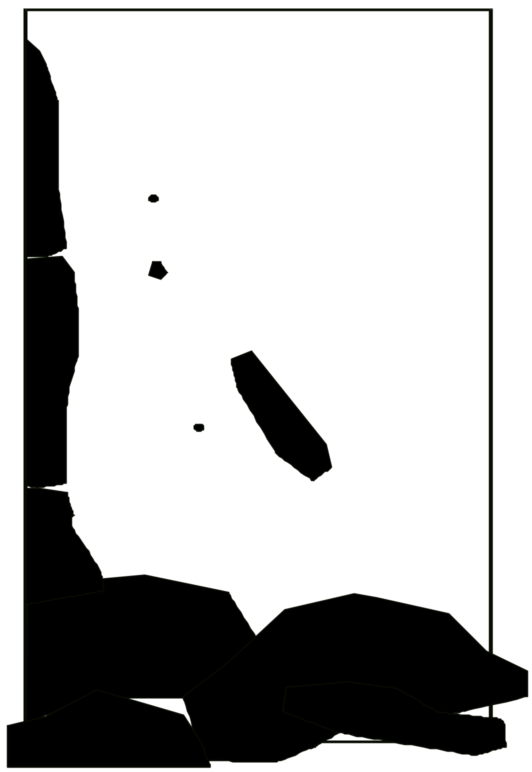
ROCKFALL

It is obvious by the rock debris strewn about the cave floor that rocks have fallen in the Mammoth Cave system during the past. Geologists suggest that observations we make about processes occurring at present are the keys to understanding the geologic past. We must consider what types of geologic processes are occurring in the Mammoth Cave system today to understand what may have caused rock to fall in the geological past and may be causing rock to fall in the cave system today.

The solutional action of water on limestone rock formed and is forming Mammoth Cave. The water enters the ground (recharges) through thousands of sinkholes in the Pennyroyal Plateau near I-65. It works its way to the groundwater table and flows as underground rivers and streams, dissolving the soluble limestone and carrying it away in solution. Eventually the water exits (discharges) through a series of springs that feeds the Green River. The level of the Green River controls the level of the groundwater table. As the river deepens and widens its valley, the groundwater table lowers, abandoning the upper passageways to form lower ones.



Groundwater can be placed in two categories: *vadose* water and *phreatic* water. Vadose water is in the zone of aeration above the groundwater table. It forms vertical shafts on its way to the groundwater table. Phreatic water flows below the groundwater table in the zone of saturation and forms horizontal cave passageways. During the cave-forming process, the action of water can create instability in the stone.

Rock may fall during the general widening process or the stream bed – as the passageway widens, the thinner, less stable layers of limestone collapse. Each layer supports the next, forming a natural arch, until a thicker, more stable layer is reached. The meandering action of the stream can undermine layers along its cutbank, also allowing rock to fall.

In passageways that are completely filled with water, the buoyant force of the water holds up the ceiling while the passageway widens to what would be an untenable dimension were it not for the buoyant force. Then, when the water lowers, the ceiling layers collapse.

In areas of the cave where water is present, there is a potential for rock to fall. Once the water has left the passageway and is not longer acting, the cave becomes relatively stable.

Scattered throughout literature are statements that the effect of earthquake shaking is less in caves than on the surface. The reason for this remains unclear. The current thinking is that the shock waves that would have the most potential to cause damage to caves actually do very little because they are unable to travel through a gaseous medium – that is, the air in the cave. The force arrives at the cave wall, displaces the air, and is absorbed with relatively little effect.

Mammoth Cave lies 150 miles from a major earthquake fault along the Mississippi River. On December 16, 1811, and again on January 23 and February 7, 1812, a series of major earthquakes centered around New Madrid, Missouri, struck with estimated magnitudes of 8.6, 8.4, and 8.7 on the Richter Scale. People throughout the eastern United States and parts of Canada felt the tremors, which cracked plaster in Virginia, rang church bells in the District of Columbia, and made the Mississippi River flow backward for three days.

In the cave, saltpeter miners reported that "about five minutes before the shock a heavy rumbling noise was heard comong out of the cave like a mighty gust of wind; when that ceased, the rocks cracked, and all appeared to be going in a moment to final destruction. However, no one was injured although large rocks fell in some parts of the cave."

To this day the region around New Madrid, Missouri remains seismically active, shaken by magnitude 1.0 quakes every 48 hours. On June 10, 1987, an earthquake centered in Laurnenceville, Illinois, with a magnitude of 5.0, caused rocks to fall in Audubon Avenue. As the magnitude of an earthquake increases, the frequency of occurrence decreases. While small shocks can be expected almost every other day, an earthquake capable of major structural damage on the surface (around 6.0) can be expected only once every 40 to 80 years. Recurrence of an event greater than magnitude 8.0 is unlikely to be more often than intervals of 600 to 1,800 years.

Note that while this would seem to be infrequent compared to our daily calendar, by geologic time it could be considered a frequent event.

Caves have relatively constant temperature zones where there is no expansion or contraction of the rock or freezing and thawing of water. The constant temperature zone of a cave reflects the average surface temperature – at Mammoth Cave, 54° Fahrenheit (12.7° Celsius). Caves farther north would colder; those farther south would be warmer. Caves also have variable temperature zones around natural openings. The depth of the variable temperature zone is related to the size of the natural opening and its adjacent passageways. In this zone expansion and contraction of rock and freezing and thawing of water could cause rock to fall.

It was this set of conditions which caused the most recent fall in Mammoth Cave, on January 19 and 20, 1994, when most of the Commonwealth of Kentucky was closed because of a fierce winter storm. Sometime after the last tour on January 18 and the first tour on January 21, frost wedging separated 35-40 tons of rock from the ceiling of the Rotunda, damaging handrails and some of the historic mining artifiacts in this variable temperature zone.

Rocks within the cave may also crack under dry conditions as gypsum crystals grow within the cracks, wedging loose blocks apart. Other agents include tree roots, if the passage is very close to the surface. As the roots grow and expand, they wedge between bedding planes and split beds apart, causing rockfall.

One of the most common questions visitors ask in Mammoth Cave is "Do rocks fall in the cave?"

Yes, they do ... but probably not today.