Moon 101

All you need to know about the moon

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There are several hypotheses created about the formation of the moon. Our group read the article, “Origin of the Earth and Moon” by G. Jeffrey Taylor. The article contained pieces of evidence that supported each hypothesis.
Hypothesis One

During a conference in Monterey, CA, 130 scientists met and came up with a hypothesis for the formation of the moon. Several components of this hypothesis include:

- It was the result of a colossal impact onto the accumulating Earth flinging raw materials, forming the moon.

Did you know? That the giant impact hypothesis is consistent with their ideas for how the planets were assembled?
In Kailua-Kona, Hawaii, other groups of scientists determined another hypothesis about the formation of the moon.

- The impactor was 10% of the size of Earth.
- It is also believed that there was a large amount of material lofted from the Earth, to form the moon.
Hypothesis Three

Cosmo chemists are reasonably sure that a global ocean of magma surrounded the Moon when it was formed. This helped form the rich anorthositic plagioclase feldspar ($\text{CaAl}_2\text{Si}_2\text{O}_8$) crust of the lunar highlands.
## Compare and Contrast Moon Hypotheses

<table>
<thead>
<tr>
<th>Hypothesis 1</th>
<th>Hypothesis 2</th>
<th>Hypothesis 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Magma Ocean</strong></td>
<td><strong>Lunar Cataclysm</strong></td>
<td><strong>Capture Theory</strong></td>
</tr>
<tr>
<td>Time to Solidify an Ocean of Magma - Cosmo Chemists are almost completely sure that an ocean of magma surrounded the Moon when it formed.</td>
<td>A bombardment of many asteroids and meteorites impacted the moon and reformed the Moon's surface approximately 3.9-4.5 billion years ago.</td>
<td>As the solar system was forming, a large object to near to the forming Earth, became trapped in it's gravitational pull, and formed to what is now the moon.</td>
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- The moon is said to made of the same material as the Earth's upper mantle. Because the upper mantle is also made of magma.
- Recent works show the lunar highlands contain many chemically distinct groups of rocks melted by impact, this suggests several collisions.
- The moon orbits in the same direction as the Earth.
- The moon and Earth are located in the same elliptical plane.

### Comparison

All hypotheses could have possibly played a part in the formation of the moon.
It took approximately one million years for the moon to form the Lunar Highlands. 3.9 billion years ago, a vast amount of asteroids and meteorites impacted the moon and reformed the its surface. Many people came to believe that at one time the moon’s surface was actually smooth, but when this bombardment of meteorites and asteroids occurred craters were formed.
Global Moon Features

Legend

Yellow=Highlands
Blue=Impact Craters
Lime Green=Complex Craters
Teal=Rilles
Purple=Rays
Pink= Maria
The lunar highlands are light in color, mountainous, and heavily covered with craters. The highlands contain the oldest rocks on the moon which are known as anorthosites, they are composed almost entirely of plagioclase feldspar with a calcium end group \((\text{CaAl}_2\text{Si}_2\text{O}_8)\). Anorthosites seemed to have formed when feldspar crystallized and floated to the top of a global magma ocean that surrounded the Earth soon after it formed. So the highlands were most likely formed by the magma ocean.
All the craters of the moon are impact craters, these craters are formed when objects from space crashed into the lunar surface.

- **Crater Rim** - extends above the height of the local surface, usually in circular or elliptical patterns.
- **Melt Sheet** - when the ice/rock melts from the impact of a meteorite or an asteroid.
- **Breccias** - rock composed of broken fragments of minerals or rocks cemented together.
- **Central Uplift** - developed from uplift of deeper target rocks presumably within a few seconds following initial impact.
**Complex Craters**

The Complex Craters are made from impact with large, fast objects that have a high energy upon impact.

- **Simple impact craters** have bowl-shaped depressions, mostly with smooth walls. This type of crater generally has a diameter less than 9 miles (15 km). Their depth is about 20% of the diameter.

- **Complex impact craters** have a single or multiple peaks in the middle of the crater. These craters have diameters between about 12 and 110 miles (20 and 175 km), and the central uplift is usually one or a few peaks. Craters with a diameter over 110 miles (175 km) can have more complex, ring-shaped uplifts within the crater.

Green represents complex craters.

[Diagram of Simple and Complex Craters]

- **Simple Crater**
  - Diameter (D)
  - Breccia
  - Impact melt
  - Impact ejecta
  - Fractured bedrock
  - Central peak uplift

- **Complex Crater**
  - Diameter (D)
  - Multiple peaks in the middle of the crater
  - Additional complex uplift structures
Meandering, valley like structures.

Rilles can come to be several kilometers wide and hundreds of kilometers in length. They are said to be formed from lava flowing above or under Earth’s surface, and are better known as “lava tubes”.

3 Types exist:
- Sinuous Rilles- meander in a curved path
- Arcuate Rilles- have a smooth curve and are found on the edge of the lunar mare
- Straight Rilles- follow a linear path and are believed to be grabbens- areas where the crust has sunk between two parallel faults.

German for “Groove”

Teal indicates rilles.
Early hypotheses suggest that rays were actually deposits of salt from evaporated water. They are actually radial streaks of ejecta thrown out during the formation of an impact crater. Rays can go on to be much larger than the diameter of their originating crater, they can also be surrounded by secondary craters formed by larger chunks of ejecta from the meteorite or asteroid that created the primary crater. They appear visible only when the ejecta is made up of material with different reflectivity than the surface on which they're deposited.

Not only are rays discovered on the moon, but also on Mars.
The Maria, which contain many of the Moon’s largest craters called the basins, were most likely caused by the lunar cataclysm. The mare rocks are young compared to the highland rocks, being formed at approximately 3.3-3.6 billion years ago. They contain mostly basaltic rock— a rock with a high percentage of iron (17%-22% by weight) and a wide range of titanium (1%-13% by weight) and a relatively low albedo as compared to the anorthositic highlands.

- Dark, smooth plains, which on average are 3 km lower in elevation than the highlands.

Pink indicates the Maria
As you can see from the screenshot above we measured the diameters of the four largest basins of the moon using a program called *ImageJ* from the *National Institute of Health*.

<table>
<thead>
<tr>
<th>Crater</th>
<th>Our Measurement</th>
<th>Actual Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nectaris</td>
<td>861.251 km</td>
<td>860 km</td>
</tr>
<tr>
<td>Crism</td>
<td>421.698 km</td>
<td>418 km</td>
</tr>
<tr>
<td>Serenatatis</td>
<td>925.332 km</td>
<td>920 km</td>
</tr>
<tr>
<td>Imbrium</td>
<td>1305.837 km</td>
<td>1300 km</td>
</tr>
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</table>
Apollo Sixteen

Apollo 16 was the fifth mission to land men on the moon and return them to Earth. Launched on: April 16th 1972 17:54:00 UT (12:54:00 p.m. EST).
Kennedy Space Center Launch Complex 39A.
Landing Site: Cayley Plains within the Descartes highlands.
Returned to Earth: April 27th 1972.

Lunar surface traversed: 27 Kilometers
Moon Rocks collected: 95.8 Kg
The main objective of the mission was to investigate the lunar surface in the Descartes Formation and the Cayley Formation because it was considered to be representative of most of the Moon's surface, due to the fact that those formations make up 11% of the nearside surface of the moon.

Light-colored rock called anorthosite was collected from the Apollo 16 landing site. An anorthosite is a rock made up almost entirely of plagioclase feldspar—with the addition of a calcium endgroup. This is a common rock-forming mineral on Earth. This rock is dated at 4.2 billion years old, much older than the lunar basalts.
The Apollo 16 mission disproved two theories of the origin of the Descartes-Cayley Formations, which said that they were both volcanic in origin. When the Apollo 16 mission obtained lunar samples from both of these areas however, it was determined that they were actually breccias formed through impact. It was also determined that, due to the density of the samples, the Cayley Formation was comparable in age to the Imbrium Impact.

The Apollo 16 mission actually landed between two fresh (relatively new) impact craters - the North Ray Crater and the South Ray Crater - which provided a natural drilling area already partway through the lunar regolith. This allowed for an easier sampling of the underlying bedrock of the area.
Apollo Sixteen

Legend

Green=Highlands
Purple=Complex Craters
Teal=Impact craters
Yellow=Rilles

The arrows are pointing to the craters Theophilus and Cyrillus.
References!

- http://www.psrd.hawaii.edu/Mar09/magmaOceanSolidification.html
- “The Scientific Legacy of Apollo”-G.Jeffry Taylor
- www.wikipedia.com
- www.google.images.com
- Glencoe-Earth Science: Geology, the Environment, and the Universe
The End

...And the cow jumped over the moon!