Lewis & Clark Caverns

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Montana Geology 2016

January

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Photo 1. Drapestone coating a rough wall surface. View about 8 feet across. Photo by Alan English, MBMG.

Photo 2. Cave popcorn with a coating of flowstone. View about 1 foot across. Photo by Alan English, MBMG.

Photo 3. A cluster of delicate, wormlike helictites growing on a cave wall. View about 3 inches across. Photo by Rich Aram.

Photo 4. The Fallen Musket, a broken stalactite stuck to stalagmites, showing post- fall calcite precipitation on the barrel. View about 6 feet across. Photo by Rich Aram.

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INTRODUCTION

Lewis and Clark Caverns State Park, created in 1937, is Montana's oldest State Park. The 3,000-acre Park is located in southwest Montana on the north side of Jefferson Canyon (fig. 1), and includes the caverns, a campground, cabins, showers, picnic areas, hiking trails, and a visitor's center. The caverns, within Cave Mountain, form the centerpiece of the Park. Visitors to the caverns descend 550 feet into the earth, walk through nearly a mile of passageways and rooms, and see beautiful cave decorations (fig. 2 and front photos). More than 50,000 visitors tour the caverns annually.

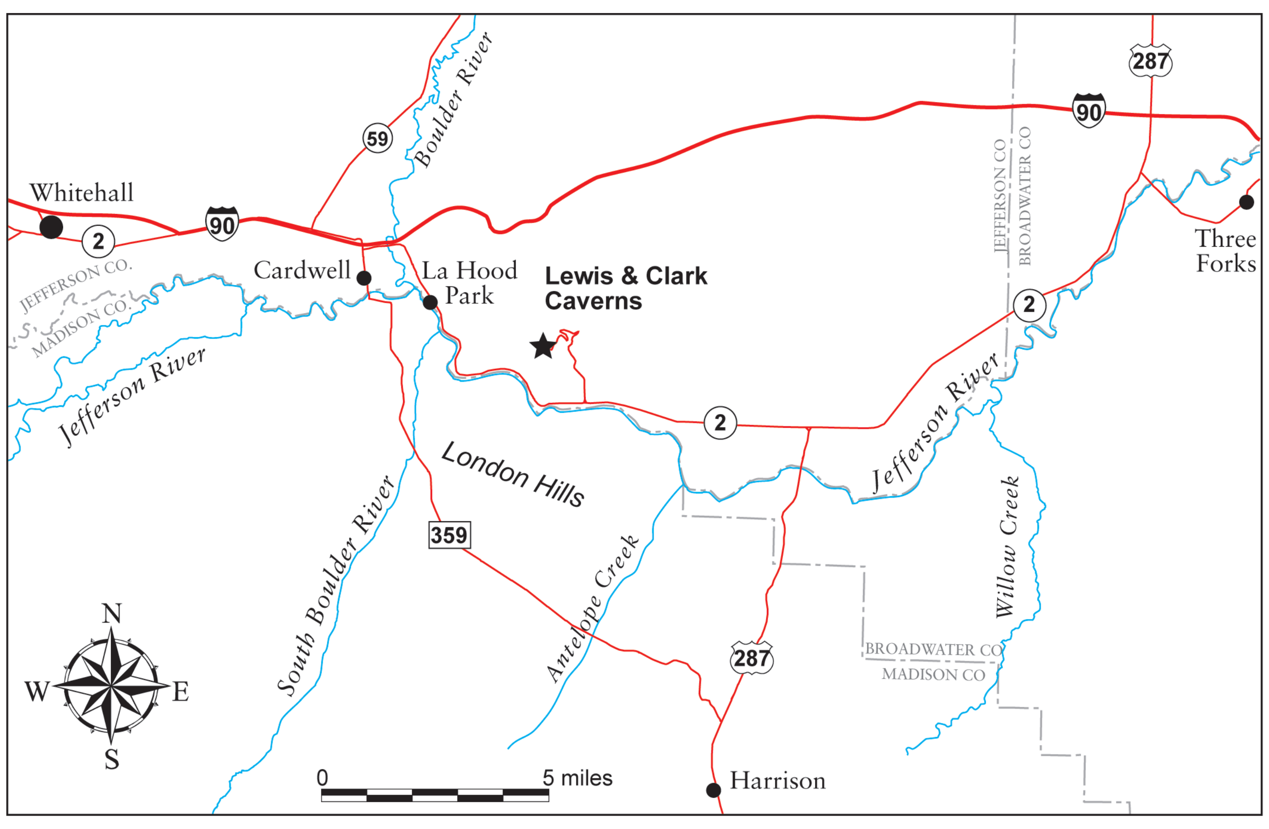

Figure 1. To get to Lewis and Clark Caverns State Park, take the Cardwell exit off Interstate 90. Travel southeast on Montana Highway 2 and follow the Jefferson River through Jefferson Canyon for 7½ miles to the Park entrance.

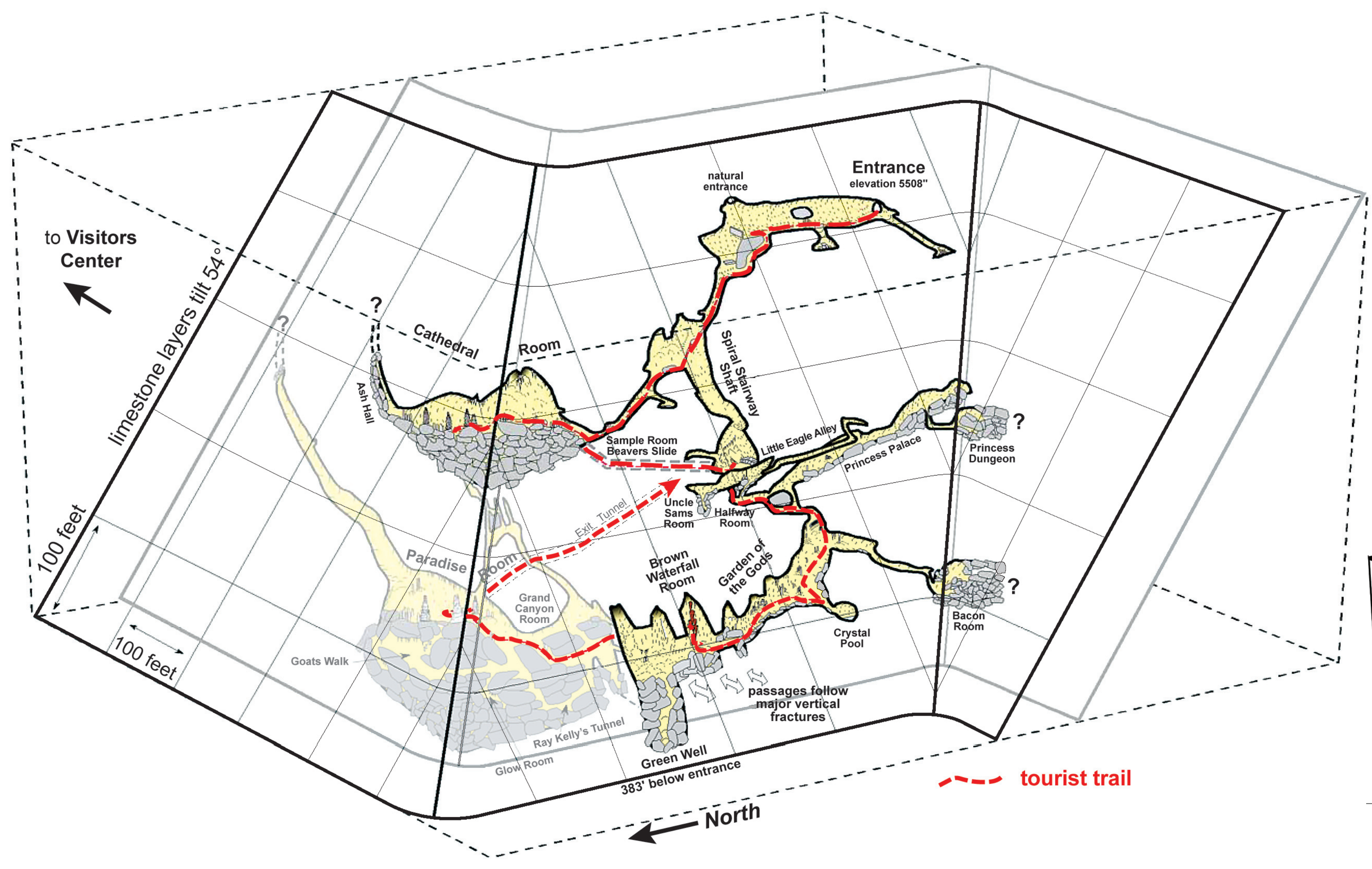

Figure 2. Three-dimensional drawing of the caverns showing the caves and passageways projected along the folded limestone layers. Modified from drawing by Rich Aram, field guide (unpublished) based on survey data by Richards, 2006 (unpublished) and Aram, 1979.

HISTORY

Discovery

Native Americans may have been first to see the caverns, but there is no evidence that they ventured inside. Discovery is credited to Tom Williams and Bert Pannell, who found the entrance while on a hunting trip in November 1892.

Early Exploration

Tom Williams returned to the caverns in 1898 and, using ropes and candles, made the first documented entry. Williams quickly recognized the caverns' potential to be a public attraction and began leading tours. In 1901, Williams asked Dan Morrison, the operator of a nearby limestone quarry, to help develop the caverns. Morrison oversaw additional exploration and constructed spiral wooden staircases so visitors could enter without ropes. Morrison also promoted the caverns in the Anaconda Standard newspaper, and in 1905 he filed mining claims around the entrance, believing the site to be on Federal land.

Land Disputes and Transfers

The Northern Pacific Railroad noticed Morrison's promotional efforts, and the company declared that the caverns were on its land. In 1908, the railroad confirmed title in a lawsuit against Morrison. The railroad recognized the caverns' geologic value and donated the land to the Federal government for a National Monument. Following through, in 1908 President Theodore Roosevelt designated the caverns as a National Monument and named them in honor of the Lewis and Clark Expedition. However, no funds were appropriated to the monument, and the entrance was locked from 1908 to 1937. Although the caverns were closed, Dan Morrison routinely cut the locks and offered tours until his death in 1932. In 1937, the Federal government deeded the land to Montana for a State Park. To aid the State in developing the Park, the Civilian Conservation Corps (CCC) did extensive work inside and outside the caverns between 1937 and 1940.

GEOLOGY

The Mission Canyon Limestone

Lewis and Clark Caverns formed in the Mission Canyon Limestone of the Madison Group, which is the most prolific cave-forming formation in Montana and host to most of the State's 300 known caves. The limestone was deposited in a warm, shallow sea 330 million years ago. This environment was favorable for deposition of thick, massive beds of almost pure limestone, composed of calcium carbonate particles formed by marine organisms. The limestone is thick-bedded with few shale, siltstone, or sandstone layers. These properties make it very soluble in groundwater, and more likely to form caves.

The Laramide Orogeny and the Colter Anticline

The Mission Canyon Limestone was slowly buried and remained undisturbed for 260 million years. About 75 million years ago, during the Laramide Orogeny, compressive tectonic forces caused extensive folding and faulting that created the Rocky Mountains. The compression folded the Mission Canyon Limestone to form the Colter Anticline (an upward fold in the earth's crust) that would later host the caverns. Continued compression faulted and tilted the Colter Anticline to form an uplifted block separated by the Jefferson Canyon and Cave Faults (figs. 3 and 4). The folding and faulting positioned the Mission Canyon Limestone within the Colter Anticline favorably for cavern formation, and created fractures and bedding plane slip surfaces within the limestone that would later become pathways for the groundwater flow that would form the caverns.

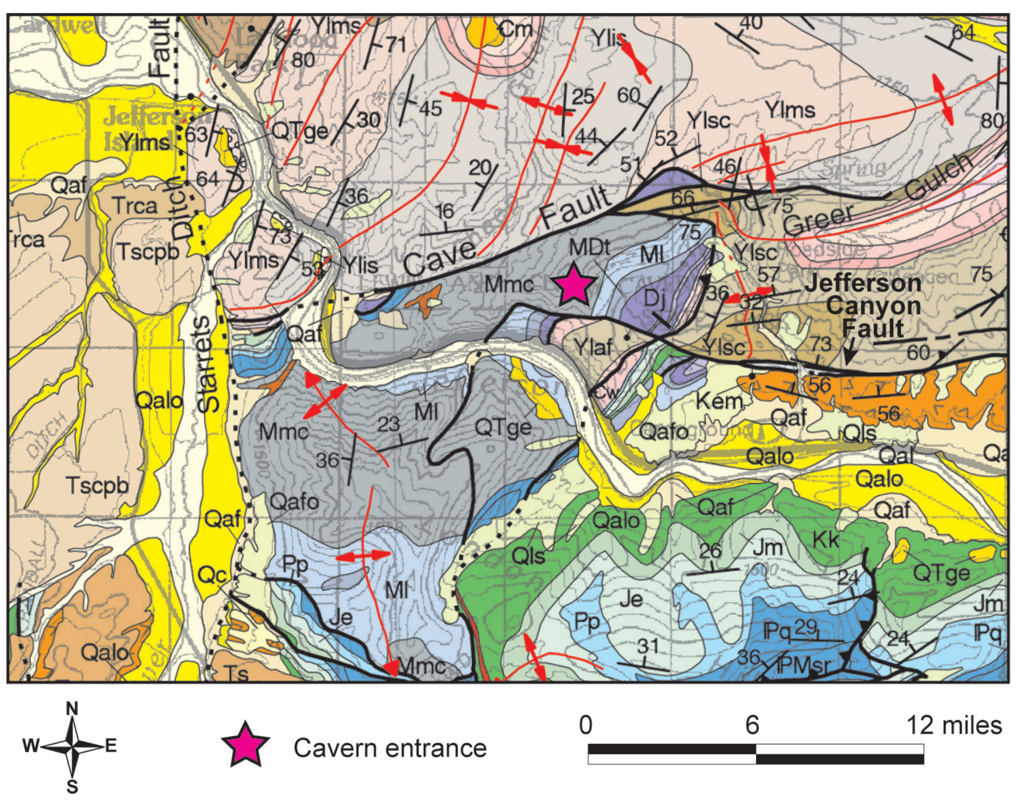

Figure 3. Geologic map showing the Cave, Jefferson Canyon, and Starrets Ditch Faults that bound the uplifted Mission Canyon Limestone at the caverns. Map modified from Vuke and others, 2014.

Tertiary Erosion and Extensional Faulting

The Laramide Orogeny ended 56 million years ago. The Rocky Mountains were gradually eroded, and sediments now known as the Renova and Six Mile Creek Formations were deposited by ancient rivers between 43 and 5 million years ago. The rivers initially flowed through valleys formed during the Laramide Orogeny, but have since been redirected many times through valleys formed by tectonic stretching of the earth's crust in southwest Montana. Starting about 15 million years ago, block faulting created the Basin and Range topography of southwest Montana. The large sediment-filled basins were cut by faults into smaller down-dropped basins separated by mountainous blocks. The Starrets Ditch fault dropped the Jefferson Valley down to the west, relative to the mountain block that includes the Colter Anticline and the future Jefferson Canyon area.

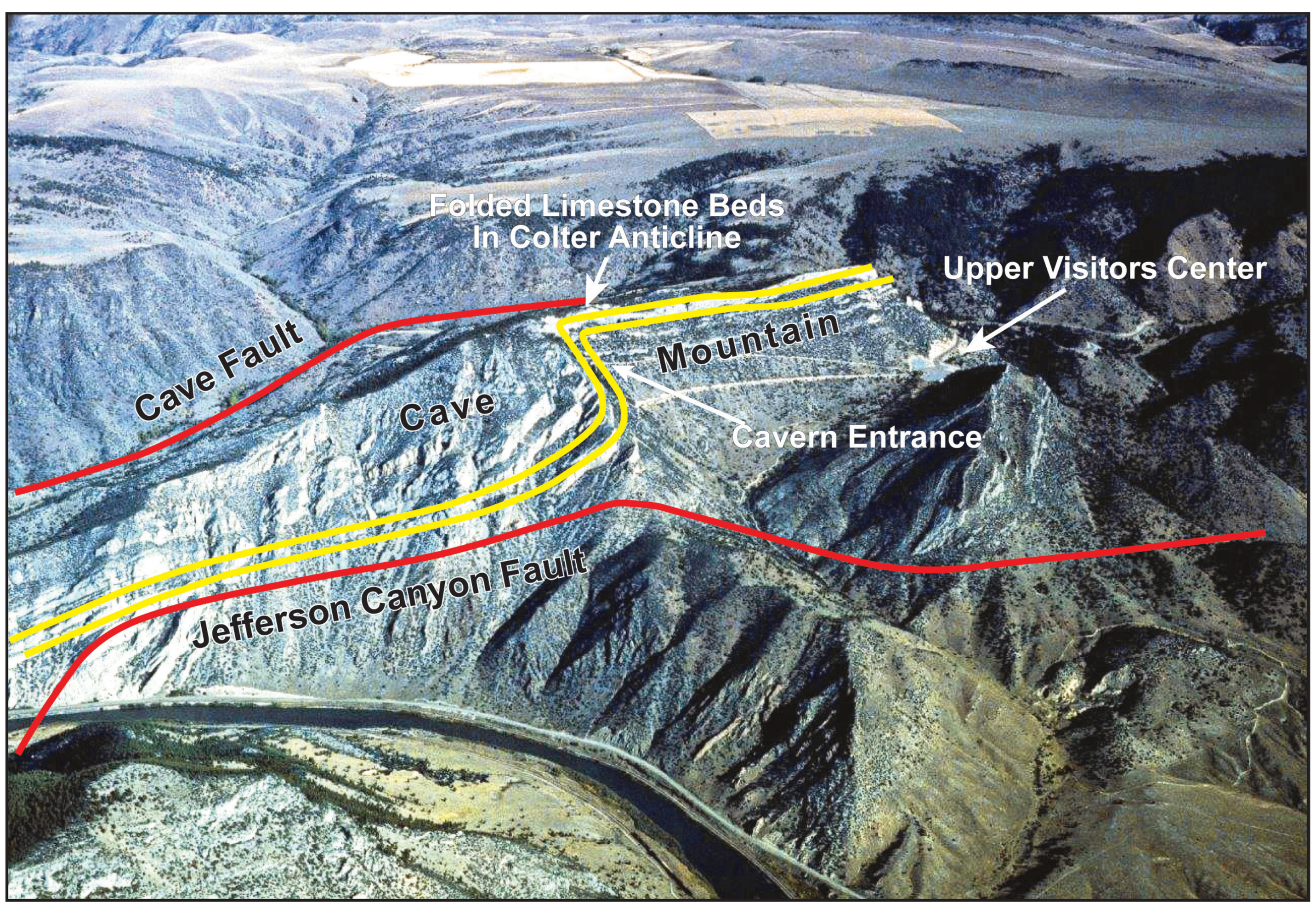

Figure 4. Oblique aerial view looking north across Cave Mountain at the folded beds of the Mission Canyon Limestone (yellow lines) sandwiched between the Cave and Jefferson Canyon Faults (red lines). Modified from image provided by Rich Aram.

Jefferson Canyon

Lewis and Clark Caverns began to form less than 4 million years ago when the Jefferson River began to downcut through the Renova and Six Mile Creek Formations. Continued downcutting by the river and tributary streams exposed the Mission Canyon Limestone along the axis of the Colter Anticline, and Cave Mountain and Jefferson Canyon began to take on their present forms (fig. 5). Water that flowed across the limestone and precipitation that fell on Cave Mountain infiltrated the land surface to become groundwater.

Within the Mission Canyon Limestone, groundwater flow followed the fractures and bedding plane slip surfaces formed during the Laramide Orogeny. The groundwater was weakly acidic due to absorption of carbon dioxide when the water was in contact with the atmosphere. As the groundwater flowed it slowly dissolved the limestone, widening the fractures and bedding plane surfaces to form the caves and passageways of the caverns.

During most of the caverns' formation the rooms and passageways were filled with water. During the past million years, the Jefferson River cut deep into Jefferson Canyon to its current position. As the canyon deepened, it gradually drained groundwater from the surrounding bedrock, eventually dewatering the limestone on Cave Mountain. When completely drained, there was no longer hydrostatic pressure within the openings to support the weight of the overlying rock. Many ceilings in the large rooms collapsed to create thick rubble fill on the floors.

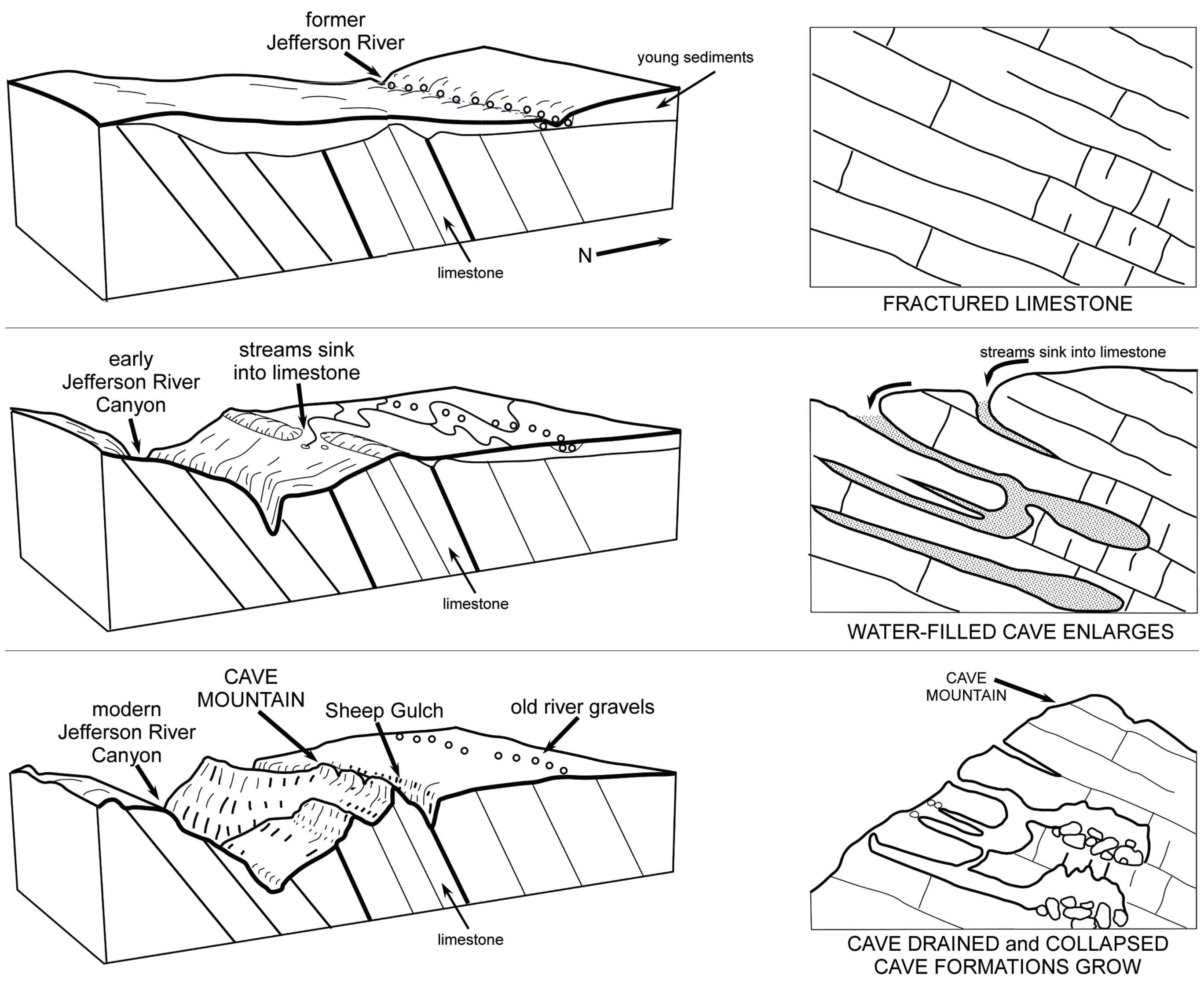

Figure 5. Block diagrams and corollary drawings showing the Tertiary geologic evolution of Jefferson Canyon and Lewis and Clark Caverns. Figure modified from Aram, field guide (unpublished).

CAVE DECORATIONS

Cave decorations began to form after the caverns were drained. Even today, some precipitation that falls on Cave Mountain finds its way into the caverns. The recharge is still weakly acidic, but there is much less flow, and the water dissolves limestone above the caverns, becoming saturated with calcium carbonate. As the water seeps into the caverns it loses carbon dioxide to the air inside, becoming oversaturated and precipitating calcium carbonate as calcite. Many types of cave decorations occur in Lewis and Clark Caverns; their size and shape depend on how the water enters and moves through the caverns.

Dripstone Decorations

Dripstone decorations (stalactites, stalagmites, and columns) form where water drips from a location on the ceiling or an overhang. If water drips slowly, calcite precipitates around the droplet before it falls to create stalactites (fig. 6). Stalactites can grow as narrow, smooth, thin-walled tubes called soda straw stalactites. If one of these becomes plugged, water may seep through the side walls, precipitating calcite along the sides and forming a stalactite that can grow large and wide, and have a complex shape (large front photo).

If water droplets fall before much calcite precipitation occurs, the calcite precipitates on the floor to form a stalagmite, which grows upward. Stalagmites may be large, wide, and have complex shapes. Stalagmites can grow to the ceiling, stalactites can reach the floor, or a stalactite–stalagmite pair can grow together to form a column (large front photo).

Figure 6. Calcite crystals growing around the sides of a water droplet at the tip of a newly forming stalactite (drop approximately 1/4 inch across). Photo by Rich Aram.

Flowstone

Flowstone decorations (shawls, drapestone, ribbons, and flowstone) form where water flows down a sloping surface and deposits calcite. If water flows down a sloping ceiling or wall along a linear path, it can deposit thin strips of calcite that gradually build up at an angle to the surface, forming ribbons and shawls. Water that flows in sheets across a floor can form smooth flowstone deposits. If the water flows over a rough surface, calcite precipitates to form drapestone (front Photo 1).

Seepstone

Seepstone decorations (cave coral, cauliflower, popcorn, shields, and helictites) form where water slowly weeps through porous sections of a cave wall or ceiling and precipitates calcite. The water may precipitate calcite over a wide area as a rough, bumpy surface called cave coral, cauliflower, or popcorn, depending on the appearance (front Photo 2). Helictites are a rare seepstone form that grows in irregular directions from places where water forms a tiny droplet (front Photo 3). The droplet hangs or perches on the end of the helictite like a golf ball on a tee, held in place by surface tension. Calcite precipitates around the tiny droplet to create tiny tube walls. Helictites are rare in most caves, but common in Lewis and Clark Caverns.

Pool Decorations

Pool decorations (shelfstone and dogtooth spar) form in pools of still water. Shelfstone precipitates on pool surfaces, forming a thin calcite crust that appears to float on the water. Dogtooth spar is clusters of near-perfect calcite crystals that grow in very still pools.

ACKNOWLEDGMENTS

Text by Alan English, layout and editing by Susan Barth, cartography and graphic work by Susan Smith, MBMG. Large front photograph by Thomas Patton, MBMG. Technical review by Katie McDonald and Colleen Elliott, MBMG. Thanks to Lynette Kemp (Park Manager), Rhea Armstrong (Assistant Park Manager), and Gene Davenport (Maintenance Foreman) for assistance and access to the caverns. Special thanks to Rich Aram for technical review, all other photographs, and figures.

ADDITIONAL INFORMATION

Aram, R.B., 1979, Cenozoic geomorphic history relating to Lewis and Clark Caverns, Montana: M.S. Thesis, Montana State University, 150 p., 4 plates.

Campbell, N.P., 1978, Caves of Montana: Montana Bureau of Mines and Geology Bulletin 105, 169 p., 2 plates.

Tucker, E.T., Aram, R.B, Brinker, W.F., and Grabb, R.F., 1981, Conference and symposium guidebook to Southwest Montana: Montana Geological Society, 406 p., 8 maps.

Vuke, S.M., 2006, Geologic map of the Cenozoic deposits of the lower Jefferson Valley, Southwestern Montana: Montana Bureau of Mines and Geology Open-File Report 537, 41 p., 1 sheet, scale 1:50,000.

Vuke, S.M., Lonn, J.D., Berg, R.B., and Schmidt, C.J., 2014, Geologic map of the Bozeman 30' x 60' quadrangle, southwestern Montana: Montana Bureau of Mines and Geology Open-File Report 648, 44 p., 1 sheet, scale 1:100,000.

For additional information on Lewis & Clark Caverns and more photos, see:
http://www.mbmg.mtech.edu/calendars/2016info.asp
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Montana Tech of The University of Montana

Scope and Organization

The Montana Bureau of Mines and Geology (MBMG) was established in 1919 as a non-regulatory public service and research agency for the State of Montana, to conduct and publish investigations of Montana geology, including mineral and fuel resources, geologic mapping, and groundwater quality and quantity. In accordance with the enabling act, the MBMG conducts research and provides information.

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