Craters of the Moon

Connections to the Moon, Mars, and Beyond

Introduction

Craters of the Moon National Monument and preserve (COM) encompasses three young volcanic fields, the largest with 60 different lava flows originating from the Great Rift along the eastern Snake River Plain. These Holocene-aged basalts (15,000–2,000 years) are unique compared to the rest of the basalts in the eastern Snake River Plain.

The eastern Snake River Plain is covered with large shield volcanoes, ranging 3–10 miles (5–15 km) in diameter. They have long, shallow dipping sides, that form when lava oozes out of the top of the volcano and flows slowly down the side. Individual lava flows form layers, such as those observed at COM and in the rest of the eastern Snake River Plain.

Courtesy of the University of Montana

Large blocks of basalt believed to have been "rafted" by a lava flow (seen at Devil's Orchard).

Blue Dragon basalt flow.

Courtesy of the University of Montana

Terrestrial basalts, including those in the eastern Snake River Plain are made of specific minerals composed of silicon, iron, aluminum, magnesium, calcium, sodium, and oxygen along with trace amounts of other elements. The different amounts of minerals determine the chemical composition of the basalts. The basalts at COM are unique because their chemical compositions differ from those of other basalts in the eastern Snake River Plain. COM basalts have more iron than other basalts in the eastern Snake River Plain. This difference is attributed to the incorporation of other rock types into the magma as it erupted from the earth (e.g., rhyolites, intermediate volcanics, etc.). The same COM basalts are similar in chemical composition to the basalts on Mars, making COM a good comparative environment.

Geological Features

Basaltic Fields

As you drive through COM, look at the vast fields of basalt. These seemingly desolate areas consist of multiple layers of basalt flows that erupted between 15,000 and 2,000 years ago. Imagine the basalt fields completely devoid of any vegetation.

In 1969, NASA astronauts from the Apollo mission visited COM to study the lava flows in anticipation of what they would see on the Moon, which scientists thought might look like COM. Astronauts and scientists realized that the craters on the Moon were made by impacts from asteroids while volcanoes formed the craters at COM, but still thought it would be a good comparative environment.

Although the Moon turned out to not be the best extraterrestrial body to model using COM, recent space exploration has proposed COM may be a good analog for Mars, which exhibits many similar features. The eruptions at COM are relatively young, making COM a good comparative environment; features are not obscured by vegetation in the Park, allowing a better comparison with Mars.

Courtesy of the University of Montana

Field of basalt at COM.

The Moon (top) and Mars (bottom) from space.

Courtesy of NASA

The martian landscape as seen by the Mars Exploration Rover Spirit.

Courtsey of NASA/JPL-Caltech

Geological Features

Rifting

The Great Rift runs over 50 miles (80 km) NW-SE through the center of COM. The crust opened in the Great Rift, and lava flowed onto the surface, forming volcanoes. From the top of Inferno Cone you can note the volcanoes, cinder cones, and spatter cones lined up to the southeast. These features trace the path of the Great Rift and demonstrate the different types of features that formed during rifting.

Rifts have been observed on Mars, thanks to high-resolution imagery. Two of the areas identified as rifts are Valles Marineris and Cerberus Fossae. Valles Marineris is a huge system of canyons just south of the martian equator. The canyons likely formed during rifting and subsequently filled with water and layered sediment. It is thought that the crust opened up and separated at Cerberus Fossae due to subsurface pressure associated with the Elysium Volcanic field.

Series of volcanoes, cinder cones and spatter cones in line with the Great Rift.

Courtesy of the University of Montana

Valles Marineris from space (over 4,000 km long).

Courtesy of NASA, Viking Project

Opening in the crust seen at Cerberus Fossae (1,630 km long).

Courtesy of NASA/JPL/University of Arizona

Cinder Cones

Among the most distinctive features at COM are the cinder cones, which are formed early in an eruption cycle as gas-filled magma explodes. This type of magma cools quickly after erupting, incorporating lots of gas bubbles into the lava. Each cinder cone formed from one or more vents along the Great Rift, often preserved as craters. The resulting crater can be very large, like the craters found at Big Craters, and is made up of loose cinders.

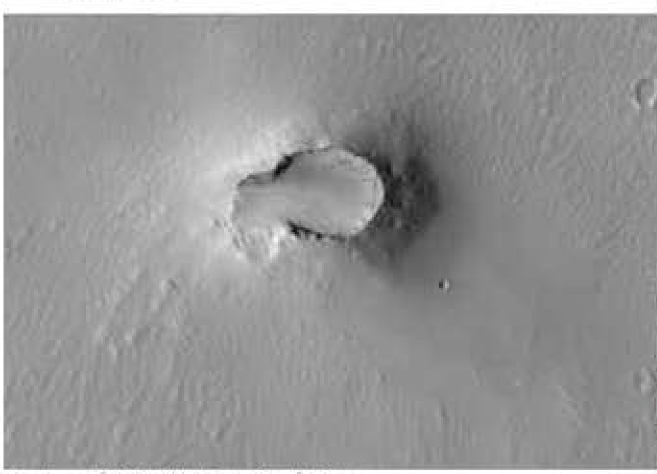
Geological Features

Courtesy of the University of Montana

One of the vents or craters found at the top of the trail to Big Craters.

There are some possible cinder cones on the slope of Pavonis Mons on Mars. Scientists cannot be sure whether these features are cinder cones because the image technology is too low resolution to see cinders on the slopes of the features. Based on their overall shape, the features resemble the cinder cones at COM.

A possible cinder cone on the slopes of Pavonis Mons. This feature has a crater like the craters seen in the cinder cones at COM.



Courtesy of NASA/JPL/University of Arizona

Caves

Caves are a common and popular stop for most people visiting the Monument; they are also an important geological feature for scientists looking for evidence of extraterrestrial life (extinct or extant) on Mars and other planetary bodies in the solar system. Many of the caves at COM are either pit craters or lava tubes, both of which form during volcanic activity.

Lava tubes are hollow tunnels where magma used to flow under the ground. These tubes will typically form a network of caves, such as Indian Tunnel, Boy Scout Cave, and many of the other caves in the Blue Dragon Flow.

A view into the lava tube called Indian Tunnel at Craters of the Moon.

Courtesy of the University of Montana

Current Research

Courtesy of NASA/JPL/University of Arizona

Pit craters and caves have been identified at Arsia Mons on Mars. Based on the association of both of these features with lava tubes at COM, it is likely the features on Mars also formed near lava tubes. The more obvious pit craters are found in a line, possibly showing the lava tube underneath. The caves are steep-walled holes that are assumed to lead into lava tubes.

Pit craters and a cave on Arsia Mons. The pit craters are the larger features that are lined up from top to bottom. The cave is the smaller feature in the middle of the line of pit craters. Some scientists think that these features may have formed above a lava tube.

The Importance of Caves

Caves provide a more habitable environment for organisms, protecting them from harsh surface conditions. Caves tend to have constant temperatures, allowing liquid water to remain in some parts of the subsurface when the conditions are unfavorable for liquid water on the surface. These characteristics make caves excellent targets in the search for evidence of life on Mars.

Courtesy of the University of Montana

The mineral thenardite seen naturally in one of the caves at COM.

Scientists have found several secondary minerals in the caves at COM. A secondary mineral is one that is formed by the weathering (or breakdown) of the basalt in the presence of water. Two of these minerals are jarosite and thenardite. Scientists are interested in these minerals because they can form with the assistance of microorganisms, a process that can be recorded in a biosignature, or fingerprint, in the mineral's structure.

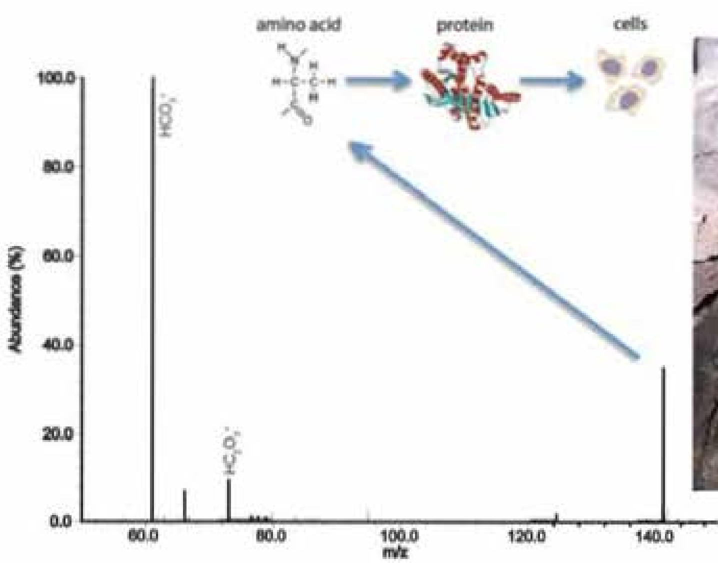
This fingerprint can be detected using an instrument that measures the masses of different compounds. This instrument, a mass spectrometer, produces a spectrum, a kind of fingerprint diagnostic for certain compounds. Just as a fingerprint is diagnostic of an individual, these spectra tells us that some sort of microorganism was once present.

Both jarosite and thenardite have been detected on Mars. If these minerals formed with the help of or in the presence of microbes, we can use similar techniques to look for their microbial fingerprints. If the fingerprints are detected in the martian samples, then microbial activity aided mineral formation, recording the presence of past life on Mars. Researchers are looking for other biosignature-bearing minerals on other planets and moons in the solar system.

Mars Science Laboratory

In the fall of 2011, NASA's Mars Exploration Program, in conjunction with the Jet Propulsion Laboratory, plans to launch the Mars Science Laboratory, which will focus on the nature of past environments on mars. The Mars Science Laboratory will arrive on Mars in 2012 and will collect data for an entire Martian year (687 days). The rover will analyze rock and soil samples to determine their chemical composition. The chemistry of the samples will tell scientists about the past environments and climates, and their ability to support life. Perhaps future research will provide yet another link between Craters of the Moon National Monument and Preserve's unearthly landscape and beyond.

Spectrum showing the bio-organic "fingerprint." The fingerprint indicates the presence of amino acids. Proteins, which are components of cells, are made of amino acids. So detection of amino acids is one piece of evidence suggesting cells were present. Inset is a picture of scientists collecting samples of thenardite.



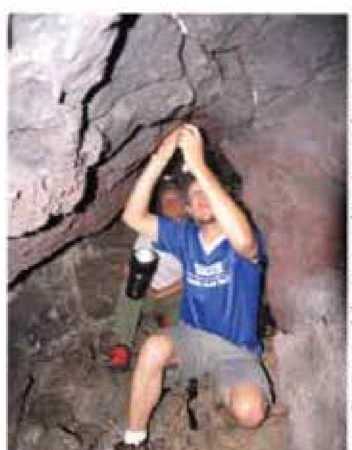


Image Courtesy of the National Institute of Health
Spectrum courtesy of Idaho National Laboratory
Photo courtesy of the University of Montana

Additional Information

For additional information, check out the following resources:

Print:

Owen, D.E. 2008. Geology of Craters of the Moon. Craters of the Moon Natural History Association. 23pp.

Websites:

Craters of the Moon National Monument and Preserve – Natural Features and Ecosystems
(http://www.nps.gov/crmo/naturescience/naturalfeaturesandecosystems.htm)

McHenry, L. J. 2008. Unusual sulfate cave mineral deposits at Craters of the Moon National Monument, Idaho: Potential analogue for Meridiani Planum, Mars. Wisconsin Space Conference Proceedings, August 2008. 10pp.
(http://www.uwm.edu/~lmchenry/McHenryCOM08.pdf)

High Resolution Imaging Science Experiment (HiRISE), University of Arizona
(http://hirise.lpl.arizona.edu/)

NASA's Mars Exploration Program
(http://marsprogram.jpl.nasa.gov/)

Jet Propulsion Laboratory – Mars Science Laboratory
(http://marsprogram.jpl.nasa.gov/msl/)