PHOLEOS

WITTENBERG UNIVERSITY
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The Wittenberg University Speleological Society

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Cover photo: Stream level bat cave.
by H. H. Hobbs

PHOLEOS

THE WITTENBERG UNIVERSITY SPELEOLOGICAL SOCIETY NEWSLETTER

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SUBSCRIPTION RATE: 1 Volume - $4.00 (2 issues), Single issue $2.00. Send to Grotto address.
EXCHANGES: Exchanges with other grottoes and caving groups are encouraged. Please mail to Grotto address.
MEETINGS: Wednesday evening, 7:00 p.m., Room 296, Science Building, Wittenberg University, Springfield, Ohio.

EDITORIAL

As promised last fall, this issue of Pholeos contains the completed survey of Bat Cave in Carter County, Kentucky. The reader will also find the second installment of Warren Luther's paper on Ohio caves in noncarbonate rocks. Unfortunately, a few minor details must still be resolved for the Zane Caverns survey, but we hope to have this work included in the next Pholeos, along with a number of small caves in Carter County, Kentucky.

Our work in Boone National Forest on surface and subsurface karst features has resulted in one completed survey contained in this issue—Fuzzy Coon Cave. We will continue to work in this area of Kentucky, and are presently involved in the survey of Chimney Cave.

I would like to thank all those who contributed their work to this issue of Pholeos, and I give a special thanks to Warren Luther and Dr. Hobbs for their help in preparing this issue for publication.

SOME INTERESTING OHIO CAVES IN NONCARBONATE ROCKS

by Warren Phillips Luther
(continued from Pholeos, 9[1], 1988)

PART III: CAVES IN EASTERN AND SOUTHERN OHIO

INTRODUCTION:

The remaining sandstone caves described in this paper are in the unglaciated portion of the Appalachian Plateaus; those in Hocking County are situated close to the glacial boundary. Various sandstone and conglomerates appear at the surface in eastern Ohio, often forming conspicuous ridges, uplands, or knobby topography since their resistance to erosion allows them to maintain higher ground. These sandstones are too numerous to list here; aside from the Berea and Sharon of northeastern Ohio, which are also important in the extreme south, the Buena Vista and Black Hand (of Mississippian age) are known cave-producers, as are Pennsylvanian and Permian formations above the Sharon. Among these are the Massillon (or Connoquenessing), Homewood, Buffalo, and Morgantown sandstones in ascending order; the reader would best consult Stout (1944) for a general overview of them. Their lithologies are variable enough to have some effect on the types of caves formed in them.

JEFFERSON COUNTY:

A cave, or group of caves, of seemingly purely tectonic origin, is reported by Condit; the one described is referred to as Skelley Cave in the Ohio Cave Survey files. He says,

> "Cave-like fissures, probably due to faulting, are said to be rather common in the sandstone near Skelley. One of these was investigated ... It is located on the steep slopes south of the valley in a sandstone above the Cambridge limestone. A fissure large enough for a person to crawl into was found to extend into the hill for many feet ... The walls are jagged and there is little evidence of any vertical displacement. The break has probably been formed by some disturbance in the past in the nature of an earthquake."

More likely this cave, and many others resembling it, have not been formed by catastrophic events, rather by the gradual slumping of hillsides (caused by seeping water removing soft shales and clays beneath the sandstone), and by the splitting of sandstones along their joint planes, thus ruling out what is now referred to as faulting. A fracture is a kind of fault, but when it is confined to one stratum only, it represents superficial tectonics in which the main force is gravity.

SCIOTO COUNTY:

Some caves exist in several of the Waverly Formation sandstones (Lower Mississippian) in extreme southern Ohio. The Berea Sandstone, which is one of them, is exposed along the escarpment marking the western edge of the Appalachian Plateaus, forming as it does in northeastern Ohio a flat table-land rising a few hundred feet above the surrounding terrain. Other sandstones appear on top of the Berea as knobs or winding ridges, producing some rugged multi-tiered topography west of the Scioto River. The Silurian dolomites have already passed underground down the regional dip to the southeast, and only shales, siltstones, and sandstones are exposed.

A few true fracture caves have been found in these sandstones, true because the rocks clearly have been split, or fractured, and the caves exhibit jagged or broken walls with sometimes little (if any) modification from erosion or weathering. Two caves of this type in Scioto County have been investigated by the Survey. One of them is Sciotoville Cave, a fracture in a shaly sandstone or siltstone of Mississippian age; its two entrances are in a steep, deeply-weathered cliff adjoining railroad tracks, apparently a natural exposure rather than an artificial cut, though likely modified (and affected) by railroad construction. The cave's alternate name, "Precarious Crack," gives some idea of its condition, which is in an advanced stage of disintegration and collapse, according to Hobbs, who visited it and mapped it. The upper, or rear, entrance is 30 feet above the lower, and leads into a steeply sloping passage. Ingressing rainwater has easy access here, no doubt contributing to the rapid demise of the cave. Near the upper entrance a low passage extends some 30 feet to impassible squeezes, and from the lower entrance a parallel passage develops into a canyon, extending also about 30 feet. The cave is in the shape of a "U" with its entrances on either side of the base, and it is roofed throughout. Erosion down steep gradients between separated fractures is the main process at work, not only in forming the cave, but in destroying it as well. Since the bedrock is thin and weak, it weathers quickly and completely, making the cave and its immediate environment unsafe.

PIKE COUNTY:

The Devil's Den is an interesting small cave presumably in the Sharon Conglomerate. In eastern Pike County as well as in adjacent Jackson County, the Sharon is well developed, forming numerous high cliffs and recess-type caves such as Canter's Caves (once a popular attraction) and Peter's Cave nearby in Ross County; they are both alsoimportant archaeological sites. The Ohio Cave Survey visited the Devil's Den, finding a roomy little cave with about 120 feet of passageway. Its entrance is through a widened joint, and slopes upward into the main room, which is about 8 feet high and roughly ovoid in shape, measuring about 30 feet from the entrance to the rear. From the left wall a narrow passage about 4 feet high continues past a smaller side passage to a lateral enlargement with breakdown, and ends.

The general shape and slope of the entrance room suggest running water as a possible agent for its formation. At this locality the Sharon Conglomerate shows a highly variable lithology with shaly partings, loosely-cemented pebbles, and limonite concretions, all in crossbedded strata, rendering it "incompetent," that is, apt to disintegrate easily on exposure. Perhaps the Devil's Den has been enlarged from both within and without: its entrance room is close enough to the outside to be affected directly by weathering, and the interior, too far from the entrance for rain and wind to reach, might be affected by water seepage from above, and by alternate freezing and thawing. Like Sciotoville Cave, the Devil's Den is a significant Ohio cave in terms of its length, and although they appear to be completely different in their origin, they are not unique. Other similar "deep" caves in sandstone will continue to be found in southern Ohio in remote places or in areas yet to be examined by the Survey.

HOCKING COUNTY:

Like the Sharon Conglomerate, the Black Hand Sandstone is a prominent cliff-former; it is exposed from Ashland County south into Hocking County, where it reaches its greatest development. The Black Hand (of Middle Mississippian age) occupies a position roughly halfway between the Berea and the Sharon sandstones, often showing a thickness of 200 feet and more. Significantly, it is divided into three zones, the middle one being cross-bedded and weaker than the others. This zone is thus easily eroded or hollowed out, and contains the characteristic overhanging bluffs and grottoes which abound along its area of outcrop. The cementing matrix is generally soluble iron oxides. The Hocking Hills State Parks, where most of the features described below are located, lie immediately south of the various glacial boundaries and therefore received tremendous amounts of meltwater during several glacial advances and retreats. It is this water which provided the force necessary to carve the narrow deep canyons, as well as the potholes encountered along their floors and ledges. Like many other places in Ohio (limestone and dolomite areas included) the present postglacial gorges are aligned along prominent joint planes in the bedrock, often showing rectangular configurations at intersections of gorges and their tributaries.

The first cave described here is outside the Park area. Tinker's Cave (also called Horsethief Cave) is a rather deep shelter in a sandstone above the Black Hand. A recent article reports that:

> "... The semicircular dripline was over 175 feet long. The height of the overhang near the center of the dripline was ... 20 feet. Slightly left of center, we measured 58 feet from the dripline to the rear ... The floor was rather smooth and gently sloped downward toward the west. A very shallow dry water channel could be seen running from the eastern end of the cave to the western end and out from under the overhang ceiling. ..."

It would seem possible that Tinker's Cave is the result of lateral erosion from a once greater flow inside the cave. That the cave slopes downward to its interior would seem to indicate this, except if the higher floor under the dripline is a "false" floor, that is, a mound of ceiling breakdown and surface debris washed in from above the cave's mouth.

Ash Cave, one of the Hocking Hills State Park units, is the most spectacular of these shelter caves, though the word "shelter" seem inappropriate for this immense formation. It has been studied and described by Carman, Hall, and Hansen (among others), so only a few remarks about it will be made here. It owes its existence to the comparative weakness of the middle zone of the Black Hand Sandstone. The ceiling of the overhang is constantly losing sand grains, which now make up the floor; rockfalls are not infrequent in the disintegrating crossbedded strata which contain the cave. Because of its present size, it seems unlikely that such a small waterfall as now plunges over the rim 90 feet above the cave's floor could have formed the entire cave. Glacial meltwater is suspected here, as well as surface weathering, the latter advancing rapidly in this weaker zone in the sandstone.

In the gorge at Old Man's Cave (also one of the Park units) below the lower "cave," a small creek enters the gorge from a narrow slot called Broken Rock Falls. Beneath the falls a large pile of boulders has accumulated, inside of which the author found an unusual cave. Its small entrance is next to a trail skirting the falls yet is easily passed unnoticed. He has described this "Broken Rock" Cave in his unpublished notebooks as:

> "... a small one, as is to be expected for a cave in and among boulders, but interesting in that it extends into the zone of total darkness. It has one main passage which is low and is floored with slabs of sandstone; it ends after 50 feet. Opening on the right, however, is a low undercut passage into an oval-shaped room not quite high enough to stand in. Aside from a few other tight crevices (too tight to explore) we found no additional passage in this cave."

Besides the innumerable shelter caves and recesses in the area, for example Cantwell Cave (at Cantwell Cliffs), Saltpetre Cave, Ash Cave, and the two Old Man's "Caves" themselves, the author has examined certain tubes in the gorge walls, some in places difficult to reach. They are apparently common; possibly they represent a final stage in differential weathering, that is, erosion and disintegration from the surface inwards—but some of them appear too deep for that. Similar tubes and small caves on Sand Hill in Geauga County have already been described in the first installment of this article; their origins are likely the same.

A process known as "piping" could be responsible for these Hocking County tubes, as well as their counterparts in the Sharon Conglomerate of northeastern Ohio. Piping has been studied in the Upper Mississippi Valley where caves occur in the St. Peter Sandstone (Lower Ordovician), and on the high plains of Kansas and Nebraska, where caves and sinkholes have formed in unconsolidated yet compact sediments such as clay and loess. The St. Peter Sandstone is a porous rock with little or no cementing matrix; underground water or captured surface water removes sand grains along weaker zones in the rock (joints, mainly) much like surface erosion, though presumably under greater pressure. Tube-like winding caves, some quite roomy, are thus formed where certain conditions allow it, and "piping caves" have been found deep underground by drilling—caves which do not, and perhaps never had, any direct surface connection. In Ohio, certain clastic rocks have little matrix, at least locally, like the Sharon Conglomerate in its most pebbly phase; other sandstones, like the Black Hand, are cemented by soluble minerals, as noted earlier. At places like Nelson Ledges in Portage County (described in the first installment of this paper) high concentrations of limonite (an iron oxide) occur locally in the conglomerate, forming deeply pitted and weathered surfaces. Perhaps these Hocking County tubes have been "piped," with the matrix removed by solution: seeping or ingressing water dissolved the cement, leaving the loose sand easily washed or blown away. The smooth walls of these tubes, and their location in unseparated joint planes, suggest piping. One nice example may be seen from the gorge floor under the lower falls at Old Man's Cave where a tube cave has a bend in it, something only flowing water could produce.

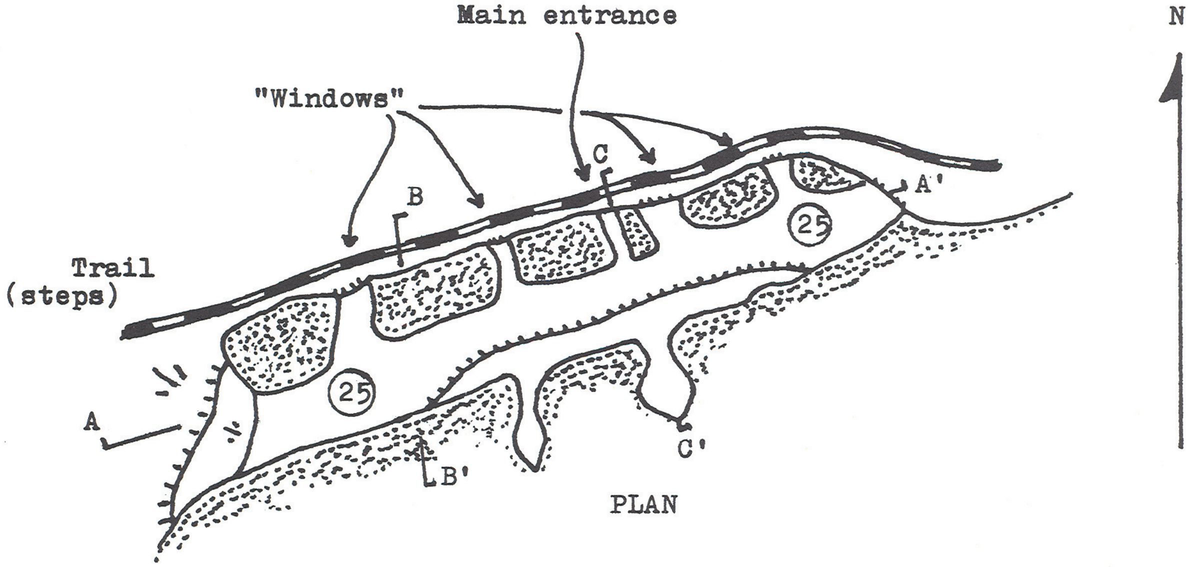
Rock Bridge, in the State Nature Preserve of that name, has been described by Hansen. The waterfall which formed this graceful arch is adjacent to it. In cases like this, water enters a lateral joint above the falls, sapping the base of the joint along a bedding plane (or another joint); when this happens at the bottom of a sandstone stratum underlain by weaker rock, the latter is removed to allow full diversion of the water under the natural bridge. Further downcutting by the stream will isolate the bridge as the watercourse deepens and the falls retreat upstream. McFarlan's treatise (1954) on the well-known natural bridges of eastern Kentucky is not entirely applicable to Rock Bridge, since the Kentucky arches (which are in the Rockcastle Conglomerate, a basal Pennsylvanian clastic much like the Sharon) occupy the tops of ridges in that maturely-dissected region, and are formed when headward erosion so narrows the divides that only a thin partition of sandstone is left standing, which is then easily breachable by various agents including aeolian erosion. A part of this wall collapses, leaving a free-standing natural arch. Most of the bridges in Ohio are of the waterfall type, though a few are remnants of collapsed cave passages in carbonate and clastic rocks.

Perhaps by now the reader will come to agree with the author that no one explanation fits even two caves of the same general type; their individual features, even if similar, could perhaps have had different histories. Some caves and related features are anomalies, as the speleothem-filled grotto in Deerlick Cave (Cuyahoga County) or the roofed section of gorge at Merkle's Caves (Geauga County) seem to be; these were described in the first installment. The most unusual of these has been saved for last, and it is indeed an anomaly with no satisfactory explanation. The present writer offers his hypothesis after other writers better qualified have given theirs, taking his chance that his speculations might either open up a more daring approach to the study of pseudokarst (rather, "allokarst"), or expose him to ridicule and scandal.

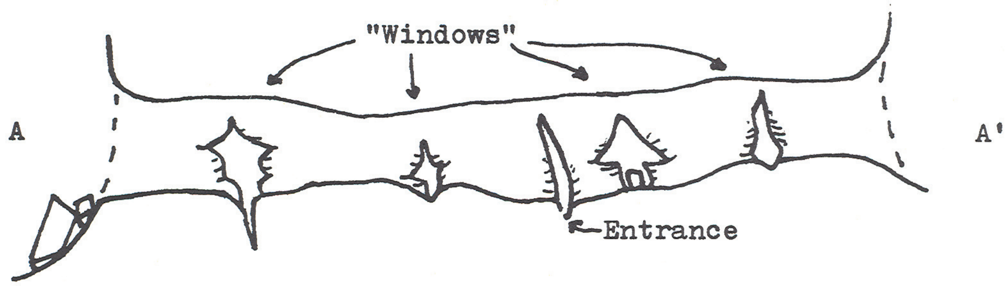
Among the remaining units of the Hocking Hills State Parks is the great Rock House, a true cavern ("cavern" meaning here, one entirely roofed underground chamber) formed in the side of a sheer cliff of Black Hand Sandstone and running parallel to it. It is as far as known the largest single cave room in Ohio, and when viewed at night with a lantern (in the absence of sunlight which comes through its seven openings) it resembles a typical large trunk passage in a limestone cave, except for the color of the rock, which is in shades of brown rather than of gray. Rock House has been discussed in detail by a number of authorities, two of whom will be quoted here. Carman studied it and produced a map, reproduced here as modified by the present writer to show inner grottoes developed in the same lateral joint planes in which the "windows" are formed, and along one conspicuous bedding plane. The cavern is in the shape of a "Gothic arch"— the general consensus of most writers—about 200 feet long, up to 25 feet high, and between 20 and 30 feet wide, open at both ends. Five entrances penetrate its length; the trail from the gorge leads into the middle one. Rock House has a true ceiling with the joint plane clearly visible. Carman explains,

> "The evidence is conclusive that the greater weathering of the sandstone along the joints has been the chief cause for the formation of Rock House. The sandstone is rather loosely cemented and the slow but persistent decay of the cement allows sand grains to fall away from the ceiling and walls. It is believed this is the chief method of enlargement.
>
> "If it appears that the slow falling away of sand grains is an inadequate method of forming the great corridor of Rock House, it may be noted that if the sand necessary to fill the 100,000 cu. ft. of space in Rock House was removed during the one million years of the Pleistocene period the rate of removal would be about one-half of an ounce of sand grains per day, which does not seem an unreasonable rate. It is believed that wind is the most important and almost the sole agent for the removal of the sand grains from the floor of Rock House."

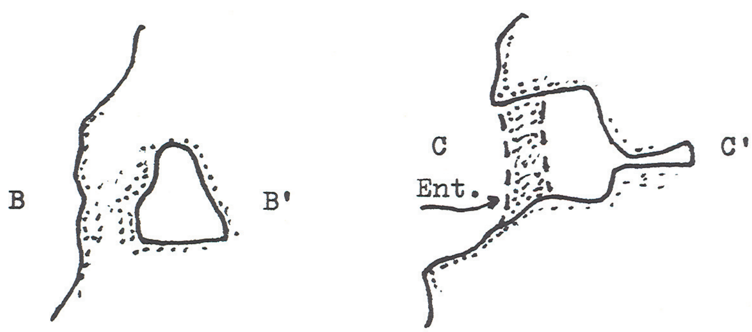
The main point here is that this zone of the Black Hand Sandstone, namely the middle one, is the weakest, and that it disintegrates upon exposure to the elements—wind included, to which Carman assigns the main role. As in the case of the natural tunnel at Merkle's Caves (see first installment), the standard theory is suspect because of the size of the feature and its improbable location. In contrast to Carman, who sees aeolian erosion not only as the cause, but as the continuing process, Hansen proposes that water movement along joints brought the cavern into existence:



PLAN



PROFILE



CROSS SECTIONS

ROCK HOUSE

Hocking Co., Ohio

(modified after map in Carman, 1946, by W. Luther, 1957)

"The passageway of Rock House is formed in the middle zone of the Black Hand Sandstone. The more resistant uppermost zone forms the roof, and the lowermost zone forms the floor; ground water percolating along the joints has caused enlargement in the middle zone. Excavation of the loose sand grains has been accomplished by running water, mostly during the Pleistocene Epoch, when climatic conditions were moist owing to glacial influence. Even today, when rainfall is abundant, springs of water issue from the sandstone in the lower part of the tunnel and flow in rivulets across the floor and out the windows."

In addition to percolating and flowing water, further chemical disintegration of the walls could happen because of atmospheric moisture and condensation, and the removal of the sand from alternating freezing and thawing. Once again, vertical and horizontal water movement is the suspected prime agent in forming a sandstone cave. Another factor in its apparently complex history is the age of the cavern in relation to the ravine which contains it, and whether or not the cavern and the ravine arose from the same causes, and at the same time. It is a matter for speculation, but careful field work might help unravel these questions; until this can be done, the present writer's hypothesis must remain tendentious at best.

The Rock House may be older than its adjacent gorge, at least in its youthful stage. It may have been a tube-like passage excavated by subterranean water entering opened surface joints, that is, a kind of elongated natural bridge or tunnel. Imagine that the creek which formed the deep gorge, some time in the past when the plateau surface was presumably flat or nearly so (the so-called Lexington-Worthington Peneplain of immediate preglacial times), worked into opened joint planes, eroding the embryonic cavern. It becomes a long but narrow natural tunnel; evidence is at hand that it was once even longer, since a possible extension of it above the upper entrance may have been destroyed by collapse of the gorge wall. Certain climatic or topographical changes, such as increased rainfall and the development of the present drainage pattern, could have diverted the creek, or plugged the upstream entrance to the cavern; the creek now cuts a gorge through a parallel system of joints, leaving Rock House high and dry. Now exposed directly to rain, wind, freezing and thawing, and other kinds of weathering, it continues to enlarge independent of its primary agent—erosion by running water. Water continually seeps and trickles through its ceiling joint and from the prominent bedding plane. The collapsed area outside will have to be examined carefully to support or discredit this hypothesis: it could have been the site of an abandoned waterfall plunging over the side wall, eventually destroying a former part of the cave, or perhaps even supplying the water which formed the cave. It is at best speculation, but a feature as large as Rock House seems to need a less placid history to explain it, considering the many climatic and topographical changes it has witnessed during the glacial epochs.

PART IV: CONCLUSIONS AND BIBLIOGRAPHY

The author will end this paper, which describes only a few of the more interesting sandstone caves in Ohio, with suggestions for future research. To understand these caves properly, he believes one must:

1) ascertain the nature of the matrix, or cementing material in the sandstone, since solution of the matrix is a possible cause for the formation of sandstone caves, or at least for their modification;

2) note the ceiling to see if it is a "true" ceiling, that is, a ceiling which consists of the bedrock in place, not debris or collapsed material, noting also whether or not the cave has more than one kind of ceiling; and

3) examine the walls for evidence of fracturing, or splitting of rock masses, and in the absence of this, note their general contours for evidence of water-carving.

There is little likelihood that caves will be found in these sandstones away from outcrops, that is, caves uncovered during deep mining. The presence of open joints is the essential condition for the formation of many of these caves having some linear extent. Jointing is more conspicuous on the outcrop, since the forces that hold the rock together deep under cover are released, and the cracks are free to separate; these cracks are the result of shrinkage and various crustal tensions (among other causes). When they appear split apart at the surface, these opened joints are sometimes called "fractures." Aside from escarpments or bluff faces, any areas, even though relatively flat, underlain by a particular sandstone, are vulnerable since water can enter the joints some distance back from the bluff's edge—a circumstance rather common in the Sharon Conglomerate caves of northeastern Ohio.

The reader should keep in mind that rocks seemingly as diverse as sandstone and limestone do grade into one another. Some of Ohio's limestones contain much sand and clay matter, though perhaps not enough to classify them as siliceous in the way the Loyalhanna Limestone (Upper Mississippian) of southwestern Pennsylvania is. About one-half of its volume is quartz sand, which makes it really a sandstone bonded by calcium carbonate. On the outcrop, especially when it is crossbedded, the Loyalhanna looks and feels like a sandstone. Among other shorter ones, a quite large solution cave (Dulany Cave, now open to the public as Laurel Caverns) is developed in it; groundwater removed the cementing matrix along joints and then removed much of the residual sand by erosion—no doubt aided by the rather steep dip of the strata at the cave, which is near the top of an anticlinal ridge. The passage contours in its main entrance passage (the entrance no longer in use and sealed, leading directly into the Hall of the Mountain King) look exactly like those of Rock House, and the chamber is equally high and wide, though somewhat longer. It is developed along one straight joint, like Rock House, and this joint is visible running down the entire length of the ceiling, also like Rock House. The ratio of cementing matrix to sand in the Black Hand Sandstone is much less than in the Loyalhanna, but even if a certain sandstone contained ten per cent soluble matrix, such as the iron oxides of some Ohio sandstones, and it were in a position to be attacked by vadose (that is, meteoric) or phreatic (that is, underground) water in the usual ways, might not "solution" caves in sandstone thus be formed? And the process described as "piping" is yet one step past solution: the matrix is already gone, and flowing groundwater simply removes the sand grains.

As mentioned elsewhere in this paper, some carbonate rocks hold up as well as the sandstones and conglomerates in forming "rock cities" and fracture caves. Likewise, some sandstone caves show features that are apparently the result of solution. In Ohio, despite the small size of most of these caves in carbonate or noncarbonate rocks alike, they are convergent in form and origin, not divergent, and the various types of bedrock containing them are likewise convergent. Ohio's caves and karst features are intricately connected with its geomorphology; while some of the longer and larger limestone or dolomite caves represent a remoter origin in time, some of the smaller ones, including those in sandstone and conglomerate, seem to be of more recent origin, possibly arising through the same causes. The glacial history of the area may prove to be the single important factor in understanding this last phase of speleogenesis in Ohio. Philip M. Smith of the National Science Foundation, and the first director of the Ohio Cave Survey, saw this from the start, emphasizing it repeatedly in portentous admonishments from his desk in Washington, D.C.: "There is also a need to look at glaciation." Perhaps a careful study of both carbonate and noncarbonate caves, including analysis of their earth fills and dating of their speleothems, could contribute substantially to the deciphering of Ohio's complex glacial past—which would certainly justify giving sandstone caves equal status in a Statewide survey of the kind now in progress.

ENDNOTES:

1) Stout, W. E., 1944. Sandstones and conglomerates in Ohio. O. J. Sci., 44(2).

2) Condit, D. D., 1912. Conemaugh formation in Ohio. O. Geol. Surv., 4th Ser., Bull. 17, p. 208.

3) Hobbs III, H. H. Unpublished notes and map in the Ohio Cave Survey files; also pers. comm., June 1989.

4) Idem.

5) Payne, E., 1985. Tinker's Cave. The Petroglyph, 21(1); reprinted in Pholeos, 6(1), 1986, p. 3. (Tinker's Cave was formerly marked on roadmaps as an attraction.)

6) Similar to Tinker's Cave is Robinson's Cave nearby in Perry County; see Payne, E., 1987. Robinson's Cave. The Petroglyph, 23(1), reprinted in Pholeos, 8(1), 1987, pp. 2, 4-5.

7) The St. Peter Sandstone is in fact mined hydraulically for its quartz sand, since water forced into it under great pressure will disintegrate the rock.

8) Carman (1946), p. 279; see Bibliography.

9) Hansen (1975), p. 9; see Bibliography.

10) Smith, P. M., letter to the Ohio Cave Survey, Jan. 1, 1973. See also his article, The Ohio Cave Survey, in O. J. Sci., 53(6), 1953.

ANNOTATED BIBLIOGRAPHY:

(Note: see the bibliography in the first installment of this article [Pholeos, 9(1), 1988] for additional material, some of which is pertinent to eastern and southern Ohio as well.)

Carman, J. E., 1946. The geological interpretation of scenic features in Ohio. O. J. Sci., 46(5); reprinted in O. Geol. Surv. Repr. Ser. 3. (A detailed account of the geological history of three widely-separated areas—the Hocking County state parks, the Greene County gorges [in Silurian dolomites and shales], and the Lake Erie Islands. The first two are of interest here because of their situation at the edge of a major lobe of glacial ice, thus owing their formation largely to the force of meltwater.)

Hall, J. F., 1952. The geology of Hocking State Park. O. Cons. Bull. 16(9); reprinted in O. Geol. Surv. Inf. Circ. 8 (1953). (A well-illustrated and readable paper, even if perhaps a bit outdated, on the many scenic features in the Black Hand Sandstone.)

Hansen, M. C., 1975. Geology of the Hocking Hills State Park region. O. Geol. Surv. Guidebook 4. (The most recent monograph on the Hocking County gorges, emphasizing more than other authorities their glacial history. Amply illustrated and completely reliable.)

Hyde, J. E. (ed. M. F. Marple), 1953. Mississippian formations of central and southern Ohio. O. Geol. Surv., 4th Ser., Bull. 51. (Distributions of various sandstones, including the Buena Vista, Berea, and Black Hand, and some discussion of the long erosion interval which removed most of the Mississippian limestones from Ohio.)

McFarlan, A. C., 1954. Geology of the Natural Bridge State Park area. Ky. Geol. Surv. Spec. Pub. 4. (Natural bridges of the "Kentucky type," that is, formed on ridge tops by convergent headward erosion, and in the basal Pennsylvanian Rockcastle Conglomerate, are described and copiously illustrated.)

Morgan, R. G., 1929. Geological aspects of Ohio archaeology. O. St. Univ., M.A. thesis, unpub. (The sandstone shelters of southern Ohio are discussed in relation to their suitability for prehistoric occupancy.)

Shetrone, H. C., 1928. Some Ohio caves and rock shelters bearing evidence of human occupancy. O. Arch. Hist. Quart. 37. (Shelter caves in the same area covered by Morgan [1929], and the work on which Morgan's thesis was no doubt based. Among the sites described in detail is the productive Kettle Hill Cave, in the Black Hand Sandstone of Fairfield County.)

Stout, W. E., 1916. Geology of southern Ohio, including Jackson and Lawrence Counties and parts of Pike, Scioto and Gallia. O. Geol. Surv., 4th Ser., Bull. 20. (A general regional geology, covering an area where the Sharon Conglomerate is well developed.)

VerSteeg, K., 1933. The state parks of Hocking County, Ohio. O. J. Sci., 33(1). (A good introduction, and with careful observations in Rock House. He sees each configuration in the cave's surfaces as indicators of the relative durability or friability of the various sandstone layers.)

__________. 1947. Black Hand sandstone and conglomerate in Ohio. Geol. Soc. Am. Bull. 58(7). (Not consulted.)

CORRECTION:

In the first installment of this article (*Pholeos*, 9[1], 1988), Endnote 5, p. 16, read "west" instead of "east" in reference to the location of the Chesterland Caves.

BAT CAVE: AN ENDOWMENT AND LEGACY TO KARST IN NORTHEASTERN KENTUCKY'S "VALLEY OF THE CAVES"

by
H. H. Hobbs III
NSS 12386RE,FE

INTRODUCTION

Along the western edge of the Eastern Coalfield in north-central Carter County, Kentucky, Mississippian limestones outcrop in a belt containing a variety of karst features. In addition to numerous sinkholes, sinking streams, springs, and natural bridges, many caves have developed in the Newman Limestone Formation (Ste. Genevieve and St. Louis limestones). In the area, a maximum thickness of cavernous limestones is only approximately 25m and much of that is heavily crossbedded. Thus, very little vertical relief is noted in caves but some features, such as Saltpetre-Moon and Bat caves (Fazio and D'Dangelo 1984, Hobbs 1985), demonstrate much horizontal development.

In 1983, the Wittenberg University Speleological Society (WUSS) initiated the survey of Bat Cave which is located in Carter Caves State Park. Since the cave serves as a hibernaculum for the endangered Indiana Bat, Myotis sodalis (see below), visitation to the cave is restricted primarily to the summer months. This is a time when most of the members of WUSS are not on campus and thus progress in the mapping project has been sporadic, at best. Students graduated and new ones arrived, necessitating the training of survey techniques each year. As one might anticipate, with long periods of time between trips, inexperience, and many individuals involved in the project, much survey error occurred and there was even loss of data. These problems have led to many resurvey trips and much frustration; however, the project has finally come to completion and a brief history, a description, and a map of the cave are presented below. Bat Cave is the longest cave in the Park with 3681 meters of total horizontal cave.

HISTORY

Regrettably, very little has been recorded about the history of the caves within the Park. The Saltpetre-Moon Cave System is probably the best documented karst feature (see Fazio and D'Angelo 1984, Hobbs 1985, and George 1987), with local tradition claiming that saltpeter was mined from it during the early 1800's. This system is the second longest cave in the Park, it being 3005 meters in total horizontal extent and only 676 meters less extensive than the total length of passages in Bat Cave.

In 1869 Greiner wrote a most entertaining article about "The Carter Caves." He stated that, "For twenty years and more, the good people of Kentucky have made the caves of Carter their summer haunt; and when Ohio learns how much pleasure and enjoyment too - as much of nature in sunlight and majestic proportions, as well as her darker and delightful labyrinths in the caverns of limestone - she will come...While the sun shines, there is the beautiful torrent called Cave Branch, to explore from its rise above the Bat Cave, through its cavernous wandering, its above-ground race down to the X Cave, and emerging from beneath the hill of the latter cave, passes by the Laurel Cave, and seeks its confluence with the Tygart River."

Greiner's predictions may have been read by some venturesome Ohioans. The following is an account of a trip to the Carter Caves area made circa 1870 (Anonymous, n.d.) by a small group from Portsmouth, Ohio who joined

"...in an expedition to seek out and explore certain caves which, rumor said, were to be found somewhere in the wild regions of Carter Co., Kentucky. Who could resist!

"Duly equipped, therefore, with all needful appliances -among which were reckoned certain well filled baskets - looking to the wants of the inner man we crossed the river from our good city of Portsmoutn and soon found ourselves amid the shadows of the Kentucky hills. Our company, as just intimated, was not large, but sufficiently so for the purpose at hand, and, as we did not doubt, of the 'right sort'."

On the morning of the second day of travel, "...we pursued our way up the valley of Buffalo by a pleasant and very passable road, about three miles; and then turning off to the south by a path which none but the most enthusiastic explorers could have found, and over hills and rocks which none but the most trusty horses, the soundest vehicles and coolest drivers - which requisites we had in perfection - could have surmounted we came, at length, without breakage or mishap of any kind, safely down in the Valley of the Caves.

"This valley extends nearly due east and west, and opens into the broad bottoms of Tygart's Creek, which comes sweeping down from the southeast. It is hemmed in by high and frequently precipitous hills; abounds in fine cool water and shady retreats; and offers as pleasant a place for summer rustication as any one could reasonably desire.

"Leaving horses and carriages at the foot of the hill, where we found a comfortable log house, and such accommodations as our independent mode of traveling required, we winded our way down the valley about a quarter of a mile, when our guide (a half-grown lad whom we had chartered for the occasion) pointed us to a large irregular opening among the rocks, on the north hillside as the entrance to one of the 'Caves.'... It is called in common parlance, the 'Bat Cave,' from the great and, almost countless, number of bats which are said to congregate here in the winter season; and in a semi-dormant state, remain suspended from the rocks overhead. Not liking this name, it being significant of nothing except a disagreeable little animal, we resolved to give it the more euphonius apellation of 'Crystal Brook Cave.' This would be expressive of its most prominent and peculiar feature; namely, a stream of pure crystal-like water, which flows, in a rippling current, through the whole length of its main avenue.

"The entrance is through a wide, irregular, rocky chasm, in the face of the cliff, on the north side of the valley. On entering we were met...by a strong current of cold, sintry-like air, rushing out with so much velocity as to extinguish some of our torches. This, however, ceased when we were fairly within, and we had no further difficulty in preserving our light. The main passages of the Crystal

Brook Cave are two; one diverging slightly to the left in a course (as well as we could judge from the indications of the compass) nearly parallel with that of the valley; the other pursues a direction inclining diagonally into the mountain and to the northwest. We first examined the former passage. It is exceedingly irregular in its opening; in some places spanned by a low arch with a base of a hundred and fifty or two hundred feet, in others opening up into lofty rooms, with walls of considerable uniformity; and then again narrowing to an outlet of only a few feet.

"In this division we had the satisfaction of finding many beautiful and curious formations in profuse variety - stalactite draperies, glittering pendants, curled, leaf-like edgings, fluted columns, stalagmite erections, etc. of almost every conceivable form and feature; some as regular in shape as if contribed and fashioned by the nicest rules of art; others out of all proportion, and as fantastic in form as the oddest genius could devise. Some reaching down, as if to shake hands and join fortunes with its stalagmite cousin below; which in its turn was solitously elevating itself to meet the embrace extended from above. With some, the union had been long consummated; and a production column-like, airy and graceful; or burly and massive was the result. Some were pigmies and some giants. In others the accretions had ceased; the attractive influences (if we may indulge the fancy) like blighted human affections, were dead; and all hope of meeting and mingling into one was forever gone. The imagination might revel and luxuriate amid this fairy scene, in conceptions and strange conceits, without end.

"Towards the further extremity of this series of chambers, were found large numbers of formations, called in scientific phrase, 'Geodes.' Of these there lay about, a great variety, in respect to form and size. The Geode is a round lump having an envelope or incrustation of silex, agate, calcareous earth, as carbonate of lime, etc. Its interior is sometimes empty and in this case, the cavity is frequently lined with crystals; sometimes empty; sometimes it contains a solid, movable nucleus; and sometimes again, as in the case of those discovered by us, it is filled with fixed particles, or pebbles of quartz flint and earthy matter, different from the exterior, forming a conglomerate which breaks and crumbles under a slight stroke of the hammer.

"Some of these we ventured to bring way as specimens worthy of the cabinet, and mementos of our successful search. We took possession also, of such other curiosities as suited our taste, provided they were already detached, and not likely to be wanted by the Genius of the caves - in other words, were useless for ornament, or any other purpose, where they were. ["Take Nothing But Pictures"] But in no instance, did we lay vandal-hands upon or apply the mutilating hammer to the beautiful ornaments, with which Nature had so profusely decorated these her private apartments. Let all others, who may be admitted to the beautiful mysteries of her penetralia, be equally scrupulous. These splendid decorations are in place, and valuable, nowhere else. They belong to no mortal man. Let them remain unmutilated and undisturbed in their sacred seclusion, to testify to the handiwork of the unseen divinity, who, for ages, has wrought so curiously, in this, her secret and silent laboratory. Succeeding visitors may then have the same gratification as those who have gone before, and in reverent contemplation, find their thoughts lifted.

"The length of the side avenue is two hundred and fifty rods or nearly a quarter of a mile. Its termination cannot be far from the house where we left our horses on our first coming into the valley. Its course, at all events, must lie between that of the valley and the main avenue, which verges more into the mountain. This latter (having retraced our steps) we were now to explore to the point where it diverges from the former.

"The general aspects of this passage are not unlike those of the former, but, of course, wholly different in particulars. The archway is generally more uniform in construction while the formations are much less profuse and ornamental. This want, however, is fully compensated for, by the pleasant streamlet, which ripples over the floor of the cavern or rests in still pellucid pools, at its side. It meanders along in graceful curves, losing itself here and there under adjacent ledges, or fallen rocks; an anon peeps laughingly out from its hiding place, like a merry child in its hide and seek play. Occasionally the way is nearly blocked up by large and sharp rocks which have fallen from the roof above; and over which it is not easy to clamber with a whole skin. We named one of these piles, the 'Alps' and fancy pictured a high peak on the right as Mount Blanc. Whoever may essay to make these passages, must take good heed to his going or he will on a sudden find himself tumbling down some sharp declivity; splashing his feet into the cold stream at the bottom, or if perchance, he is required to stoop low, in his efforts to maintain his wonted posture, he will find his shoulders in contact with the millions of great frigid droops that stud the low ceiling and glitter like ice; which they emulate in purity and coldness.

"Towards the upper end of the cave there is a long reach, say of three hundred feet, spanned by a low ceiling slightly raised along the middle forming what the architects term a crushed arch. The floor or ground through this space (which is composed of shale, pebbles, gravel and sand intermixed) inclines uniformly, by a gentle slope, to one side, where the stream flows along washing the base of the arch. This proved the most wearisome part of our journey, as it could be made only in the stooping posture, frequently requiring the hand for support.

"At length, after a toilsome progress of several hours, persevering efforts in climbing, creeping, stooping, erect walking; and down tumbling in successive turns (and many turns we had all these modes of traveling) we hailed the daylight in the distance, and bent our steps thither, with mingled feelings of gladness and regret, that our laborious, but most interesting and exciting work was accomplished.

"The distance through the Crystal Brook Cave is by measurement, something more than half a mile so that including the main side passage and other small branches we had traversed upwards of a mile in our subterranean journey.

Certainly numerous articles have appeared in the literature since this early account of a trip into the Carter County area and Bat Cave. One of the earliest records of the cave and of fauna occurring in Bat Cave was that of Packard (1888) in which he cited ten species of animals

Fig. 1. Historic entrance into Bat Cave: note remnants of chain-link fence

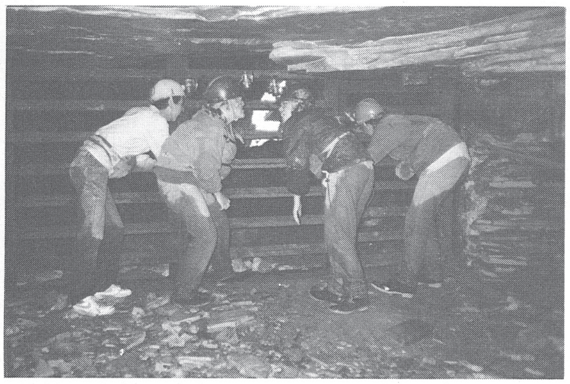


Fig. 2. Angle-iron gate located 70m inside Historic Entrance

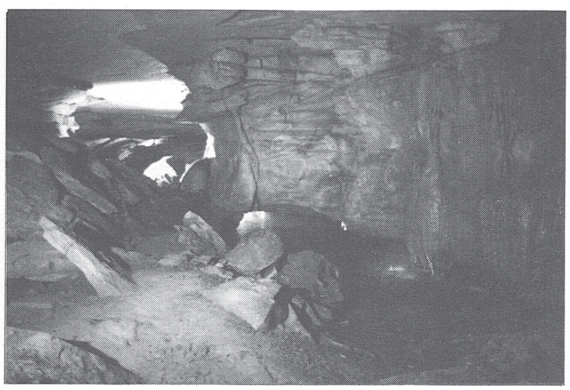


Fig. 3. Stream passage and waterfalls downstream from Breakdown Room

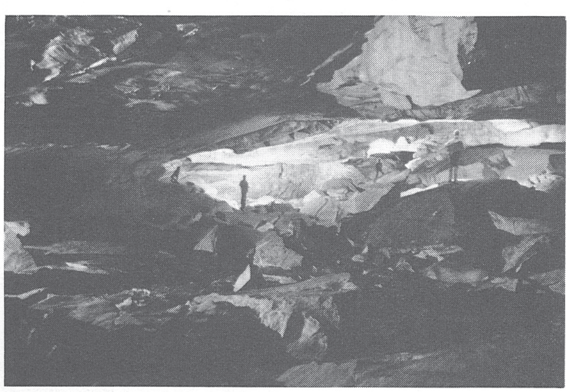


Fig. 4. The Breakdown Room

Fig. 5. View looking back toward Historic Entrance

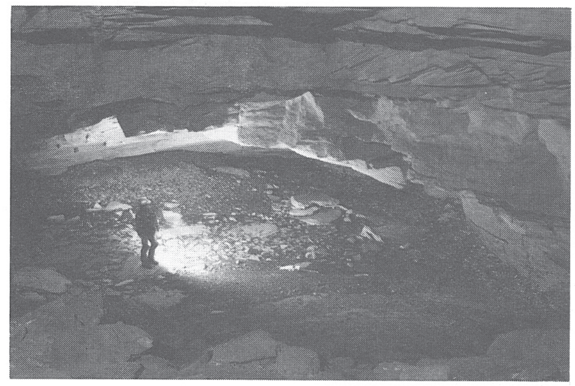


Fig. 6. Main stream passage near lower gate

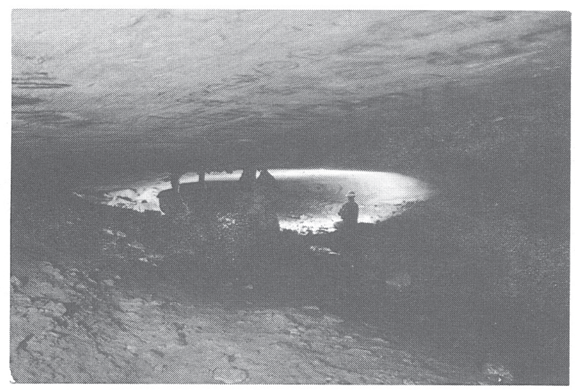


Fig. 7. Dry upper level with small columns and ceiling graffiti

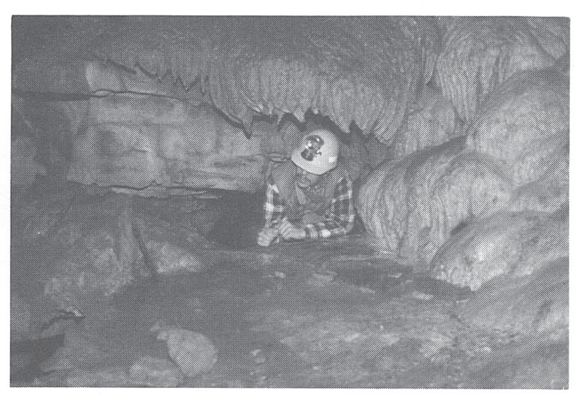


Fig. 8. Caver emerging from a small passage near Donald Duck's Walk

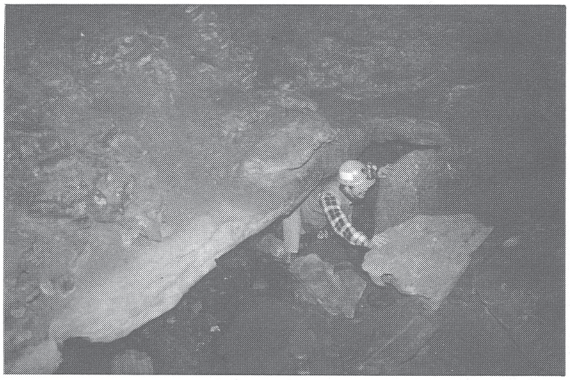


Fig. 9. One of the many connections to upper and lower levels in Bat Cave

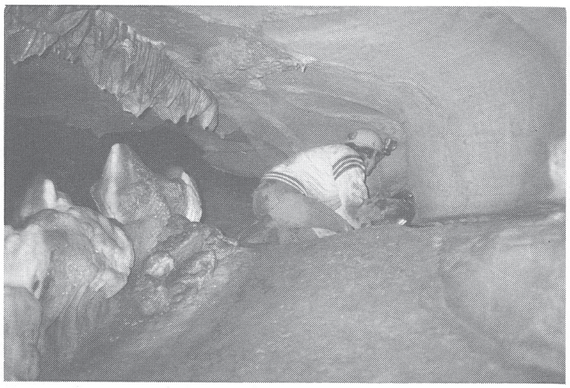


Fig. 10. Entrance to a small, low loop passage in the upper level

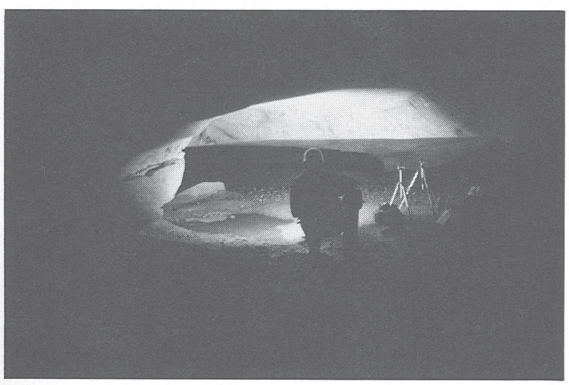


Fig. 11. Setting up for photographs at intersecting passages in the lower level

Fig. 12. Main stream passage is intersected by Bathtub Alley as an elevated crawl (above flowstore, behind caver)

Fig. 13. Survey crew taking a break at intersecting passages

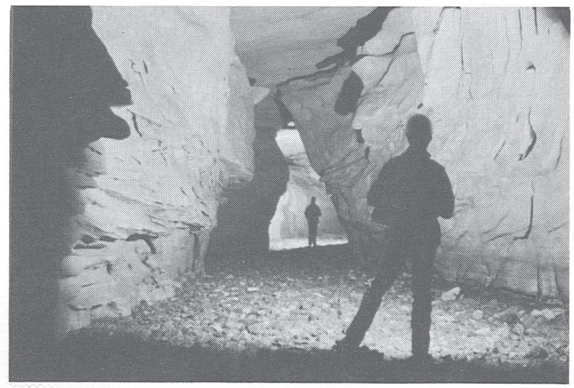


Fig. 14. Canyon Passage - this section can flood completely during storms!

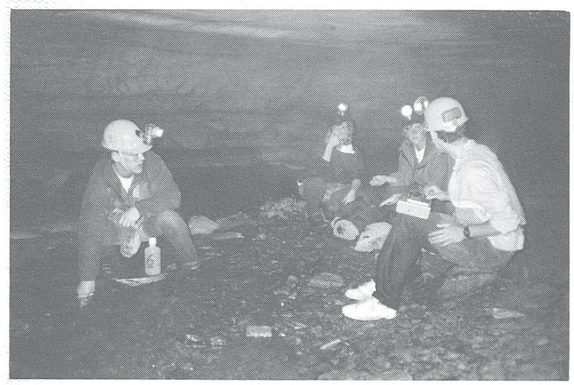


Fig. 15. Water sample being collected from the main stream

Fig. 16. Cluster of the endangered Indoara Bat, *Myotis sodalis*, in the Bat Room

inhabiting the cave yet he did not mention the presence of any bats, suggesting that the cave was not visited during the winter months. In 1896 the Oligunuk (=Oligunuck, Oligonunk, Ollegunuk) Caves [now known as the "Carter City Connection" or "Cow and Counterfeiter"] Caves were opened as a commercial venture. During the summer of that year the "Kinniconick and Freestone Railroad" began running excursions to the caves from Cincinnati. "The train would leave the Queen City at 7 a.m. and arrive at Garrison at 9:30 a.m. Here the train would split into sections of four coaches which was the limit the locomotives could handle over the Big Hill through Deep Cut.

"At the caves there were separate grounds for city folks and country people. On those rare occasions when an excursionist wandered into the wrong area, a good fight would inevitably result" (Sulzer 1967:92). Although not documented, it is highly likely that some individuals continued their journey to the caves in what is now Carter Caves State Park.

During the latter part of the 19th century, several publications appeared in which Bat Cave was cited as a locality for specific organisms (e.g., Emerton 1875, Packard 1883, Bollman 1893). Since that time many additional reports concerning the cave have been made, including Jillison (1924), Wolf (1934-1938), Williams (1962), McGrain (1966), Anonymous (1985), Hobbs (1985), and Conn (1981, 1986). [This is not intended to be a complete summary of the literature.] Conn (1986) not only mentioned the bats that occur in the cave but also discussed the beetles that have been observed. For further details concerning the fauna of Bat Cave and other caves in the Park, the reader is referred to Conn (1981).

In late 1961 the Central Indiana Grotto of the National Speleological Society constructed gates at the entrances to the cave. This was done in response to several bat kills that occurred during the previous decade. The gate was functional for a few years but floods took their toll on these structures. In 1969 a chain-link fence (Figure 1) was placed at each entrance but did little to deter traffic into the cave. In 1972-73 gates consisting of stone and a metal grate were placed at the entrances. Concern for the bats and an unobstructed flyway into the cave precipitated the construction and placement of the current angle-iron gates (Figure 2) in 1983. Roy Powers and numerous volunteers utilized the materials supplied by the Park and donated their expertise and hard labor to put the gates in place.

CAVE DESCRIPTION

Although a discussion of Bat Cave as observed circa 1870 has been quoted above (Anonymous, n.d.), the following is a brief summary of the passages mapped during this study. To date, only two previous attempts at mapping the cave are known: a 1961 map by Johnson, Keller, and Voigt and a 1966 map by Bill Edson; copies of both are in the collection of John Tierney at the Park. A very simplified map of the lower level also was published by McGrain (1966:14).

A description of Bat Cave naturally begins with a mention of Cave Branch. This stream traverses a surface and subsurface route through the Park prior to its entry into Tygarts Creek to the southeast. It is the local base level to which all small streams and springs drain and is directly responsible for the formation of several caves. It first sinks into the ground in the northwestern part of the Park near the upper, North ("Scenic") Entrance of Bat Cave ("Crystal Brook Cave" - Anonymous n.d.) and flows through the lower level of the cave (Figure 3) before surfacing near the Historic Entrance (Figure 1). It courses as a surface stream for several hundred meters and then passes beneath Carter Bridge, an impressive remnant of Bat Cave. The stream then winds its way southeast past a picnic area and enters Cave Branch Cave which underlies X Cave (see D'Angelo 1984). Cave Branch continues its southeasterly flow, passing by a number of small caves and pits (e.g., Constipation Cave, Green Trail Pit - see Hobbs and Pender 1986) and by the hanging valley of Horn Hollow (Hobbs and Pender 1985) and also Laurel Cave (Pfeffer et al. 1981). Within a kilometer it enters Tygarts Creek.

This 3.7 kilometer long cave is developed in the St. Louis and Ste. Genevieve limestones. For the most part, passages are of phreatic origin and Cave Branch flows on the upper section of the St. Louis limestone. In addition to dissolution, some areas have enlarged due to collapse of the thin, cross-bedded strata (Figures 3 and 4) of the overlying lower Ste. Genevieve limestone, which forms the ceiling in virtually all parts of the cave. The rocks in this area dip gently to the southeast at approximately 6 meters per kilometer and the Mississippian limestones are capped by the resistent Pennsylvanian Lee Sandstone.

At the lower or "Historic Entrance," the floor is irregular and covered with large breakdown blocks (Figure 5). Immediately adjacent to the main entrance are two additional openings. One is small with a low crawlway that intersects Cave Branch and connects to the main entrance passage. The other, larger entrance is to the east and leads to a 70m long tube that generally parallels the main passage but terminates in a sump. Just inside the main entrance on the west wall is a sizeable opening to the surface that is fenced. Approximately 70m into the cave from the fenced entrance is a sturdy angle-iron gate located at a constricted area less than two meters high and about eight meters wide (Figure 2). This gate is maintained by the Park and access is gained only by permission from the Park Naturalist.

Inside the cave, Cave Branch is observed crossing the main passage (Figure 6) and flowing into a smaller tube. This wet, pooled section can be traversed for approximately 60m to a sump, presumably the opposite side of the sump encountered in the eastern entrance passage (see map). By returning to the gate one can reach the "Bat Room" by following the passage upstream or by taking a short upper loop to the west; this shortly enters the southwest part of the Bat Room. During the winter thousands of Indiana Bats hibernate in this part of the cave (see below).

In this room, approximately 75m from the gate, the cave splits into upper and lower passages. The upper level is most easily reached through "Mud Hole Alley" (a short, slippery, stoop section with mud and a few shallow puddles) although there are several tight crawlways leading to it out of the Bat Room. This western, elongated, upper level parallels the lower stream level and is generally low (2m or less) and wide (Figure 7 and inside back cover). Development of a variety of speleothems occurs in this level, ranging from rimstone dams (e.g., "Great Walls of China" and "Bathtub Alley") and flowstone (Figure 8) to stalactites, stalagmites, and helectites. In addition to these sporadic forms, columns (Figure 7) are also occasionally observed. Kettles are part of the ceiling decor in the environs of "The Ladder". In addition to Mud Hole Alley, at least six connections to the lower level can be made: 1) "The Ladder" - a vertical tube; 2) a hands-and-knee crawl (Figure 9) beneath 3) "Donald's Duck Walk"; 4) Bathtub Alley is a crawlway over several rimstone dams; 5) numerous crawlway connections to the lower level in the area southeast of the "Pool Room"; and 6) the "Pool Room" connection. In addition, this generally dry level has many side nooks and several loop passages that are worthy of viewing (Figure 10). During Spring and late Winter drip pools near the Great Walls of China can become 10cm deep and many speleothems throughout the cave are active only during this period. Approximately 700m of passage are known from this part of the cave.

The lower level of Bat Cave is characterized by a stream that meanders across the gravel and mud floor with alternating shallow pools and riffles. For some 220m upstream from the Bat Room the height of this passage is less than two meters, thus earning this section the name of "Backache Avenue" (McGrain 1966:14). At the point where Donald's Duck Walk converges with the stream level a western loop passage parallels the main level and intersects it about 60m upstream (Figure11). Seventy meters upstream from here Bathtub Alley enters as an elevated crawlway (Figure 12). Here, the lower passage is 2.5-3m high and within 130m a waterfall is encountered, which during wet weather actively deposits flowstone on the west wall of the passage (Figure 3 and map). Within approximately 30m the stream disappears beneath the west wall near "Hatter's Hole". At this point the passage is 6-7m high and up to 30m wide and many large breakdown blocks clutter the floor of this large "Breakdown Room" (Figure 4), the largest room in the cave. Many crawlways and small cracks can be negotiated in this room and are not sketched on the map. A near-ceiling level connection to a wide and low upper level can be made in the northwest corner of this room; numerous small tubes and crawls are found in this upper level characterized by mud, breakdown, and a few speleothems. This wide, upper level connects through several conduits to the lower passage (Figure 13); several "rooms" are encountered, including the "Sauna". However, this level continues to the northeast for approximately 160m to the North Entrance.

If the lower level is followed northwest out of the Breakdown Room, the stream is again encountered (a low stream passage may be traversed for about 50m beneath the Breakdown Room - an interesting passage to negotiate with a carbide lamp since methane gas bubbles explode on the waters' surface as one moves through the stream!!). The main stream passage continues as a rectangular-shaped Canyon Passage (Figure 14), considerably different in character from any other section of the cave. [A no longer active landfill is situated immediately upstream from the North Entrance, used prior to 1963, and is being exposed by erosion; much refuse is washed into the cave during periods of high water. The nature of the material accumulated in the dump is unknown and much glass, plastic, etc. is observed in the Canyon Passage following storms. Water analyses currently are being made (Figure 15).] Several sharp bends in the canyon lead to a wider section where the stream first appears in the cave. Here, the large throughway is floored with much breakdown and passages continue to the west, south, and to the north. By continuing straight (west) one is brought into a large, high room that has a steep looping passage to the south which leads directly to the North "Scenic" Entrance, also gated with angle iron. By turning left (south) one can climb up a slope and enter the wide upper level at the Sauna Room. The right (north) passage is characterized by a flat, elevated area above the stream and is termed the "Bedroom". A climb north takes one over breakdown and into a series of moderately high (>3m), wide rooms having some breakdown and speleothems. Several small, low passages are found on the west walls of these interconnected rooms but little extensive passage has been found. This "Northern Extension" terminates in a mud-filled, breakdown area with very strong air flow. Continued efforts in this part of the cave have failed to produce additional passages but this is a promising lead that needs considerable digging effort.

THE BATS

Several species of bats occur periodically in this largest of the Carter County State Park caves: the Little Brown Bat (Myotis lucifugus), the Big Brown Bat (Eptesicus fuscus), and the Eastern Pipstrelle or "Solitary Bat" (Pipistrellus subflavus). By far the largest population of bats inhabiting the cave is represented by the Indiana Bat, Myotis sodalis. Individuals of this species inhabit the cave yearround but during the winter approximately 50,000 bats utilize the cave as a site for mating and hibernation. During late August and September, this migratory species begins to move south from Michigan, Indiana, and Ohio. Thousands arrive at Bat Cave (and others) and during the fall the population is active and moves outside at night to forage for insects in wooded areas. Mating takes place at night on cave ceilings near the entrances, typically in late September and early October, although mating may also occur through late November and can even take place in the spring as the hibernating colony begins to disperse. After the fall breeding period, the bats start a long duration of hibernation, lasting until the following spring (mid to late October into late March, April, or early May). They congregate in densely-packed clusters (300 or more individuals per square foot - see Figure 16) in moderately humid (average relative humidity is 87%) cave passages that range from 4-8C during the hibernation period. Generally they are suspended from the ceiling of caves although they are commonly in one or more layers wedged into wall or ceiling crevices. By mid May nearly all have migrated north. The young are born in late June or early July (each female produces a single batlet per year) and the females raise their young not in caves but in tree cavities, hollow tree limbs, or beneath exfoliating bark in riparian or floodplain woodlands and along wooded stream corridors. Little is known about the summer habits of this bat (see Barbour and Davis 1969) but young bats accumulate fat reserves in preparation for the autumn migration to the hibernation site.

In 1967 the Indiana Bat was listed as a Federally Endangered Species (see Lera and Fortune 1979) because its numbers had declined drastically. In 1976, recognizing the sensitivity of this bat to disturbance, 13 caves and mines in Illinois, Indiana, Kentucky, Missouri, Tennessee, and West Virginia were listed as Critical Habitats for this bat. Bat Cave in Carter Caves State Park is one of these sites and also is part of a Kentucky Nature Preserve that limits visitation to the cave during the hibernation period for scientific study purposes only. Thus, protection is provided not only for the bats in Bat Cave, but for the species as well. A Recovery Plan was approved June 1976 and part of its implementation includes population monitoring. During the early 1960's the bat population in Bat Cave was estimated to be approximately 100,000 (Michael Harvey - pers. comm.). For the past quarter century it has remained at about 50,000.

ACKNOWLEDGMENTS

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LIFE HISTORIES OF THE AMBLYOPSIDAE WITH AN EMPHASIS ON REPRODUCTIVE CYCLES

By Monika J. Palunas

ABSTRACT

This paper examines the life histories of the six species of the family Amblyopsidae. Special emphasis is placed on reproductive cycles using *Chologaster cornutus* as the base line species for comparison.

INTRODUCTION

The family Amblyopsidae, commonly known as cavefish or blindfish, is comprised of six species in four genera. *Chologaster cornutus* Agassiz is the only epigean (surface) species and is found in swamps and heavily shaded streams in the Coastal Plains. *C. agassizi* Putnam, a troglophile (facultative cave species), is primarily found in springs but is also known to inhabit streams and caves. *Typhlichthys subterraneus* Girard, *Amblyopsis spelaea* DeKay, *A. rosae* (Eigenmann), and *Speoplatyrhinus poulsoni* Cooper and Kuenhe, are all troglobites (cave obligate species). Both the troglophile and the troglobites occupy limestone caves in the Interior Low and Ozark plateaus (Cooper, 1985) (Fig. 1).

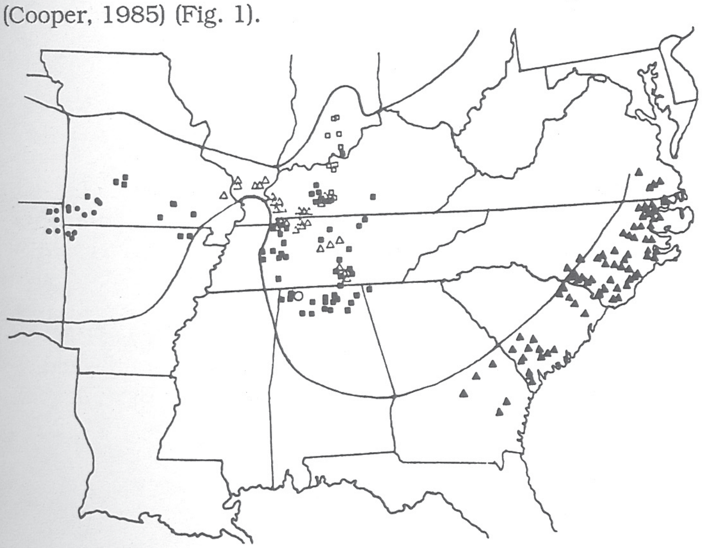

Fig. 1.—Published distribution records of the Amblyopsidae: *Amblyopsis rosae* (●), *A. spelaea* (□), *Typhlichthys subterraneus* (■), *Speoplatyrhinus poulsoni* (○), *Chologaster cornuta* (▲), *C. agassizi* (△), Modified from Cooper (1980) and Cooper and Rohde (1980)

The six species are ranked according to progressive degeneration of the eyes and loss of pigment. These characteristics are used as indicators of phylogenetic age because they reflect the length of time a species has been isolated (Poulson, 1985). Amblyopsidae may be subdivided into three phylogenetic lines: *Chologaster-Typhlichthys*, *Amblyopsid*, and *Speoplatyrhinus* (Culver, 1982). The focus of this paper is to compare life histories, with a special emphasis on reproductive cycles, within the family Amblyopsidae and its phylogenetic lines.

METHODS AND MATERIALS

The study of life histories in this report is structured in two parts: population structure and reproductive cycles. Observations and/or collections were carried out at many localities and were recorded over the course of several years. In addition water quality was monitored at all locales. Population structure was examined in the field by means of fish surveys (Poulson, 1963) and mark recapture techniques (Welch, 1972). Reproductive cycles, when possible, were monitored for fish in the wild as well as in captivity. Measurements were made on both living and preserved specimens (Poulson, 1963).

RESULTS

Data collected are shown in Tables 1 and 2 as well as Figures 2, 3, and 4. In Table 2, caloric cost of a clutch was calculated by multiplying eggs per clutch by egg volume, times 1.1 (density conversion factor), times 7300 calories per gram, times 2.5 for cost of production of a gram of egg. Risk to reproducing female is clutch calories divided by caloric equivalent for the reproducing female, times months of oral incubation, times standard metabolic rate (Poulson, 1985).

DISCUSSION

The absence of light and therefore primary producers; silence; relatively constant temperature which approximates the mean annual temperature of the region of the area in which the cave is located; and high humidity characterize the cave environment (Barr, 1967). Cave aquatic systems are well buffered from extreme change because unlike surface systems they are not as subject to seasonal changes. In the cave system such changes are noted by fluctuations in water temperature and alkalinity due to flooding and ground water infiltration (Poulson, 1963). These factors have played a major role in the evolution of Amblyopsidae population structures and reproductive cycles. As one moves along the phylogenetic line trends toward older populations and reduction in the reproductive effort are developed.

Chologaster cornuta inhabits swamps and well shaded streams in the Coastal Plains, areas which have readily available food sources. The species shows no eye degeneration or pigment loss; however, it is relatively inactive and nocturnal suggesting possible preadaptation to the cave environment. Individuals enter open streams in early April to spawn (Poulson, 1963). *C. cornuta*, unlike the other members of the family Amblyopsidae, are semelparous (ie. spawn and die) (Culver, 1982).

Chologaster agassizi, a troglophile, is found primarily in springs. Food sources here are significantly reduced from the environment of *C. cornuta*. Eye degeneration and pigment loss become apparent in this species, but not as significantly as in the four troglobites (Table 1) (Poulson, 1985). Spawning is thought to occur in February when water levels are at their highest and ova are fully matured. Fry and adults appear in epigean portions of their habitats again in early March (Poulson, 1963).

Typhlichthys subterraneus is the phylogenetically youngest troglobite and is found in caves which are close to the water level. Food is not abundant. These caves are flooded in the spring and consequently little is known about their breeding habits (Poulson, 1963). Woods and Inger classified this species as well as the two species of *Chologaster* in the same phyletic line: the *Chologaster-Tryphlichthys* line. Data show that to this point reproductive effort and risk increases with increasing cave adaptation (Table 2), indicating that the species has not been isolated long (Culver, 1982).

Amblyopsis spelea and *A. rosae* constitute the second major phylectic line according to Woods and Inger (Culver, 1982). Both species are troglobitic the latter being phylogenetically younger. *A. spelea* and *A. rosae* distribution may be seen in Fig. 1. Eigenmann reported in 1909 that *A. spelea* carried their eggs and yolk sac fry in their gill cavities (Poulson, 1963), today the Amblyopsidae are the only known family to be such gill-chamber brooders (Moyle and Cech, 1982). *A. spelea* breed anywhere from February through April, when water is at its highest level. Females then carry the eggs and subsequently the fry till they loose their yolk sacs, a period ranging approximately 4 to 5 months. Young therefore appear in late summer and early fall. Reproductive cycles in *A. rosae* closely parallel those of *A. spelaea* (Poulson, 1963). The *Amblyopsid* phyletic line shows a trend of decreasing reproductive effort and risk with increasing cave adaptation (Table 2), implying increased isolation (Culver, 1982).

Speoplatyrhinus poulsoni is the only species in the third phyletic line (Culver, 1982). Only recently found, 1967, this species may possibly be one of the rarest vertebrate species in the world. It is only known to inhabit Key Cave in Lauderdale County, Alabama from which eight specimens have been collected and preserved and only another ten specimens have been sighted. Little is known about this species due to its extreme rarity and difficulty in observing it in its habitat (Cooper, 1985). The species demonstrates increased troglomorphism and therefore is presumed to follow trends in life history and reproductive cycles as well (Poulson, 1985).

Several trends can be followed across all species. Longer life spans, older age at first reproduction (Fig. 1) and infrequent reproduction by fewer adults (Table 2) all indicate density dependence as a selective factor. In the cave environment, where food is a limiting factor, many individuals simply do not have the energy to reproduce. Poulson calculated that in *A. spelaea* only ten per cent of the population reproduces in any given year. He goes on further to say that, although iteroparous, most reproduce once at most and a larger more significant number never reproduce (Culver, 1982).

CONCLUSION

Life history data of the six species of the family Amblyopsidae reflect a movement away from r selection towards K selection. Poulson calculated as high as a five hundred fold decrease in r values from *C. cornuta* to *A. rosae* (Poulson, 1963). This evolutionary trend occurs due to increased isolation, the well-buffered cave environment, and density dependent populations (Poulson, 1963, 1985; Culver, 1982)

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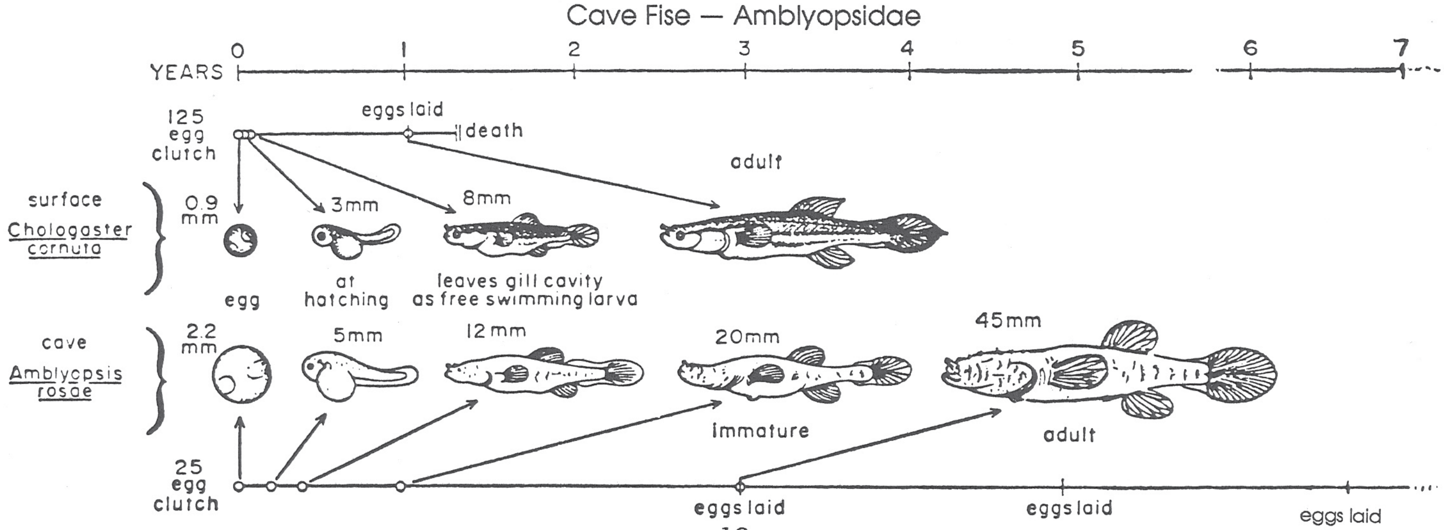
Life History Adaptations: Troglobite vs. troglophilic relative

Cave Fise — Amblyopsidae



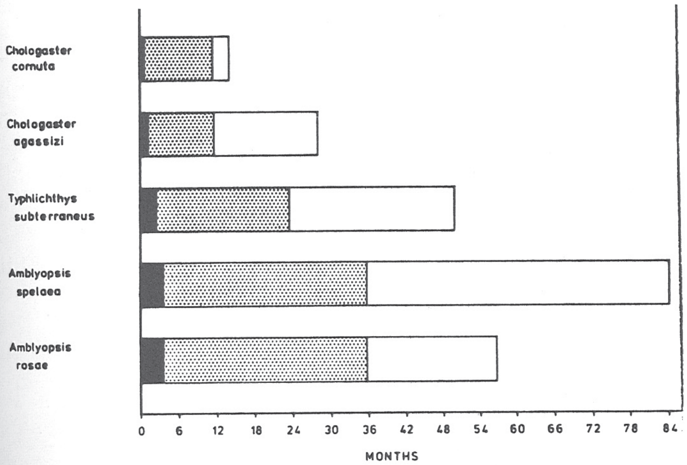


Figure 3–3 Life spans of species of amblyopsid fish. Black bar is time to hatching, speckled bar is time from hatching to first reproduction, open bar is reproductive life span. (From Poulson 1963.)

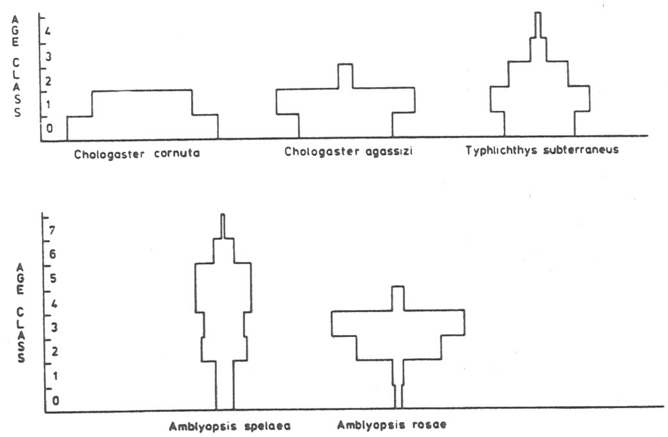


Figure 3–4 Age structure of five species of amblyopsid fish. (Modified from Poulson 1963.)

REDUCTION		Cc	Ca	Ts	As	Ar	Sp
VISION							
Eye	size (mm)	1.25	0.72	0.18	0.20	0.085	
	slope (b)	.94	.80	.25	.43	.09	
	parts missing	1	2	10.8	12.6	16.0	
Optic Lobe	(mm^3)	2.12	1.55	1.01	1.37	0.94	0.38
PIGMENT							
Melanophores	(no.)	103	50	90	6	0.7	0.6
	(b)	.71	.42	1.50	-1.10	-2.37	
	($mm^2 \times 10^{-3}$)	1.00	0.83	0.21	0.06	0.15	0.04
Dispersion	(range)	5	3.5	2	1	1	1
Chromatophores	(kinds)	3	2	1	1	1	1

Table 1. (Poulson, 1985)

Reproductive effort of amblyopsid fish. (Data modified from Poulson 1963.)

Species	Habitat	Mean no. ova per female	Ovum vol. (mm^3)	Female wt. (gm)	Average no. reproductions	Maximum no. reproductions	Per brood	Reproductive effort/ gm of female (mm^3) Lifetime observed	Lifetime maximum	Reprod. nsk to O	Clutch (ccu.)
Chologaster cornuta	Swamp	98.0	0.61	0.93	1.0	1	64	64	64	0.044	1863
Chologaster agassizi	Spring	152.1	2.80	2.87	2.0	2	148	297	297	0.084	12954
Typhlichthys subterraneus	Cave	49.8	5.20	0.86	1.5	3	301	452	903	0.065	7429
Amblyopsis spelaea	Cave	69.5	5.20	6.88	0.5	5	52	26	260	0.045	7914
Amblyopsis rosae	Cave	23.0	4.50	1.25	0.6	3	83	50	249	0.017	3809

Table 2. (Poulson, 1985)

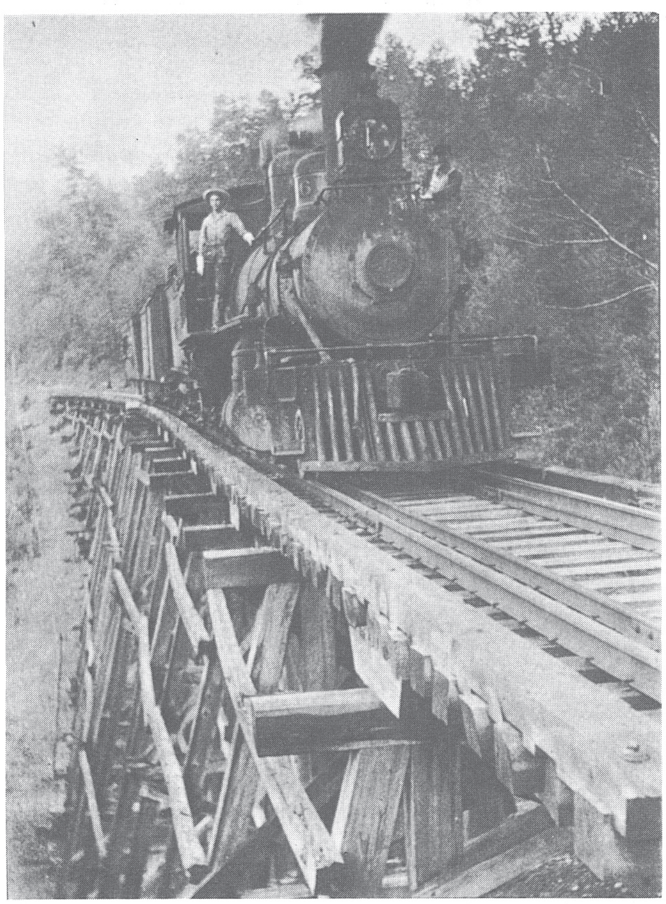
THE TRAIN TO OLIGUNUK CAVE

by Tom Klekamp

In March of 1890 the Kinniconnick & Freestone Railroad began operations by hauling freestone from mines at the towns of Tannery and Wolf Creek in Lewis County, Kentucky. The tracks worked their way north, along Trace Creek, to the railhead at Stone City, Kentucky (later renamed Garrison) on the Ohio River.

The railroad was named after Kinniconnick Creek in Lewis County, and "Freestone," a builders term for the thin fine-grained sandstone beds found in the eastern part of Lewis County. The "Kinney," as the railroad was called by the locals, eventually would carry visitors to the caves at Carter City.

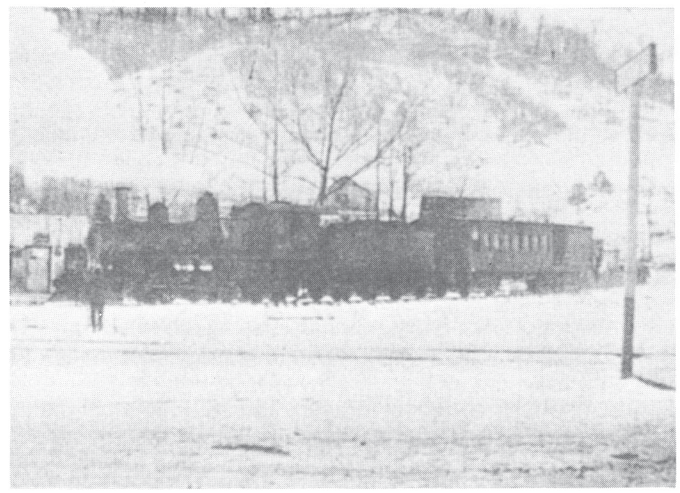
By 1892 the line was pushed further up Trace Creek to a point known as Wright (formerly known as Blue House). Here, freestone quarries were opened and also at Beckett's Spur. Eventually the line was extended up a very steep grade and across five treacherous wooden-timber bridges to Deep Cut, where it literally cut through the hilltop. (This is probably the present day 60-foot highway cut aproximately four miles west of Carter City, on Ky 1149 where it intersects Ky 474.) Trains passed through the cut and descended another steep grade the valley of Smith Creek, eventually reaching the sawmills at Poplar, just west of Carter City. Quarries were also opened at Poplar to take advantage of the new railroad. (These are the old Poplar Ballast quarries, 0.6 mi west of Carter City on Ky 474.)



The Kinney reached Carter City by 1893, twenty miles from its origin at Garrison. At Carter the trains reversed direction by backing onto a wye ("Y") shaped track. The Ramey Hotel was nearby, serving noontime lunches to the hungry train crews before the return trip.

1906-07 saw the merger of the K&F Railroad into the Chesapeake and Ohio, the major railroad in that part of Kentucky.

The final leg of the Kinney line was completed in 1926-27 when track was extended another two miles beyond Carter City, to Gesling, in order to reach a deposit of fire clay for brick-making. This brought the total length of the line to almost 22 miles.



The Oligunuk Caves were opened at Carter City in 1896. That summer the C&O Railroad began running tourist excursions to Oligunuk from Cincinnati. The train would depart Cincinnati at 7:00 a.m. and arrive at Garrison at 9:30 a.m. Here the train would be uncoupled into sections of four coaches which was the limit locomotives could haul up the grade to Deep Cut, reaching Carter City in the early afternoon.

There were separate areas at Carter City, the city folk and country folk each having their own "camps." This was done to prevent fights that would inevitably occur when a cave tourist wandered into the wrong camp. A pavilion was built for the cave tourists at the base of the hill below the Oligunuk Caves. In later years it was used as a cattle barn. (The 1978 photorevision of the Tygarts Valley Quadrangle shows the location on the north side of Smith Creek, near the junction of Ky Rte 2 & 474.) The Oligunuk Caves were situated near the top of the hill, two hundred feet above the valley floor. The Oligunuk is actually a "pocket-sized" cave system (now called the Cow-Counterfeiter's Cave System) with several entrances into the limestone bluffs at the top of the hill. These entrances lead to an intricate complex of passages. Remains of some old wooden stairways can still be seen in what is now called Cow Cave.

How long the Oligunuk Cave remained in operation is not known. There is, so far, nothing to suggest side excursions beyond Oligunuk to what is now Carter Caves State Park. Nor is there much known about the history and operation of the Oligunuk Caves, another interesting subject.

The timber, freestone and fire clay eventually became exhausted or in less demand. (Cave visitors may likewise become exhausted after a hike up the hillside to Oligunuk.) Improved roads opened up the region and the demand for rail service began to wane. The C&O Railway finally abandoned the track on April 22, 1941. In the end, the fate of the humble Kinney Railroad was dictated by the laws of economics. Interestingly there was one other railway hauling cave tourists in Kentucky during this time period. The Mammoth Cave Railroad (1886-1931) operated between Glasgow Junction and mammoth Cave, a distance of nine miles.

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3) John Tierney, Caves of Northeastern Kentucky, in Caves and Karst of Kentucky, *Kentucky Geological Survey*, SP 12, 1985, p. 83-84.

4) Ralph Haney (proprietor of the Haney Grocery, Carter City, Ky.), pers. comm., circa 1959.

FLOYD COLLINS REBURIED

(from the CRF Newsletter)

Sixty-four years after his untimely death in Sand Cave, William Floyd Collins has been buried in what will surely be his final resting place. On Friday, March 24, Collins' remains were removed from the bottom of the Grand Canyon in Crystal Cave, where his casket has lain since 1927, and buried in the Mammoth Cave Baptist Church cemetery, where his mother and several siblings are also buried. A private graveside ceremony was conducted by the Reverend Gary Talley. The burial took place at the request of some of Collins' descendents. According to Park Superintendent Dave Mihalic, it has been a long held family concern that Collins' remains be relocated and properly cared for in a maintained cemetery. CRF representatives attending the burial included Roger McClure and Kevin Downs.

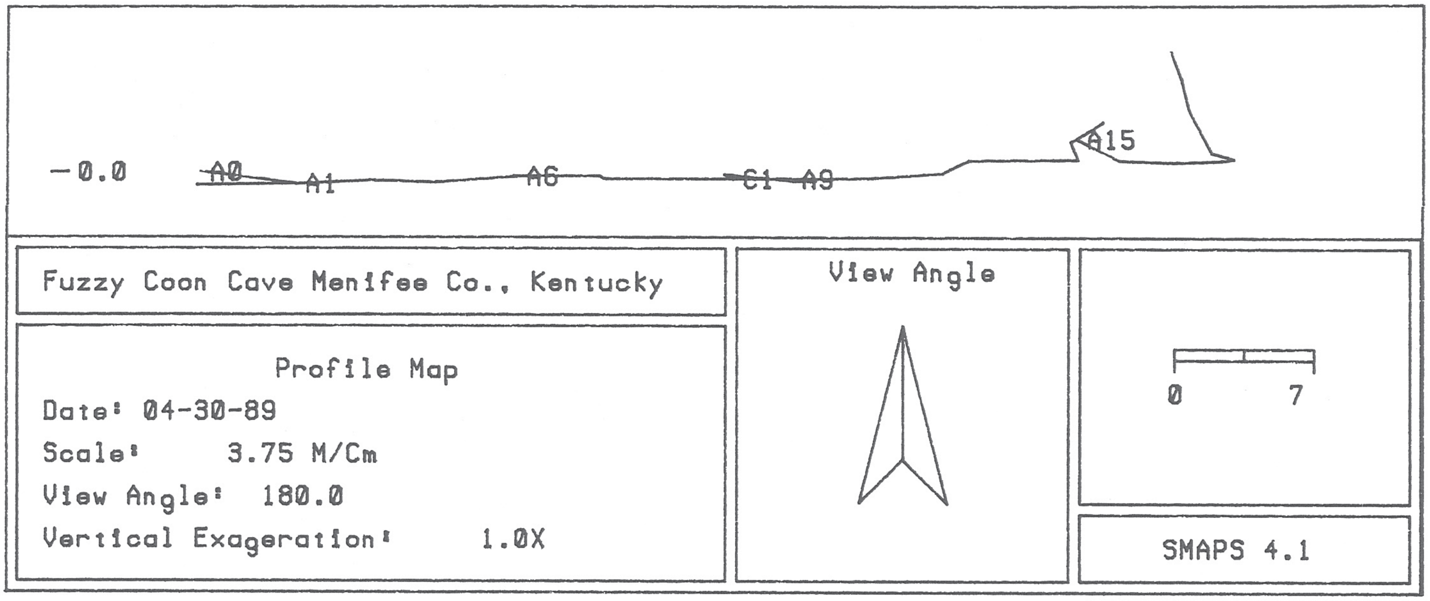
Collins' postmortem travels are legendary. When he died in February, 1925, after a long entrapment in Sand Cave, his father wanted the cave to be his tomb. His brother Homer, however, raised enough money to remove the body for proper burial. Two months after his death, his body was brought to the surface and reburied in the Collins' homestead cemetery, close to Crystal Cave on Flint Ridge. In 1927, Dr. Harry Thomas bought the Crystal Cave property, and with it the rights to Collins' remains. Thomas had the body disintered, and after necessary remedial work, placed it in a glass-topped casket in Crystal Cave's Grand Canyon, where it was a highlight of the commercial tour. In March 1929, the corpse was stolen. The following day, the body was found nearby and replaced in the cave, where it remained until this past March. On Thomas' death in 1948, the glass top was covered, but the casket remained a tourist attraction until the National Park Service bought Crystal Cave in 1961, and closed it to the public.

Floyd Collins has a special place in the affection of the Cave Research Foundation. It was Collins' discovery and early exploration of Crystal Cave that led the way for the later connection, by CRF cavers, of the major caves of Flint Ridge, and ultimately to the connection with Mammoth Cave in 1972. The present-day exploration and mapping program had its beginnings in Crystal Cave in the late 1950s. Floyd had always seemed to be a permanent fixture of the Flint Ridge scene. Crystal Cave will seem strange without him.

AN ACCOUNT OF FUZZY COON CAVE, MENIFEE COUNTY, KENTUCKY

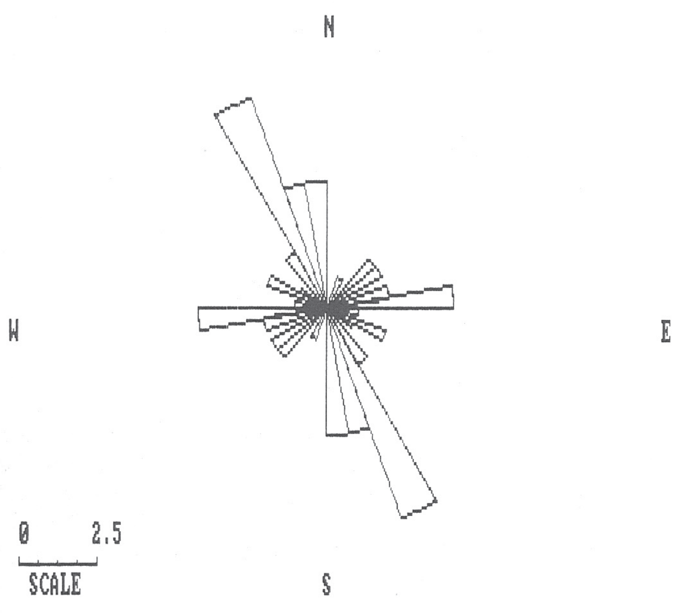
by
H. H. Hobbs III
NSS 12386RE,FE

Fuzzy Coon Cave is a small cave discovered by Chris Cooke and Bill Stitzel while ridge walking in the northern sector of the Daniel Boone State Forest. This represents the first of a series of cave descriptions to appear as a result of the Wittenberg University Speleological Society working in conjunction with the Boone Karst Foundation and other grottoes of the National Speleological Society



to locate and assess the resources of the caves developed within the Daniel Boone State Forest.

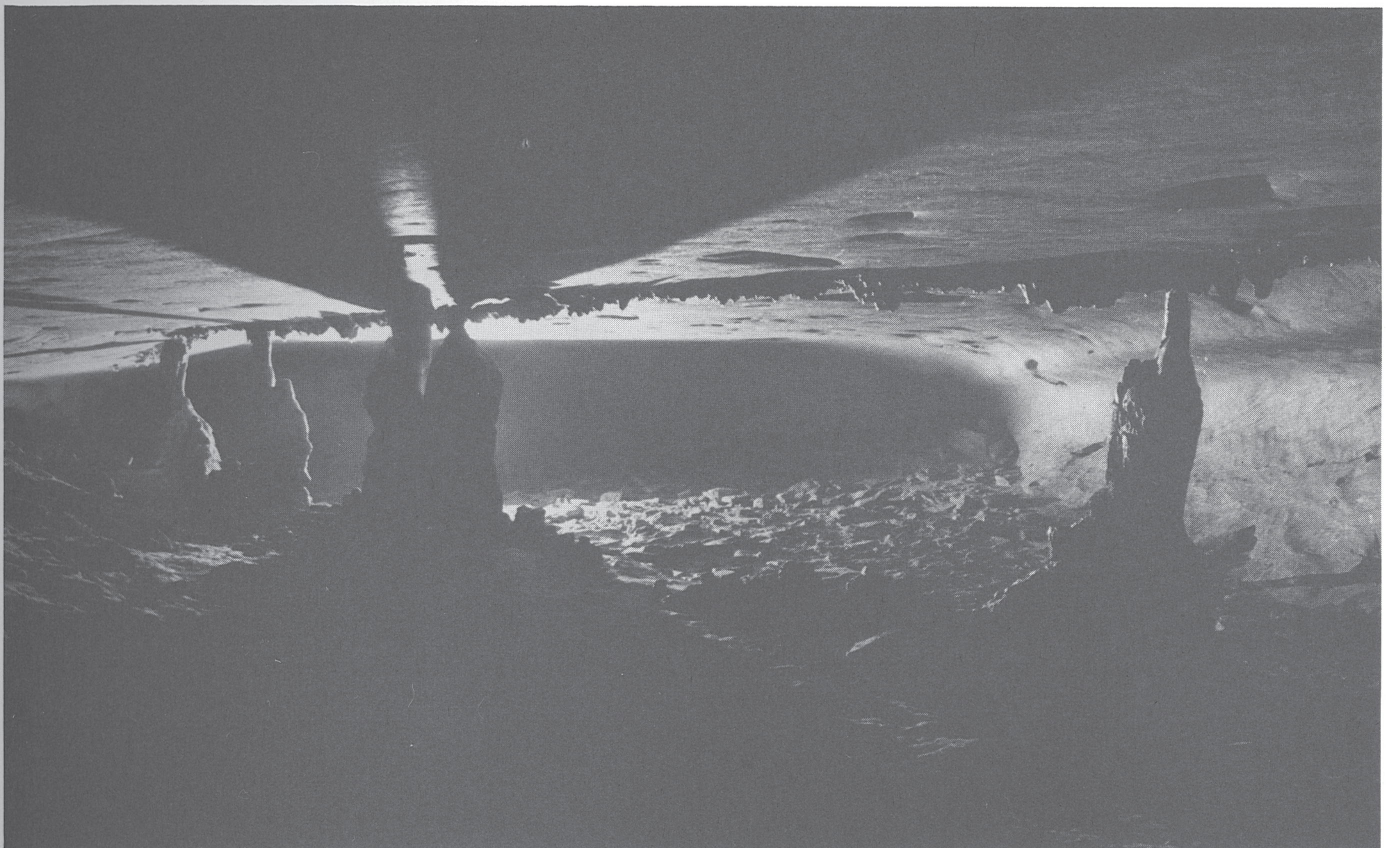
The cave is located in east central Kentucky, Menifee County, the entrances east of Indian Creek and south of Co. Rte. 713. The lower bluff entrance is situated at an elevation of 297m (975 feet) and is approximately 100m east of Chimney Cave (description and map will appear in a future issue of Pholeos). Although the cave probably was not virgin, no evidence of prior entry was noted by the pair during their initial reconnaissance. This entrance is approximately 4m wide and 1m high and the floor slopes downward as does the ceiling. Eleven meters into the cave the passage splits: a short right (south) and slightly uptrending crawlway becomes too small for further progress and a left (northeast) hands-and-knee crawlway leads to the remainder of the cave. This "Sand Tunnel" continues for approximately 20m before turning sharply to the right (south); a small passage branches to the left (north) at this point but is small and probably intersects the



bluff on the surface. By continuing along the 0.9m high Sand Tunnel a T-intersection is encountered some 29m down passage. At this point ("Tempestuous Junction") the character of the cave changes dramatically, with cobble replacing the sand floor. The passage to the right (southwest) trends upward slightly and is decorated with flowstone and rimstone. It turns left (south) and slopes downward to a shallow pool of water covering 9m of crawlway. Beyond this the tube continues as a low straight mud-floored passage and is in line with a prominent sinkhole on the surface near the Sinkhole Entrance.

By turning left (northeast) at Tempestuous Junction another intersection is encountered within 6m. The main passage continues to the right (south) and because of numerous large crystals in the ceiling, this area is termed "Crystal Bend". Breakdown is strewn on the floor and the passage height is as high as 1.8m but it soon drops to less than 1m. About 10m further into the cave the passage splits: the floor slopes upward and leads to several domes ("The Domes" - see map); a crawlway continues through a shallow pool to a low tube floored by a small stream and bounded on the west side by breakdown. This level terminates in breakdown but the cave continues at a higher level trending in the opposite direction (north). A climb up boulders brings one into Rat Hall where nests of the Cave Rat, Neotoma floridana, are conspicuous. An additional climb, now heading south, brings one to the Sinkhole Entrance.

This cave was mapped on 5 November 1988 and much wind blew through the cave and reversal of direction of flow was noted. While surveying, the cave cricket (Hadenoecus sp.), a phalangid, heleomyzid flies, and several solitary bats (Pipistrellus subflavus) were observed. On the initial trip Bill and Chris saw a raccoon (Procyon lotor), thus the name of the cave. The total horizontal cave is 118m (387 feet), with a maximum vertical extent of 9.97m (32.7 feet - see Figure 1); Figure 2 is a Rose diagram, indicating the general trend of the cave and thus joint patterns in the limestone bedrock.



Upper level bat cave.
by H. H. Hobbs