Astrobiology & Lunar Exploration

Ariel D. Anbar

School of Earth & Space Exploration
and Dept. of Chemistry & Biochemistry
Arizona State University

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

March 1, 2007
Astrobiology ≠ bug-hunt!
Astrobiology aims to...

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

- ~4.55 Ga - Oceans?
- 3.85 Ga - Chemical evidence of life?
- 3.5 Ga - Earliest known microfossils
- 2.7 Ga - Eukaryotes
- 2.2 Ga - Rise of oxygen
- 0.57 Ga - Multicellular fossils

- 0.54 Ga → Phanerozoic
- Neoproterozoic
- Mesoproterozoic
- Paleoproterozoic

- 2.5 Ga → Late Archean
- Middle Archean
- Early Archean

- ~3.8 Ga → Hadean
2.5 Ga: Rocks!

Hamersley Basin, W. Australia
Age Profiles in Zircons
S. Mojzsis, personal communication
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)

http://nai.arc.nasa.gov/about/lunar_astrobiology.cfm
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

L. Leshin, 2007
Take-home Message #1

Some of the identified major science themes for lunar exploration **are important** astrobiology themes
Planetary-Scale Biosignatures

Reflectivity vs. Wavelength ($\mu$m)

Disk-averaged Earth VPL Model

Planetary-Scale Biosignatures
Planetary Protection
**S. Polar Outpost**

*Not ideal but could significantly advance astrobiology*

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**South Pole** (Approx.)

**Resource Zone** (100 Football Fields Shown)

**Power Production Zone**

**Habitation Zone** (ISS Modules Shown)

**Landing Zone** (40 Landings Shown)

**Monthly Illumination** (Southern Winter)

- 50-60%
- 60-70%
- >70%

**Potential Landing Approach**
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What’s Missing?
The Moon as "Earth's Attic"

Armstrong, Wells and Gonzalez, Icarus, 2002
How Much Stuff?
How Hard to Find?

- 7 parts per million

- About 200 kg of material in 1 sq. km.

- Size distribution *unknown*
Typical Rock
Martian Sky
Heatshield Rock - Reflected Sky

Mini-TES IR Spectrum
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!