Lunar Geology

Formation

The moon was formed in an impact between the protoplanet *Theia* and Earth a long time ago. This impact ejected matter from both celestial bodies into space, which reformed into the earth and moon today! We share similar rocks such as basalt, olivine, and pyroxenes due to this! Historically, the moon did have molten lava, as seen by lava tubes, basalt deposits in Marias, and the prevalence of igneous-type rocks.

Features

The moon does NOT have plate tectonics that we do, so it is a unique geological time capsule, as plate tectonics are what change and resurface Earth on a daily basis. There is no subduction or rifting occurring on the lunar surface at this time. In the past though, the moon did display geological evidence of tectonic activity, such as wrinkle ridges. There are features such as Marias, lava tubes, mountains, valleys, and craters!

Marias

Marias, or mares are the darker portions of the moon, which contain basalt. You may have heard of basalt in school, as a type of dark, igneous rock. The reason these are called "Marias" is because before we knew what they were, Early lunar astronomers believed that they were aquatic oceans. Indeed, they were LAVA oceans, so our ancestors did get it partially correct.

Craters

Craters are caused by impacts on the moon from asteroids, comets, & meteorites (NOT meteors! They are meteorites that burn up in a planet's atmosphere!) Like the Chicxulub asteroid that killed most of life during the Cretaceous-Paleogene extinction roughly 66 million years ago, these impact events throw out large amounts of *ejecta* out from the impact site in a radial pattern. These form what are called *"rays."*

Lava Tubes

Just how volcanoes have lava tubes that radiate out from the volcano's "central stovepipe," (central vent) the moon has these features as well! These are visible either at their entrances on the lunar surface, or where we can see a *"skylight,"* where the lava tube's ceiling has collapsed into the lava tube, leaving a rift-like or ridgelike depression feature on the moon.

Domes

Akin to shield volcanoes such as Mauna Loa in Hawaii, these are the remnants of shield volcanoes on the moon. These volcanoes erupt slowly, with a thinner lava rather than exploding like cinder cones or stratovolcanoes. Due to this, their shape is a much more gentile slope than what we imagine as a stereotypical volcano, as the lava is able to flow further before cooling, making a spread out, shield-shaped volcano. These lunar volcanos currently lie dormant and haven't erupted since 2 billion years ago from what we currently know.

Wrinkle Ridges

Wrinkle Ridges are tectonic features found in lunar maria, formed by the contraction of lunar basalt. This causes faulting to occur, and results in the formation of these sinuous ridges.

Regolith

Regolith is what people commonly refer to as "moon dust." However, there is an important distinction. Earth does have regolith, but it is different from the moon's regolith. Ours is oxidized, and the moon's is reduced, due to the lack of an oxygen-rich atmosphere on the moon. Taking a scoop of Earth's regolith, you would find a heterogeneous mix of dirt, sediment, dust, and rocks. A scoop of lunar regolith would contain primarily igneous-type minerals, some fragments, volcanic glass created from impact forces, feldspars, and lunar soil. These sediments can be very fine, and do pose a risk to health and a challenge for engineers as the grains have a tendency to adhere to surfaces.

Lunar Geologic Timescale

There are 5 Periods in the lunar geologic timescale. They are (from oldest to newest): Pre-Nectarian, Nectarian, Imbrian, Eratosthenian, and Copernican.

Pre-Nectarian

4.533-3.920 Billion years ago. This period stretches from the formation of the moon to the formation of the Nectaris Basin. Rocks from this period are primarily anorthosite, a phaneritic igneous rock, which says that the moon likely formed from the cooling of hot magma. This period coincides with Earth's Hadean period.

Nectarian

3.920-3.850 Billion years ago. The Nectarian period is the shortest period, and is during the Archean period on earth, which was when life on Earth was first seen (Stromatolites, caused by microscopic prokaryotes).

Imbrian

3.850-3.200 Billion years ago. The Imbrian period starts around the end of the late heavy bombardment of the inner solar system, with its namesake being the formation of the Mare Imbrium basin forming at the start of the period. Here we see mares beginning to form with basalt. This period still coincides with Earth's Archean period.

Eratosthenian

3.200-1.100 Billion years ago. The Eratosthenian period is characterized by the formation of the Eratosthenes Crater. The basaltic volcanism cooled off during this period. This period coincides with the Archean through Paleoproterozoic periods. During this, life on earth became eukaryotic, and began to develop into multicellular organisms.

Copernican

1.100 Billion years ago to Present. The Copernican period is characterized by the appearance of ray systems formed by impact ejecta. During this period, the geologic activity on the moon came to a halt due to the moon cooling off.

Weathering and Erosion

The moon's surface does experience weathering (the breakdown of rocks) and erosion (the movement of rocks/sediment). While the moon does not have rivers, oceans, rain and such like we do, it does experience unique mechanisms of weathering. One process we both share is meteorite/micrometeorite impacts. This is when meteorites make an impact on rock, breaking them apart, vaporizing them, or melting them due to the impact forces involved. This is more common on the moon than earth due to our atmosphere vaporizing meteors often, whereas the moon is left vulnerable due to its lack of an atmosphere. Most lunar weathering is on the microscopic scale. Looking at electron microscope images of lunar regolith shows odd tracks, or etchings left behind by cosmic ray particles impacting the surface of the rock. Another mechanism that the cosmos enacts on the moon is solar wind irradiation, which breaks down lunar rocks into a more amorphous state in terms of crystal structure.

How Does This Affect the Eclipse?

The moon's geological features, such as craters, mountains, and valleys, form an irregular and craggy surface as opposed to a smooth sphere. If we have a small foil ball and hold it out so it just barely fully covers a flashlight, we can see that the irregularities in the foil cause some blobs or beads of light to shine past the edges of the ball. During the eclipse, the moon does the same thing. These are called *Bailey's Beads*. When observing these, you will need to wear your eclipse glasses, as the light shining off them can still damage your retinas. The lunar regolith also can reflect additional light, adding to the brightness. This reflection is called *Albedo*. Another way to observe albedo in action is during the winter, in which people get blinded by the light reflecting off the white snow.