MOON 101
RESEARCH

Evan Clark
Alleeza Qamar
Michael Batista
Nicole Murray
Kristina Bates
Sol Cordova
Juvariya Lat
Topics

- Formation
- Geology
- Apollo Landing Sites Picture Analysis
- Timeline
Formation of the Moon
4.5 Billion Years Ago

Theory 1 - Capture Hypothesis

Says that the Earth captured the Moon in it's gravity.

Negating Evidence:
A body passing near the Earth would likely collide with it rather than orbit it.
Negating Evidence: Earth would have to be spinning extremely fast in order to throw off enough material.

Postulated that the Earth was spinning extremely fast.
Theory 3- Double Planet Hypothesis

Earth and Moon formed concurrently from a cloud of gas and dust.

Negating Evidence: Does not explain how the ring of material that formed the Moon could have acquired enough circular motion to stay in orbit around Earth.
4.5 Billion Years Ago

**The Giant Impact Hypothesis**

- The best explanation for how the Moon was formed.
- Moon formed as a result of a colossal impact with a Mars-sized body.
- There are elements on the Earth that are similar to what is on the Moon.

Negating evidence: Models show that much of the material would re-bound and hit the Earth again.
While the moon was forming, the less dense material rose to the surface creating the highlands.
Lunar Cataclysm

A time of heavy bombardment of the inner planets and the moon.

Most, if not all, of the basins on the moon theorized to have been created in this time period.
3.92-3.85 Billion Years Ago

**Lunar Cataclysm**

**Cause:**
- **1:2 resonance:** where Saturn and Jupiter migrated such that Saturn orbited once for every two orbits of Jupiter.
- This is theorized to have caused sporadic movement of meteors and planets.
Lunar Cataclysm

Proof:
- Many impact melt breccias found in exploration of moon were created between the 3.92 to 3.85 billion years ago.
- There are few found before or after that time period.
Lunar Cataclysm

Skepticism:

- Apollo program only took from a single impact basin, so the evidence should be expected as such.
Alternate ideas:

- **Stone-wall effect**: the idea that the impact craters during the Lunar Cataclysm covered the older craters.
  - Disproved by the finding of lava flows up 4.25 billion years ago.
3.92-3.85 Billion Years Ago

**Mare**

- The mare-basalt magmas originated by partial melting of ultramafic mantle material.
- Dark spots on surface of the moon. Cover 16% of surface, 30% near side, 2% far side.
- Resemble terrestrial volcanic terraces.

![Image of lunar surface](image-url)
Basalt Flows / Extrusion

- Formed after the moon’s creation
- 2 stage process formation:
  - source of heat
  - planetary accretion (2nd stage melting)
The moon was almost completely molten when it formed.
- This is determined by the composition of the lunar crust.
- The magma ocean took 100 million years to solidify.
- Formation of much of the anorthosite crust (crystallization 75% completed), 61 million years later.
- End of crystallization (maybe a few percent magma left over), 39 million years later.

**Crust**

![The Lunar Magma Ocean](PSRD graphic)
Geologic History
Craters

- Simple Craters
- Complex Craters
Simple Craters

- Floor is underlain by lens-shaped deposit of broken material, breccia lens.
- Typically created by smaller meteors.
- Smooth bowl-shaped craters.
Complex Craters

- Consists of inward-facing terraces that have slipped downward.
- Flat floors, terraced walls, central peaks.
Lunar Rilles

Long, narrow depressions in the moon's surface resembling channels.

Three types:
- Sinuous Rilles
- Arcuate Rilles
- Straight Rilles
Sinuous Rilles

- Found in lunar mare which is filled with basaltic rock.
- Characterized by their meandering curves.
- Remnants of ancient lava flows.
Arcuate Rilles

- Have smooth curvatures
- Found on the edges of the dark lunar maria.
- Formed from cooled magma.
Straight Rilles

- Long and undeviating
- Cut surfaces outside mare-filled basins
Cones
- Concentrated in the Marius Alls
- Reflect variations in composition / eruptive process
- Favorite by Apollo mission in hope of yielding different volcanic rocks

Domes
- Circular features with low profiles topped by small smooth rimmed craters
- Major factor in endogenic interpretations of Maria
- Concentrated in Marc Tranquillitatis
Apollo Landing Site
Picture Analysis
Apollo 11 Landing Site

- Pink Circles - Domes
- Green Circles - Cones
Apollo 17 Landing Site

- Red Circles - Domes
- Yellow Circles - Cones
- Blue Outline - Sinuous Rille
Apollo 15 Landing Site

- White-Straight Rille
- Yellow Circles-Simple Craters
- Brown-Mare
- Blue-Highlands
- Purple Circles-Complex Craters
Relative Age

1) Dome
2) Dome
3) Dome
4) Dome
5) Cones
1) Sinuous Rille
2) Dome
3) Dome
4) Dome
1) Highlands: ~4.5 billion years ago
2) Mare: ~3.9 billion years ago
3) Straight Rille
4) Complex Crater
Lunar Missions

- Ranger Missions (1961-1965)
- Apollo (1963-1965)
- Clementine (January 1994 - June 1994)
- Lunar Prospector (Launched January 7, 1998; Duration: 5 hrs)
- Lunar Reconnaissance Orbiter (2009-Ongoing)
Sources

- The Scientific Legacy of Apollo, Jeffrey Taylor, 1994, Scientific American, volume 271, number 1, pages 40-47