



Mesa and butte

Spanish explorers in the mid-sixteenth century ranged over the American Southwest. They had come north from Mexico, looking for gold and gems and the legendary Seven Cities of Cibola (pronounced SEE-bow-lah), allegedly filled with such treasures. In their quest, they found neither gold nor riches. They did, however, become the first Europeans to view the geological wonders of the area, and they were amazed at what they saw.

Among the canyons, plateaus, and rock towers and arches, the explorers saw landforms that appeared plateaulike, only smaller and isolated. They called these geologic features mesas (pronounced MAY-suz), which means table in Spanish, because the explorers thought the landforms resembled tables with their smooth, flat tops and sides that drop away steeply. Populating the spare, arid (dry) landscape of the area along with mesas were still smaller landforms that had a similar appearance. At the beginning of the nineteenth century, the word butte (pronounced BYOOT) was coined from the French word meaning mound or hillock to describe these solitary landforms.

The shape of the land

A mesa is an isolated, flat-topped hill or mountain with steep sides that is smaller in area than a plateau. A butte is also a flat-topped hill with steep sides, though smaller in area than a mesa. Definitions of the surface areas of mesas and buttes vary. One source states that a mesa has a surface area of less than 4 square miles (10 square kilometers), while a butte has a surface area less than 11,250 square feet (1,000 square meters). Another source states that the surface area of a mesa is larger than 1 square mile (2.59 square kilometers); the surface area of a butte is smaller than that dimension. Some simply define a mesa as a

MESA AND BUTTE



Junction Butte in Canyonlands National Park, Utah. Part of the Colorado Plateau, the landscape of sedimentary sandstone in this area was eroded into countless canyons, mesas, and buttes by the Colorado River and its tributaries. PHOTOGRAPH REPRODUCED BY PERMISSION OF THE CORBIS CORPORATION.

landform that is wider than it is high and a butte as one that is higher than it is wide.

A mesa's and butte's characteristic shape—flat top and clifflike sides—is due to the layers of rock forming them. These landforms are most often composed of sedimentary rock, formed by the accumulation and compression of sediment (which may consist of rock fragments, remains of microscopic organisms, and minerals). This type of rock covers more than 75 percent of Earth's land surface. Most sedimentary rocks occur in layers, called strata, that are mostly horizontal or flat when first formed. Forces within Earth that rupture the surface to form volcanoes, mountains, plateaus, and many other topographical features (physical features on the planet's surface), may later cause these layers to tip, fold, warp, or fracture.

The top layer of a mesa and a butte is a hardened layer of rock that is resistant to erosion, which is the gradual wearing away of Earth surfaces through the action of wind and water. Sometimes this top layer, called the cap rock, is not sedimentary rock but is cooled and hardened lava that had spread out across the landscape in repeated flows from fissures or cracks in

Words to Know

Canyon: A narrow, deep, rocky, and steep-walled valley carved by a swift-moving river.

Cap rock: Erosion-resistant rock that overlies other layers of less-resistant rock.

Cliff: A high, steep face of rock.

Crust: The thin, solid, outermost layer of Earth.

Erosion: The gradual wearing away of Earth surfaces through the action of wind and water.

Fault: A crack or fracture in Earth's crust along which rock on one side has moved relative to rock on the other.

Pinnacle: A tall, slender tower or spire of rock.

Plateau: A relatively level, large expanse of land that rises some 1,500 feet (457 meters) or more

above its surroundings and has at least one steep side.

Plates: Large sections of Earth's lithosphere that are separated by deep fault zones.

Plate tectonics: The geologic theory that Earth's crust is composed of rigid plates that "float" toward or away from each other, either directly or indirectly, shifting continents, forming mountains and new ocean crust, and stimulating volcanic eruptions.

Sedimentary rock: Rock formed by the accumulation and compression of sediment, which may consist of rock fragments, remains of microscopic organisms, and minerals.

Strata: Layers in a series of sedimentary rocks.

the ground. Beneath this flat protective cap of rock are horizontal layers of softer sedimentary rock. To varying degrees, these layers are not as resistant to erosion.

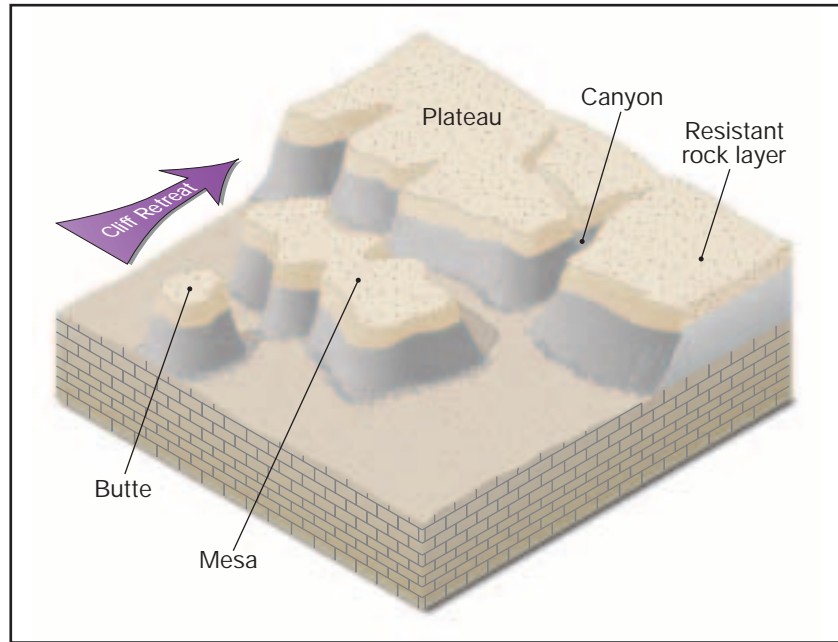
These landforms are found in arid and semiarid regions. Arid regions are defined as those that receive less than 10 inches (25 centimeters) of rain per year; semiarid regions receive 10 to 20 inches (25 to 50 centimeters) of rain per year. Precipitation in these regions often comes in the form of sudden, heavy rainfalls. Because water evaporates quickly in these normally dry environments, plants and other ground cover are scarce. Left exposed to the action of running water, the bare sides of the softer rock layers of mesas and buttes are eroded away over time. The base of these landforms is often gently sloped, contrasting with the almost-vertical sides leading down from the top. Rock material that has been eroded from the sides is carried downward, forming this sloping base.

Forces and changes: Construction and destruction

Mesas and buttes do not arise as completed landforms through sudden geological events. They have been shaped over millions of years by the slow, orderly process of erosion. They are part of a series of landforms that naturally erode into other landforms. That series begins with plateaus, which are relatively level, large expanses of land that rise some 1,500 feet (457 meters) or more above their surroundings and have at least one steep side.

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Plateaus develop in a few ways, all of which are directly related to the internal heat forces of Earth. These forces stirring beneath the crust (the outermost layer of the planet) are responsible for the physical features on the surface, from mountains to volcanoes to rift valleys and many others. Earth's internal forces have put pressure on the bottom of the crust, causing it to fracture into sections. As these sections, called plates, move about the surface in response to that pressure, they collide, slide past one another, or slide under each other. The interaction between the plates or the stress created within a plate as it has interacted with other plates have brought about the many landforms defining Earth's surface. The scientific theory explaining the plates and their movements and interactions is known as plate tectonics. (For further information on plateau formation and plate tectonics, see the **Plateau** chapter.)

Like all landforms elevated above their surrounding landscapes, a plateau is prone to erosion. Water, in the form of rain, snow, ice, rivers, runoff, and groundwater, is the primary force of that erosion. Wind also plays a part in this erosion, but to a far less degree. Rivers are the great cutting agents on plateaus. Whether raised with the plateau as it was elevated or formed afterward, a river will flow downward, seeking out the level of the body of water into which it drains. And it will do so as quickly as possible. It will seek out the path of least resistance, finding areas where rock is weak. Wearing away that rock, the river will cut downward deeper and

deeper. Over millions of years, a river will form a valley, then a canyon, separating the plateau into sections. (For more information on canyon formation, see the **Canyon** chapter.)

On plateaus, areas of weak rock occur along faults, which are cracks or fractures in Earth's crust. Faults arise when pressure from underground forces pulls apart or compresses plates, creating stress within the plate. Faults are common in elevated regions. Rocks along a fault tend to be weak and broken, and a river or other flowing water easily cuts through the broken rock. Over time, valleys or canyons form, and a plateau is further dissected. (For more information on fault formation, see the **Fault** chapter.)

Rivers erode by picking up sediments (loose rock fragments) and transporting them to a new location. The speed or velocity at which a river flows determines the size of the material it can carry. A fast-moving river carries more sediment and larger material than a slow-moving one. The sediment acts as an abrasive as it is carried along, scouring and wearing away the banks and bed (sides and bottom) of the river. As new material is eroded, the river picks it up. In turn, this new sediment helps the river cut even deeper into its channel.

From plateaus to mesas to buttes to...

Geologically speaking, no landscape is ever "complete." The surface of the planet is in constant motion. As new landforms are built up, others are eroded away. As vast as it may seem, a plateau is relentlessly carved by erosion. The Colorado Plateau in the four corners region of the American Southwest is eroding at a rate of 500 vertical feet every 1 million years. Deep valleys and canyons form steep cliffs that retreat endlessly as water from storm runoff and streams and rivers washes away soft rock. Were it not for sections of resistant rock on the surface of a plateau, the entire landform would wear away over millions of years to a valley floor.

Those resistant sections allow a plateau to erode into mesas that rise above the ever-widening valley floor. Mesas maintain their shape because their cap rock offers protection to the layers of softer rock beneath. That protection, however, is short-lived. Again, water from storms washes over the sides of the mesa, wearing them away. As the sides retreat inward, the overhanging sections of cap rock weaken, fracture, and fall.

As the process of erosion continues, a mesa shrinks in size. Over time, it becomes a butte, taller than it is wide. Unrelenting, water erodes the butte as it had the mesa before it and the plateau before that. Capped by its resistant rock but ever shrinking, the butte may eventually erode into a pinnacle. This tall, slender tower or spire of rock will stand until it, too, succumbs to erosion and eventually crumbles to the valley floor.

The Face of Mars

In July 1976, the planetary probe *Viking 1* orbited Mars searching for a potential landing site for a sister probe, *Viking 2*. While photographing areas of the Cydonia region of the planet, the probe captured an image of a landform that resembled a face with darkened eyes, a narrow nose, and a frowning mouth. When the National Aeronautics and Space Administration (NASA) released the image to the public, it caused a sensation.

NASA scientists reasoned that sunlight on the landform created the apparent image, but many

people thought otherwise. They believed that the face was artificially created. It was proof, they asserted, that intelligent life existed on Mars.

More than twenty years after the *Viking 1* probe was released, NASA sent another probe to Mars, the *Mars Global Surveyor*. In early 2001, after having taken tens of thousands of images of the planet, the *Surveyor* aimed its strong camera lens on the “Face of Mars.” This time, the image clearly showed that the landform was simply another mesa in an area of mesas and buttes, very much like those that exist in the American Southwest.



Aerial photograph of a Martian mesa that resembles a human face. PHOTOGRAPH REPRODUCED BY PERMISSION OF THE CORBIS CORPORATION.



Spotlight on famous forms

Enchanted Mesa, New Mexico

In west-central New Mexico stands a mesa made of sandstone, a type of rock composed of grains of sand bonded together by a mineral cement, like calcium carbonate. The mesa rises impressively 430 feet (131 meters) above the surrounding valley. Known as Enchanted Mesa, it was called Mesa Encantada by Spanish explorers and Katzimo by the Acoma (pronounced AK-ah-ma), the Native Americans who inhabit the area. The Acoma live in a pueblo (Native American village) on top of another sandstone mesa located a few miles away from Enchanted Mesa. The pueblo, believed to have been founded in the twelfth century, is the oldest continuously inhabited community in the United States.

According to Acoma legend, Enchanted Mesa is the ancestral home of the Acoma people. They lived on top of the mesa. One day, when the Acoma were tending their fields in the surrounding valley, a violent rainstorm arose. The rain washed away the stairway leading to the top of the mesa, leaving the elderly and the very young stranded on top. They eventually died from starvation. Another version of the legend states that only

The Enchanted Mesa, in Acoma Pueblo, New Mexico, rises 430 feet from the desert valley.

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