Mammoth Cave

National Park Service
U.S. Department of the Interior

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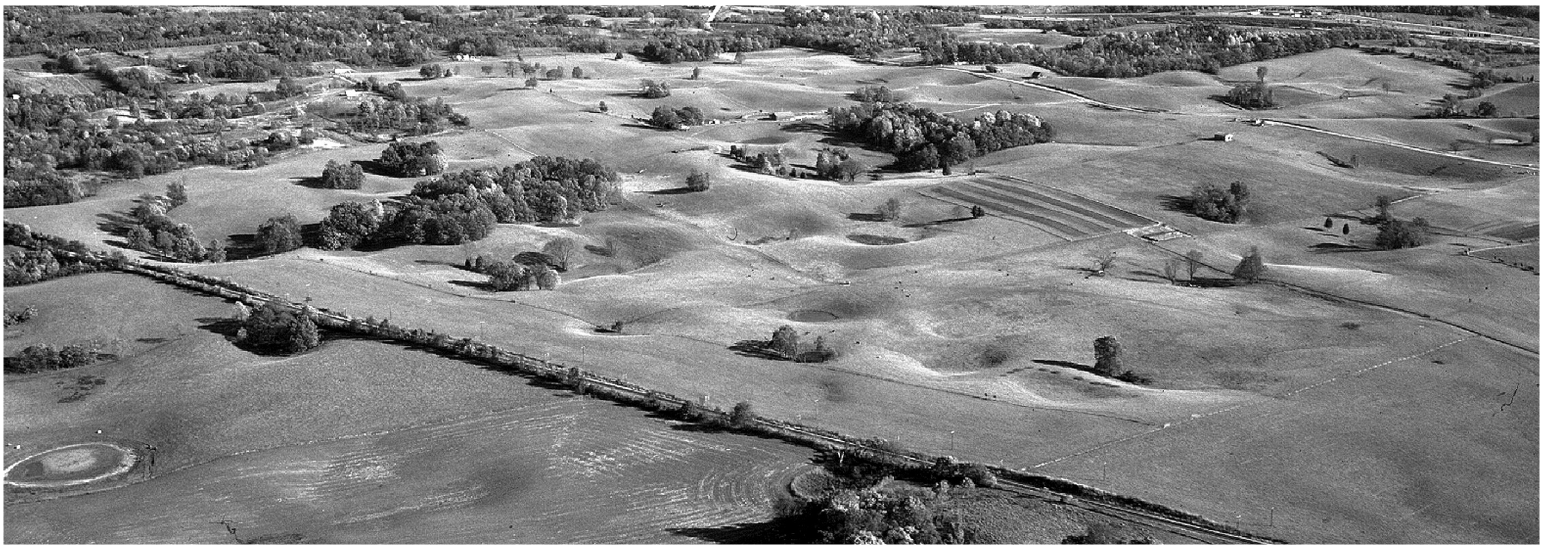
National Park

Karst Geology



Look Beneath

Beneath the surface of South Central Kentucky lies a world characterized by miles of dark, seemingly endless passageways. The geological processes which formed this world referred to as Mammoth Cave began hundreds of millions of years ago and continue today.

The Ancient World

350 million years ago the North American continent was located much closer to the equator. A shallow sea covered most of the southeastern United States, and its warm water supported a dense population of tiny organisms whose shells were made of calcium carbonate (CaCO3). As these creatures died, their shells accumulated by the billions on the sea floor. In addition, calcium carbonate can precipitate from the water itself. The build-up of material continued for 70 million years accumulating seven hundred feet of limestone and shale followed by sixty feet of sandstone that was deposited over much of the area by a large river system flowing into the sea from the north.

About 280 million years ago the sea level started to fall exposing the layers of limestone and sandstone. Additional tectonic forces caused the earth's crust to slowly rise causing cracks to form in and between the limestone and sandstone formations. As the uplift continued, rivers developed which over millions of years have created the sandstone-capped plateau above the Green River and the low, almost flat limestone plain which extends southeast of I-65.

"Acid Rain"

Rain water, acidified by carbon dioxide in the soil seeped downward through cracks in the limestone and began to dissolve and create the labyrinth of passages we know as Mammoth Cave. As the land continued to rise slowly, Green River eroded its channel deeper and deeper, passages created drained through the limestone toward the river which became the out-source for waters creating the cave. Because the major drains carried the most water, they enlarged faster. As Green River eroded its channel deeper into the bedrock, cave passages continued dropping to the same level as the Green River. Upper level passages drained and became dry. At the present water table, cave passages are still forming.

Surface Clues

As you approach the park, several clues suggest the existence of caves. Road cuts along the highway expose vast amounts of soluble limestone which display solutionally enlarged vertical cracks, an indicator that caves are forming. The undulating landscape along the interstate is created by crater like depressions called "sinkholes', which funnel surface water into the passages below. It is referred to as the "Land of 10,000 sinks" or the Sinkhole Plain. At the southeast edge of the Sinkhole Plain, surface streams suddenly sink underground joining the drainage from thousands of sinkholes and continuing to the Northwest where they become the underground rivers in Mammoth Cave. Soluble limestone, sinkholes, sinking streams and caves create a landform called Karst Topography.

The Uplands

Driving Northwest from Cave City or Park City, you climb the Chester Escarpment which rises some 300 feet above the sinkhole plain. Beyond the top of the escarpment the plateau is divided into flat sandstone capped ridges separated by steep, limestone-floored valleys with many sinkholes. It is the sandstone capped ridges that protect the cave.

Putting It All Together

The unique features of karst topography have made Mammoth Cave the longest cave in the world, with more than 360 miles of mapped passages. Water from sinking streams and sinkholes under the sinkhole plain which created the cave system flows beneath the protective sandstone caprock to spring outlets along the Green River. Echo and River Styx springs are historic examples of such outlets. Over time the Green River has paused many times as it deepened its valley resulting in the formation of multiple cave levels. In addition, textural and structural differences between limestone beds created different flow paths in and between different cave levels. Water flowing horizontally off the sandstone caprock seeps into the limestone below creating vertical shafts in the limestone. These are younger than the horizontal passages that they by chance interconnect. The shaft drains, eventually joining actively forming passages at the water table, thus adding to the cave's complexity. Finally, the caprock on the plateau protects older upper level passages from collapse. This is in contrast with the Sinkhole Plain where the land surface continues to erode, causing upper level cave passages to collapse and are eroded away faster then newer passages can be formed at the water table.

Creation and Destruction

Cave passages also collapse in Mammoth Cave. As the valleys below the ridges widen and deepen they intersect the older upper level passages which eventually collapse resulting in a "terminal breakdown".

The Historic Entrance to Mammoth Cave is an example of valley deepening as a small stream migrating up-valley eroded through a passage causing collapse.

Artistry In Stone

Water and time also enable the deposition of "cave decorations" called "speleothems" which include the familiar stalactites and stalagmites, as well as gypsum flowers. The two most common types are composed of calcium carbonate ($CaCO_3$) and calcium sulfate ($CaSO_4$). Carbonate speleothems, stalactites and stalagmites, are formed where the protective sandstone has been removed and limestone outcrops at the surface. The limestone, which is of moderate porosity and permeability, allows vertically seeping water to dissolve minute amounts of limestone on its vertical descent. Upon reaching an air-filled passage the water looses carbon dioxide to the atmosphere at the same instant it precipitates excess calcium carbonate as travertine speleothems.

Soda Straw stalactites form on the ceiling by slowly dripping water. As each droplet falls it leaves behind a minute deposit of calcium carbonate around its circumference and a hollow tube slowly develops toward the floor. Should the tube become plugged water flows to the outside creating a conical stalactite. Fast dripping water falling from the tip of the stalactite deposits its reciprocal, a stalagmite, on the floor. When stalactites and stalagmites meet they form a column.

Water seeping along cracks on a sloping ceiling or a high wall precipitate draperies and flowstone. Different colors associated with carbonate speleothems are the result of oxidized iron components or tannic or humic acids.

The Dry Formation

Sulfate speleothems, gypsum flowers, are deposited in dry passages beneath the sandstone caprock. Pyrite (FeS_2), a sulfide, found disseminated within three feet of the passage wall is entrained by small amounts of water that seeps through the pores within the limestone where it is converted to calcium sulfate. The sulfate-bearing water is drawn into the cave by capillary action where some of the water is evaporated and gypsum ($CaSO_4 \cdot 2H_2O$) is deposited. Gypsum speleothems continue to develop from the base forming the beautiful cave blisters and flowers as seen in Cleaveland Avenue on the Grand Avenue Tour.