How Have Results from Recent Lunar Missions Changed Our View of the Moon?

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Where are we now?

Samples: Apollo, Luna, lunar meteorites

Human exploration: 1969-1972: Apollo

Robotic spacecraft: 1959-Present: Lunar Reconnaissance Orbiter, Chandrayaan-1, Kaguya, Chang’e, SMART-1, Lunar Prospector, Clementine, Apollo, Luna, Lunokhod, Surveyor, Ranger, Zond

Earth-based observation: 1609 (Thomas Harriott) - present

Summaries:
- New Views of the Moon
- The Lunar Source Book – A User’s Guide to the Moon
- 40+ years LSC/LPSC
Kaguya

Launch: September 14, 2007
EOM: June 10, 2009
Payload:
- Terrain Camera
- CCD HDTV
- X-Ray Fluorescence Spectrometer
- Gamma-Ray Spectrometer
- Magnetometer
- Spectral Profiler
- Laser Altimeter
- Radar Sounder
- Charged Particle Spectrometer
- Plasma Analyzer
- Upper Atmosphere / Plasma Imager
- Radio Science
- Subsatellites for far-side gravity
Chang’e - 1

Launch: October 24, 2007
EOM: March 1, 2009
Payload:
  Stereo Imaging
  VNIR Spectrometer
  Microwave Radiometer
  Laser Altimeter
  X-Ray Spectrometer
  Gamma-Ray Spectrometer
  High Energy Particle Detector
  Solar Wind Detector
Chandrayaan - 1

Launch: October 22, 2008
EOM: August 29, 2009
Payload:
- Terrain Mapping Camera
- Hyper Spectral Imager
- Gamma / X-Ray Spectrometer
- Laser Altimeter
- Impact Probe
- X-Ray Fluorescence Spectrometer
- Atom Reflecting Analyzer
- Mineralologic Mapper
- Near Infrared Spectrometer
- Mini-SAR
- Radiation Dose Monitor
Lunar Reconnaissance Orbiter

Launch: June 18, 2009
EOM: ....
Payload:
  Laser Altimeter
  Narrow- / Wide-Angle Imager
  Neutron Spectrometer
  Thermal Radiometer
  UV Mapping Spectrometer
  Cosmic Radiation Telescope
  Imaging Radar
Geology of the Moon

Near Side

Far Side
Don’t We Already Know Everything About the Moon?

Which of the following is the largest?

A: A Peanut
B: An Elephant
C: The Moon
D: A Kettle

ELEPHANTS
Larger than the moon
Don’t We Already Know Everything About the Moon?

Scientific Context for Exploration of the Moon: Final Report

Bombardment history of the inner solar system uniquely revealed on the Moon. Structure and composition of the lunar interior provide fundamental information on the evolution of a differentiated body.

Key planetary processes are manifested in diversity of lunar crustal rocks. The lunar poles are special environments that may bear witness to the volatile flux over the latter part of solar system history.

Lunar volcanism provides a window into the thermal and compositional evolution of the Moon.

The Moon is an accessible laboratory for studying the impact process on planetary scales.

The Moon is a natural laboratory for regolith processes and weathering on anhydrous airless bodies.

Processes involved with the atmosphere and dust environment of the Moon are accessible for scientific study while the environment remains in a pristine state.
Characterize chemical/physical stratification of mantle, particularly nature of the putative 500 km discontinuity and composition of lower mantle.

Estimated at <460 km radius, metallic Fe with some Ni, S, And C, but could also be molten Ti-rich silicate magma.

Determine the size, composition and state (solid/liquid) of the core of the Moon.
Bombardment History

Flux considerably greater early time.
Several basins have similar ages.
Question of biased sampling – all the samples saw the same small set of events.

Bombardment history of the inner solar system.
Early cataclysm?
Episodic variations over the last 0-3 Ga?
Regolith Formation / Evolution

Regolith develops due to meteoroid bombardment (macro to micro).

Regolith / megaregolith
Older the surface – thicker the regolith and the more mature.
Lateral variations, complex layered medium.

The Moon is a natural laboratory for regolith processes and weathering on anhydrous airless bodies.
Who Cares?
Who Cares?

Moon – Terrestrial planet with a complex and long-lived geologic history in its own right.

Moon – Rosetta Stone of Solar System

Records history of solar system events and processes
  Impact history
  Solar history
  Volatile flux
Space weathering on planets without atmosphere
Exosphere formation and evolution
Formation and evolution of planetary regoliths
Cryogenic processes – volatiles
Planetary evolution
Haven’t We Been Everywhere?

Jolliff et al. (2000) JGR 105, 4197
Haven’t We Been Everywhere?
Haven’t We Been Everywhere?
What’s Next?

Few, if any, of the major outstanding questions can be resolved by a single mission.

Questions require
  Global access
  Detailed, planned sampling
  Numerous samples
  Multiple, extended observations

P³ (Plescia’s Personal Picks)
  Ages of mare volcanism
  Interior structure
  Polar volatiles
  Petrologic diversity
What’s Next?
Lunar Atmosphere and Dust Environment Explorer - LADEE

Launch: May 2012
Mission Length: 100 days
Payload
- Neutron Mass Spectrometer
- Dust Counter
- UV Spectrometer
- Laser Communications
GRAIL
Gravity Recovery and Interior Laboratory - GRAIL

Launch: September 2011
Mission Length: 90 days
Payload:
Ka Band Imaging
Summary

Many major scientific questions remaining.
- Environment, surface and interior
Pure science – applied science
Few questions can be addressed with a single mission, none with a single sample or measurement.
Any mission will make some progress on some subset of the questions.
Any location can add to understanding about many questions.
Global access and samples are key.

Lunar science doesn’t end. Questions are addressed, understanding matures, new problems are discovered, new techniques are developed, new samples are acquired, analysis continues.