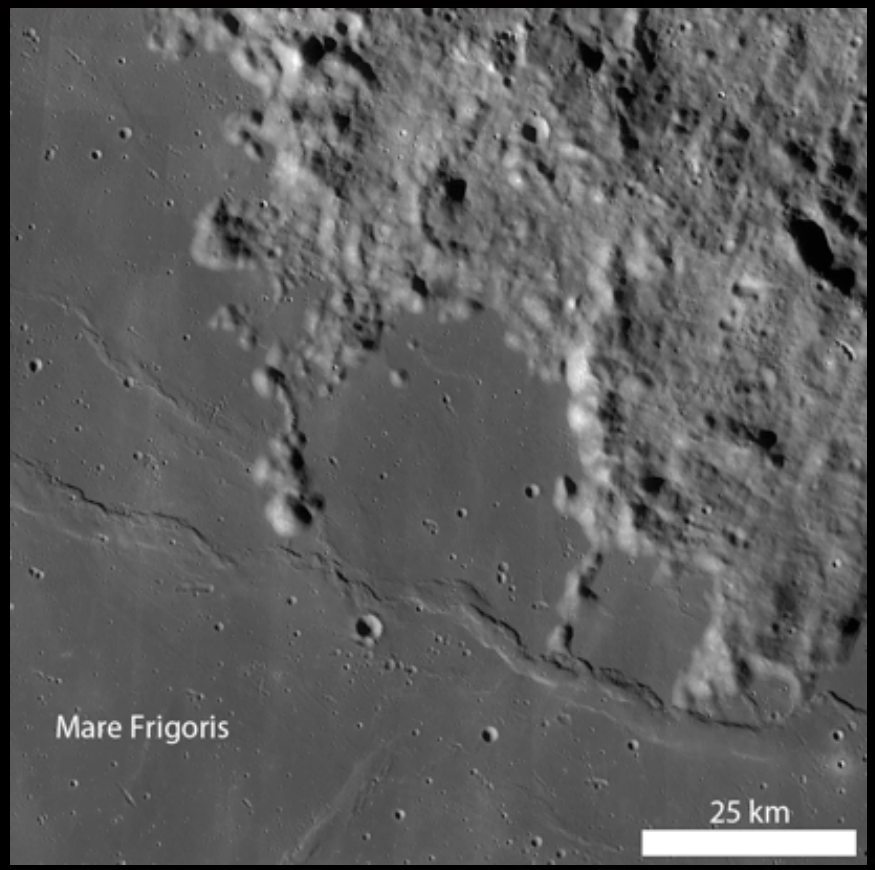


Art credit: Hernán Cañellas. Source: Renee C. Weber, NASA

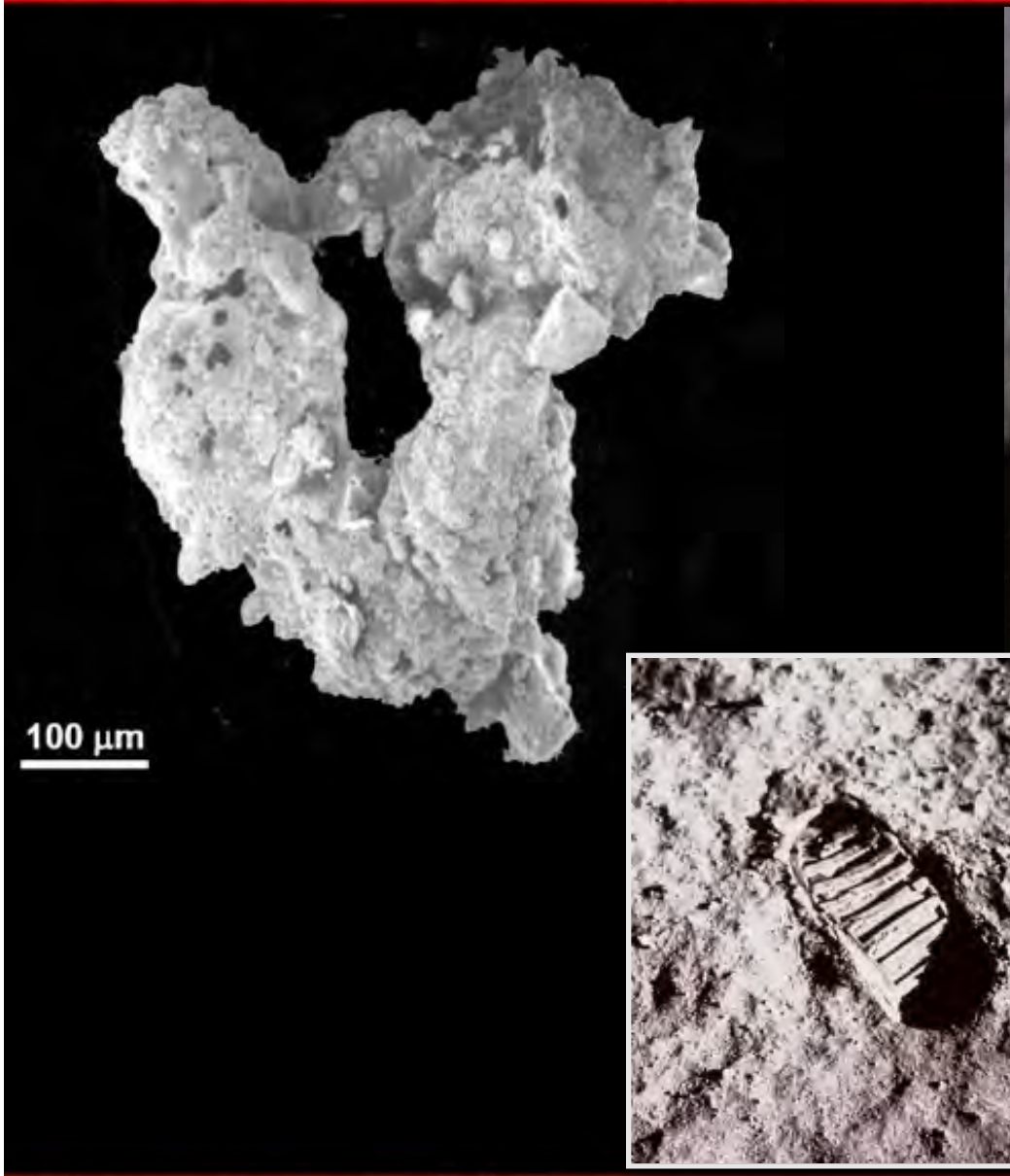
Moonquakes!


Cumulative number of events per year per 10^6 km^2
1
0.1
0.01
0.001
Seismicity of central U.S.A.
Shallow Moonquakes
Minor - Felt indoors
Light - Felt by most; Slight damage
Moderate- Felt by all; Minor to moderate damage
3.5
4.0
4.5
5.0
5.5
6.0
Body wave magnitude

Craters!

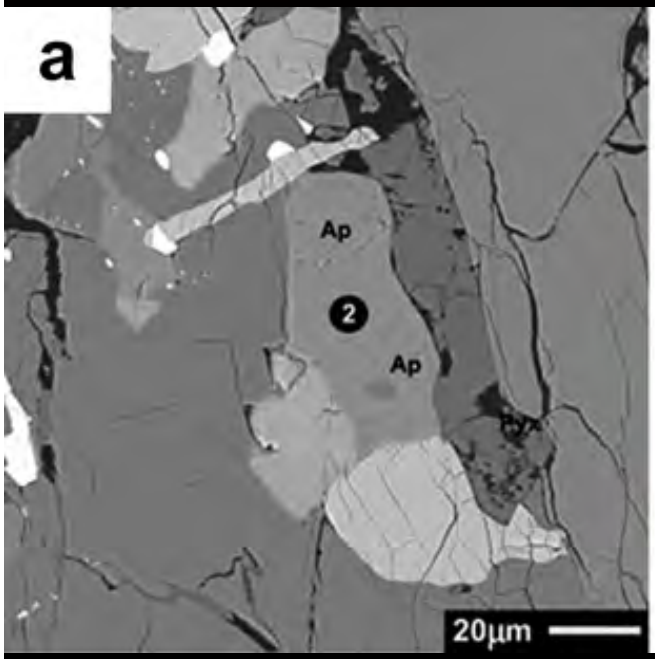


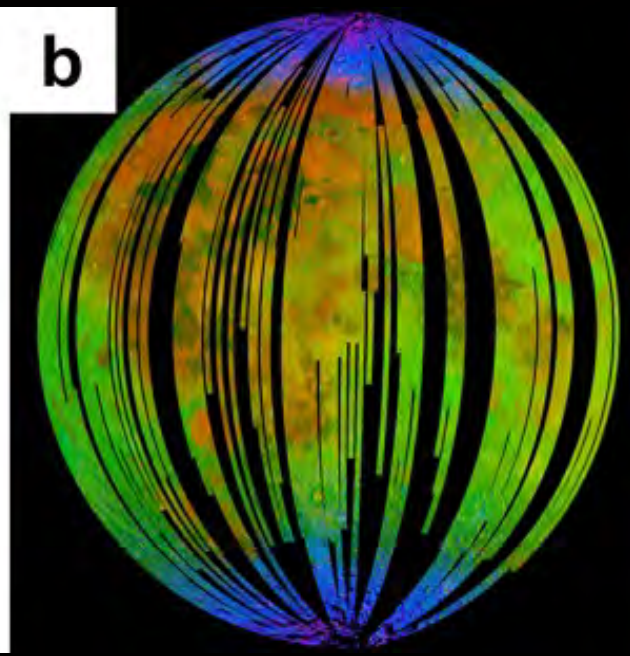
Lunar dust

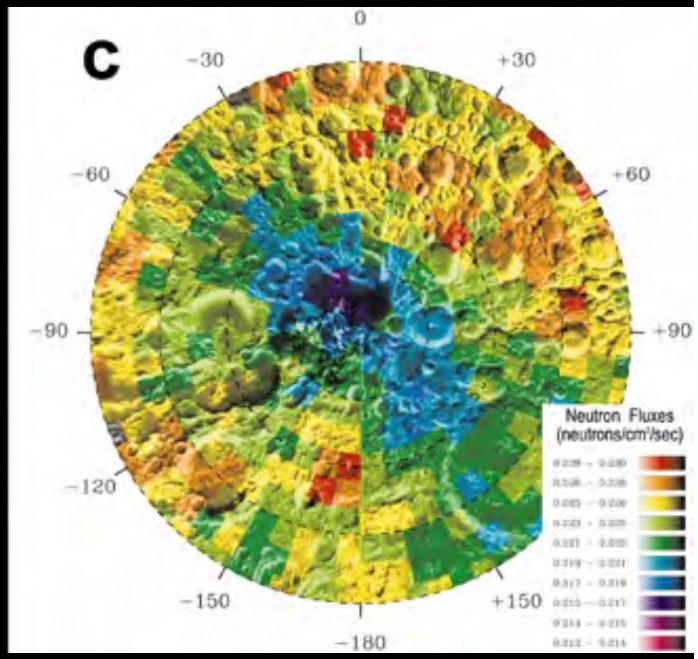


Permanent sunlight and shadow

Water on the Moon!







a) Interior (magmatic) – in deep mantle rocks

a) Surficial (in upper mm of grains)

a) Polar deposits

Water is a resource

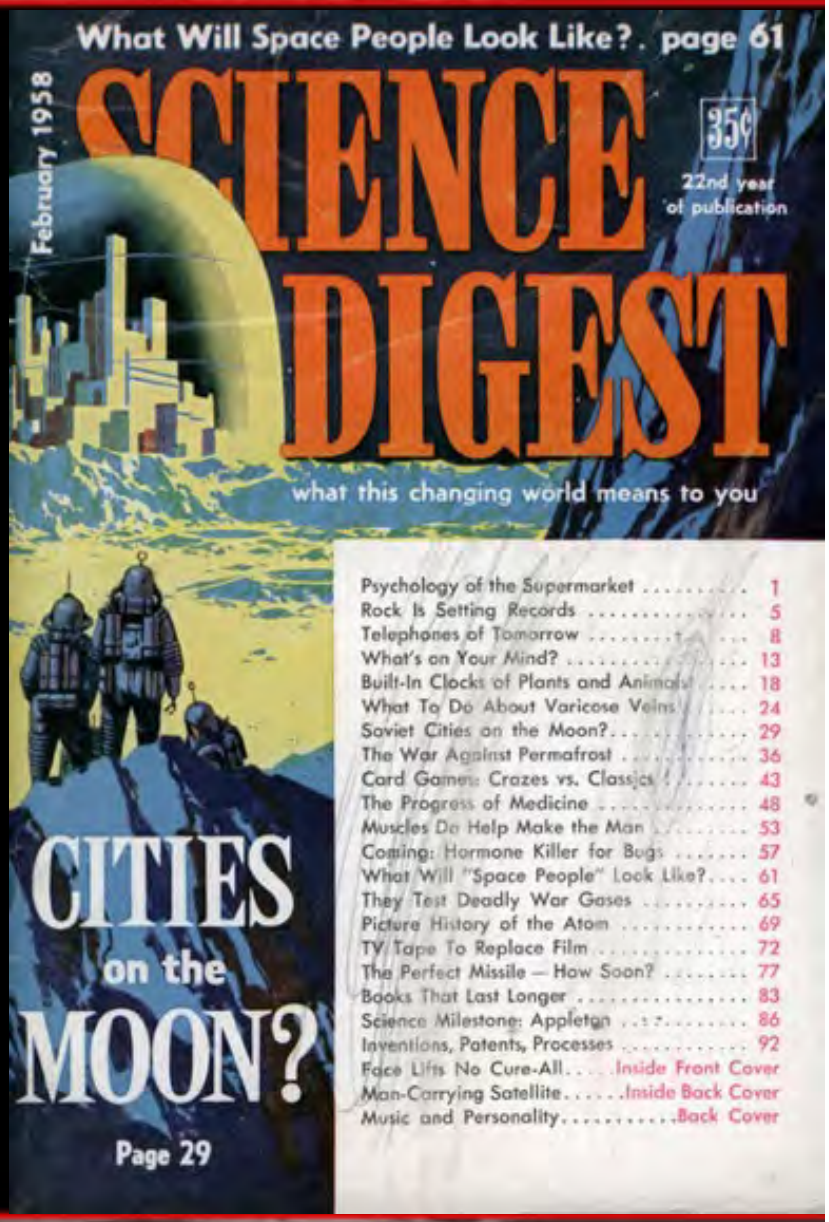
The Moon - been there, done that?

<u>Lunar Science</u>

Our Moon is a window back in time to understand how all rocky worlds formed and evolved

<u>Lunar Exploration</u>

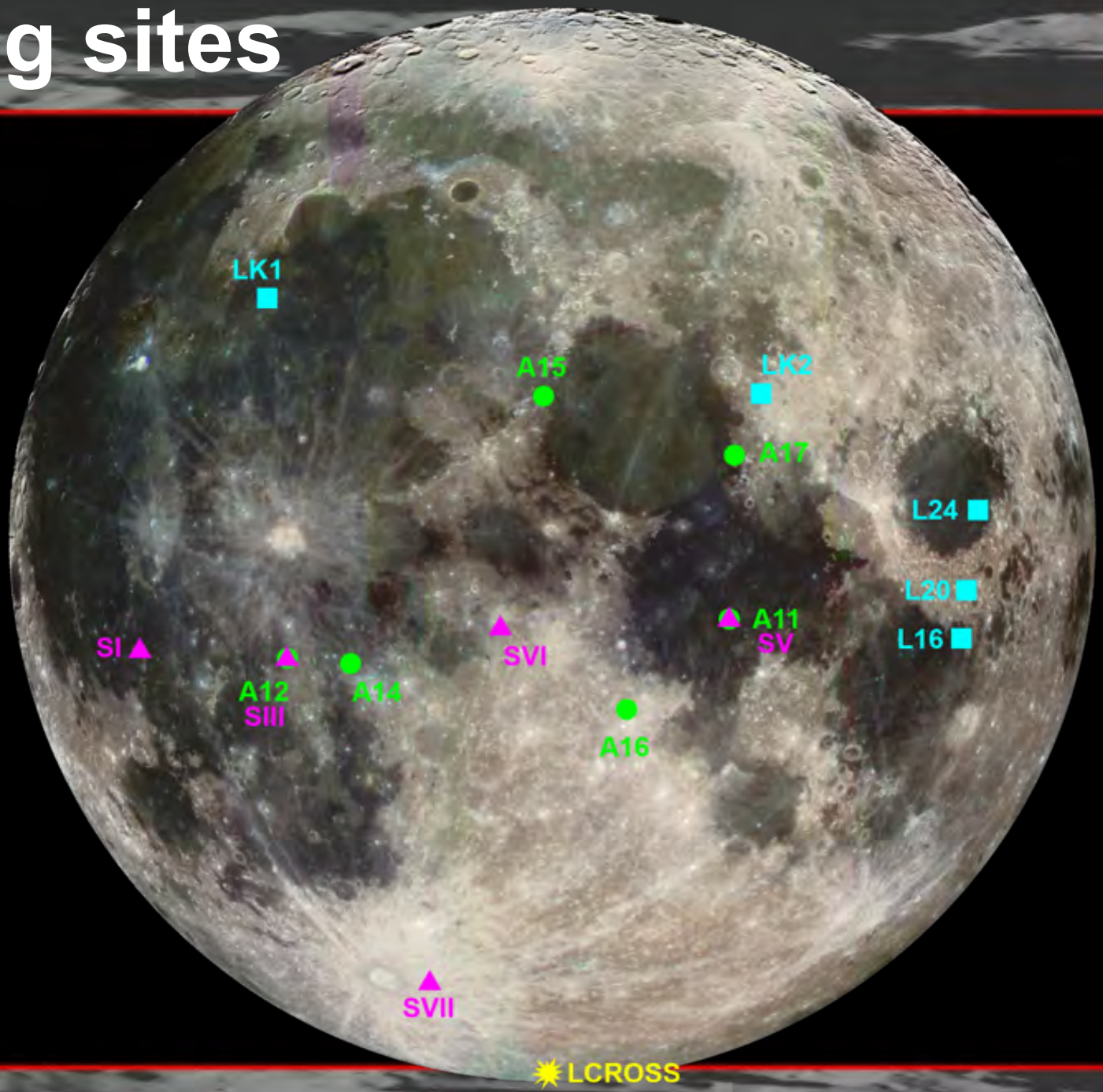
We'll learn to live and work on another planet



Exploring our Moon: Part 1

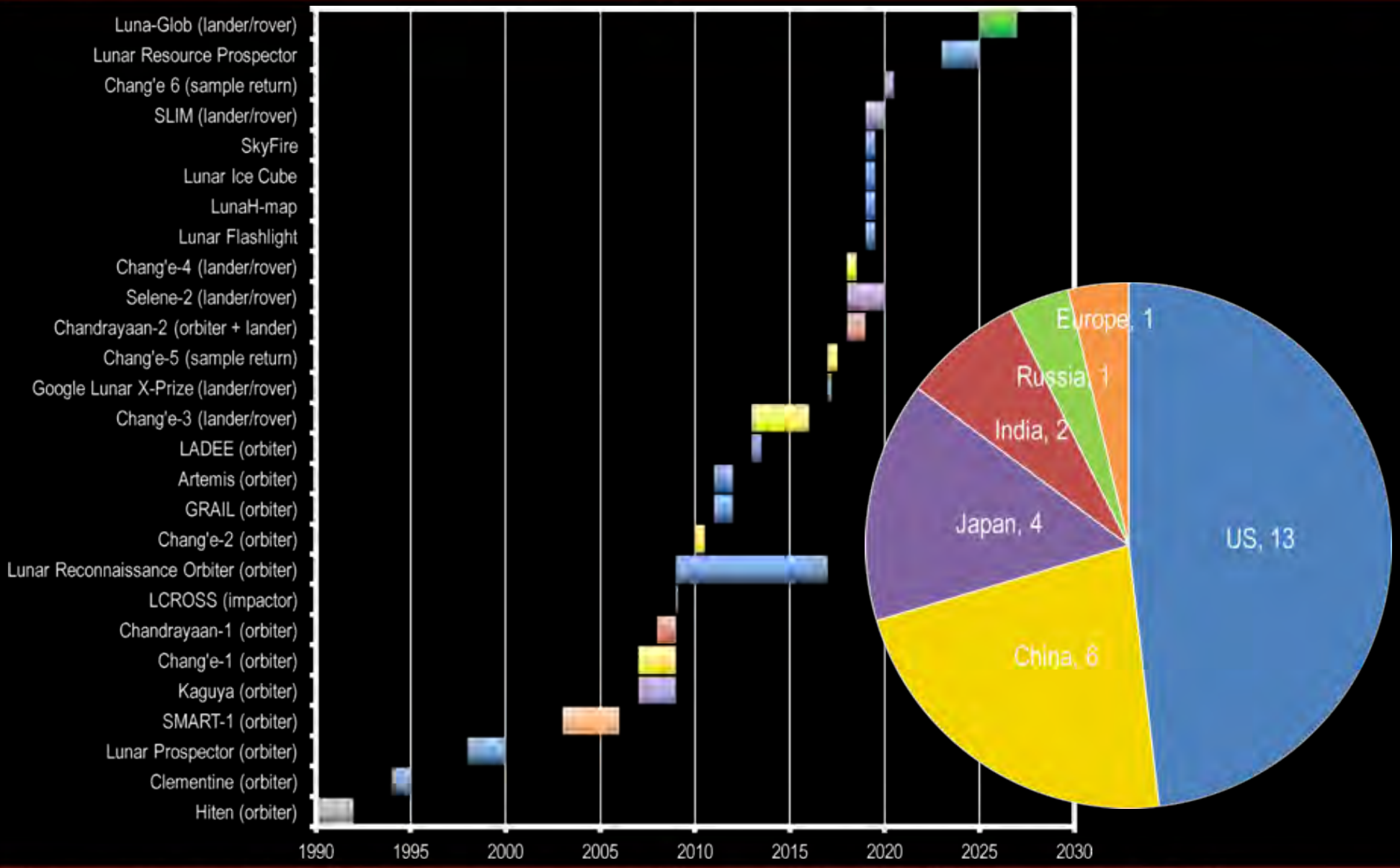
- 1960s – robotic Surveyor missions
- Six Apollo missions (1969-1972)
  - 382 kg (842 lbs) rocks
- 12 Americans have walked on the moon
- USSR: Robotic landers, rovers, sample return missions

Landing sites

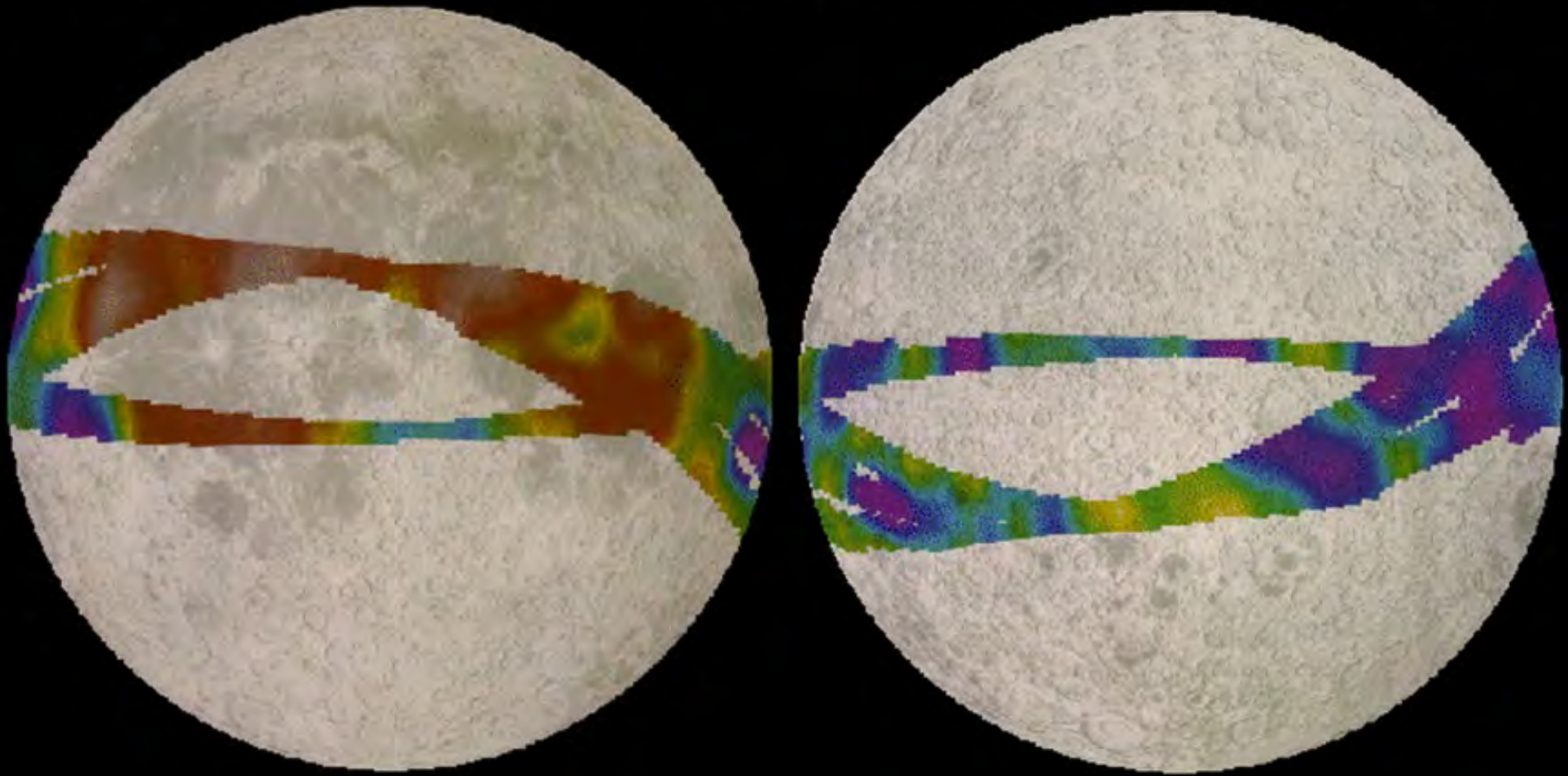


Luna and
Lunokhod
Surveyor
Apollo

Exploring our Moon – Part 2



Apollo Gamma-ray Iron Abundance

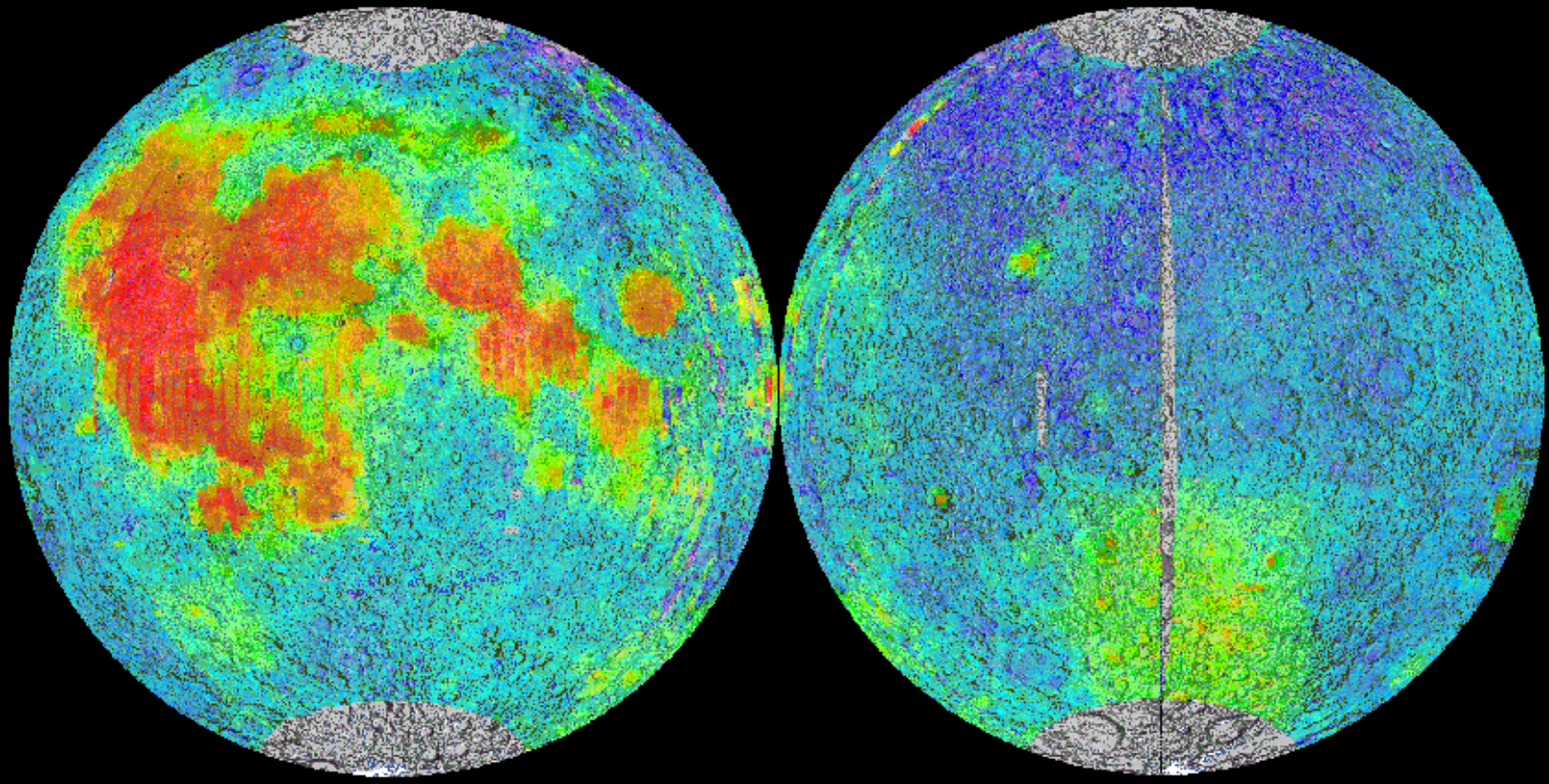


Nearside

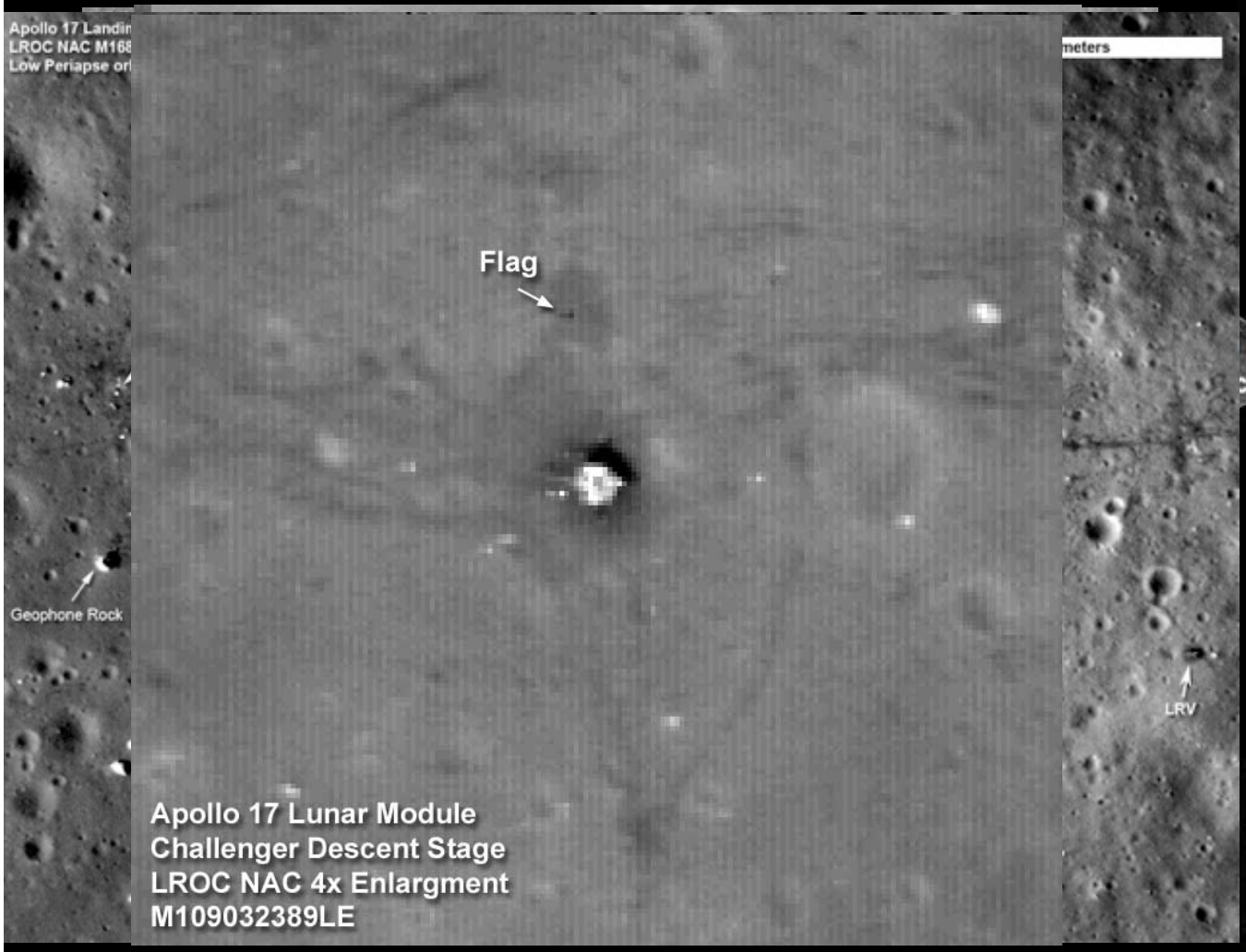
Farside

Clementine Iron Map of the Moon

Equal Area Projection



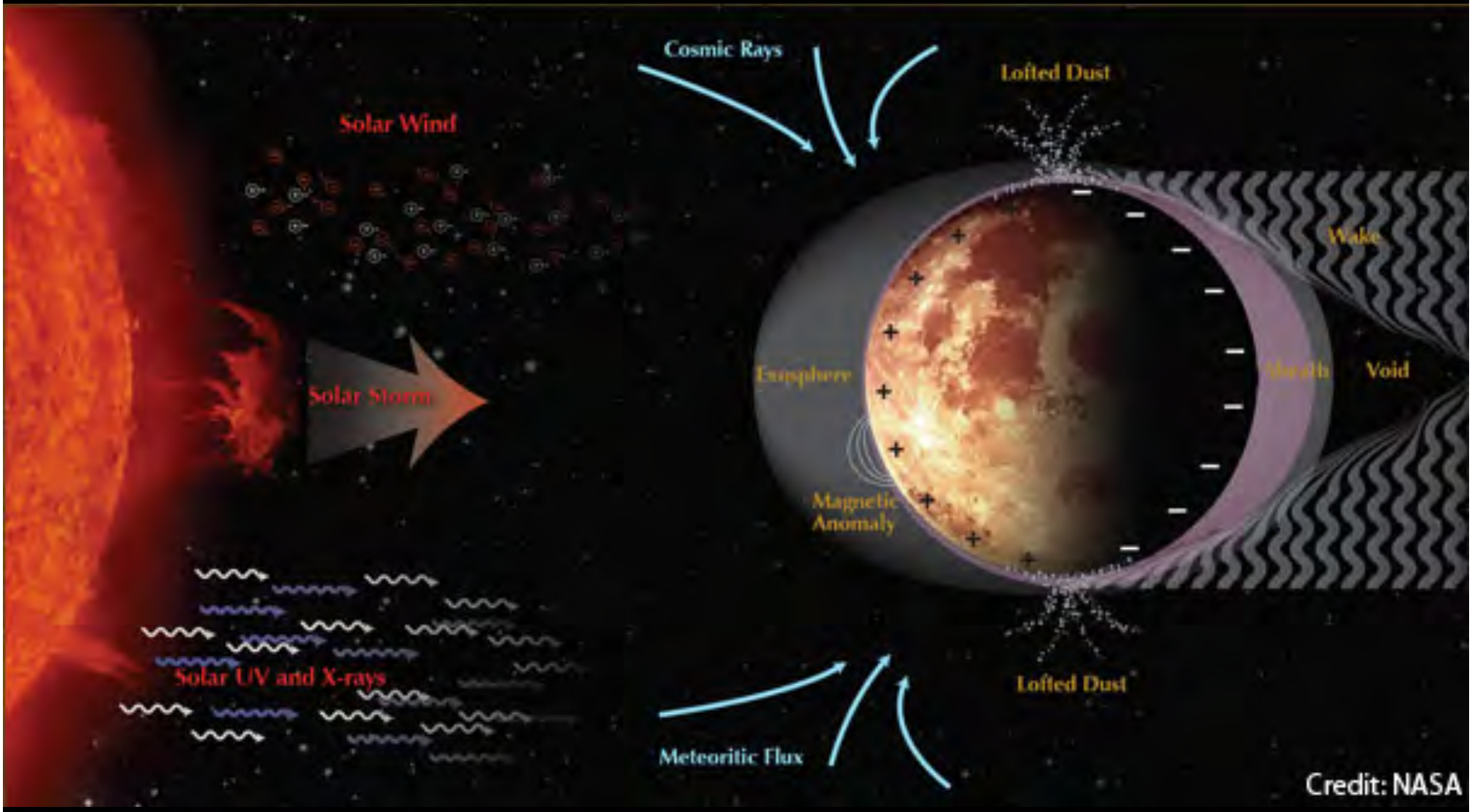
Lunar Reconnaissance Orbiter (2009)



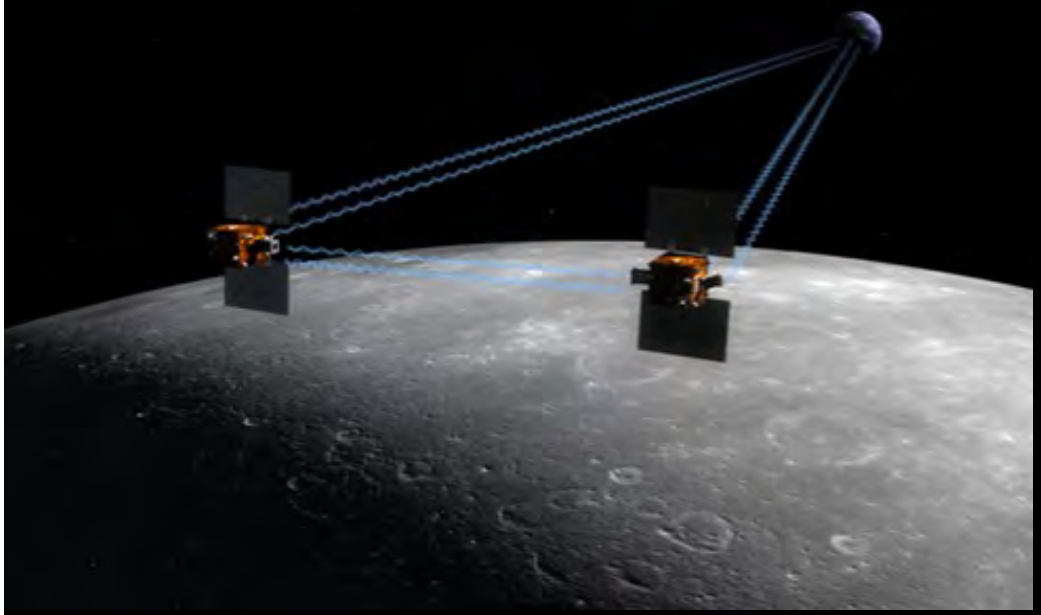
LCROSS (2009) Lunar Crater Observation and Sensing Satellite

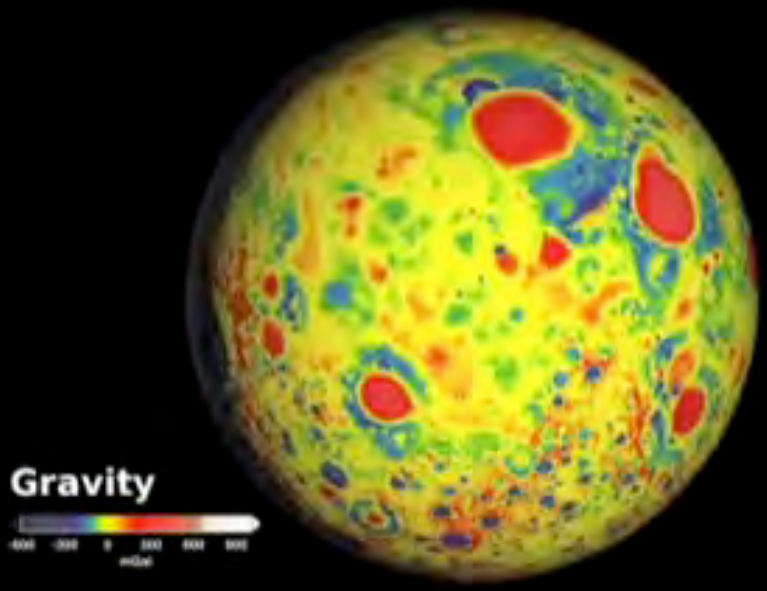
- Used the expended LRO upper stage as an impactor and flew through the plume with cameras and spectrometers
- Create an ejecta plume and analyze it for the presence of water (ice and vapor), hydrocarbons and hydrated materials

ARTEMIS (2010) Acceleration, Reconnection, Turbulence and Electrodynamics of the Moon's Interaction with the Sun



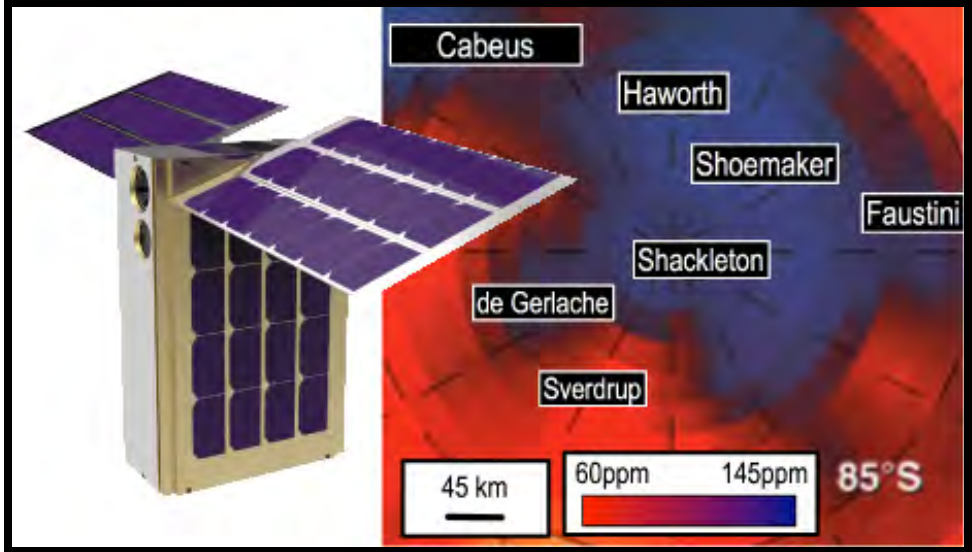
GRAIL (2011) Gravity Recovery and Interior Laboratory





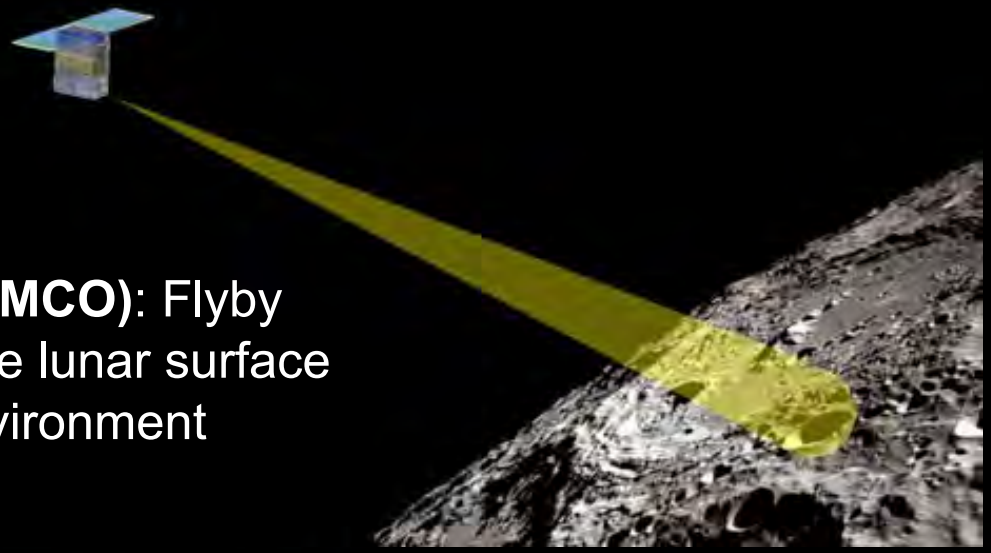
LADEE (2013) Lunar Atmosphere, Dust and Environment Explorer

EM-1 Cubesats (2018)



LunaH-map (ASU): Deep polar H deposits at the lunar south pole with low-altitude neutron spectroscopy

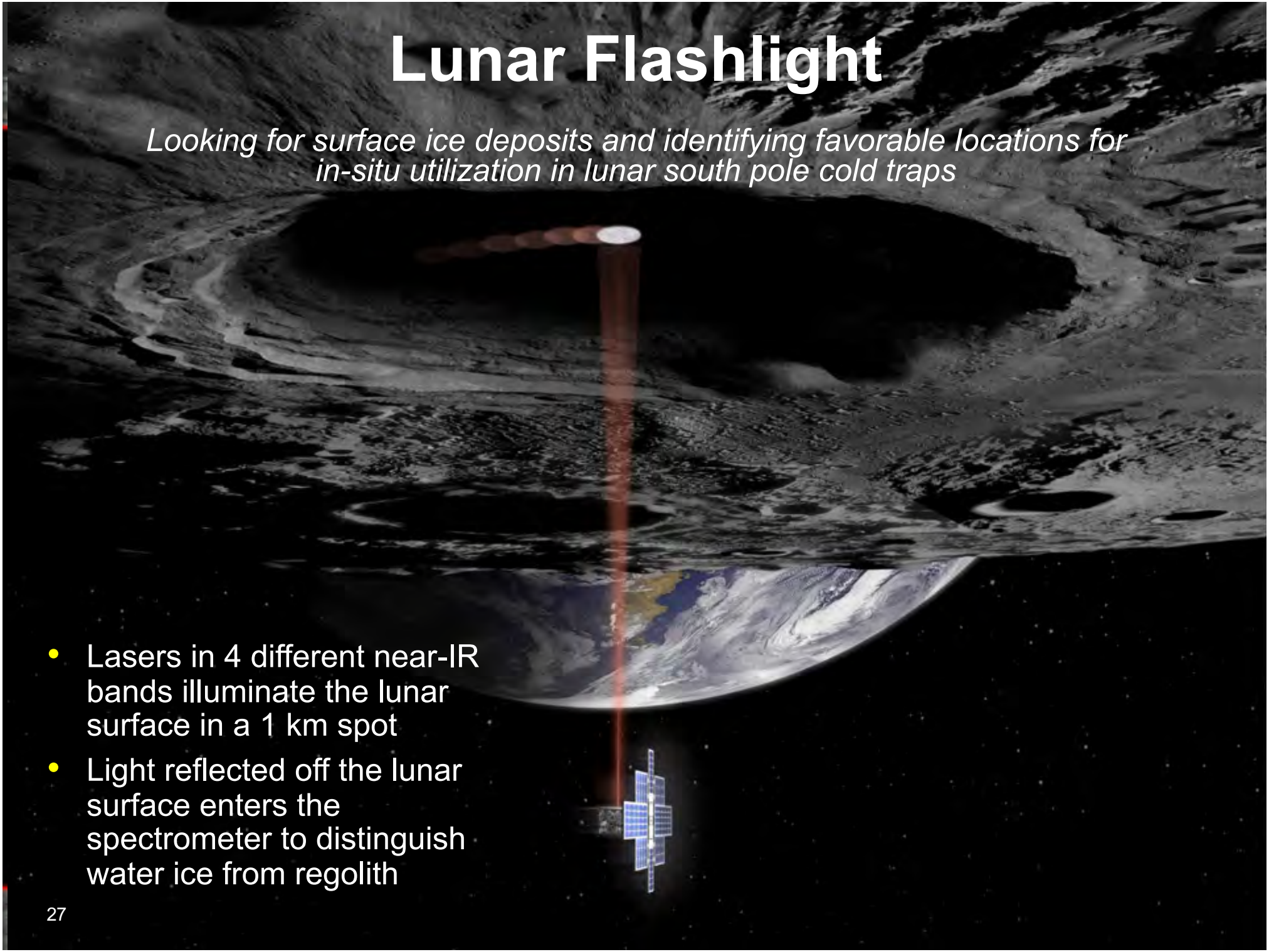
Lunar IceCube (Morehead State): Characterize surfical water and its variability using a passive IR spectrometer (1-4 μm)



SkyFire (LMCO): Flyby imaging of the lunar surface and environment

Lunar Flashlight

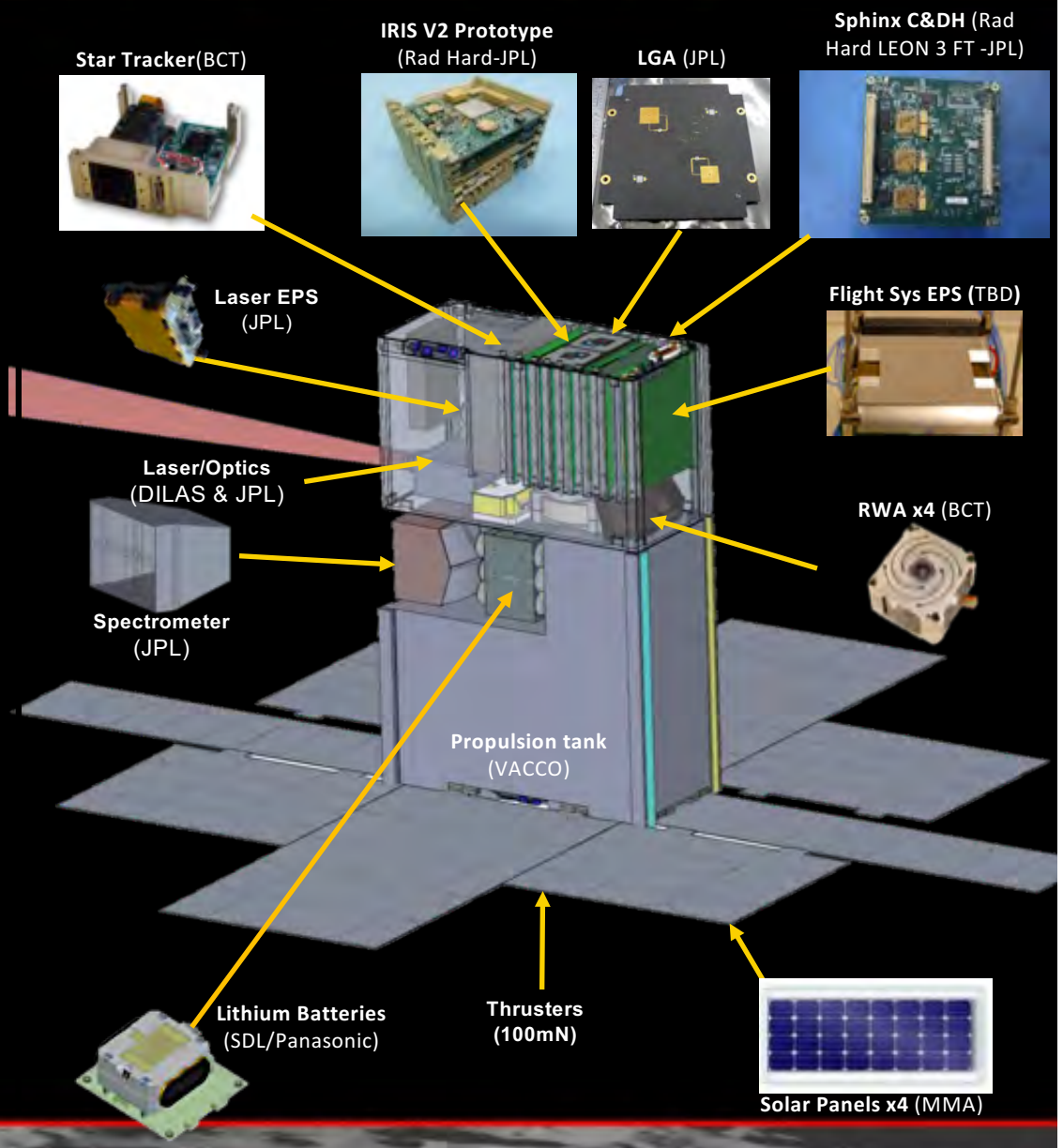
Looking for surface ice deposits and identifying favorable locations for in-situ utilization in lunar south pole cold traps



- Lasers in 4 different near-IR bands illuminate the lunar surface in a 1 km spot
- Light reflected off the lunar surface enters the spectrometer to distinguish water ice from regolith

LF Flight System Overview

Payload	• Lunar Flashlight: Custom spectrometer • Four separate 25-50 watt pulsed lasers at spectral bands between 1-2μm
Mechanical & Structure	• "6U" CubeSat form factor (116x239x366 mm) • <14 kg total launch mass • Modular flight system concept
Propulsion	• Chemical propulsion system (in design).
C&DH	• Rad-hard LEON 3 FT Dual core CPU, 268MIPS@100MHz, 8GB NAND, 6 digital interfaces (RS422,I2C,SPI,SpW, GPIO, UART)
Electrical Power System	• Simple deployable solar arrays with UTJ GaAs cells (~35 W at 1 AU solar distance) • 6.8 Ah Battery (3s2p 18650 Lithium Cells) • Separate Laser EPS – 800w with Super capacitors coupled with Li-ion batteries
Telecom	• JPL Iris 2.0 X-Band Transponder; 1 W RF, supports doppler, ranging, and D-DOR • 2 pairs of LGAs (RX/TX) • Lunar Flashlight: >500 bps to 34m DSN at all times.
Attitude Control System	• 15 mNm-s (x3) & 100 mNm-s RWAs • Nano StarTracker, Coarse Sun Sensors & MEMS IMU for attitude determination.



Resource Prospector (2023)

Global Lunar Village