

# Fossilization of Bat Skeletons in the Carlsbad Caverns

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**ABSTRACT**—Cave deposits are important sites for the large accumulation and preservation of animal remains. Most of what we know about fossil bats is derived from cavern sediments.

Bats estimated to number in the trillions have lived within the Carlsbad Caverns over a period of at least 17,000 years. Vast deposits of their guano and skeletal remains are found throughout the Caverns. In those rooms which are now, or have been inhabited, both guano and bone material is found. In other rooms, skeletal remains only are found.

These latter rooms are not inhabited intentionally, but, having small entrances through which bats might enter accidentally on a random flight, they act as natural traps. Becoming lost and trapped, the bats die within these rooms and their bones accumulate in the pits and depressions in the floors.

Fossilization of some of the bones occurs beneath silt and calcite which covers them. Some bats are preserved *in toto* within the tops of active formations (speleothems) by the rapid deposition of calcite. Most skeletons, however, are disarticulated. A few bones become the nuclei for the forming of cave pearls.

The large deposits of bat skeletons in the Carlsbad Caverns are probably the most extensive of any found in the large bat caves of the Southwest.

Caves are important sites for the accumulation and preservation of large deposits of animal remains and these have contributed greatly to our knowledge of life in the past. Generally, caves are of such a nature they become the habitats for numerous kinds of vertebrate animals. Some of these are carnivorous species and they bring into the caves other animals as food items and an assortment of bones may be accumulated which represent the fauna of a wide area around the cave entrance. Therefore, a distinct advantage to cave deposits, over others, is that large samples frequently are available which give a good idea of former local faunas.

The conditions which favor the preservation of fossils are relatively rare and the fossilization of bone material is a matter of such rare occurrence that of the millions of individuals that must have existed in the past, it was perhaps an exception that an animal was in such a position that its skeleton was preserved in a hardened matrix. The conditions by which fossilization occurs can not always be known precisely but in the Carlsbad Caverns there are at present large

quantities of bat skeletons being fossilized by the deposition of silt and calcite and the exact methods which lead up to the accumulation and preservation of large quantities of these mammal skeletons can be observed in detail.

Bats seem almost synonymous with animals that are cave inhabitants and they have been hanging head downward in caves for over 50 million years. Much of what we know of fossil bats is derived from cavern sediments and of such a nature are the remarkably preserved fossil bats of the Eocene from the "Braunkohle" of Messel in Darmstadt, Germany (Revilliod, 1917). Numerous North American Pleistocene local faunas, especially those of the Wisconsin epoch, include bats and all except one of these occurrences are from cave deposits (Merriam and Stock, 1925; Schultz, 1938; Skinner, 1942; Handley, 1955; and Jones, 1958). In 1960, Lawrence described another Pleistocene bat, from the ancient guano deposits of New Cave, New Mexico, a large cave near the Carlsbad Caverns.

The Carlsbad Caverns in New Mexico have long been famous for their large colo-

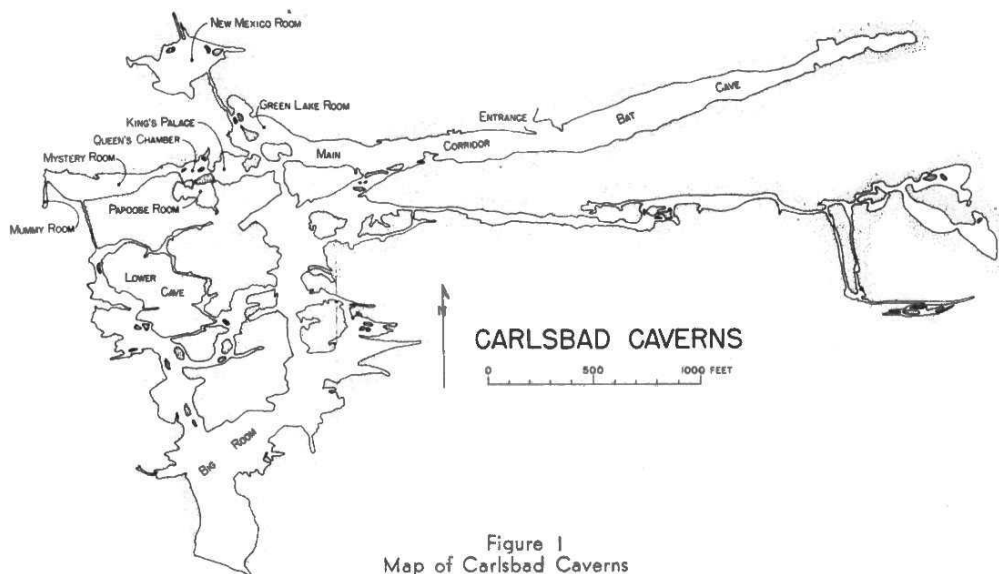


Figure 1  
Map of Carlsbad Caverns

nies of freetail bats, *Tadarida brasiliensis mexicana*. More than one million of them may live at once within the Caverns and exit flights may last for as long as three hours. When these flights are at their densest, up to 5,000 bats a minute will pass a given point. The moving mass resembles black smoke from a distance, rising from the hillside, and it is believed that sight of these flights led to the discovery of the Caverns in the early 1880's.

In addition to the Mexican Freetail, eight other bat species are recorded from the Caverns. Carbon-14 datings of the ancient guano deposits from nearby New Cave (Libby, 1954) indicate that bats have used New Cave for at least 17,800 years. Since the extinct Pleistocene freetail is found also in the Carlsbad Caverns, bats no doubt have been living in these caverns for just as long. It would, of course, be impossible to make even an approximate estimate of the total numbers of bats which have dwelled inside the Carlsbad Caverns, but quantities in the trillions are feasible and certainly not unlikely. If we can assume, as an average, just 1/2 million bats per year, the total would be over 8 trillion in 17,000 years. The vast guano deposits which were mined from the caverns from about 1903 to 1940, an estimated 100,-

000 tons covering thousands of square feet of cave floors and in places to 50 feet in depth, help make this total figure a little more realistic and comprehensible.

With such multitudes of bats, great numbers must have died inside the Caverns and many hundreds still die each year. Their bones become deposited in abundance and in places are several inches deep covering many square feet of the Cavern floor. In rooms where bones are most abundant, it is difficult to walk without stepping upon them.

Various rooms of the Caverns have been occupied by bats at one time or another, and these contain both guano and skeletal remains. Other rooms which have not been occupied intentionally contain no guano but may have quantities of skeletons. These are rooms which are too inaccessible for daily habitation but are entered occasionally by bats in random flight. Becoming lost and trapped they soon die and it is in these rooms that the best preserved skeletal remains are found. Bats can be found in all stages of decomposition from freshly dead to ancient bones.

Bats are good flyers in total darkness, yet this does not keep them from becoming lost within the twisting passageways of a large



Figure 2

Mummified body of a Mexican Freetail bat, (*Tadarida brasiliensis mexicana*), in the Mummy Room, Carlsbad Caverns.

cavern system such as the Carlsbad Caverns. Once lost in rooms having small entrances, they become trapped as it is difficult for them to find the opening and escape. The rooms may have other adjoining passageways and be filled with domes, pits, and large solution pockets which lead nowhere. Several rooms of this type which can trap bats are found in the Carlsbad Caverns.

Upon entering the Caverns from the outside, bats fly in an easterly direction towards the Bat Cave (fig. 1), a large room approximately 1/2 mile in length with ceiling heights to 100 feet. It is this section of the Caverns that is most used by bats. They prefer to roost in places where the ceiling is domed and guano deposits beneath these domed areas are several feet in depth. Dead and dying bats may be found in abundance scattered over the surface of the guano, but are covered quickly by the continual deposition of this material. Some sections of the Bat Cave contain deposits of fossilized guano, capped by several inches of flowstone, and scattered through it are the bones of the extinct Pleistocene freetail.

In the direction opposite the Bat Cave, the Main Corridor leads into the more extensive portions of the Carlsbad Caverns. Bats infrequently roost in the Main Corridor, using certain crevices in the ceiling area adjacent

to the Cavern entrance. Large deposits of fossilized guano found deeper in the Main Corridor indicate that this area was once more heavily used. To enter the Main Corridor, bats may fly straight from the Bat Cave or may turn 180 degrees as they come in from the entrance. Observers have noted that they do both. When an occasional bat or group of bats flies the entire length of the Main Corridor, they are funneled downward into one of several rooms collectively called the "scenic rooms." These are the New Mexico Room, Green Lake Room, King's Palace, Queen's Chamber, Papoose Room, Mystery Room, and the Mummy Room.

Why bats should fly as far as these rooms is not understood. To reach them, bats must descend over 800 feet beneath the surface and in a direction opposite that of the Bat Cave and cave entrance. Generally, bats enter a cavern only as far as is necessary to find the first dark room suitable for habitation. To go any further is needless and only increases the chances of their becoming lost. It is likely, however, that in flying from the Bat Cave toward the outside, some bats may occasionally miss the entrance and in searching for it will continue down the length of the Main Corridor. These two sections of the Caverns are hollowed along the same fracture lines and are nothing more than extensions of one with the other. They are arbitrarily divided at the location of the entrance area and it is a straight flight from one room into the other. Also, since it is usual for the bats to continually mill around in small numbers in the area of the entrance for several minutes prior to leaving the Caverns, it may be that during this time a few wander off into the Main Corridor and, becoming confused, penetrate into the deeper parts. Small flights of bats are seen occasionally in the scenic rooms.

The geography of the scenic rooms is significant to the bat remains found in them. A few bat skeletons are found in the Green Lake Room and the King's Palace but because of the proximity of these two rooms to the Main Corridor, bats that may be trapped temporarily can escape easily back into the Main Corridor. Often, they will



Figure 3

A bat which died on a sloping surface. The main portion of the skeleton is being imbedded in calcite but the arm and finger bones of the left wing are being carried slowly down slope by water action.

penetrate deeper and once past the Green Lake Room and the King's Palace they can be considered lost. From the Green Lake Room some enter the New Mexico Room by way of a long narrow corridor, and many bat bones are found in this isolated room.

Some of the more extensive deposits of bone material occur in the Papoose Room. Until the 1930's this room could be entered only through a small opening from the Queen's Chamber, yet many hundreds of bats found their way into it. The present connection between the Papoose Room and King's Palace is a man-made tunnel, the construction of which has upset the ecology of the Papoose Room. The tunnel is large enough and in such a position that it may be found easily and bats are no longer trapped. In addition, the opening into the

Queen's Chamber has been enlarged, furthering the chances for escape.

From the Queen's Chamber, bats enter a large opening leading into the Mystery Room and they are seen frequently flying back and forth between these two rooms. In the ceiling of the Mystery Room a small opening leads directly into the Lower Cave. That bats enter the Lower Cave from the Mystery Room is evidenced by numerous skeletal remains found in the Lower Cave near this opening. Probably, however, most of the bats that enter the Lower Cave come in from the direction of the Big Room which shows much evidence of former usage. The Big Room has some extensive, ancient guano deposits indicating bats used this room for a long period of time in the past. It is believed the bats entered the Big Room



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Figure 4

A natural accumulation of disarticulated skeletons of Mexican Freetail bats, (*Tadarida brasiliensis mexicana*), in the Papoose Room, Carlsbad Caverns.

through a former opening over the south end of the room which has since been sealed by slumping.

The Mummy Room extends as a small grotto off the end of the Mystery Room and is quite difficult to enter, yet a few bats have managed to find their way into it. Because of the dryness of this area, the dead bats mummified. Many of the mummies are hanging on the walls, ceilings, and formations (fig. 2) and most are in excellent stages of preservation. Mexican Freetails are the most numerous, but there are mummies of the genera *Myotis*, *Lasiurus*, and *Eptesicus*. It is somewhat surprising that *Lasiurus*, a tree bat rather than a cave bat, would be found in the Caverns, yet numerous mummified bodies and skeletal remains of *Lasiurus borealis* and *Lasiurus cinereus* prove that these

species frequented the Carlsbad Caverns at least in the past. Recent specimens have been reported, however, from other caves (Beer, 1954). Perhaps their abundance in the past is indicative of a more boreal climate than the arid conditions that prevail today in the area of the Carlsbad Caverns.

In rooms where the larger bat skeletal deposits are found, bones are scattered unevenly across the floors. Wherever one steps some bones are found but for the most part they are deposited only in certain areas. The cave floors are highly irregular with many pits, shallow depressions, sloping surfaces, and formations. The bats may die in any location but their bones tend to accumulate at the base of the slopes or in the bottoms of the pits and depressions. Dripping water is responsible for most of the movement of



Figure 5

Depression in the floor of the Mystery Room, Carlsbad Caverns, showing a deposit of silt and bat bones. Note where dripping water bored a hole through the silt revealing more skeletal material. In upper left corner limb bones occur which have been cemented to the floor by calcite.

the bones but no doubt dying bats crawling around over the floor break up many of the skeletons and cause them to slide or roll down sloping surfaces (fig. 2). Most skeletons become disarticulated in the processes of accumulation and the bones become scattered at random throughout a deposit (fig. 3). The sorting appears in several cases to be the results of intermittent pooling actions of dripping water.

In the Mystery Room silt and sand accumulates in some of the floor depressions along with the bat skeletons and the bones are buried. In one such deposit the recent dripping of water has bored a hole down through the silt for several inches exposing the bones buried in it (fig. 4). More often, however, calcite fills a depression to cover

the bones and the whole area becomes cemented as a "coquina" of bat bones. As newer bones are deposited on top of the calcite, they too are cemented. Where bats die directly in a depression or are carried into one before decomposition occurs, the skeleton may remain intact and be preserved *in toto* (fig. 5). Many thousands of bat bones are encased in the flowstone of the scenic rooms and in one section of the Papoose Room the whole floor is nothing but calcite and bone material.

Frequently bats die clinging to the tops or sides of active formations (speleothems) and as the formations grow the bats are embedded in the deposit of calcite (fig. 6). On many formations the barest outlines only are discernible of the bats which have died



Figure 6

Bat bones and broken bits of formations (speleothems) accumulated in a floor depression and now being imbedded in calcite. Most skeletons are disarticulated from sliding down adjacent sloping surfaces but some skeletons are intact. A recently dead bat is in a depression (lower circle). A bat partially buried (in toto) is in the upper circle.

upon them. In one formation a bat was found preserved in its center, completely hidden from view.

On rarer occasions a single bone, usually a limb bone, becomes the nucleus for the forming of a cave pearl. Dripping water deposits calcite around the bone and the force of the dripping water continually turns it keeping it from being cemented to the floor. Eventually a cave pearl is formed which may be several millimeters in diameter and rounded longitudinally with the limb bone in its center.

Although great numbers of bat bones are being fossilized at present and have been in the past, there are perhaps more that deteriorated completely and never achieved fossilization. Bats often die in places unsuitable

for their preservation. These are areas where silt and calcite are not being deposited and the high humidity of the cave air causes the bones to soften and crumble.

It is fortunate though that the Carlsbad Caverns have rooms such as the scenic rooms in which large quantities of bone material collects and is displayed. There is no guano deposition to bury them and, other than those places where they are embedded in silt or calcite, the bones lie exposed, loose, and easy of access. They can be scooped by the handfuls. Because of this abundance, the Carlsbad Caverns may be outstanding for the bat remains found in them.

Ironically, the Carlsbad Caverns are the largest known, yet they have one of the smallest bat populations of the several large