The geological history of the Moon

The last blast-off from the Moon

http://www.youtube.com/watch?v=9HQfauGJaTs&feature=channel

Ages of Formation of Lunar Rocks

The age of formation of lunar rocks can be determined by radioisotope dating. See p144 of the textbook for a description of this technique. A radioisotope that proves useful in dating rock samples is Rubidium 87, which decays to Strontium 87.

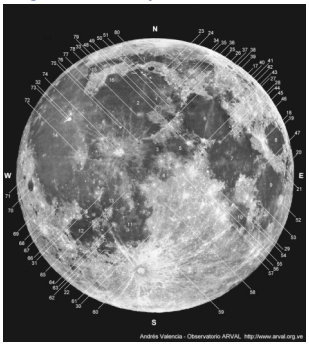
The following conclusions result from the dating of Moon rocks.

1. Moon rocks are extremely old relative to Earth rocks. All of the samples returned had formation ages from 3.2 to 4.5 billion years. Check previous notes for the comparison of this to Earth rocks.
2. The rocks found on the Maria ranged from 3.2 to 3.8 billion years.
3. The rocks found in the terrae, or thought to come from terrae regions, ranged from 3.8 to 4.5 billion years.

Moon Rocks and the Age of the Solar System

No lunar rocks have been found which are older than 4.5 billion years. Furthermore, no rock has been found anywhere in the solar system that is older than 4.5 billion years old. This is because the whole solar system is only slightly older than 4.5 Gyr (Gyr= billion years).

What do moon rock ages tell us about the geological history of the moon?



Inferring the Geological History of the Moon

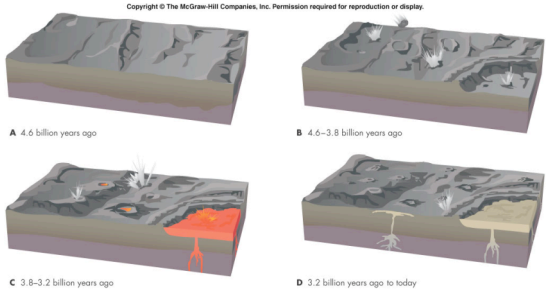
The rocks on the maria are about 500 million to one billion years older than the rocks on the terra. The terrae are heavily scarred by impact craters, whereas the maria have relatively few impact craters. This means that most of the impacts of objects on the Moon which produced craters occurred in the first billion years or so of the lifetime of the Moon during the "Age of Bombardment". By 3.2 billion years, most of the impacts producing craters were over.

A good illustration of our inference of the geological history of the Moon is given in Figure 9.25 of the book. Look at it. A simulated view of how the Moon would have looked at different times in the history of the solar system is given in Figure 9.26.

When you look at the face of the Moon, either with a telescope or with the naked eye, you are looking on a scene which has changed very little during the last 3 billion years of history.

We will next consider the question of why doesn't the Earth have impact craters, if they really are/were a widespread, solar system phenomenon. (**Hint:** Earth does have them. Tune in next week.)

The geological history of the Moon



The lesson to be learned for the rest of the solar system

- The rate of crater-producing impacts was far higher early in the history of the solar system (4.5 - 3.8 Gyr ago)
- A planet (like Earth) which is geologically active will have nearly obliterated evidence of ancient impacts
- So, if a planetary surface is heavily cratered, it indicates little surface modification has occurred in the last 3-4 billion years
- A smooth planetary surface means "something is going on"

Where are the impact craters on Earth?

http://www.unb.ca/passc/ImpactDatabase

Where did the Moon come from? How did it form?

- Why worry about it?
- Answer: Earth is only terrestrial planet with a large Moon.
- There are moons with comparable masses and diameters around Jupiter and Saturn, but Jupiter and Saturn are 318 and 95 times the mass of Earth
- So, something is unusual about the Moon

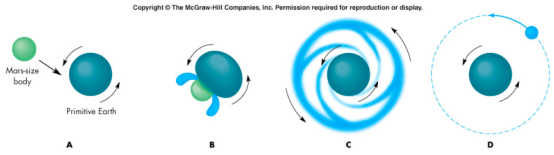
Clues to the origin of the Moon, *or* facts that have to be explained by a theory

- Densities of Moon and Earth are different, 5.52 vs 3.34 g/cc
- Lunar rocks deficient in "volatiles", substances that vaporize when heated to high temperatures
- Lunar rocks deficient in iron, nickel ("siderophile" elements)
- Other than that, composition of rocks is similar to Earth's mantle

⇨ The Giant Impact Hypothesis (1975) Hartmann and Davis

"We suggested that a very large planetesimal (building blocks of the planets) hit the Earth after the core had formed, and blew hot mantle material into orbit where it lost its volatiles and aggregated into the Moon" … William Hartmann

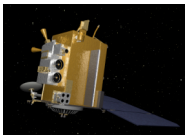
The Giant Impact Theory for the origin of the Moon



The Giant Impact Hypothesis and the rarity of Earth-like planets

Some scientists think that a collision of the sort which produced the Earth's Moon might be highly improbable. That would make our Earth-Moon system rare in the universe. If the Moon played a crucial role in making the Earth the way it is (tides, stabilization of the rotation axis), then Earth-like planets might also be rare in the universe

Lunar exploration since Apollo

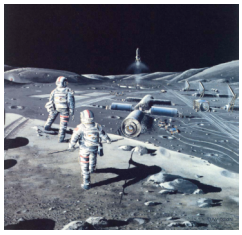


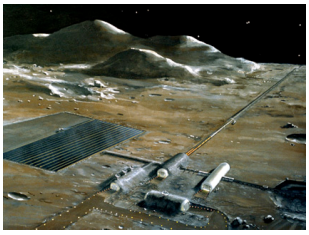
- Nothing for 21 years after the last Apollo landing
- Since 1994, 8 orbiting, unmanned spacecraft from US, Europe, Japan, and India
- Several spacecraft have reported controversial evidence for water in bottom of permanently shadowed craters
- Latest mission was LCROSS impact mission to stir up bottom of crater (October 9, 2009)

The LCROSS impact in the bottom of a permanently-shadowed crater, October 9, 2009

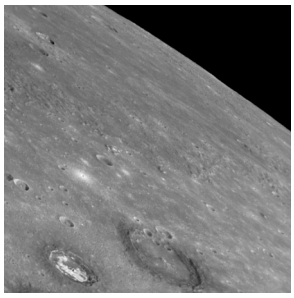
http://antwrp.gsfc.nasa.gov/apod/ap091010.html

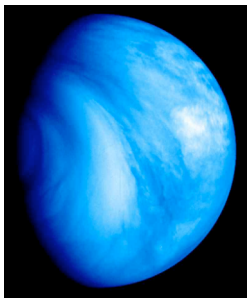
The future: Moon bases with people?



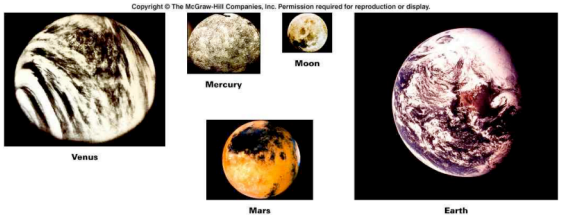


Mercury and Venus

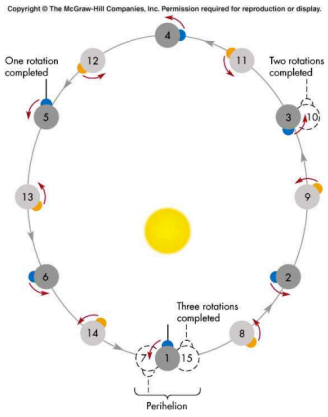




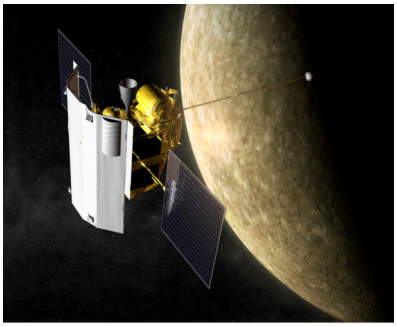
Relative sizes of Mercury and Venus



3/2 synchronous rotation and the weird day of Mercury



The Messenger spacecraft and the study of the planet Mercury



The Messenger Spacecraft: launch and arrival

http://messenger.jhuapl.edu/the_mission/movies.html

The surface of Mercury