

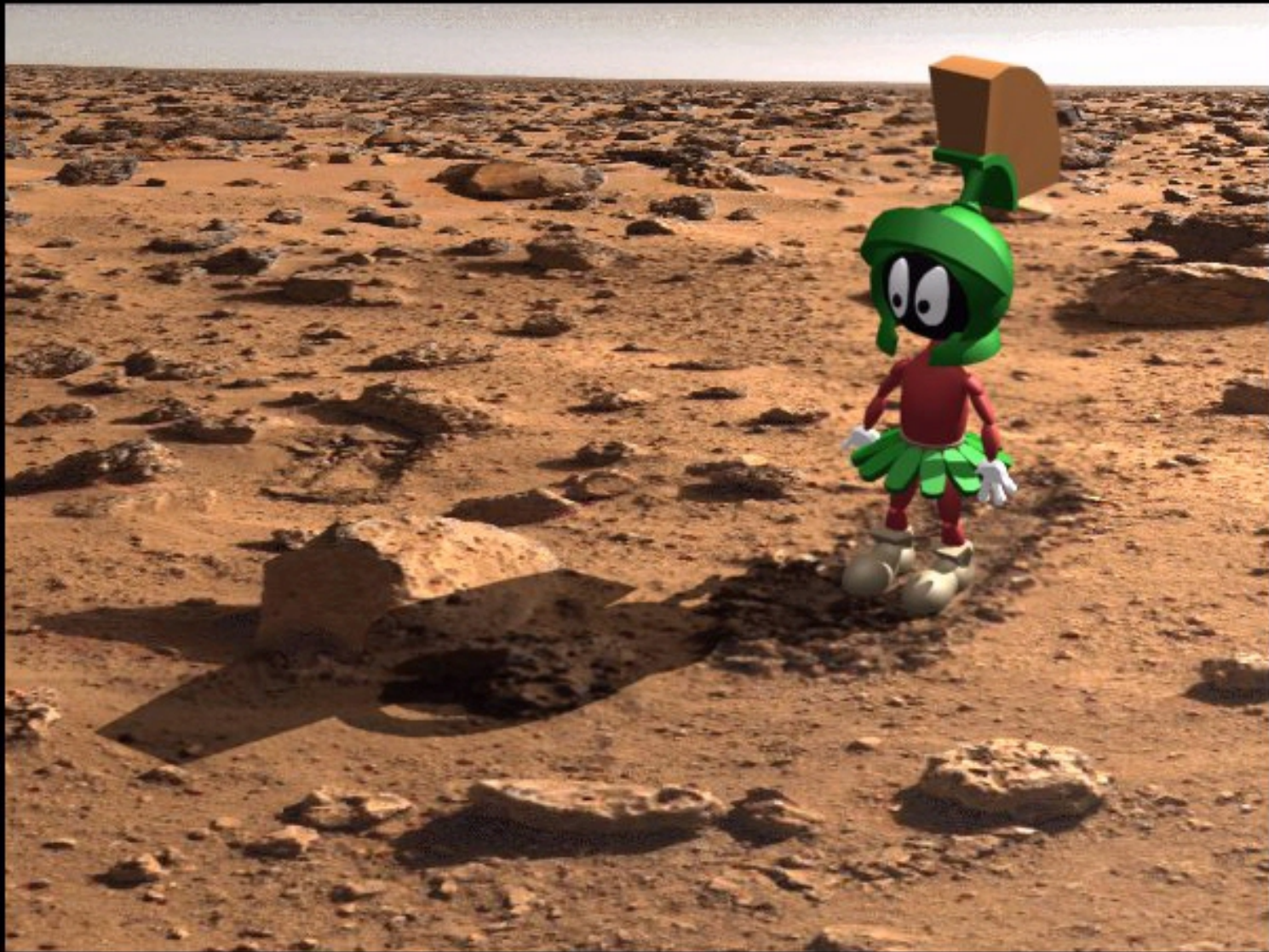
A full moon is visible in the upper left quadrant of the image, set against a dark, starry sky. Below the moon, a body of water reflects the moon's light, creating a shimmering path that leads towards the bottom center of the frame. The overall scene is serene and evokes a sense of space exploration and lunar study.

Astrobiology & Lunar Exploration

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Presentation to NAC Workshop on Science Associated
with the Lunar Exploration Architecture

March 1, 2007





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Astrobiology aims to...

*...determine the distribution of life
in the Universe and understand
how this distribution relates to
the occurrence of different
planetary environments.*



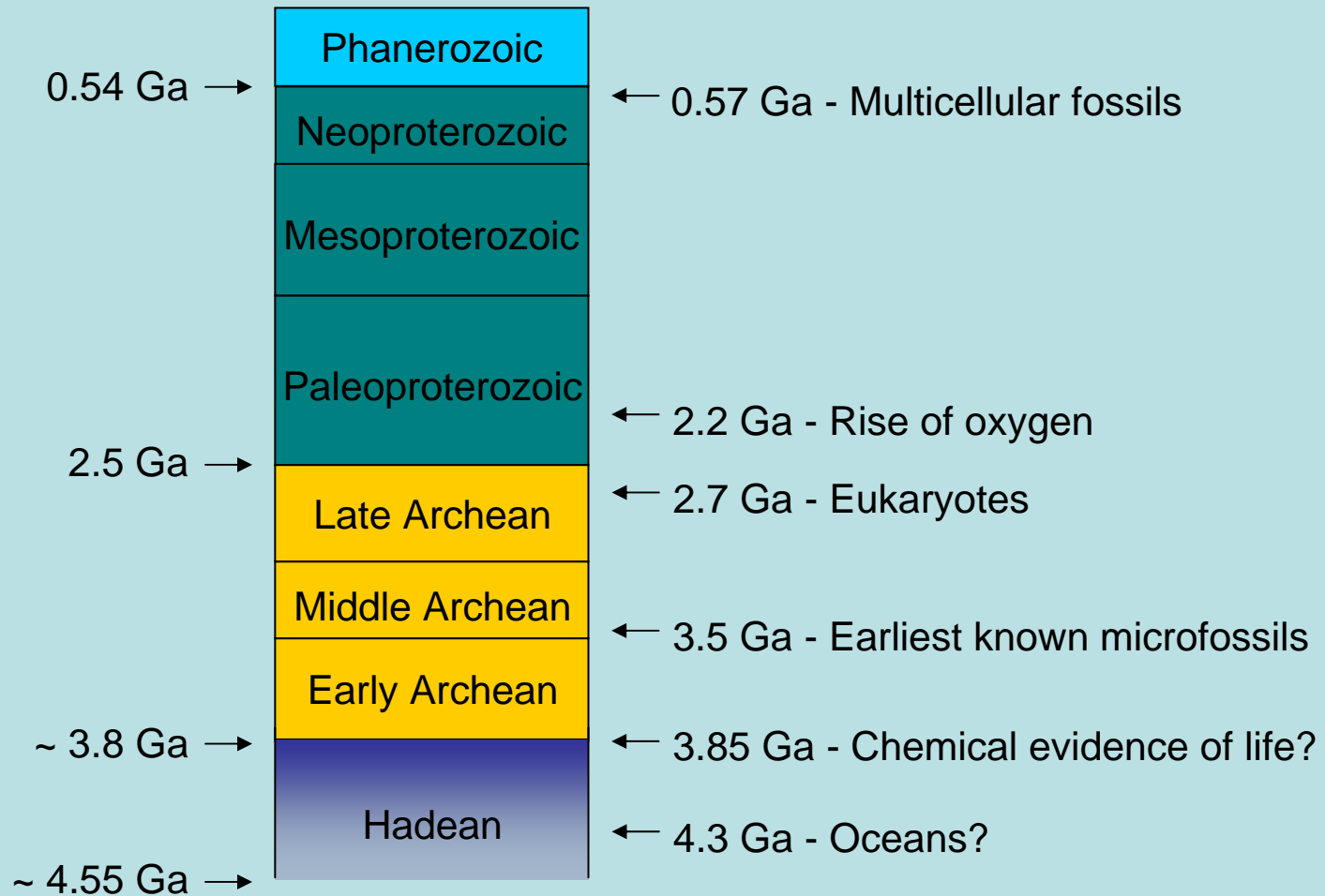
Early Bombardment



Massive impacts on the young Earth
profoundly affected habitability at the time of
life's origin and early evolution

Geologic Timeline

Ga = billions of years ago



2.5 Ga: Rocks!

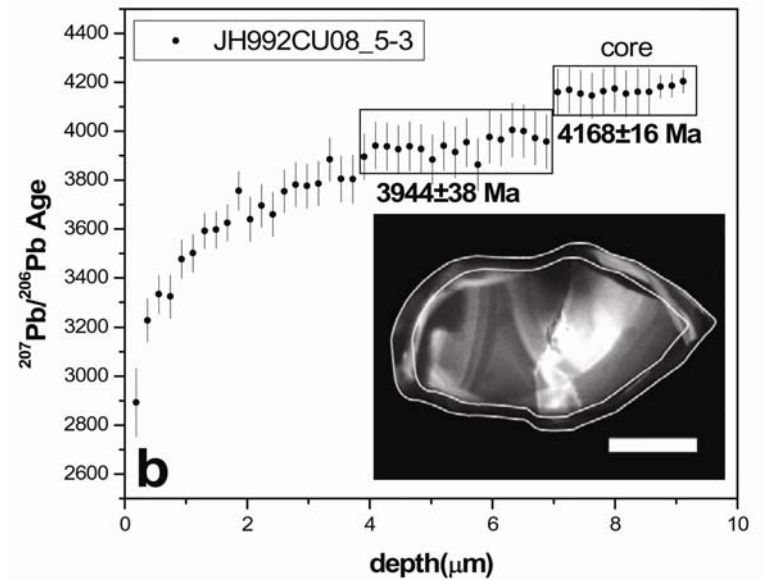
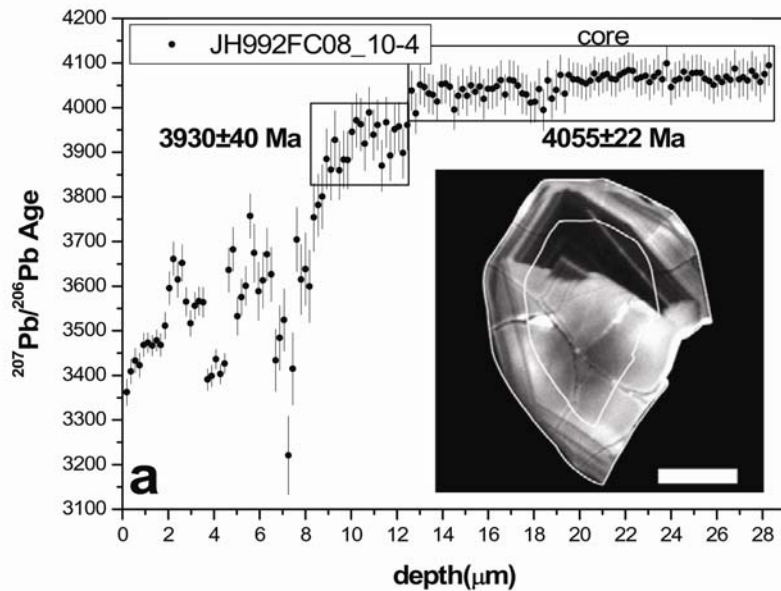


Hamersley Basin, W. Australia



> 3.8 Ga: Fragments!

Age Profiles in Zircons *S. Mojzsis, personal communication*



A full moon is visible in the upper left quadrant of the image, set against a dark, starry background. Below the moon, a bright, shimmering reflection of the moon's light is cast across a dark, rippling surface of water, extending towards the bottom center of the frame. The overall scene is a serene, nocturnal celestial view.

NAI White Paper, 2004

Astrobiology Science Goals and Lunar Exploration

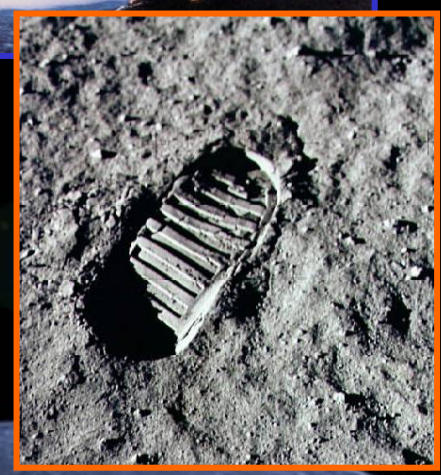
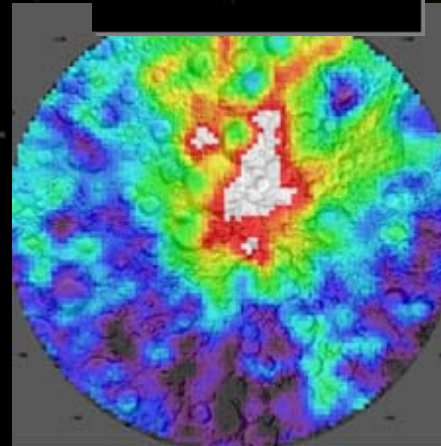
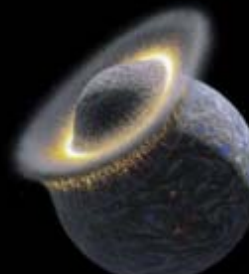
Key Themes:

- Bombardment history
- Solar history recorded in regolith
- Origin of the Moon
- Volatiles (sources and prebiotic chemistry)

The Moon Presents Compelling Science Opportunities



- Bombardment of the Earth-Moon system: Consequences for the emergence of life
- Lunar surface and interior processes and history
- Scientific treasure in the permanently shadowed polar environment
- Regolith as a recorder of the Sun's history
- The Moon as a Science Platform: Astronomy, Earth and Solar Activity Observations
- Testing Planetary Protection protocols



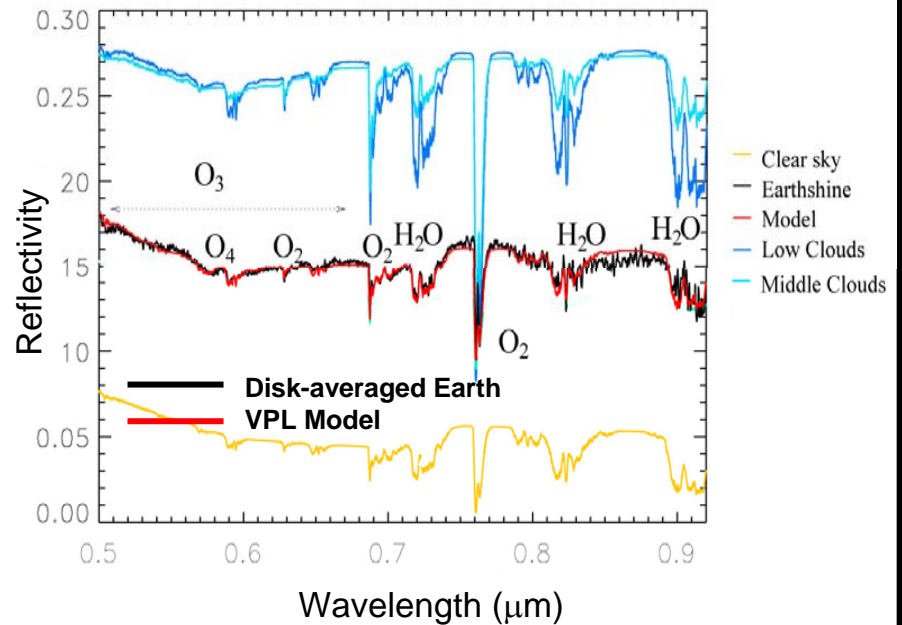
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Take-home Message #1

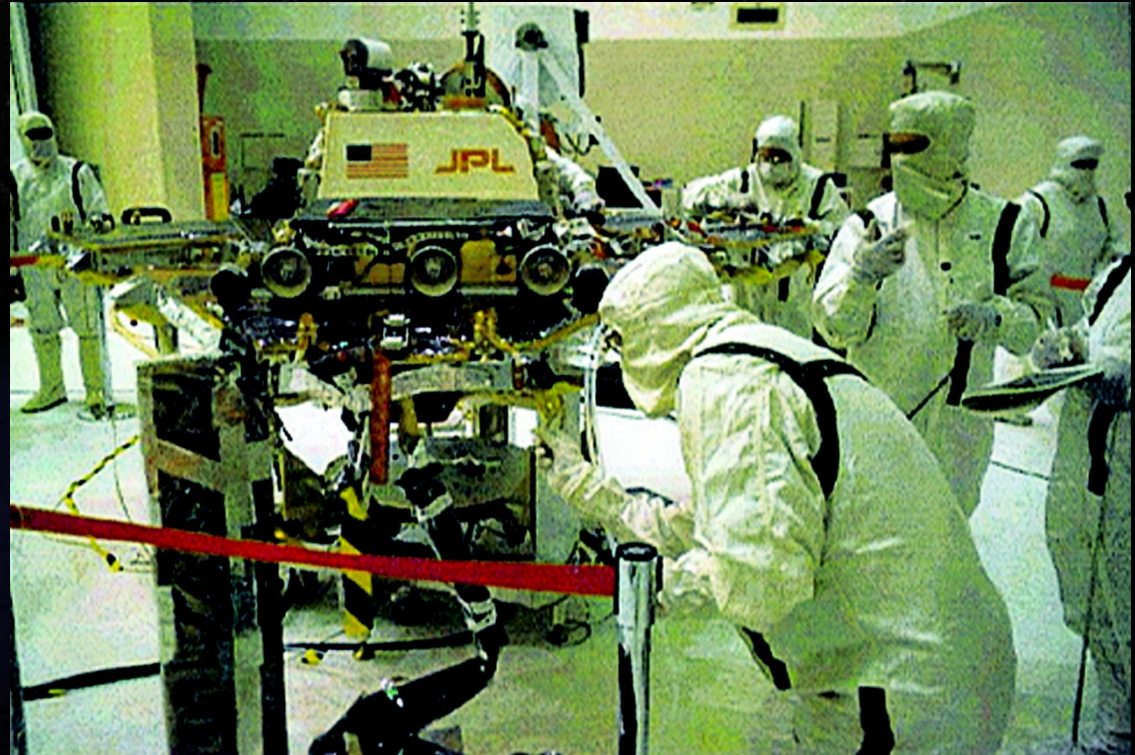
Some of the identified major science themes for lunar exploration *are important astrobiology themes*



Planetary-Scale Biosignatures

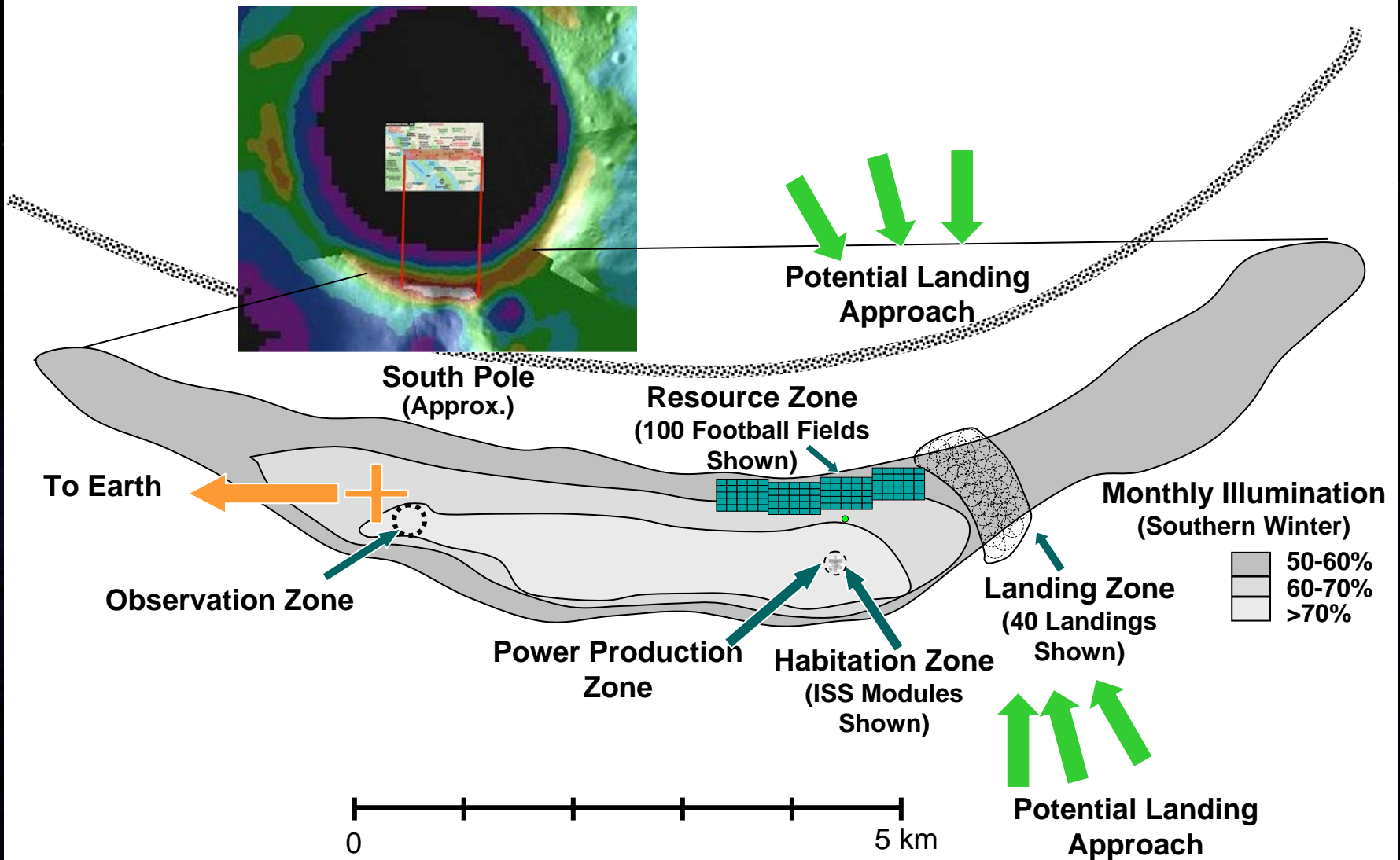


Planetary Protection



S. Polar Outpost

Not ideal but could significantly advance astrobiology

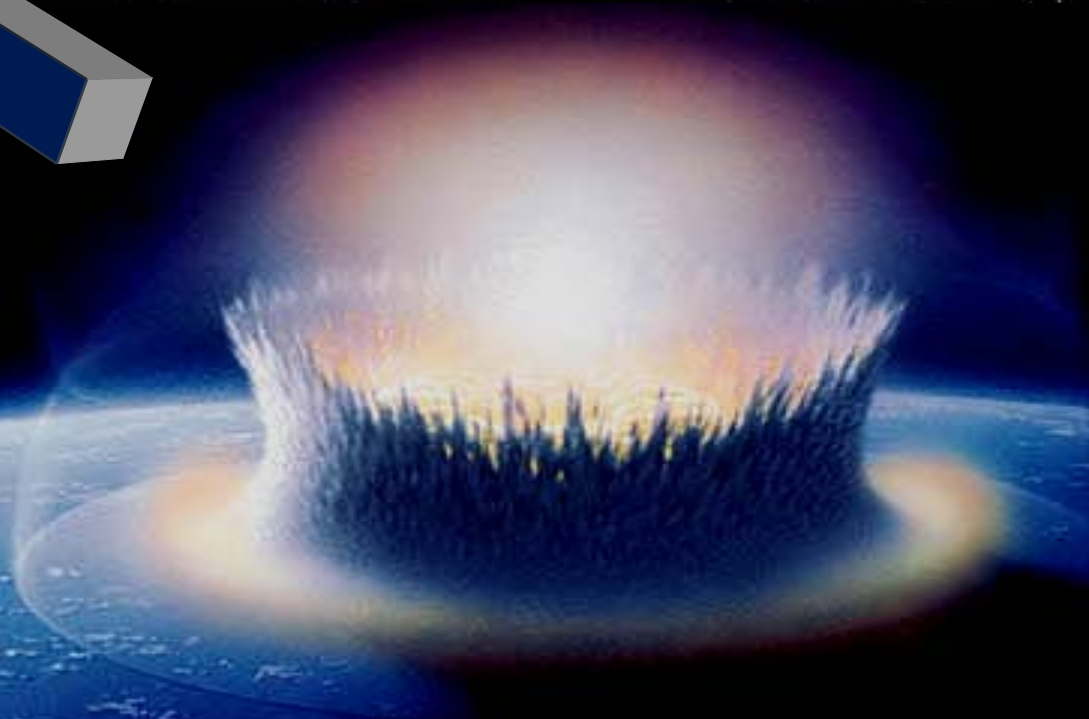
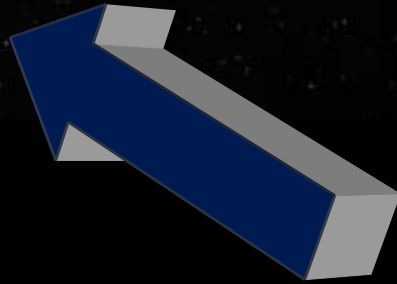


What's Missing?



Objective ID Number	Notes	Summary	Values	Missing				Supportive Knowledge	Least Exploitation Themes	Economic Expansion	Resilience	Justification for EOE	Support Sources
				Missing	Least Exploitation Themes	Economic Expansion	Resilience						
AA1	Perform radio astronomy (both interferometric and single-dish) from the Moon to map the cosmic web and observe other astronomical objects.	Radio interferometry allows arrays in the DM region, as well as single-dish antennas located on the far side of the Moon can potentially provide a wealth of important data for studies of	Radio astronomy allows us to probe some of the most exotic phenomena in the Universe: pulsars, black holes, nearby exoplanets of the long-baryon and planetary radio emission.		X								
AA2	Perform radio astronomy on the lunar surface.	Perform radio astronomy on the lunar surface to observe the structure of DM, optical and infrared wavelengths, including observations of solar-wind plasma.	The Moon is a dark sky surface an atmospheric scattering phenomenon in the context of a radio could have additional advantages for DM observations because of the cold temperatures there.		X	X	X	X	X				
AA3	Perform optical/infrared astronomy from the Moon.	Perform optical/infrared astronomy from the Moon.	The Moon is a dark sky surface an atmospheric scattering phenomenon in the context of a radio could have additional advantages for DM observations because of the cold temperatures there.			X							
AA4	Direct gravitational waves to understand gravitational waves and test theories of General Relativity.	Direct gravitational waves from nearby supermassive black holes will have compact objects.	Gravitational waves are produced by asymmetric phenomena, such as black hole mergers, and are expected to be detectable by ground- and space-based detectors in the next decade. Once detected, understanding astrophysical phenomena is critical for probing general relativity in the environment of our own solar system and the Earth within it.		X								
AA5	Direct and monitor exoplanets.	Monitor nearby stars over time to detect transit by planets.	Understanding astrophysical phenomena is critical for probing general relativity in the environment of our own solar system and the Earth within it.			X							
AA6	Perform long duration measurements of near-galactic particles (cosmic rays and solar energetic particles) at the Moon's surface.	Perform long duration measurements of near-galactic particles (cosmic rays and solar energetic particles) at the Moon's surface.	Because the Moon is outside the Earth's magnetosphere and lacks an atmosphere, energetic solar particles and cosmic rays of all energies and types reach the Moon's surface unhindered.			X			X				
AA7	Test the five-point force of nature.	The relatively low cosmic masses on the Moon may make it an excellent place to search for small dark matter candidates, such as the Strategic Dark Matter Experiment (SDME). This particle has	Strongly spin-dependent interactions with the different form of nuclear matter, and may exist in the vicinity of neutron stars. It might have also been produced during the Big Bang.			X	X			X			
AA8	Testing general relativity and probing the internal structure of the Moon.	Perform laser interferometry at a number of sites on the back side of the Moon would allow the relative motion of the Moon with respect to the Earth to be measured to the sub-centimeter level.	Perform laser interferometry at a number of sites on the back side of the Moon's surface has great value as one of our most accurate tests of Einstein's theory of gravity (which has not yet passed all its tests). Probing			X			X				

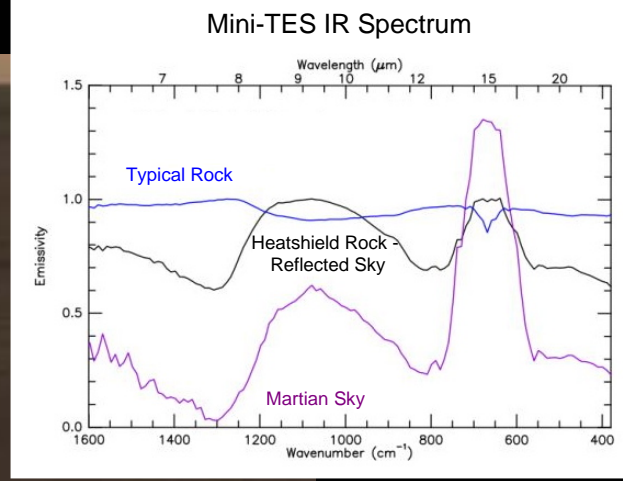
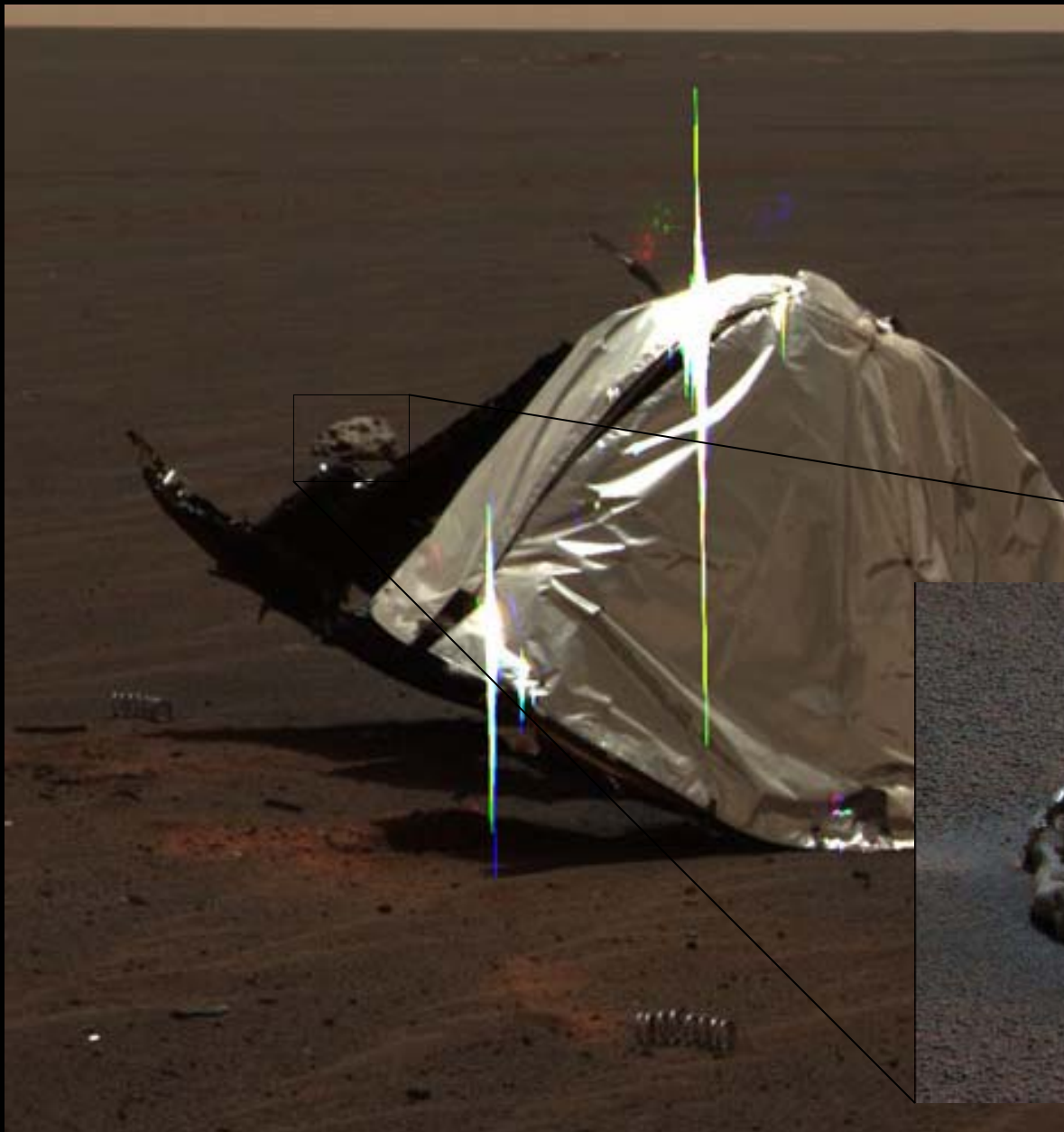
The Moon as "Earth's Attic"



How Much Stuff? *How Hard to Find?*



- 7 parts per million
- About 200 kg of material in 1 sq. km.
- Size distribution *unknown*



Credit: P. Christensen, ASU



Take-home Message #2

On the Moon (eventually):

Keep eyes (and options) open!

On Earth (until we return, and beyond):

Support development of NEW ideas.

Integrate into mission plans.

Iterate. Then do it again!