Carlsbad Caverns

National Park Service
U.S. Department of the Interior

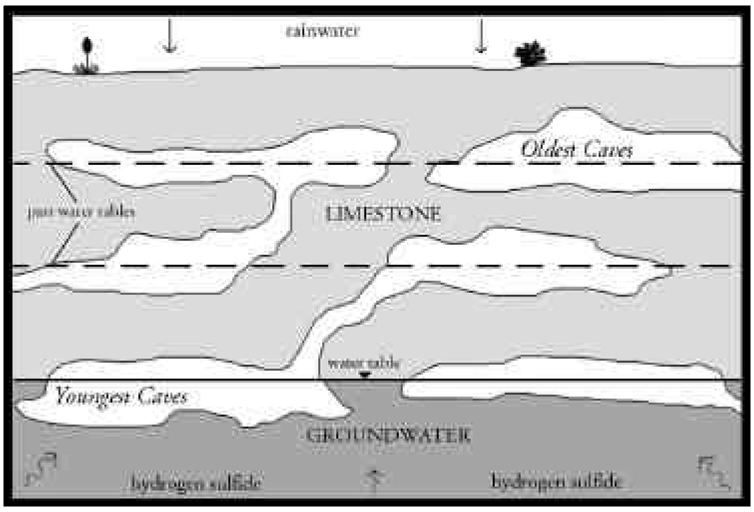
Carlsbad Caverns
National Park

CAVE GEOLOGY: Dissolution and decoration

Carlsbad Caverns National Park was designated a World Heritage Site by the United Nations in 1995, confirming the worldwide significance of its spectacular natural resources. There are over 300 caves in the Guadalupe Mountains and more than 100 have been surveyed in this park alone, many of which exhibit the characteristically large rooms associated with their unusual method of dissolution. With 8.2 acres of floor area, the Big Room in Carlsbad Caverns is the largest cave chamber in North America. Decorations in these caves are arguably unsurpassed in the world. Discovered in 1986, another cave in the park called Lechuguilla Cave is the third longest cave in the United States, as well as the deepest. This cave is known to have massive gypsum chandeliers that dazzle the senses. Perhaps the most valuable aspect of Lechuguilla cave is the potential for scientific breakthroughs. Recent studies of bacteria found only in Lechuguilla Cave have yielded promising leads in the development of cancer- fighting drugs. For countless reasons Carlsbad Caverns National Park is undoubtedly worthy of its honorable designation and should be protected and enjoyed by all.

Capitan Limestone: Origin of the rocks that enclose Carlsbad Caverns.

Carlsbad Caverns is found within the tomb of millions of marine organisms. Today's desert landscape was once the coastline of an inland sea 250 million years ago during the Permian period. A rich diversity of ancient marine life inhabited this sea. A reef grew along the coastline by the buildup of the remains of mostly algae and sponges. By the end of the Permian, the sea had dried and the reef was eventually buried. The reef was much later uplifted and sculpted by erosion, thus creating the Guadalupe Mountains. The Permian reef deposits are now the rock formation called the Capitan Limestone, which is about 750 feet thick. The bulk of Carlsbad Caverns is found within this soluble limestone.



Speleogenesis: The dissolution of caves within limestone.

Caves of the Guadalupe Mountains are extraordinary in that a very aggressive "sulfuric acid bath" is shown to have played a major role in cave development by dissolving limestone from the bottom upward through the water table. In comparison most of the world's caves are formed by the dissolution of limestone by weak carbonic acid. Carbonic acid is formed by rain and snowmelt combining with carbon dioxide in the air and soil as it seeps downward.

The Permian Basin of western Texas and southeastern New Mexico contains some of the country's most prolific oil fields. During the late Tertiary period (perhaps as late as 12 million years ago), hydrogen sulfide began migrating upward from these petroleum reservoirs deep under the Capitan Limestone. When the upwelling hydrogen sulfide rich water met with groundwater, it combined with oxygen in the water table to form sulfuric acid:

$$\underset{\text{(hydrogen sulfide)}}{H_2S} + \underset{\text{(oxygen)}}{2O_2} = \underset{\text{(sulfuric acid)}}{H_2SO_4}$$

Highly aggressive dissolution of limestone thus occurred at the water table. This unusual sulfuric acid mechanism is responsible for the very large chambers found in this region. One of the clues which led geologists to the development of the sulfuric acid theory is the presence in most caves here of the mineral gypsum. Gypsum here is produced as a chemical by- product of the reaction between the sulfuric acid and limestone during dissolution.

$$\underset{\text{(sulfuric acid)}}{H_2SO_4} + \underset{\text{(limestone)}}{CaCO_3} + \underset{\text{(water)}}{2H_2O} = \underset{\text{(gypsum)}}{(CaSO_4 \cdot 2H_2O)} + \underset{\text{(carbon dioxide)}}{CO_2} + \underset{\text{(water)}}{H_2O}$$

This soft white mineral coats the walls in many parts of the cave. Look for yourself at the large amount of massive gypsum in the Big Room past the Bottomless Pit. This quantity of gypsum attests to the large amounts of sulfuric acid required to dissolve the immense rooms of Carlsbad Caverns and all the other caves in the Guadalupe Mountains.

Speleothems: The ongoing growth of cave decorations.

The impressive decorations, or speleothems, found in Carlsbad Caverns did not begin to form until a cave chamber was drained of the "acid bath." The natural entrance to the cave formed within the last million years by erosion and collapse of the hillside. The entrance allowed air from the surface to circulate through the cave. As rainwater and snowmelt percolates downward, it picks up carbon dioxide from the air and soil to form a mild carbonic acid:

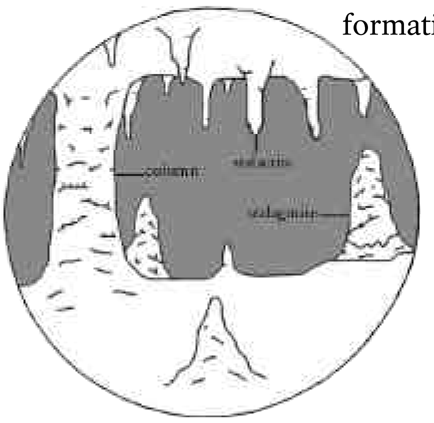
$$H_2O + CO_2 = H_2CO_3$$

(water) (carbon dioxide) (carbonic acid)

The mild acidity of the surface water allows it to dissolve some of the limestone it encounters on its way down. When the mineral- laden water reaches the open void of a cave, it forms a drop on the ceiling. The carbon dioxide in the water is released, making the water saturated with respect to the dissolved calcite (limestone). In order to reach equilibrium with the cave air, the water must unload the mineral. When the water evaporates or drops off the ceiling, a small mineral deposit is left behind. Drip by drip, these deposits will form a *stalactite* on the ceiling. The water that falls to the floor may also carry minerals which are deposited on the floor, eventually creating blunt *stalagmites*.

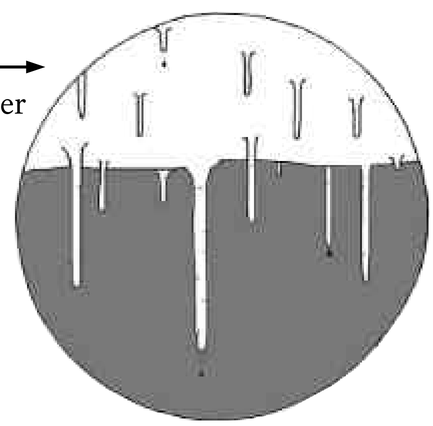
Speleothems do not grow at the same rate. Surface temperature and climate affect the rate of organic decay in the soil. Increased rates of decay increases the amount of carbon dioxide in the soil, which increases the acidity of the water. The stronger the carbonic acid, the more minerals it can dissolve and deposit. Another factor affecting speleothem growth is rainfall. Even if the surface factors are the same, some areas of the cave below will get more water than others, depending on the rock type, its orientation, depth, and fractures. Size is not a reliable indicator of the age of a speleothem.

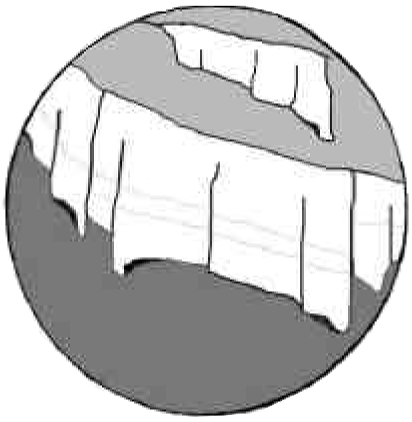
Stalactites and stalagmites are not the only speleothems decorating Carlsbad Caverns. A wide array of beautiful formations are encountered on the cave trail. Most spleothems in Carlsbad Caverns are made of calcite ($CaCO_3$), but they can also be made of other minerals like gypsum ($CaSO_4 \cdot H_2O$) and aragonite ($CaCO_3$). Pure calcite speleothems are white or clear, but other minerals can also be present to give the formations different colors. Common elements leached from the rock or soil are iron and manganese, which can make formations red or brown.



← COLUMN
A continuous pillar of calcite formed when a stalagmite and a stalactite meet.

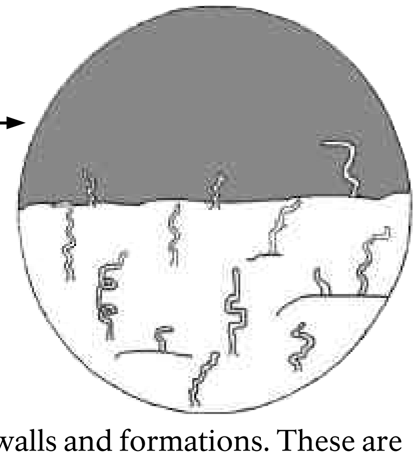
SODA STRAWS →
Thin precursors to stalactites, they form as water drips from the ceiling, creating a ring of calcite on the outside of the drop. It grows into a hollow "straw" of uniform diameter until something plugs it, forcing the water to back up and flow down the outside.

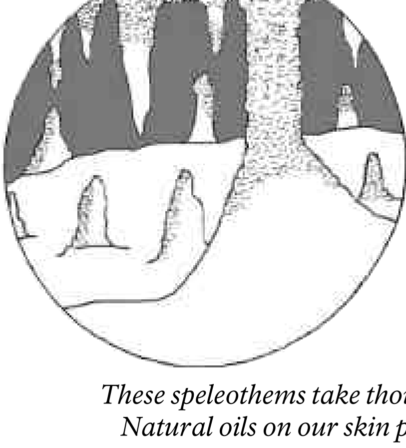




← DRAPERIES
These sheet- like structures are formed by water dripping down a sloped ceiling. They are often folded.

HELICTITES →
Curved, branching formations that defy gravity. No one is certain how these form, but one hypothesis involves hydrostatic pressure in the central canal of the helictite. Excellent examples can be seen in the Queens Chamber.





← POPCORN
Clusters of small bulbous protrusions found on walls and formations. These are likely to have formed by a convection- like system of air movement in the caves. As warm humid air travels from floor to ceiling, it absorbs minerals from rocks it encounters. The air rises and loses heat to the rocks and its relative humidity decreases. As the air cools, it begins to sink. The moisture in the air evaporates, causing it to deposit the minerals on the walls and formations it meets. Popcorn is sometimes found only on one side of a formation, indicating the direction of air flow at the time of formation.

These speleothems take thousands of years to grow and are very fragile. Please help preserve them by not touching. Natural oils on our skin prevent water from depositing minerals on a formation, thereby stopping new growth.