CAVE RESEARCH FOUNDATION 1975

Annual Report

CAVE RESEARCH FOUNDATION

Cover photo: Remains of aboriginal (?) basket in Ganter Avenue, Mammoth Cave. Photo by Roger W. Brucker.

Cave Research Foundation
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Cave Research Foundation 1975 Annual Report

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ACKNOWLEDGMENTS

Many of the projects outlined in this report have been conducted within the National Park System. The support and encouragement of the Superintendent and staff at Mammoth Cave National Park and at Carlsbad Caverns National Park have contributed greatly to the success of these projects and are gratefully acknowledged.

Dr. Patty Jo Watson's archeological researches were supported by the Cave Research Foundation, the National Geographic Society, Washington University and royalties from Archeology of the Mammoth Cave Area (1974), P. J. Watson (editor).

Dr. Thomas L. Poulson's biological work was supported in part by a N.S.F. grant.

Dr. Arthur N. Palmer's geological work was supported in part by a research grant from the State University of New York.

Highlights of 1975

The participation by Cave Research Foundation personnel in the Cave Management Seminar early in October is probably the major contribution of the Foundation this year. Held in Albuquerque and jointly sponsored by CRF, National Speleological Society, Bureau of Land Management, National Park Service, and U.S.Forest Service, the meeting attracted more than 100 individuals involved in or interested in cave management primarily on federal lands. A dozen CRF members and joint venturers presented contributions, backed by behind-the-scenes efforts from many other CRF people. We believe that there is substantial evidence that the findings from CRF research and activities are having a profound influence on how caves will be protected and managed in the future. CRF is subsidizing the publication of the Proceedings from the Seminar as part of its interpretive goal.

At the instigation of the Board of Directors, the CRF President has been carrying on a series of negotiations aimed at obtaining the interest of The Nature Conservancy, Inc., in the protection of Mill Hole Farm, near Park City, Kentucky. The farm contains an outstanding karst window, which reveals a section of an underground stream that has been traced from several locations on the Sinkhole Plain, and from there to Turnhole Spring on Green River, via Cedar Sink. Mr. Charles K. Elmore, the landowner, is a conservationist at heart and has been most cooperative in helping us describe the farm's many values to the Nature Conservancy.

We have substantially increased the number of announcements of the CRF Fellowship, and as a result experienced a 300% increase over last year in applications for support (5 vs. 15). Most of the applications were of excellent quality. We were pleased to award a $750 Fellowship to Mickey W. Fletcher, Southwest Missouri State University, for support of his project: "Microbial Ecology of Bat Guano". The committee also awarded two grants of $400 each to Barbara J. Martin, University of Illinois at Chicago Circle, for support of her project "Cave Communities Around Bat Guano", and to Jim I. Mead, University of Arizona, for his project "Pleistocene Plant and Animal Remains in Vulture Cave, Arizona". We provided additional support in the form of remission of fees of $500 to Kenneth C. Carstens, Washington University, for his continuing project on the archeology of the Mammoth Cave area.

Many of the Foundation's publications in 1975 resulted from efforts by dedicated individuals going back several years. The second edition of the CRF Personnel Manual has been acclaimed as an excellent sourcebook for "project caving". We also published the Lee Cave map, and the Gazetteer of Place Names in Lee Cave. Both are exemplary prototypes of some new maps of the Flint Mammoth Cave System currently in preparation. A new map card showing the Flint Mammoth Cave System updates an earlier edition and is a popular interpretive tool at Mammoth Cave National Park. The CRF Report on the Barra Honda Karst has been submitted to the Costa Rican government, and negotiations are underway for its publication. A reprint edition of The Caves Beyond is scheduled for publication in December. Significant work has been done on three projects "in the pipe": Ogle Cave Symposium, a comprehensive report on a single cave slated for an NSS Bulletin; a map card showing New Cave in Carlsbad Caverns National Park, and The Longest Cave, scheduled for May 1976 publication.

The Foundation initiated a new project in the form of a reconnaissance of the Wupatki National Monument earth cracks in Arizona. Field work is expected to be completed by the end of 1975. Earth cracks are tectonic features in limestone, modified by solution. The project involves mapping, biological, geological, and archeological reconnaissance, and photography. The Saltpeter Project of the Foundation continues from the work started in 1974.

In the interpretation area, CRF personnel carried out a successful presentation to personnel at Carlsbad Caverns National Park. The National Park Service expressed thanks for this contribution. In the Mammoth Cave area, a significant interpretive effort in "Rock Reading", a method of teaching the recognition of bedrock members to exploration and survey personnel, resulted in two contributions: a large illustrated wall chart, and a monograph on the subject. Interest remains high in developing this tool as a means for bringing back more information about the caves.

Exploration and survey continued in the Mammoth Cave area and Guadalupe area and in Arizona. Although we experienced no spectacular breakthroughs, progress was solid and substantial.

Finally, communication among CRF personnel has increased. CRF Newsletter issues this year totaled 16 pages. And the President's extended visit with CRF personnel in Texas, New Mexico, and Arizona helped make us feel more in touch with the many CRF programs.

Roger W. Brucker, President
Cave Research Foundation

President's Report

Sowing and Reaping

Cave Research Foundation programs might be viewed as a simultaneous sowing and reaping process that continues through time. Some programs stretch out toward the foreseeable horizon of time, like the cartographic program in the Central Kentucky Karst. Other programs are brief. Some are so fleeting as to be classed as short-lived phenomena, such as our offer of a $500 emergency interest-free loan for a paleontological project related to a cave in Wyoming.

The need for the money was explained to the president in a long-distance telephone call. The CRF President conferred with the CRF research director by phone. Between them they reasoned that the emergency might be de-fused by a firm loan offer to the investigator. A few days later, the investigator reported that the offer of the CRF loan had been a factor in convincing the authorities of the importance of the project, and the problem was no longer an emergency. We urged the investigator to apply for a CRF Fellowship or grant, even though the need for an instant loan had passed.

How many other educational and scientific support organizations could respond so rapidly to an opportunity? And how many other foundations can afford to solicit, review, evaluate, and respond to small and medium size project requests? If the Cave Research Foundation has a niche, it is in its commitment toward encouraging talented people to undertake important -- and sometimes risky -- research in the absence of massive government support. Our problem is that we find five promising people for every one we can support.

How can this be done with a volunteer staff? Caves tend to attract self-reliant people who are resourceful and industrious. Since our founding in 1957, we have successfully "grown our own" research support staff, and, through CRF support, some individuals have been helped to reach a position of pre-eminence in their own fields of science. The generosity of these two groups provides the cash; and the dedication and sweat-equity of others provides the capital.

If CRF is to respond to increasing opportunities to support cave-related science, education, and conservation, we will need more money. One of the "reaping" programs is the anticipated publication in May, 1976, of The Longest Cave, by Roger W. Brucker and Richard A. Watson, published by Alfred A. Knopf, Inc. The book is the story of the connection by Cave Research Foundation personnel which resulted in the integration in 1972 of the Flint Mammoth Cave System. Revenue from the book will go to CRF for its programs.

In the future we expect to seek funds more aggressively from other sources. We will look for organizations that want their money to produce maximum-leverage in basic science -- particularly in the encouragement of individuals likely to make lasting contributions. Such organizations will want assurance that their funds are managed prudently, and that accountability is evident. The Cave Research Foundation is prepared to render this kind of service.

To those impatient with the slow growth of CRF (to a $25,000 annual budget in 18 years), we can only report solid progress, and offer the observation that the caves weren't made overnight, either. Prospects for a good future crop are encouraging.

CRF Problems

Our major problem is to encourage investigators who are competent but are not professionally motivated by "publish or perish" pressures, to report what they have found. Without externally-imposed deadlines it is human nature to wait until more information is available before rushing into print. To tackle this problem CRF operates several cartography programs directly. Maps are basic to many cave studies (and therefore can be a bottleneck if they are not available), so we have tried to focus a great deal of our science support on timely map production. We also operate several networks of editorial assistance to help investigators get written reports into the best possible form. And we try to provide field assistants and the facilities of two field stations when investigators need them. Nevertheless, getting out publications remains our primary internal problem.

A second problem CRF faces is to develop an international viewpoint. After the Guadalupe Cave Survey merged with CRF, we spent several years trying to convince ourselves that we had achieved instant national focus, when in fact we had only acquired two regional foci. I am pleased to report evidence that our parochialism has been diminishing and our outlook is becoming more global. We are considering the possibility of a second CRF expedition outside the U.S.A., to Iran in 1979. (The first was the 1974 CRF expedition to Costa Rica.) We are looking for other worthwhile projects to support. The regional emphasis is also shifting: 60 percent of the current CRF directors reside west of the Mississippi River.

A third problem for CRF is to find ways to make meaningful contributions to the science or art of cave management. Cave managers are showing increased understanding of, and sensitivity to, environmental threats. CRF, among others, has provided some of the background on which this awareness has been built. The problem is this: given CRF's goals of helping to conserve and interpret caves, how can we make a more direct impact? One strategy we have pursued is to advocate the establishment of several areas of Underground Wilderness under the provisions of the U. S. Wilderness Act of 1964. We are exploring ways to support studies on cave "carrying capacity" -- the assessment of the impact of cave use on the cave environment. We need better insights to define the problem.

I think the opportunities and challenges inherent in these problems will intrigue us and stimulate us to new initiatives. What helps to make the effort worthwhile is a shared sense of mission, an optimism based on real accomplishment, and personal satisfaction among friends.

Roger W. Brucker

Roger W. Brucker
President

Scientific Programs

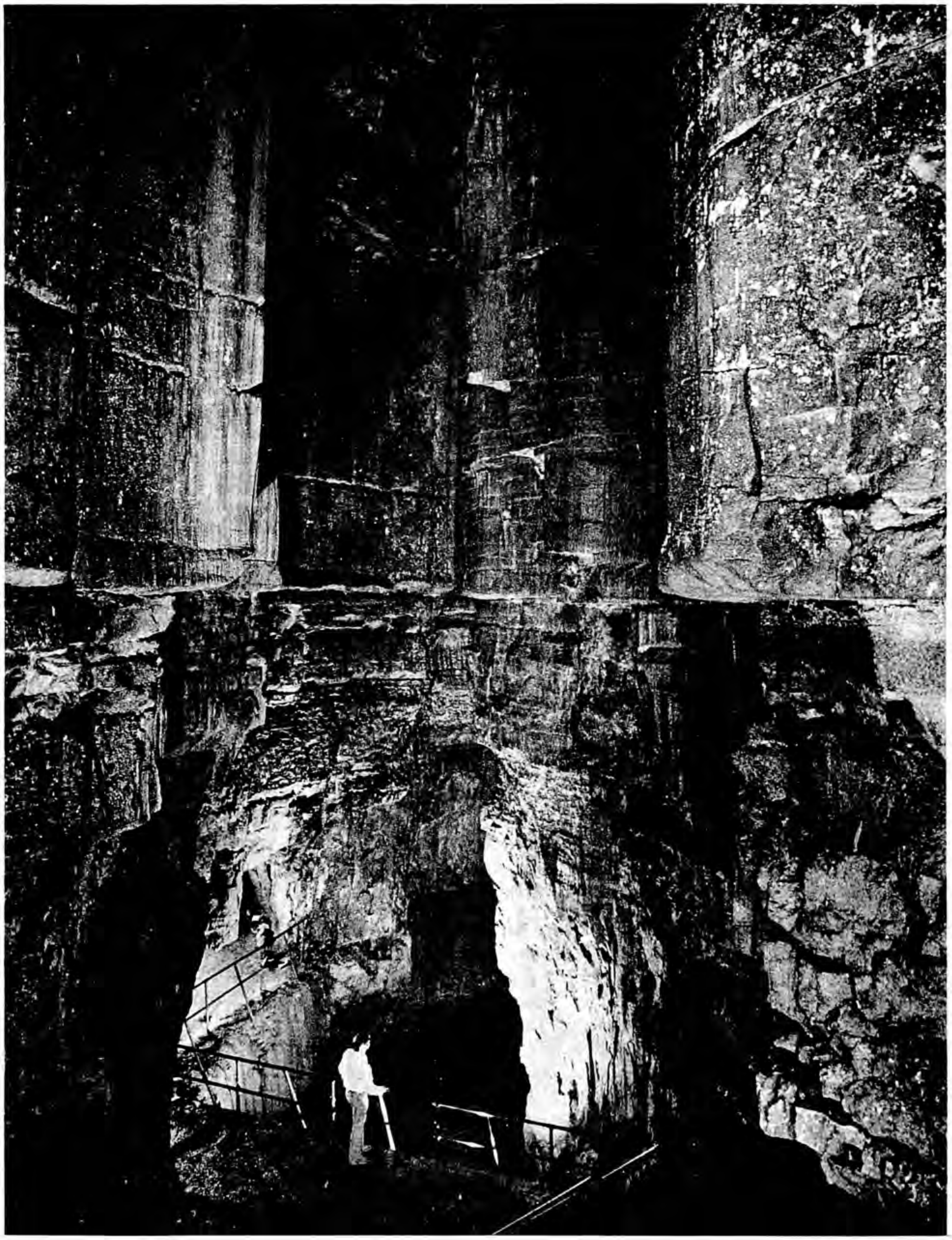


Figure 1 (page 7): Mammoth Dome, in Mammoth Cave, Kentucky. The massive rock unit shown in the upper half of the photo is an oolitic bank deposit locally more than 20 feet thick within the Fredonia Member of the Ste. Genevieve Limestone. The irregular weathering below is predominantly within dolomitic limestone. The basal unit of the Ste. Genevieve is the massive, fluted biosparite that forms the lowest beds visible in the figure. Photo by Arthur N. Palmer.

Cartography

Exploration and Cartography in the Central Kentucky Karst

John P. Wilcox, Patricia P. Crowther, William R. Crowther,
William F. Mann, and Diana O. Daunt

Field work this year has been concentrated in Mammoth Cave, where extensive new passages have been found under the north flank of Mammoth Cave Ridge. The past and present patterns of drainage from Eaton Valley are being revealed.

Underground survey during the twelve-month period ending November 1, 1975, has totalled 15.65 miles, 92.6 percent of it in passages previously unsurveyed by the Foundation. The surveyed length of the Flint Mammoth Cave System has been increased to 176.7 miles.

The Lee Cave map and Gazetteer has been published, as has an updated Flint Mammoth Cave System map card with the additions of Great Onyx Cave and Proctor Cave. Updated field maps of the Cleaveland Avenue - Mystic River Area, Colossal Cave, and Proctor Cave have been drafted. Detailed manuscript maps of the east end of Mammoth Cave are in progress.

Exploration and Survey in Flint Ridge

Again this year, most of the 1.73 miles of new survey in Flint Ridge came from the Bedquilt section of the cave. The Silver Lining Passage, discovered last year as a result of the Crowthers' intensive work in Bedquilt, has been extended eastward under the valley containing the Bedquilt Entrance, but seems to comprise only local drainage. In Crystal Cave, a new connection was found between the Black Onyx Pit area and Eyeless Fish Trail. The Storm Sewer is no longer the only passage linking Crystal Cave with the rest of the system. The current surveyed length of the Flint Ridge Cave System is 92.92 miles.

Exploration and Survey in Mammoth Cave

The survey of passages shown on the Kaemper map was virtually completed this year, and most of the 12.35 miles surveyed in Mammoth Cave was in previously unmapped passage. The explored length of the cave continues to grow rapidly.

In the historic northwest end of the cave, Fort's Way, Gallows Way, Sylvan Ave., and Briggs Ave. have been surveyed. The most exciting new discoveries have been made through Carlos' Way, a low-level tributary to Echo River near River Hall. This passage trends northeastward, passing under the Wooden Bowl Room area and continuing far out under the center of Eaton Valley, where it gives access to a drainage network including two important rivers. It also gives access to two segments of twenty-foot-wide walking tube passage at a higher level, several thousand feet of an important paleo-drainage system that probably carried water into the Gorin's Dome area.

In the middle portion of the cave, Cutliff's Way, an upper-level passage off Silliman's Ave., has been found to extend far beyond the end of previous surveys to a shaft complex with active drainage located approximately above Cascade Hall. Other leads extending northward from Emily's Ave. have been followed to junctions with two segments of a ten-foot-wide and thirty-foot-high canyon paralleling the known sections of the cave to the northeast.

Recent exploration in Franklin Ave. has led to a low-level walking passage that is heading southeast under the head of Deer Park Hollow.

Numerous survey teams have completed the pedestal lines through tourist trails from the Carmichael Entrance to Frozen Niagara and from the Historic Entrance to Violet City. Sparks Ave. and other low-level portions of the Historic Tour route have also been surveyed.

CRF survey in Mammoth Cave now totals 82.11 miles. The Kaemper map shows an additional 1.7 miles of passage not yet surveyed by the Foundation. The surveyed length of Mammoth Cave is therefore approximately 83.8 miles.

Small Caves

Two small caves adjacent to, but unconnected with, Mammoth Cave were surveyed this year. Dixon Cave comprises 900 feet of main trunk passage between Mammoth Cave and the Green River. Hackett's Cave is a 345-foot-long, multi-level shaft complex near the Frozen Niagara Entrance.

On Joppa Ridge near the east boundary of the Park, McGowan's Pit was descended. It has 130 feet of survey and going leads.

Exploration and Survey Report: CRF-West

John J. Corcoran III and James M. Hardy

The following summary is for the period of January 1, thru November 1, 1975. Activities were widely spread geographically this year with projects in southern New Mexico recieving the most attention. A new project in Wupatki National Monument was begun in Northern Arizona, and considerable work took place in smaller back-country caves in the Guadalupe Mountain area. Small but productive expeditions were sent to Fort Stanton Cave and Edgewood Caverns to fill out the year's efforts.

CAVE	1975 SURVEYS		TOTAL TO DATE
Carlsbad Caverns	2,180	ft. (cave)	108,888 ft.
Chiveros	443		443
Corkscrew	564		564
Crystal	687		687
Decorator	164		164
Doc Brito	808	(cave)	808
	1,000	(surface)	7,200
Dome	236		236
Dry Pot	1,732	(cave)	20,308
	729	(surface)	27,917
Edgewood	723		9,605
Fort Stanton	3,937		39,437
Ladder	136		136
Porcupine	180		180
Swallow	582		582
Wind	180		4,347
Wupatki *	720	(cave)	720
	24,778	(surface)	24,778

* The surveys in Wupatki National Monument were in the Doney, Lomaki, and Malmquist fissures, which are non-solutional earthcracks.

CRF-West Cartographic Projects

John J. Corcoran III and James M. Hardy

Projects within Carlsbad Caverns National Park

CARLSBAD CAVERNS: Work continued on the quadrangle maps in the Left Hand Tunnel area, with three quadrangles now in manuscript stage, and two others about 90% complete. An overall work map of the entire cave was begun with the intention of eventually producing an index map of the cave at a scale of 1:6,000. The map of Bat Cave was begun.

DOME CAVE: The map has been completed except for final inking.
PORCUPINE CAVE: Map completed.
LADDER CAVE: Map completed.
RAINBOW-OGLE CAVE: Map completed, to be published in 1976.
NEW CAVE: Master map completed, currently being redrafted at a smaller scale for publication in early 1976.
SPIDER CAVE: All surveys are now drafted and the manuscript map is now being prepared. Publication is hoped for by mid-1976.

Projects in Guadalupe Mountains National Park

CHIVEROS CAVE: Map completed.

Projects in BLM Caves

DRY POT: Redrafting and updating of the map is under way, with completion of all existing surveys hoped for by December, 1975. Publication is planned soon.
FORT STANTON CAVE: Drafting of Valentine Passage, Sewer Pipe, and Snowflake Passage Quadrangles brought up to date, to be inked early in 1976, bringing total number of completed quadrangles to 10.
WIND CAVE: Drafting up to date, preliminary manuscript map to be prepared early 1976.
DOC BRITO CAVE: Drafting of preliminary map is currently being worked on, to be completed early in 1976.

Figure 2: Mather Avenue, Flint Mammoth Cave System. Photo by Roger W. Brucker.

Hydrology

Drainage in the Eastern Sinkhole Plain, Central Kentucky Karst

Joseph W. Saunders

Grady's Cave

Several square miles of sinkhole plain adjacent to the Green River east of Munfordville are drained by the main stream in this cave. All but 800 feet of the 9.75 miles of presently surveyed passage lie at base level. Flow in dry weather assumes a dendritic form, centering around four miles of trunk passage (having an average cross-sectional area of three hundred square feet). In high flow more than three miles of flood routes carry drainage in a more braided pattern. Most overflow passages can be interpreted as either diversions around collapse in the main stream, or segments of former main-stream passage containing collapse. Collapse diversion passages in Grady's attain cross sectional areas as great as fifty square feet. The abandoned main stream passage is usually larger. In addition, flood routes are known which do not obviously fit into either category.

Inference about the history of subsurface drainage in the area of the cave is limited by the nature and extent of the known passages. Speculation based on available observations suggests that the present resurgence of the main stream (low-flow discharge of 1 - 2 cubic feet per second) on the Green River is the third in a series. The cave's two entrances on the river, one a spring and the other an overflow discharge site, appear to have been past resurgences. There are also indications that part of the main stream passage was formerly used as a subterranean cutoff of the mile-wide meander of the Green River nearby. The cave is situated in the shaly and cherty limestones of the lower St. Louis, and flow orientation is a combination of along the strike and down the dip. (The local dip is 50 feet per mile to the WSW, according to the Canmer geologic quadrangle.) Except for the far downstream reaches of the main stream, low-flow drainage is entirely by free-surface streams graded to the Green River. The Grady's system may be intermediate between smaller systems upriver which are perched on the underlying Salem Limestone, and the apparent alluviated systems downriver. Gerald (Boyd) Spring, the next major spring downriver from Grady's Spring, is a gravity spring only in low flow. The Blue Hole, next downstream from Gerald Spring, is completely alluviated.

The overflow passages are the features in Grady's Cave that are important for an understanding of the extreme degree of cave and drainage integration found in the Flint Mammoth Cave System and to a lesser extent in other Central Kentucky Karst areas. The ability of a cave stream to develop bypasses around collapses contributes both to the complexity of the system and to accessibility for explorers to a greater proportion of the past and present drainage systems. One overflow route in Grady's links the main stream with a smaller system to the north at base level. Another flood route (cross sectional area approximately 350 square feet) carries water and air through a massive collapse choke into the main stream. It is likely that this flood water is derived from the adjacent drainage system to the southwest. Verification awaits future exploration and dye tracing.

The Blue Hole

Divers Kevin Hennings and Ed Arters penetrated this alluviated spring (1 - 2 cfs in low flow) 150 feet before their line ran out. They reported a flat ceiling at 30 feet below low-flow pool level, in a eight-foot-high, fifteen-foot-wide passage trending northwest, parallel to the Green River. What was described as small quantities of eroded ceiling formations are perhaps the first evidence from local cave passages that the river level was lower at one time. Future diving at this spring will attempt to penetrate farther through the low-visibility water, with further efforts to characterize the formations found.

Crump Spring Cave, A Chester Cuesta Cave

Joseph W. Saunders

Crump Spring Cave is located on the northern edge of Fisher Ridge, 4½ miles east of the Salts Cave entrance of the Flint Mammoth Cave System. A total of 9.5 miles of passage is known, consisting of two sub-parallel abandoned trunk passages of modest size, many active or abandoned tributaries and abandoned diversion passage. No active trunks or recognized base-level passages are known. Present flow and paleo-flow appears to consist mainly of local shaft drainage, most likely to the vicinity of Lawler Blue Hole two miles north on the Green River. About thirty percent of the proposed paleo-flow distance from head-waters to river can be seen in the cave.

Interpretation of past flow patterns is relatively easy in Crump . Passage modification due to collapse and flowstone is minor, probably owing to the small size of the passages and to the sandstone caprock overhead. Integration of the cave with former drainage lines was primarily through three recognized passages which crossed drainage divides, as well as through lower-level cutoffs that provided a hydrological connection with different drainage levels. These cutoffs are traversable piracy routes. One classic series of cutoffs consists of five different piracies of drainage from one shaft area. The uppermost conduit draining this shaft area comes in at the top of the Crump Avenue Trunk, with ceiling, but not floor, graded. The initial piracies of this tributary returned drainage to the trunk downstream at a lower level in the wall. Later cutoffs carried drainage in separate lower-level conduits which joined other tributaries and a diversion route at grade. Given even a small seasonal vertical range of base level, pirated upper levels could have

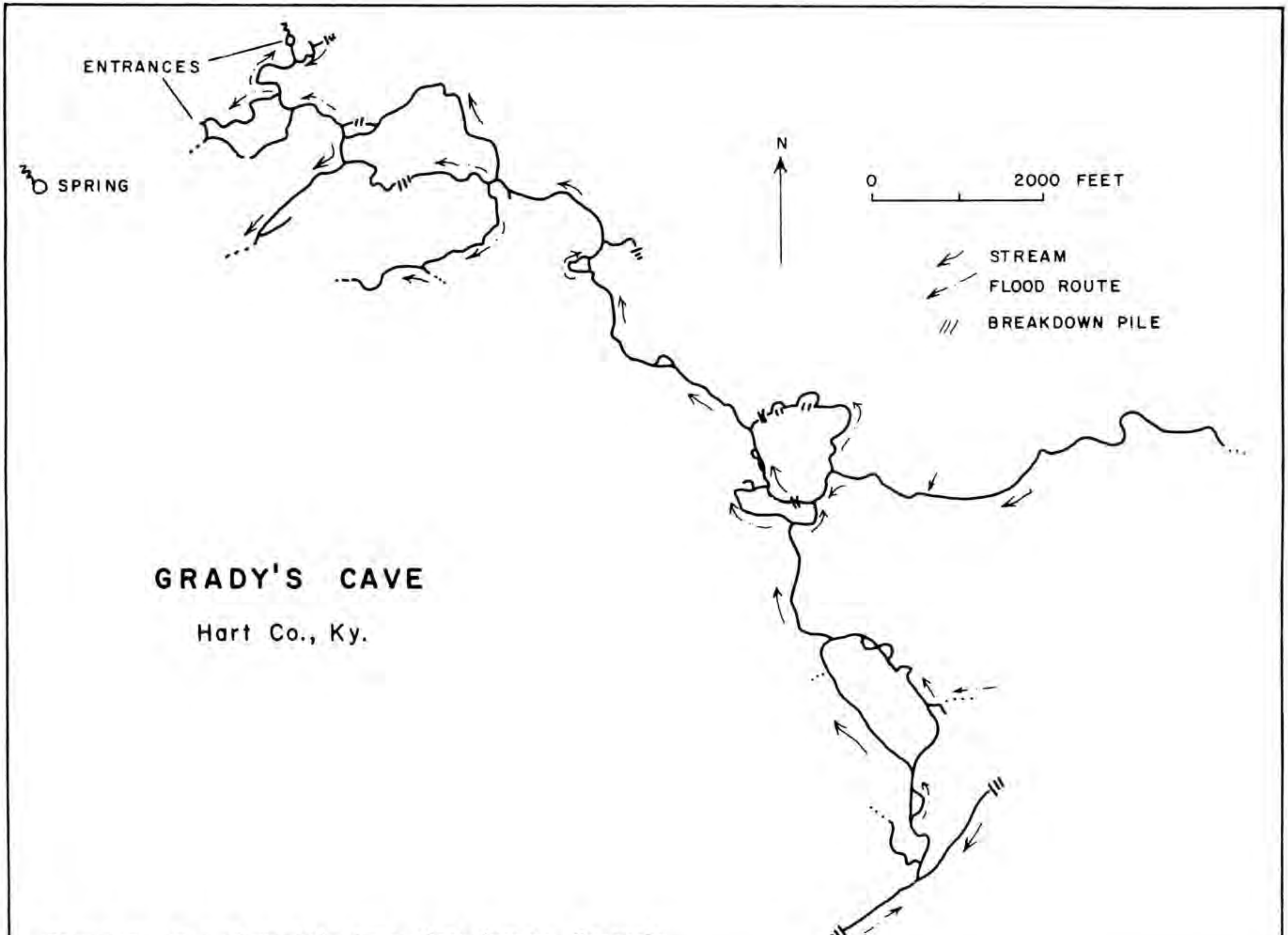


Figure 3: Map of Grady's Cave, Hart County, Kentucky

served as flood routes in high water. Not only did these cutoffs serve to vertically integrate drainage, they also integrated drainage laterally, just as did collapse diversions. An example is the 2000-foot-long Expedition Crawl which cut off the eastern trunk stream and carried it westward into the western flow route.

One goal of karst hydrologists is to understand the processes by which drainage routes for subsurface waters are localized horizontally as well as vertically, whether by stratigraphic, topographic, or other restrictions. It would appear that in caves of the Central Kentucky Karst these restrictions are minimal. Lateral integration of drainage by shifting or by seasonally disappearing drainage divides, such as between Flint and Mammoth Cave Ridges, is a major reason for the length of the Flint Mammoth Cave System.

As exploration and survey continue in Crumps, interpretive work will concentrate on stratigraphic location of important ceiling bedding partings, their relation to the lower-level cutoffs, and the way in which passages change beds as they work their way up or down in the geologic column.

Paleohydrology Patterns in Toohey Ridge

James D. Borden

Reconnaissance work on Toohey Ridge has been conducted in earnest this year. The principal goals of this work are to discover and map the caves within Toohey Ridge in order to further the knowledge of the paleohydrology of the Central Kentucky Karst. Principal work to date has been conducted by James C. Currens and James D. Borden.

Toohey Ridge, just east of Mammoth Cave National Park, is one of the major ridges of the cave-studded Mammoth Cave Plateau. It measures four miles in length and about one and a half miles in width. This ridge is one of the few north-south trending ridges in the area. Valley bottoms adjacent to the ridge lie at about 675 feet and the top of the ridge reaches an altitude of nearly 1000 feet.

Two years of systematic surface exploration climaxed in the location of 27 caves, potentially leading to extensive passageways. At least six of these are noteworthy. American Beauty, Renick, and Jakes Caves all contain segments of trunk passage at various levels within the geologic column. Jakes Cave terminates, but an excavation is in progress through breakdown that emits enough air to extinguish one's carbide light. American Beauty and Renick Caves still have lower level leads that remain to be explored. Three other caves (Wildcat Hollow, Dry Valley, and a cave below the ridge in the plain between Toohey Ridge and Huckleberry Knob) hold much promise. The former two appear to be valley drains directly enterable from the surface. Wildcat Hollow Cave has been explored several thousand feet as a low crawlway blowing much air. Dry Valley appears to be of similar nature but it still remains unexplored. The cave beneath the plain appears to be a horizontal passage exposed at the surface by collapse of the ridge side. Owing to landowner problems and sudden wet weather, exploration of these three caves has been postponed. The remaining known caves are mainly open pits leading to shaft complexes. As these are at elevations of roughly 900 feet, some very deep shafts would be expected, but only one in excess of 40 feet in depth has been found; and that one is only 90 feet deep. Obviously a restricting, less soluble bed is impeding vadose drilling. From all investigations, the restricting bed appears to be a thin shale in the upper or middle Girkin Formation. The majority of the pits on Toohey Ridge remain unexplored.

Most stratigraphic horizons can be traced from within the National Park to Toohey Ridge, so geologically the areas are nearly identical. Toohey Ridge is up-dip from the Park, so the rock units are located at higher elevations. The top of the Girkin Formation is at an average altitude of 880 feet, and the capping Big Clifty Sandstone extends upward for more than 100 feet. At the lowest, only the upper parts of the Ste. Genevieve Formation are exposed on the surface in the immediate vicinity of Toohey Ridge.

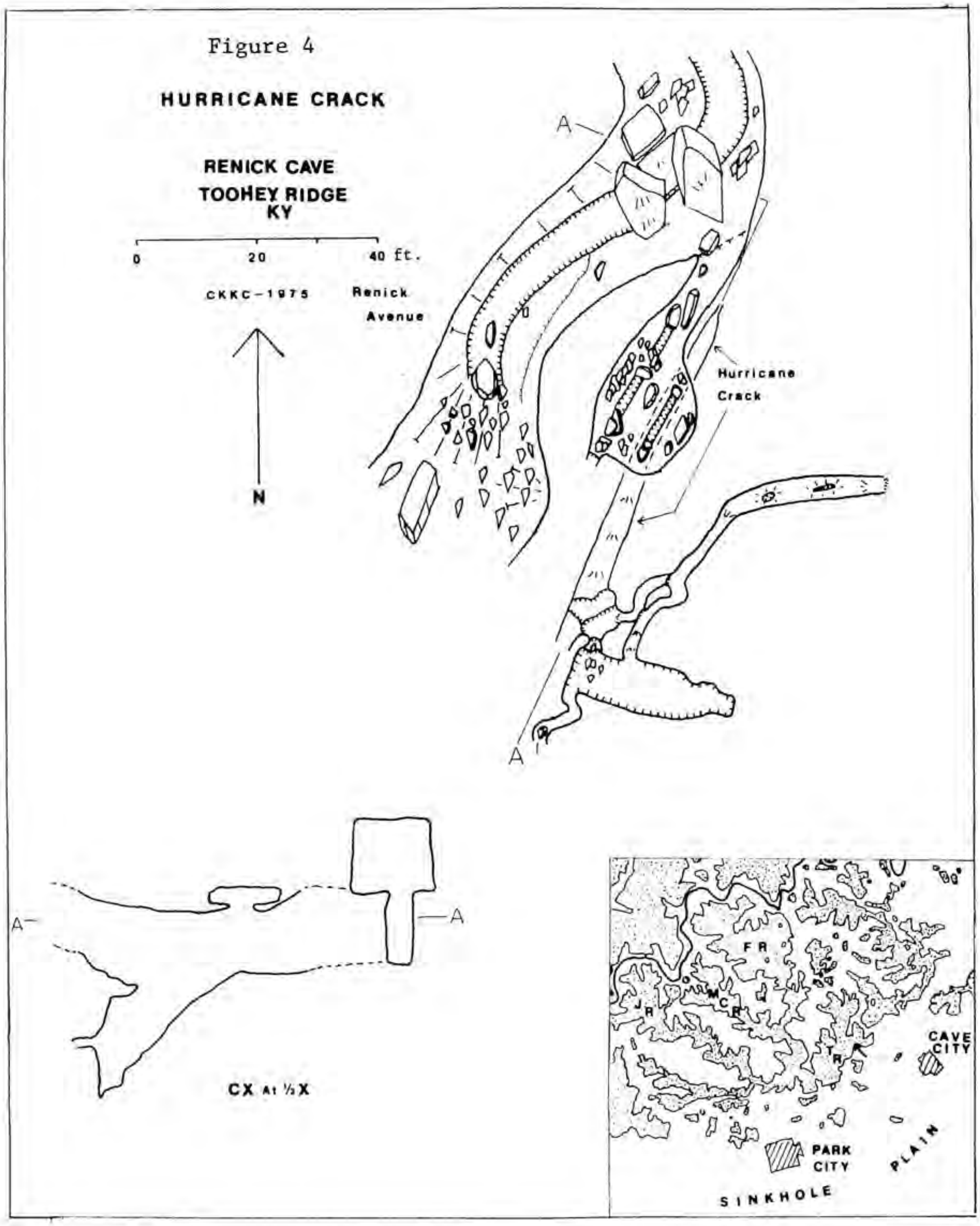
Renick Cave appears to be unique in that Renick Avenue is stratigraphically the highest trunk passage in Central Kentucky. The original tube can be traced at the contact of the Girkin and Big Clifty units. The trunk approaches dimensions of 40 feet in height and 25 feet in width. This trunk also exhibits a low-radius 180° meander that appears to have promoted the development of a complex joint-controlled maze. Downstream from the maze, the trunk size is only 10 by 5 feet. This sudden diminishing in size can be accounted for by the exit of two major passages, both of which are untraverseable and remove a substantial amount of cross-sectional area from the trunk. Why this occurs in the vicinity of a joint controlled maze requires further investigation, but sheer coincidence is possible.

The lower levels of Renick Cave are reached through Hurricane Crack, a narrow, extremely high-gradient, joint-controlled canyon. This canyon appears to have been used as an underdrain to Renick Avenue. In less than 60 horizontal feet the passage drops from approximately 829 feet to 754 feet. Perhaps this drain was formed because of a sudden drop in base level, and a joint provided rapid vertical solution. This joint-controlled canyon intersects the lower cave at the top of a vertical shaft.

Shafts observed on the lower levels are quite dry, with no evidence of retreat which, indicates a sudden cut-off of input to the shafts. This sudden cut-off can be attributed to the formation of the entrance sinkhole. The formation of the sink left a saddle of sandstone approximately 100 feet in width at the edge of the ridge. At this saddle, little water reaches the sandstone-limestone contact because of the small drainage area, and consequently water does not reach the shafts below.

The hydrology and paleo-hydrology of Toohey Ridge still remain a mystery; however, with the recent explorations in the ridge, a pattern seems to be emerging. All high-level trunk passages in the upper Girkin flowed from ESE to WNW, shaft drains extend SSE, and lower-level trunks in the upper Ste. Genevieve and lower Girkin have north-south orientations. Paleo-flow of the lower-level trunks has yet to be interpreted, but northward flow seems to be a good possibility. Changes in flow within trunk passages throughout geologic history can further support the concept of the sinkhole plain drainage changing from westward flow to northward flow. Further exploration will allow the paleo-flow pattern to be more firmly established.

Exploration and study of the caves within Toohey Ridge appears to be critical to the more complete understanding of present and paleo-flows of Central Kentucky. Current exploration will concentrate on a recent breakthrough into the central part of Toohey Ridge, made in November, 1975.



Kinetic Effects in the Development of Karst Aquifers

William B. White

Karst aquifers are distinguished by the presence of integrated conduit systems which localize the flow of ground water and produce fast through-put for storm recharge and sinking stream waters. The pattern of the conduit systems seems to be that of an integrated branchwork or drainage net in many cases. Highly interconnected maze patterns of various types are relatively rare. The geochemical problem is to produce a mechanism that will account for single linear tube as a basic cave element rather than the universal occurrence of mazes.

It is highly probable that the mechanism is concerned with the kinetics of carbonate rock solution rather than conditions of chemical equilibrium. However, efforts to produce a kinetic mechanism have not met with much success. Considerable significance has been attached to the onset of turbulence in the aquifer. Increased solution rates in turbulent flow, so the argument goes, would mean that the first hydraulic path through the aquifer to achieve turbulent flow would be dissolved faster, which would permit more water at higher velocities to flow through it, which would increase the solution rate still more and so on. In effect, the existence of a single conduit requires some kind of runaway process and the onset of turbulence was deemed to be the trigger. Unfortunately the most detailed calculations of the role of flow hydrodynamics on solution rate predict that nothing very much happens to the rate when the flow becomes turbulent (Curl, 1965).

New laboratory work on the solution of calcite under fixed carbon dioxide pressures and fixed level of undersaturation (Berner and Morse, 1974) has produced some very important new insights into the solution process and can be used to demonstrate another possible trigger. Undersaturation is measured as $\Delta pH = pH\ (equilibrium) - pH\ (solution)$. ΔpH is simply related to the saturation index widely used to describe the undersaturation of carbonate waters by $\Delta pH = -1/2\ SI_c$. Berner and Morse's important discovery was that the rate of solution decreases by about three orders of magnitude near $\Delta pH = 0.1$ to 0.2, the exact value depending on the nature and concentration of various inhibitors present in the water. Near saturation, and away from the regime used in most previous laboratory experiments, the solution rate is very slow although not zero.

The applicability of Berner and Morse's laboratory results to the carbonate aquifer was tested by examining the degree of undersaturation of spring waters. Most limestone springs are undersaturated, the residence time being too short for the waters to come into complete equilibrium with the wall rock. The results are shown in Figure 5. Although some very open conduit springs remain highly undersaturated, the large regional springs tend to cluster near the boundary marking the critical undersaturation for inhibition of the solution kinetics. These data suggest that the reason for the widely observed undersaturation of limestone springs is the decrease in solution rate near $\Delta pH = 0.1$.

The time required for complete saturation of the water is very long compared with the residence time.

The critical change in solution rate can also be used to provide a trigger for the development of single-conduit caves. To visualize the mechanism, begin with a mass of limestone containing no solution cavities but having a secondary porosity consisting of joints, fractures, and bedding plane partings. Introduce an undersaturated ground water which must flow from one side of the mass to the other. Initially the flow velocities are very low, flow is laminar, and the solution kinetics are sluggish because the water becomes nearly saturated early in its travel through the limestone mass. However, there will be some solution because the sluggish kinetics will permit water to traverse the entire mass without becoming completely saturated. Many possible hydraulic paths are slowly enlarged. Eventually one path will enlarge to the point where water can traverse it in a time less than the time necessary to reach critical undersaturation. The rate of reaction along that path will greatly increase, it in turn will enlarge faster allowing both more water and a higher level of undersaturation, and the runaway process has been triggered.

The qualitative picture presented here can be made quantitative by adopting some model for the rate of solution in the highly undersaturated regime and secondly assuming some specific geometry, hydraulic gradient, and pressure gradient for the hydraulic path. These calculations are now underway but one very curious result has already emerged. If reasonable slopes and carbon dioxide partial pressures are assumed, and the kinetics model of Plummer and Wigley (in press) is used, the distance that the water will travel (called critical distance, L_9 in Figure 6) can be calculated as a function of capillary radius. Given that typical travel distances through carbonate aquifers are on the order of 1 to 10 kilometers, the transition from proto-cave, random solution openings to a true cave takes place when the capillary path is from one millimeter to one centimeter in diameter. This is very nearly the same boundary between cave and proto-cave found by assuming that the onset of turbulence was the trigger in the very earliest calculations!

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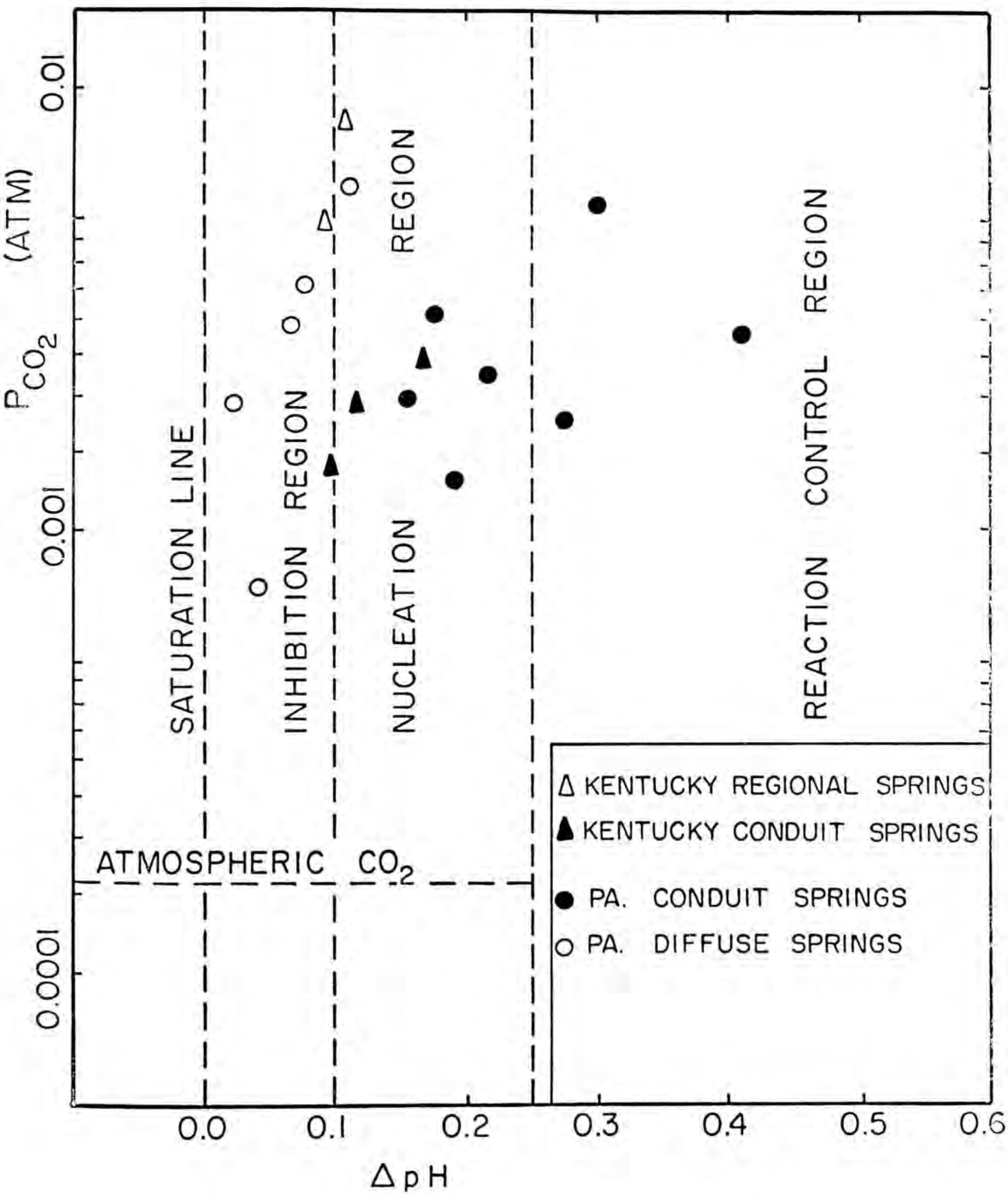
R.L. Curl (1965) Solution kinetics of calcite. Proc. 4th Internatl. Congress Speleol., Ljubljana, Yugoslavia, Vol. 3, pp. 61-66.

L.N. Plummer and T.M.L. Wigley (in press) The dissolution of calcite in CO_2-saturated solutions at 25° C and one atmosphere total pressure. Geochim. Cosmochim. Acta.

Figure 5: The observed carbon dioxide pressure and undersaturation of limestone spring waters with respect to the kinetic regions of Berner and Morse. Data points represent averages of all measurements made on individual springs during July, August, and September (low flow period) of the water year. The two Kentucky regional springs are Graham Spring and Turnhole Spring (sampled at Owl Cave).



P_{CO_2} (ATM)
0.01
0.001
0.0001
SATURATION LINE
INHIBITION REGION
NUCLEATION REGION
REACTION CONTROL REGION
ATMOSPHERIC CO_2
Δ KENTUCKY REGIONAL SPRINGS
▲ KENTUCKY CONDUIT SPRINGS
● PA. CONDUIT SPRINGS
○ PA. DIFFUSE SPRINGS
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Δ pH

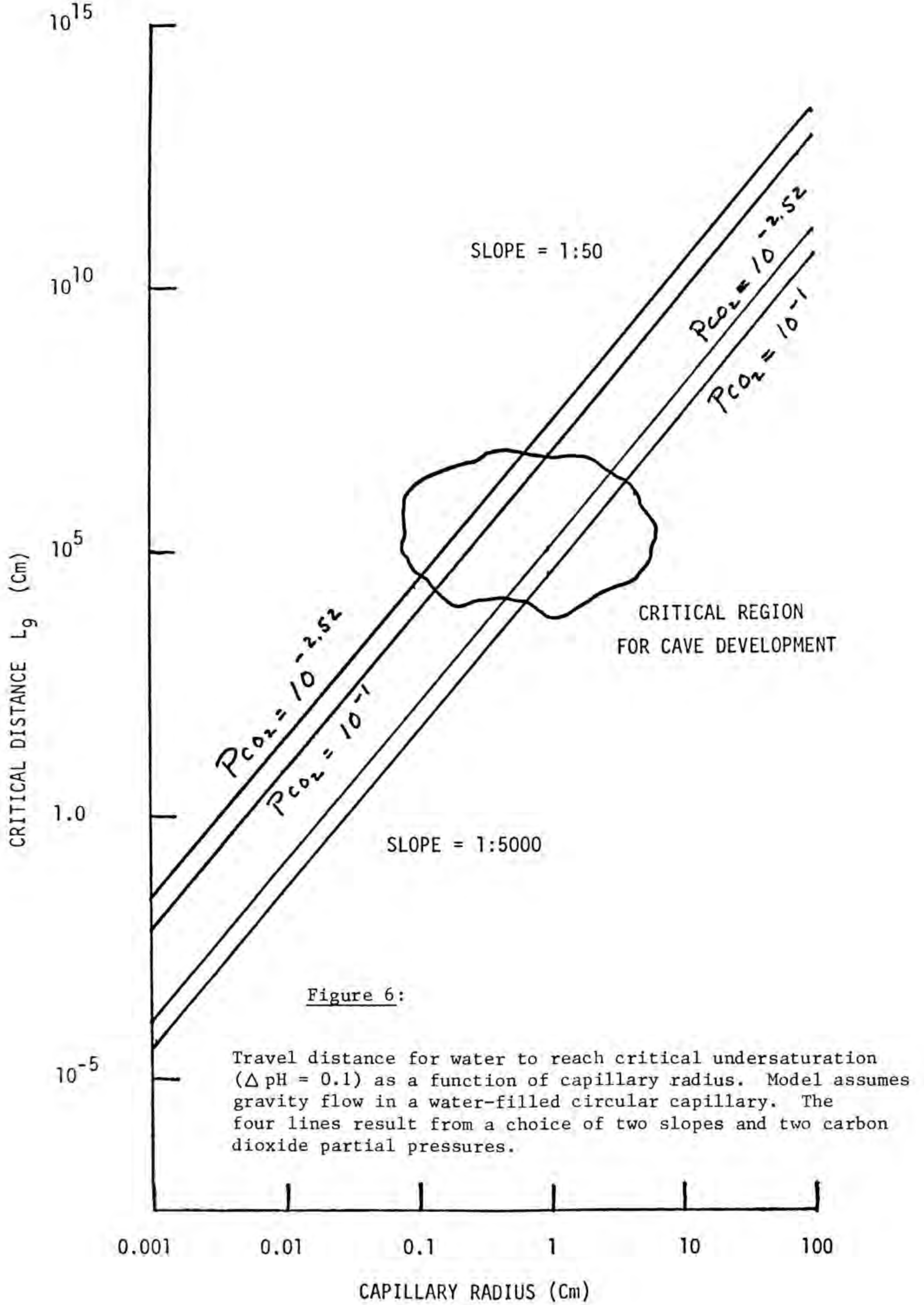


Figure 6:

Travel distance for water to reach critical undersaturation (Δ pH = 0.1) as a function of capillary radius. Model assumes gravity flow in a water-filled circular capillary. The four lines result from a choice of two slopes and two carbon dioxide partial pressures.

Earth Crack Investigation at Wupatki National Monument, Arizona

Rondal R. Bridgemon

In August, 1975, the National Park Service requested that the Cave Research Foundation aid in the study and interpretation of the earth cracks found at Wupatki National Nonument in northern Arizona. The Foundation subsequently submitted a proposal to the NPS and the Wupatki Project was started in late September.

Three major grabens are located in the monument, each with multiple bounding normal faults, which are locally known as earth cracks. Several of these cracks are enterable, one to a depth of more than 500 feet. Surface expressions of these faults can be followed for up to half a mile, and they range in width to about 20 feet. The interiors of these fissures are one to three feet wide as they pass through the Permian Kaibab Limestone and widen to as much as 15 feet when the Coconino Sandstone is reached at a depth of 245 feet. Fault displacements are small, not exceeding ten feet.

It is possible to assign a relative age to the cracks on the basis of basalt flows that cross the grabens. Some flows exhibit faulting and others clearly occurred subsequent to graben formation. A late- or post-Tertiary origin is suggested for the earth cracks. Large sinkholes in the area resemble karst but are due to the enlargement of earth cracks, primarily by collapse.

The CRF is currently surveying all enterable fissures in the Monument and tying them into a theodolite surface survey. A descriptive biological investigation of the cracks is being conducted, and the CRF is providing field support to the National Park Service in an archeological reconnaissance of the fissures. An interpretive geological cross section of the 500-foot-deep Sipapu Cavern will be prepared as well as an interpretive slide presentation on various aspects of the earth cracks.

As of the first of November, the Foundation has conducted one major expedition and two smaller reconnaissance trips. A theodolite survey of 20,000 feet has tied in all the prominent features in the Sipapu-Lomaki area. A 4,000-foot survey has tied in the fissures on the south side of Cedar Canyon. The known areas of the Lomaki, Doney, and Malmquist fissures have been surveyed and new areas were located in Doney and Lomaki. A faunal and archeological survey has been conducted in these three cracks.

Additional surface and fissure survey work remains, especially in the

Doney and Sipapu areas. The faunal and archeological reconnaissance is continuing. The biota in similar earth cracks located 50 miles south of the Monument will also be investigated for comparative purposes. Field work on the Wupatki Project is scheduled for completion by the end of 1975.

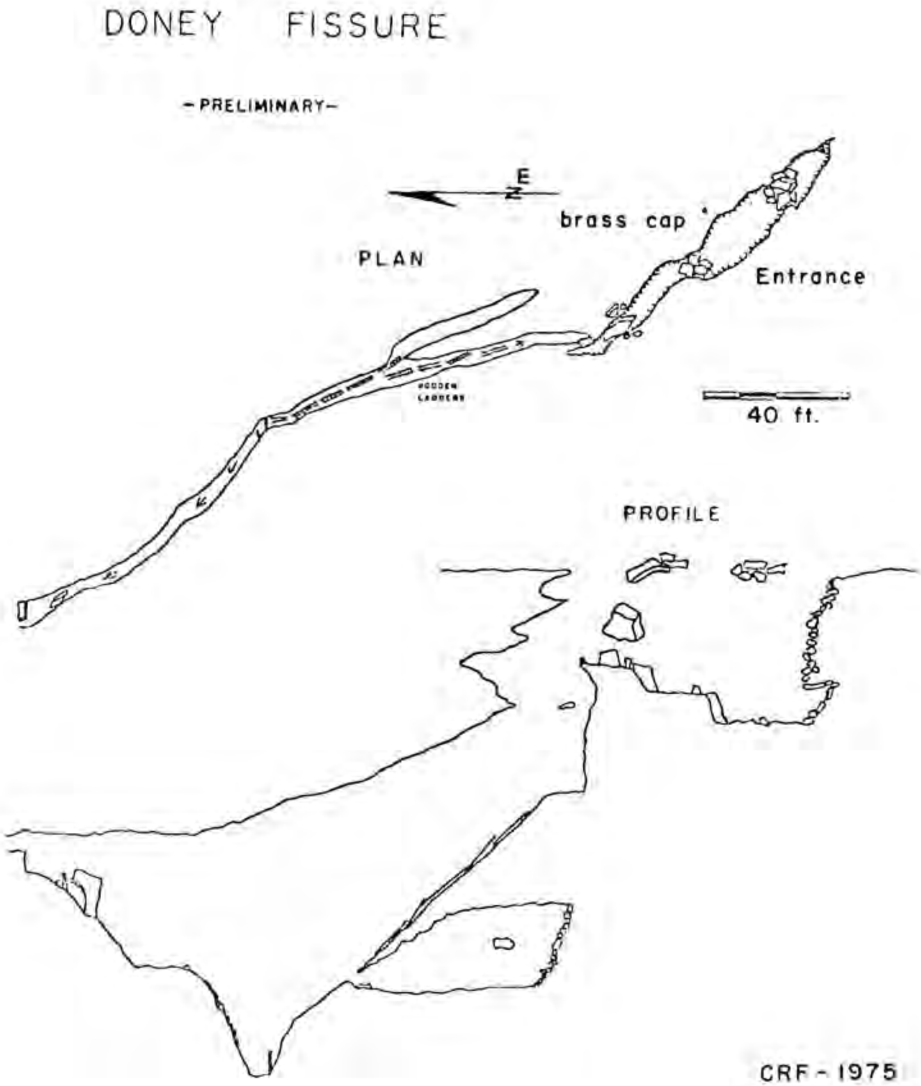


Figure 7: Preliminary survey of the Doney Fissure. The entrance is in Coconino National Forest, but the fissure extends beneath Wupatki National Monument.

Figure 8: Typical earth crack at Wupatki. Photo by R. Bridgemon.

Figure 9: Cross-cectional view of an earth crack. Photo by R. Bridgemon.

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Geology

The Paleontology of Edgewood Caverns

Dr. Barry S. Kues, Dept. of Geology, University of New Mexico

Introduction

At the request of the Cave Research Foundation I examined several of the fossiliferous limestone deposits occurring in Edgewood Caverns, Santa Fe County, New Mexico, during a trip through the cave on May 10, 1975. While precise identification of many fossils would necessitate removing them for examination in a laboratory, some conclusions about the nature of the assemblages may be drawn on the basis of field observations and study of photographs taken in the cave.

Paleontological Observations

The walls of passageways at Station A-37 are composed primarily of a micritic limestone encrusted by cave deposits, and a variety of fossils are present in these walls. Many of them have been etched into relief and are nearly complete, though surficial features are often dissolved away or obscured by precipitated cave deposits. Of special interest are two large species of gastropods, described briefly below.

Several specimens of an extremely large bellerophontid species were conspicuous. These measured up to 70 mm in width and 65 mm in length, and were characterized by a slightly raised selenizone, thin growth lines, and the lack of any other visible external ornamentation. The shape of these shells, and their lack of ornamentation suggests that they belong to a species of Bellerophon (Bellerophon). The large size of these individuals distinguishes them from any previously described Pennsylvanian bellerophontids of the western United States. Yochelson (1960, p. 219-220) discussed size in southwestern Pennsylvanian and Permian bellerophontids, and noted that the only species equivalent in size to the Edgewood specimens come from the Lower Permian Hueco and Leonard formations of Texas and southern New Mexico. Wood and Northrop (1946) recorded some large bellerophontids (termed by them Bellerophon cf. giganteus) similar in size to the Edgewood specimens on some stratigraphic sections of the Pennsylvanian Madera Limestone in the Nacimiento Mountains. I examined these specimens at the University of New Mexico, but no definite conclusions about their relationships with the Edgewood specimens could be drawn because the Nacimiento specimens were poorly preserved steinkerns. However, in view of their similar extraordinary size, relative geographic proximity, and approximately similar position in the Madera Limestone, it is reasonable to suppose that they may represent the same, as yet undescribed, species. The Nacimiento specimens are confined to Wood and Northrop's (1946) "Faunal Zone D", which is Missourian in age.

Figure 10: Giant bellerophontid (anterior view) Bellerophon (Bellerophon), new species showing outer whorl broken and an inner whorl exposed on inside. Found at station A-37. (X 0.7) Photo by Barry Kues.

Figure 11: Etched elongate bivalve (Wilkingia?). Found at station A-37. (X 0.7) Photo by Barry Kues.

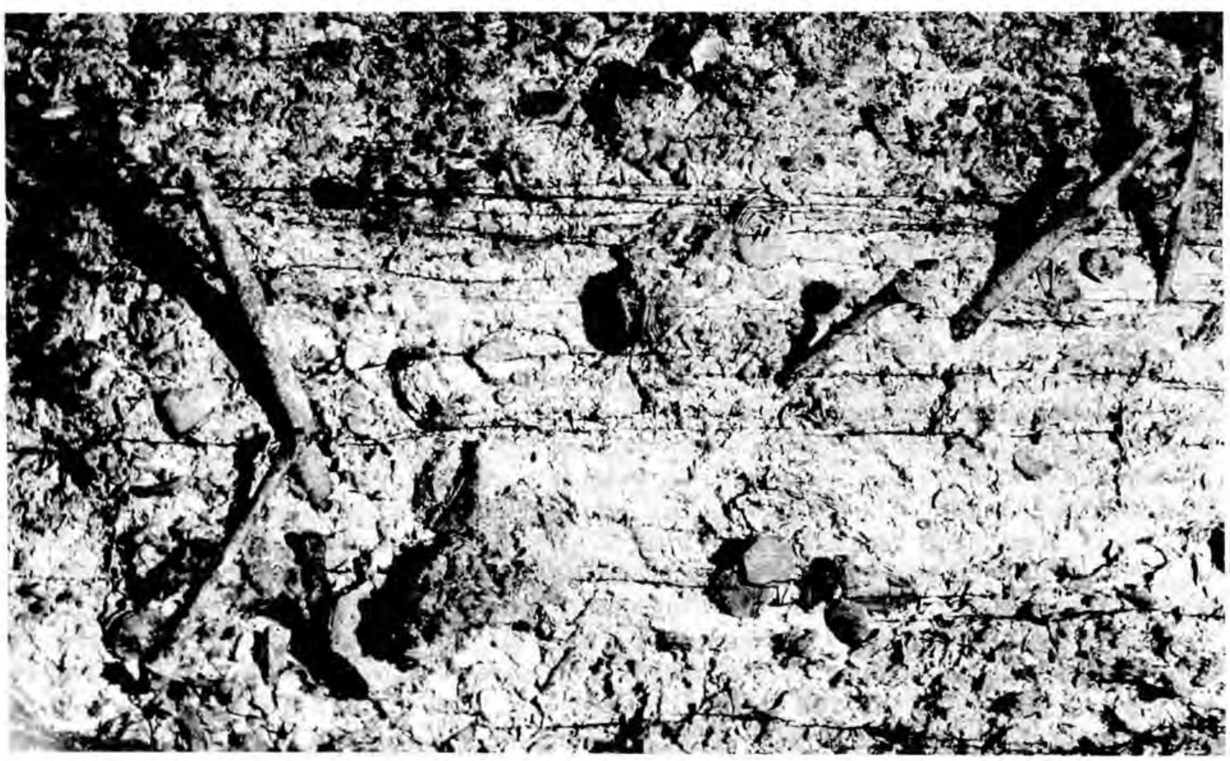

Figure 12: Composita subtilita (showing spiralia), prominent spines and plates of the echinoid Archaeocidaris, at "Fossil Flats". (X 0.7) Photo by Barry Kues.

In the same area and level as the large bellerophontids,are delicately etched, raised shells of large specimens of the gastropod genus Omphalotrochus. All of these specimens were so positioned that only their ventral and parts of their lateral sides were exposed.

At the "Fossil Flats" locality the limestone walls are essentially a highly bioclastic coquina composed of small, heterogeneous shell fragments oriented generally in a horizontal position. The most abundant fragments viewed during examination of these walls were crinoid stems, some as long as 25 cm and consisting of as many as 15 articulated segments. The brachipod Composita subtilita (including the form ovata) was also very common. Other fossils observed were huge echinoid spines (8-10 cm long and almost 1 cm wide at the base) with widely spaced spinelets; the bivalue Astartella, and the brachiopods Crurithyris (common), Cleiothyridina (few), Wellerella (rare), Histriculina (few), Neospirifer (few), Anthracospirifer (rare), and a few chonetid shells. Conspicuous by their absence were remains of bryozoans, although long, sometimes tube-like fossils occasionally observed may have been "stick" bryozoans. Careful examination of this coquina would undoubtedly reveal many other species of invertebrate fossils. The fossils in this coquina are extremely well preserved, and such a dense accumulation of shell material in the Madera is highly uncommon.

Along the walls in one passageway were large numbers of fusulinids, but no identification was possible because this requires preparation of thin sections showing internal skeletal structures.

Summary

The fossil fauna observed in several places on the walls of Edgewood Caverns are consistent with a late Pennsylvanian age. The presence together of large, reasonably well-preserved specimens of the gastropods Bellerophon (Bellerophon) and Omphalotrochus in Upper Pennsylvanian rocks of New Mexico has not been previously reported from any other locality. Both of these forms may represent new species. The fauna as a whole, particularly the gastropods and the coquina of "Fossil Flats" is an exceedingly interesting one, possibly unique in the Madera, and certainly worthy of further study. If it becomes possible to extract a small number of specimens for detailed study in the laboratory, the following samples could be taken without significantly affecting the number and visibility of fossils in the Caverns: 1) two or three specimens each of the large Bellerophon (Bellerophon) and Omphalotrochus; 2) A few well-spaced blocks of moderate size from the extensive coquina deposit at "Fossil Flats", and 3) A small block from the fusulinid locality. The latter sample would also allow determination of a precise date for the cave limestone at this level.

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Figure 13: Omphalotrochus (dorsal view). (X 0.8) Photo by Barry Kues.

Gravity Survey at Carlsbad Caverns

John S. McLean

Stations at the top of the elevator tower and in the lobby of the visitor center were occupied repeatedly to determine the value of the free-air gravity gradient in the area. A true value for the free-air gradient will aid in analyzing the gravity profile of the elevator shaft. Drift curves for the surface stations have been cross checked to reduce drift error. A draft copy of a free-air gravity map was prepared to aid in checking erroneous values and identifying stations which need to be resurveyed. Most of the drift-corrected station data has been coded for computer keypunching.

Geologic Reconnaissance, Wind Cave, New Mexico

Arthur N. Palmer and Margaret V. Palmer

Observations were made of the stratigraphic setting and weathering character of Wind Cave, near Carlsbad, New Mexico, in August 1975, using the preliminary CRF map of the cave as a base map. The cave is a complex 3 - dimensional maze, but with several distinct horizontal levels. It is located in the back-reef deposits of the Guadalupe Series (Tansill and Yates Formations) less than half a mile from the Capitan reef escarpment. The exposed rocks are quite varied in texture and composition, including dolomitic and silty limestone, as well as sandstone-limestone breccia with fragments ranging from a few centimeters to several meters in diameter. The major rock types exposed in the cave are shown in a generalized manner in Figure 14.

Of particular interest is the nature of weathering among the various rock types. The silty limestones alter to a fine-grained red and yellow, fluffy powder that is so delicate that even minor disturbances such as air movements can cause particles to drop from the walls. (This type of weathering is even more pronounced in Spider Cave, near Carlsbad Caverns, which will be the target of a future intensive study by the CRF.) Pisolitic limestone disintegrates in concentric flakes (Figure 15). Wedging and wall replacement by gypsum is apparent in the non-silty limestones, particularly in the lowest level. Coarse grained limestone (such as biosparite) weathers with solutionally sculptured, granular surfaces, including prominent ceiling pockets.

Much of the vertical development of the cave occurs within the breccia facies. Walls are highly irregular in these areas, with numerous large intergranular pores, many of which appear to be primary. Some pores are lined with white, powdery calcium carbonate having the appearance of popcorn but a texture like that of moon milk. It is common

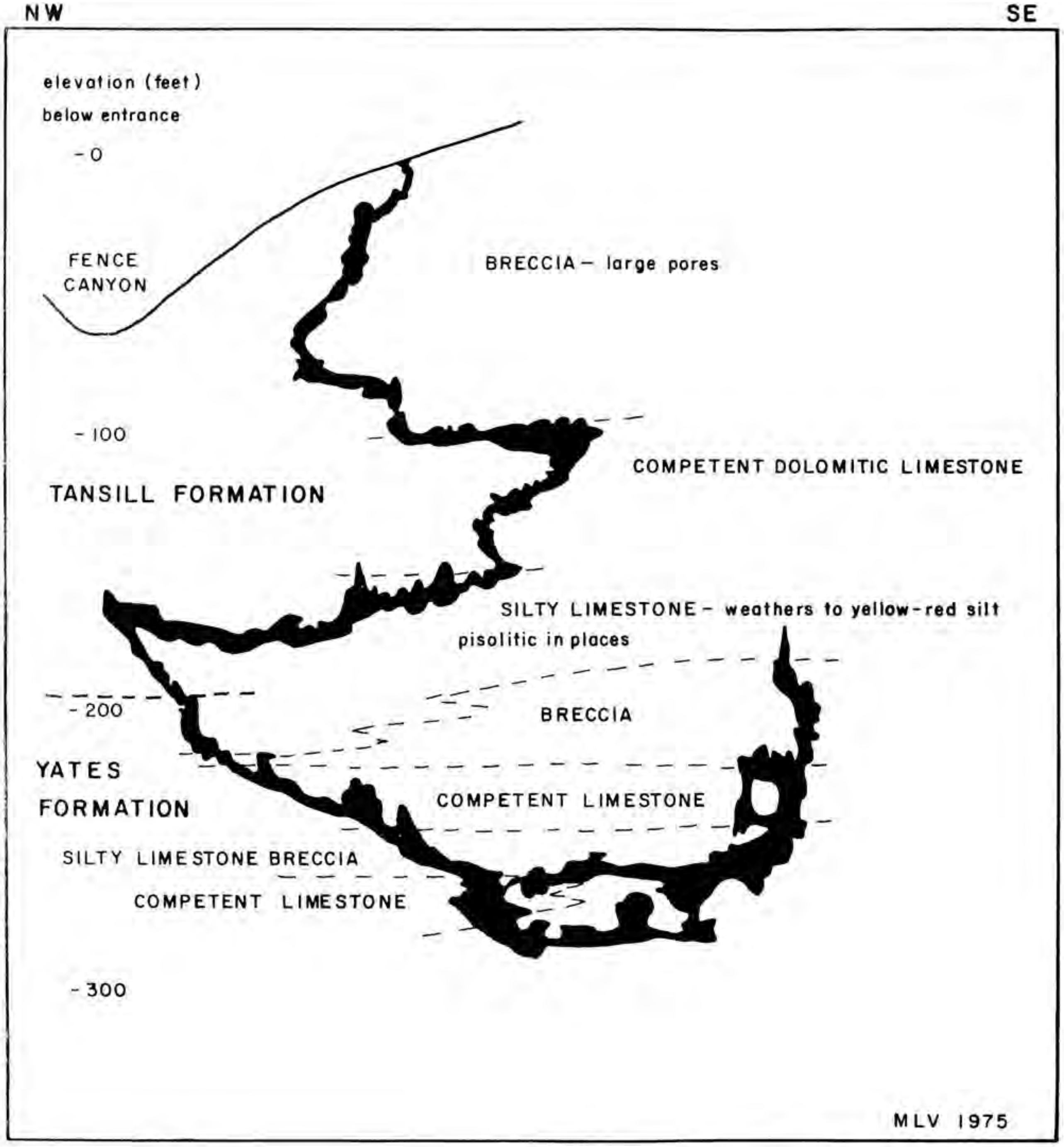


Figure 14: Profile through Wind Cave, New Mexico, showing geologic setting. Cave map by CRF-West.

Figure 15: Weathering of pisolitic limestone near the base of the Tansill Formation, Wind Cave, New Mexico; tip of index finger for scale. From a color slide by A.N. Palmer.

for the larger of these "pores" to be intersected by the solutional walls of the cave at sharp angles, with the white pore lining planed off concordantly with the solutional wall. At first glance it seems strange that the cave could intersect the pores without modifying them and destroying the carbonate lining; on closer examination, it appears that a few of the lined pores are the evacuated sockets of weathered sandstone pebbles, and that disintegration of the sandstone during and after solutional cave development, with concomitant growth of the white lining, has produced wall pockets. However, in most cases the carbonate coating appears tentatively to be the result of post-solutional accretion, which was retarded or prevented from growing on the more exposed walls by humid air currents.

Cementation by active flowstone occurs in local areas, particularly at the "River of Blood", which lies directly beneath Fence Canyon, roughly 80 feet below the canyon floor. Typically for this region, the hydrologic relationships between the cave origin and that of the neighboring canyons are obscure.

Stratigraphy of Mammoth Cave National Park

Arthur N. Palmer

The detailed stratigraphic column derived from a leveling study of Crystal Cave by A.N. Palmer and M.V. Palmer in 1970 - 1973 was extrapolated through most of the trunk passages of the rest of the Flint Mammoth Cave System during 1974. A geologic reconnaissance of Bedquilt and Proctor Caves was carried out by parties led by W.R. Crowther, who simplified their method of rock identification into a "rock-reading chart", illustrated with color photos by R.W. Brucker, now on display in the Austin house at Flint Ridge. A formal description of the stratigraphic units, their commonly accepted nomenclature, and the uses of stratigraphy by surveyers and explorers have been assembled into a 13 - page report by A.N. Palmer, copies of which are available at the Austin house. The generalized stratigraphic section for the Mammoth Cave National Park, taken from this report, is shown in Figure 16 .

On the basis of field work during the summer of 1975, it is apparent that the rock names in Figure 16 can be revised slightly to reflect their regional correlation with the rocks of Illinois and Indiana, where most of the rock units were first studied and named. The following revisions are recommended:

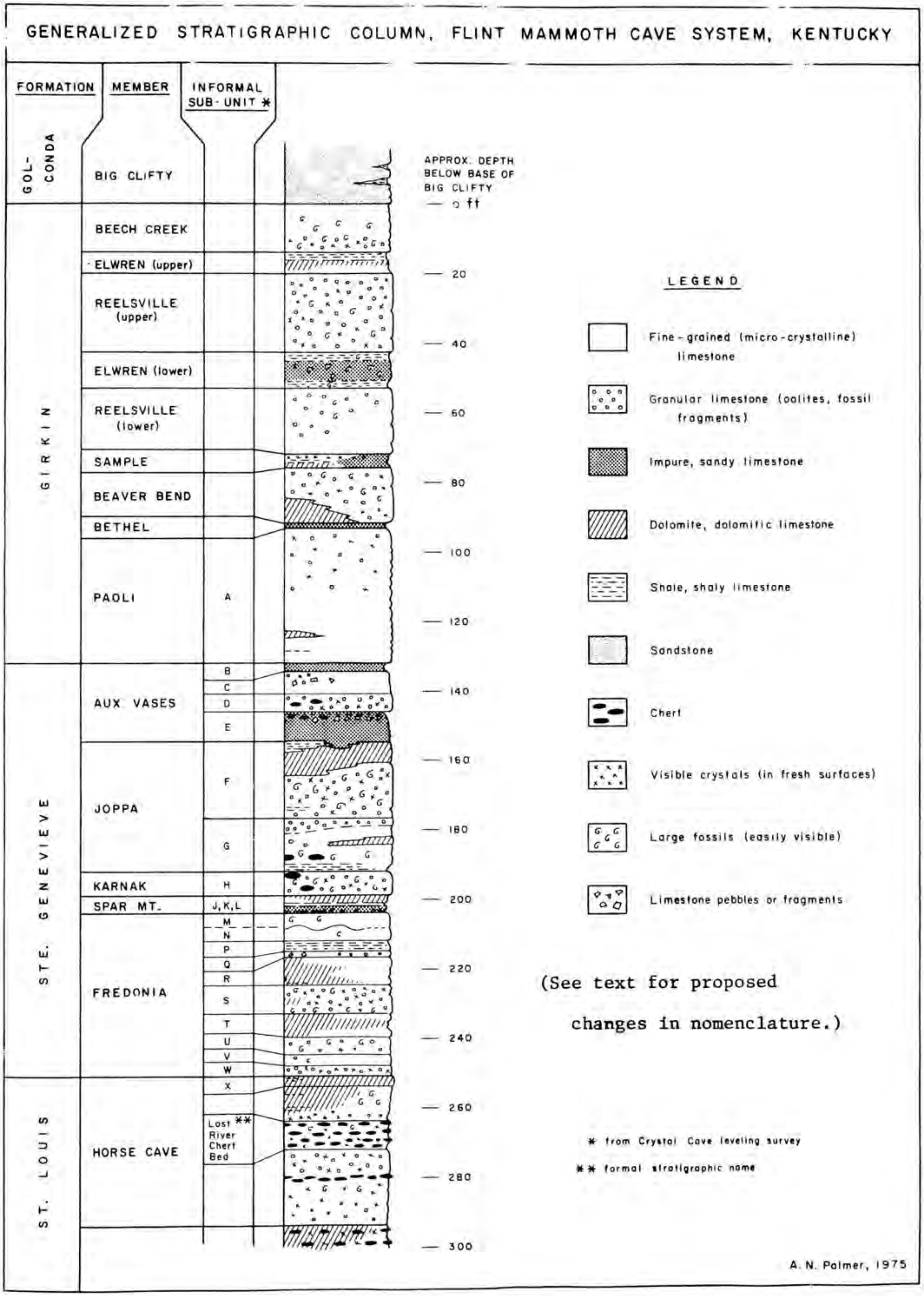
1. The Sample Member of the Girkin replaces the "lower Elwren" on the stratigraphic column. The Beaver Bend Member therefore should extend upward through the units labeled "Sample" and Reelsville (lower) in Figure 16 . Pohl (1970), on the contrary, extends the Beech Creek downward to the top of the "lower Elwren", and resumes the column downward as shown in Figure 16 .

2. Unit B should be included as the basal unit of the Paoli Member. It can be traced as a silty calcarenite northward to the Popcorn Sandstone Bed of Indiana.

3. Although Pohl (1970) extends the Aux Vases Member to the top of the Ste. Genevieve Formation, it is appropriate to restrict this member to unit E, which correlates with the Rosiclare Member of the Aux Vases Sandstone of Illinois. Units C and D are equivalent to the Levias Member of the Renault Formation in Illinois, and therefore the Levias can be considered the topmost member of the Ste. Genevieve. This nomemclature is compatible with that of Indiana, except that the Levias is extended downward to the top of the Spar Mt. in Indiana (where, incidentally, the Spar Mt. is inappropriately called "Rosiclare"). This correlation is made in accordance with the work of Swann (1963) throughout the Illinois Basin.

4. It is common practice in Kentucky to combine the Big Clifty, Haney, and often the Beech Creek as members of the "Golconda Formation".

Figure 16


GENERALIZED STRATIGRAPHIC COLUMN, FLINT MAMMOTH CAVE SYSTEM, KENTUCKY
FORMATION
MEMBER
INFORMAL SUB-UNIT *
GOL-CONDA
BIG CLIFTY
GIRKIN
BEECH CREEK
ELWREN (upper)
REELSVILLE (upper)
ELWREN (lower)
REELSVILLE (lower)
SAMPLE
BEAVER BEND
BETHEL
PAOLI
A
STE. GENEVIEVE
AUX VASES
B
C
D
E
JOPPA
F
G
KARNAK
H
SPAR MT.
J, K, L
FREDONIA
M
N
P
Q
R
S
T
U
V
W
X
ST. LOUIS
HORSE CAVE
Lost River Chert Bed **
APPROX. DEPTH BELOW BASE OF BIG CLIFTY
0 ft
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
LEGEND
Fine-grained (micro-crystalline) limestone
Granular limestone (oolites, fossil fragments)
Impure, sandy limestone
Dolomite, dolomitic limestone
Shale, shaly limestone
Sandstone
Chert
Visible crystals (in fresh surfaces)
Large fossils (easily visible)
Limestone pebbles or fragments
(See text for proposed changes in nomenclature.)
* from Crystal Cave leveling survey
** formal stratigraphic name
A. N. Palmer, 1975

Considering the lateral persistence of both the Beech Creek and Haney, it is appropriate to elevate the upper two units to formational rank, as is done in Illinois and Indiana, and to include the Beech Creek as a member of the virtually continuous limestone sequence of the Girkin Formation. The Big Clifty does not maintain its identity northwestward, but grades into the Fraileys Shale; however, shale-sandstone facies changes are typical of all Chester clastic units.

It may seem an unnecessary pastime to attempt to force-fit a correlation between the rocks of Kentucky and those farther north, particularly since there has obviously been a great deal of controversy among geologists in applying names to the rock units. However, by providing a correlation throughout the Illinois Basin, the influence of each rock unit on cave development can be assessed on a regional scale in the light of variations in lithology, structure, and topography.

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Swann, D.H., 1963, Classification of Genevievian and Chesterian (late Mississippian) rocks of Illinois: Ill. Geol. Surv. Rept. of Investigations 216, 91 p.

Ecology

Terrestrial Ecology

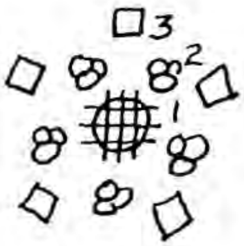
Thomas L. Poulson

During this past year we have defined six subcommunities on the basis of food payoff and food risk. The first figure shows that subcommunity species diversity and % predators increase while total biomass and species dominance decrease as payoff and risk decrease. The total number of species ever present in a subcommunity increases as the ability to pre-empt the resource (payoff) decreases and as there is an increase in the amount of microsuccession possible, starting with a fresh resource.

↑FOOD PAYOFF ≅ ↑RISK ⇒ FEW SPP + DOMINANCE

		CARRION	RAT SHIT	LEAF LITTER	CRICKET GUANO	organic SILT	LEACHED TWIGS + LEAVES
PAYOFF cal/time	available cal/g, fresh g/m², fresh g/time, pulse } Σ	19	12	11	10	8	4
RISK	$\frac{\sigma^2}{\bar{x}}$ cal/g, g/m²; unpredictable (~ autocorrel'n) time, space } Σ	24	11	10	9	8	6
HETEROGENEITY ~ microsuccession		8 (pre-emption ↓ 4)	4	6	2	1	½
COMMUNITY properties	max. species	5	9	11	15	11	13
	min/total spp.	1/7	5/16	6/23	5/18	4/15	9/14
	% predator	15	34	30	37	46	50
biomass per 10m² mg.	total	8298	650	235	123	48	90
	spp dominance (by rank) 1:2	137	9.5	2.4	2.0	1.3	1.2
	1:5	8200	30	8	5	4	5
	1:10	82,000 (7)	1320	645	240	160	123

We also have completed an experimental manipulation in five different cave areas to see if the natural experiments (subcommunities) are based on food payoff. We used an analogue of rat feces (horse manure) and of leaf litter (dead beech tree leaves). The experimental design is diagrammed at the top of the following page.



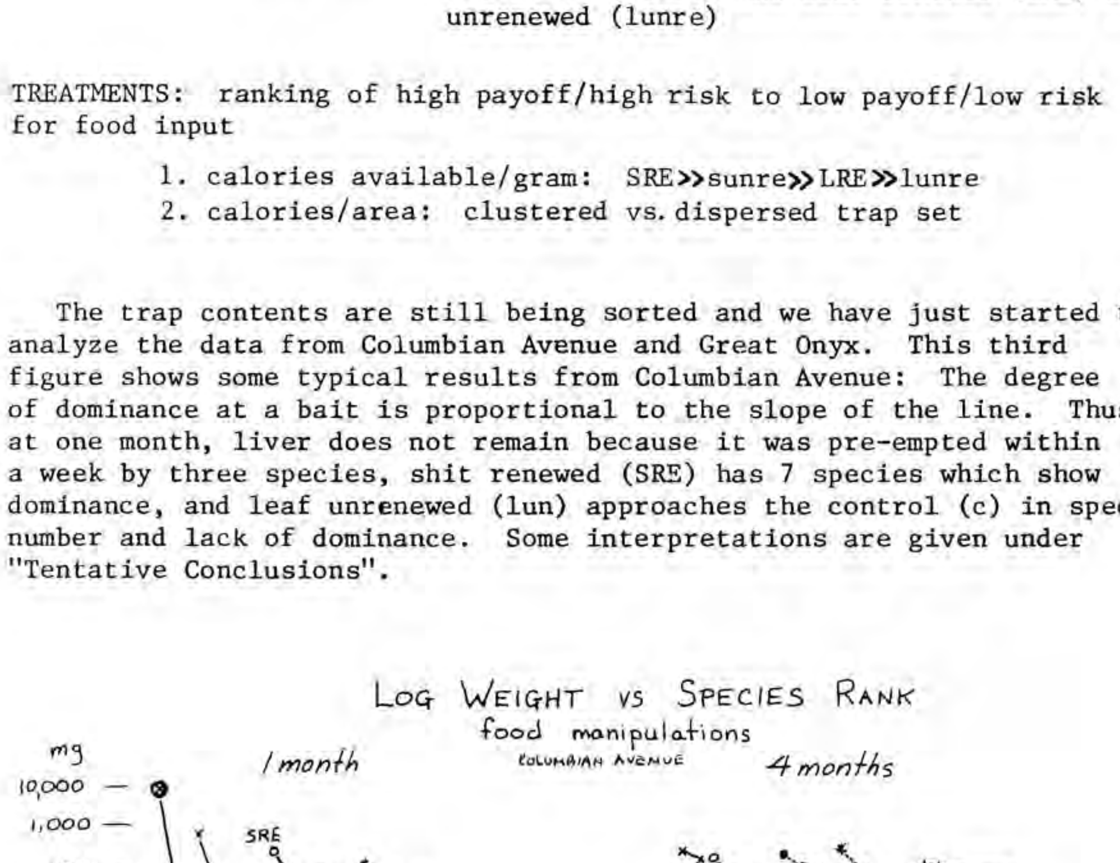
TRAP UNIT:
1. pitfall trap--preserves organisms present between censuses and those not reliably censused visually (mites); gives size-frequency data for small species
2. food bait in 5 piles, 30g. each (control lacks food); censused visually and berlesed last month
3. 5 rocks censused visually for species that avoid bait (e.g. predators)

TRAP SETS: 1 each of control, shit renewed (SRE) and unrenewed (sunre) and leaf renewed (LRE) and unrenewed (lunre)

TREATMENTS: ranking of high payoff/high risk to low payoff/low risk for food input

1. calories available/gram: SRE>>sunre>>LRE>>lunre
2. calories/area: clustered vs. dispersed trap set

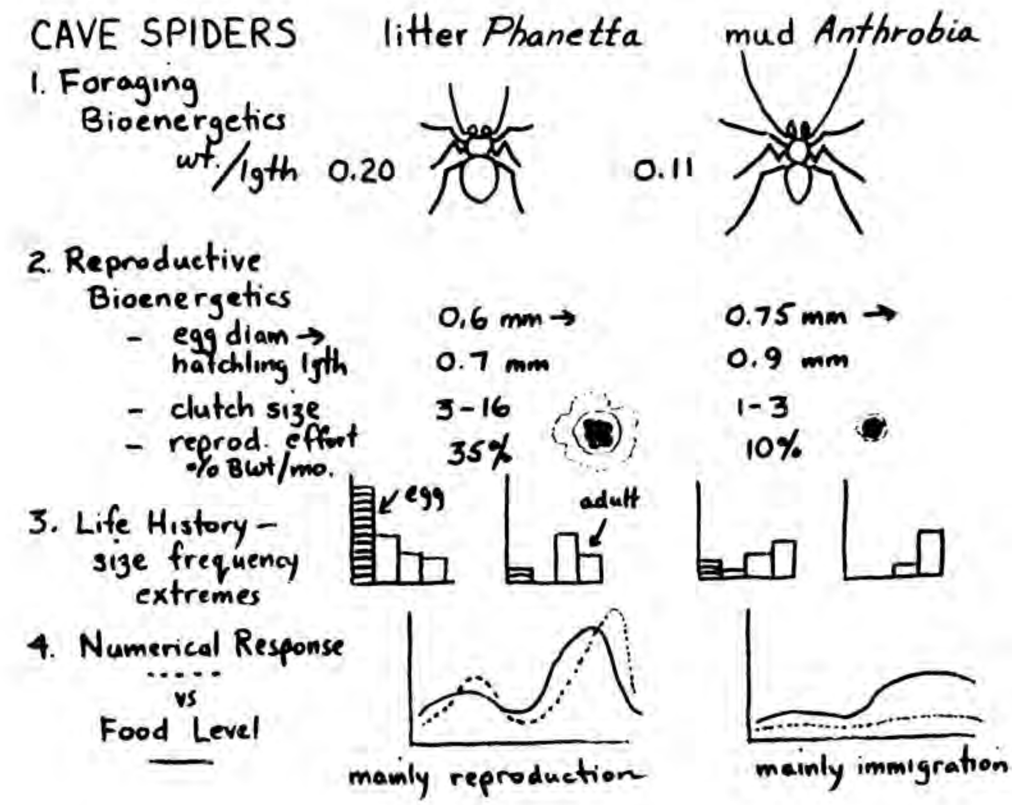
The trap contents are still being sorted and we have just started to analyze the data from Columbian Avenue and Great Onyx. This third figure shows some typical results from Columbian Avenue: The degree of dominance at a bait is proportional to the slope of the line. Thus, at one month, liver does not remain because it was pre-empted within a week by three species, shit renewed (SRE) has 7 species which show dominance, and leaf unrenewed (lun) approaches the control (c) in species number and lack of dominance. Some interpretations are given under "Tentative Conclusions".



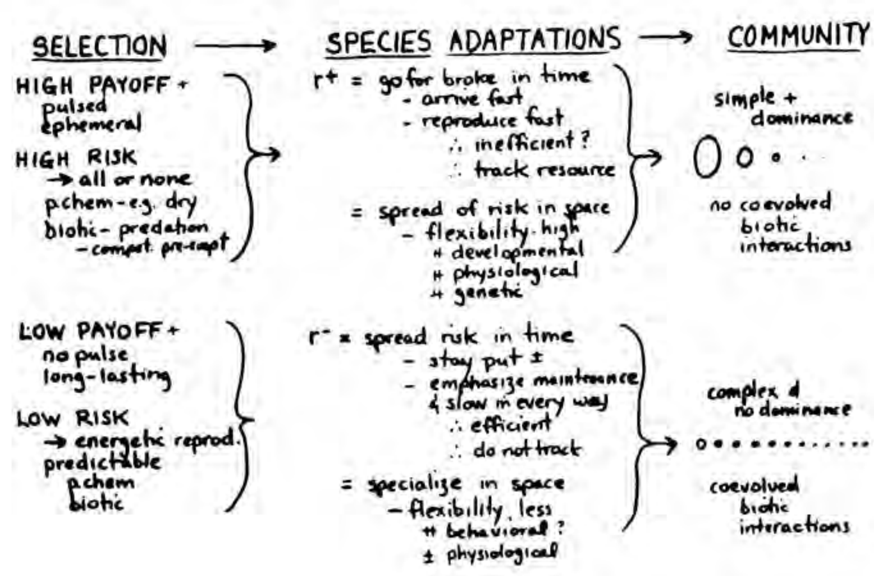
TENTATIVE CONCLUSIONS

1) 1 month – high payoff/high risk → ↑dominance, ↓ equitability
2) 4 vs 1 mo – spp # & equitability ↑ more in renewed
3) 1 mo. dominants (<u>Ptomaphagus</u>, <u>Leptocera</u>) not dominant at 4 mos; collembola and mites more important at 4 mos ∴ arrival time + season important
4) increased equitability in renewed S & L at 4 months due to
   a) failure to completely remove old particles at soil/food interface at renewal
   b) each replicate more alike than at 1 month (island intermigration effect)
   c) r+ dominants dropped out since evolutionarily keyed to seasonal food.

The mechanisms which allow dominance of high-payoff food by opportunistic, short-lived species (r^+) and favor efficient long-lived species (r^-) on low payoff food are basic to an understanding of subcommunity structure. One way to study this is to compare related species that differ along an r^+ to r^- continuum. Van Zant and Kane discuss beetles elsewhere in this report. My data on spiders are shown in this next figure. The most interesting result is that the r^+ species (Phanetta) increases in density and reproduction as food increases but the r^- species (Anthrobia) does not.



Other aspects of r^+ and r^- species and their relations to subcommunity structure are shown in this final figure. This figure shows my current working hypotheses for all of our studies of terrestrial ecology.



Co-existence of a Multi-Species Complex of Carabid Cave Beetles in the Mammoth Cave Region

Terry Van Zant and Thomas C. Kane

One of the current thrusts in ecology is to determine under what circumstances biotic interactions and/or abiotic factors are controlling influences on community diversity and stability.

Differences in morphology and patterns of resource utilization among closely related species may result from interspecific competition. Another explanation is that differences in physical rigor, variability, and predictability of resources may provide different selective pressures resulting in particular kinds of species adaptations.

We chose five caves in the Mammoth Cave region which we view as a system of natural experiments for this study. They contain a multi-species complex of carabid cave beetles. The subjects of our study are the monotypic genus Neaphaenops tellkampfi and three species of the closely related genus Pseudanophthalmus. The caves differ in the following parameters: 1) Beetle co-occurrence patterns. To determine whether species interactions are important in determining co-occurrence patterns we looked at differences in body size and reproductive characteristics and asked whether the differences were related to the co-occurrence patterns. 2) Substrate and food heterogeneity (in space and time). If the co-occurrence patterns and the differences noted between the species (see CRF Annual Report, 1974) are an evolutionary response to local food opportunities (seasonality, availability, and accessibility) in different habitats, then beetle distribution would be related to substrate and food distribution. 3) Physical rigor. The degree of flooding and temperature and humidity fluctuations differed between the caves. These factors impose physiological constraints on a species such that the climate, or micro-environment, is another class of habitat dimension. Distribution and seasonality may be a function of a species tolerance of or adaptations to these physical factors.

A Geographic Comparison of Terrestrial Cave Communities

Thomas C. Kane

The scope of this study is two-fold. The major objective is a comparison of community organization between the Appalachian Valley and central Kentucky terrestrial cave ecosystems. The second objective is to gain information which will be the basis of future research detailing foraging and life history strategies of various species in the community. The present study has concentrated on a comparison of the effects of food type and habitat type in the two systems. At the community level, species diversity, to include richness and evenness, has been used as a response variable. At the population level, niche breadth and niche overlap are being determined for each species for three niche dimensions: feeding niche; habitat niche; and body size. The experimental procedure adopted includes a quantitative survey of the food and substrate parameters of each of four caves in each geographic region. In addition food has been manipulated using three baits of different quality and trapping for a two-week period in both areas during the past summer. These pitfall trap samples are presently being analyzed for the parameters mentioned.

The Comparative Foraging Behavior of Two Cave Crickets, Hadenoecus subterraneus and Ceuthophilus stygius

Ellen S. Levy

From March 1974 through April 1975, research on the foraging strategy of the cave cricket, Hadenoecus subterraneus, and the camel cricket, Ceuthophilus stygius, was conducted in Great Onyx Cave. The following is a summary of the results obtained in my Master's thesis research.

There are few empirical tests of foraging models; furthermore, these tests are concerned primarily with vertebrates. This study, utilizing both field and laboratory data, tests the hypothesis that an insect scavenger which relies on a rare and unpredictable food supply should be more efficient at foraging than a related insect herbivore. Specifically, the comparison of these two sympatric "cave" crickets, Hadenoecus and the more herbivorous Ceuthophilus, allows an empirical test of current foraging theory.

Ceuthophilus stygius (hereafter referred to as Cs) is found primarily in entrance and near-entrance areas where it has easy access to plentiful food resources. Hadenoecus subterraneus (hereafter referred to as Hs) however, roosts, molts, and oviposits in deeper cave areas. Low amounts of food necessitate periodic migrations out of the cave to forage in the surrounding forest areas. The thin cuticle (compared to the thick, glabrous cuticle of Cs) may restrict the conditions under which Hs can leave the cave, and also, the length of time it can spend outside Therefore, Hs must be an efficient forager.

Pitfall traps, baited with substances varying in pungency, caloric content, and available calories, were run monthly. From gut content analyses, it was found that in any given month crickets in entrance and near-entrance areas had more material in their crops than animals from deep cave areas, which had empty crops. Traplines were therefore set up in a near-entrance area (Larval Area) and a deep cave area (Bubbly Pit) to test the hypothesis that satiated animals would be more selective in their choice of food items than hungry crickets.

Baits were ranked on the basis of the average of three separate rankings: degree of pungency, caloric content, and caloric return. From low to high rank, the baits were as follows: control $<$ leaf litter $<$ fresh crushed leaves $<$ horse manure $<$ blueberries $<$ limburger cheese $<$ rotting meat $<$ peanut butter. The results indicate that small crickets are attracted to all of the baits in about equal frequencies. Medium-sized animals come to the four highest baits more often than the lower ranking substances. They appear to avoid horse manure in that more crickets were caught in the control traps than in the manure traps. Adult crickets show a definite bias for peanut butter, followed by the other three high-ranked baits. The four low-ranked baits attract few adults; in fact, no adults were caught in the manure traps in the Larval Area and only one individual was caught in Bubbly Pit. In general, the results of the trapping were similar for both areas with respect to increasing discriminatory ability with size. The major difference was the fact that the bias for peanut butter and against manure was not as sharp in Bubbly Pit as compared to the definite trends evident in the Larval Area.

The fact that Bubbly Pit adults were not as selective as the adults in the Larval Area is explained by gut-content analyses, which indicate that crops from the near-entrance area generally contain some food material, while the entire digestive tract is usually empty in cave crickets deep in the cave. Since the percentage of empty crickets is much greater in Bubbly Pit for any given month, the observation that these adults are less selective is consistent with optimal foraging models which predict that hungry animals are less selective in choosing food items than satiated individuals.

The difference in discrimination observed between age groups is tentatively explained as follows. Small crickets, by virtue of their small size, must forage at ground level, where there is little air movement, and are thus able to get only local information about food. Adults, however, have long legs that raise their bodies off the ground and allow them to travel great distances in short periods of time. They also possess extremely long antennae, which enable them to get sensory receptor cells further into moving air and are thus able to obtain information about distant food. Once closer to food, the long antennae, moving in specific patterns, are used to triangulate in on odors. Thus, adult crickets are able to detect and get to food that may be relatively far away.

This hypothesis is further supported by the "trapline effect" seen in the Larval Area. The traps were run through three substrate types: an extremely rocky area with large boulders, a flat, sandy area, and a section with some small rocks and standing puddles of water. Many young crickets were found on the undersurfaces of the boulders, presumably to escape predation from the carabid beetle, Neaphaenops telkampfii, as very few young instar Hs were ever observed in the sandy area, which was heavily populated by the beetle. The trapline running through the boulder area attracted the greatest number of animals, whereas the trapline running through the sandy area attracted the lowest number. The percentages of crickets attracted to each bait were approximately the same within each trapline, thereby indicating that the location of a given trapline did not affect the discriminatory ability of the young crickets. This localized effect was barely evident in medium-sized animals and was totally absent for adults. Thus, further support is given to the hypothesis that small crickets are restricted to local patches of food whereas adults travel great distances to food.

Other trends, which have not as yet been analyzed in depth, include differences in selection of food items between males and females. Preliminary data indicate that females, needing more calories for egg production, are less selective than males. Also, further support of the satiated vs. hungry (empty) hypothesis comes from recording the percentages of hungry and satiated crickets attracted to each bait type. Fully satiated animals selected four to five high ranking baits, while animals with empty guts were caught at all eight trap types. It should be noted that only three Cs were caught during the year of trapping inside Great Onyx.

Laboratory investigations concerning morphology and behavior show definite differences between Hadenoecus and Ceuthophilus with respect to foraging efficiency. These differences, some of which were reported last year, are consistent with the more herbivorous habit of Ceuthophilus. Further studies of Hs and Cs sensory receptor anatomy are needed to provide empirical evidence for the observed behavioral differences (i.e., antennal beating, etc. discussed in last year's report).

Biotic and Abiotic Studies of a Terrestrial Cave Ecosystem in Indiana

James H. Keith

This study was carried out in Murray Spring Cave, near Paoli, Indiana, from May 1973 through November 1974. The study is composed of three sections: an analysis of variations of the cave's physical environment in space and time, an analysis of variations in abundance of each common species in space and time and an analysis of changes in species diversity in space and time. The results of the first section have been reported previously (CRF 1974 Annual Report: 50-52).

The second section of the study consisted of a list of the species inhabiting Murray Spring Cave. This list was compared with one made by Banta during his study of Mayfield's Cave and differences between the two were discussed. Next, the abundance patterns of the individual species were plotted in space and time. The data were gathered from 24 9 m^2 census areas spaced at 50-foot (15.2 m) intervals along the cave stream margin. Additionally, 9 m^2 areas on four mudbank tops were censused and these data were compared with those from the streamside stations. Finally, the troglobitic beetle Pseudanophthalmus tenuis was the object of a life history study, which included not only its temporal and spatial distribution, but also data on movement, recruitment, tolerance to stress and reproductive changes.

The results of the second section will be summarized as briefly as possible:

1.) When the fauna of Murray Spring Cave are compared with that of Mayfield's Cave, it is seen that the latter contains almost three times the number of species of Murray Spring Cave. The bulk of the species differences are attributable to the high number of dipteran and arachnid species, which hibernate and find refuge in Mayfield's Cave. A small entrance area and frequent flooding probably restrict the number of species that are able to occupy Murray Spring Cave.

2.) Spatially, the abundance patterns of individual species vary from one species to the next. However, two general observations can be made. The first is that the distribution pattern of a species within the cave depends upon that species' size and mobility. Large, mobile organisms occur at low densities and are scattered evenly throughout the cave. Examples of these are the diplopod Pseudotremia indianae and the dipluran Plusiocampa sp. Smaller, less mobile organisms, such as the collembolans, exist at higher densities and are most numerous in areas of the cave where the substrate organic content is highest. The second observation is that few, if any, of the species present in the cave appear to be food limited. This observation is supported by the fact that no part of the cave is devoid of organisms, and by the observation that densities of organisms on the mudbank tops, where floodwaters rarely reach to replenish the food supply, are much higher than at the streamside stations (Figure 17). Thus the organisms, in general, are probably limited in abundance by the physical rigor of the cave rather than by food.

3.) The temporal distributions of the organisms show two patterns: either a summer abundance peak with the organism being rare or absent in the cave during the winter, or low or intermediate abundances in the cave throughout the entire year. The presence or absence of seasonality appears to be tied closely to an organism's use of the cave (i.e., as a refuge or a habitat), its habitat preference within the cave and its size and mobility. Organisms which use the cave as a refuge and feed outside will have seasonal distributions since resources and environment will change seasonally. Organisms which occupy the streamside level are often reduced in abundance by the onset of flooding, which is a seasonal phenomenon. The collembolan Arrhopalites shows summer peaks at the streamside level in Figure 17. On the mudbank tops, however, it shows no seasonality. Instead, there is an abundance peak and then a decline which may be related to the amount of food available on the mudbank tops. Finally, large mobile organisms are usually present the year round in more or less constant numbers. This may be due to an ability to escape flooding or to withstand immersion.

4.) Pseudanophthalmus tenuis is a troglobite. However, it has a seasonal distribution and a seasonal reproductive cycle. Furthermore, the adults live only one year. This was determined by a mark-recapture study and by examination of female ovaries. Eggs are laid by adult females in the fall and the adults die by mid-winter. The eggs apparently hatch during the winter and the larvae undergo several molts. Teneral recruitment begins in early summer and it takes about three months for a teneral beetle to develop into a fully sclerotized adult. Copulation occurs in mid to late spring. This seasonality may serve to decrease competition for food between different age groups of beetles and summer emergence of tenerals occurs when physical rigor is lowest and prey availability is highest. This would insure the survival of the next generation. Spatially, the beetles respond to a combination of physical rigor and substrate heterogeneity. There is no correlation between the presence of beetles in a given area and the presence of prey. It appears that a heterogeneous substrate acts to slow the movement of beetles and so, over the course of the study, more beetles are found on this type of substrate. Physical rigor, in the form of flooding, results in the movement of the beetles from high rigor to low rigor areas during periods of flooding.

The third section of the study showed the pattern of species diversity (H') for the cave in space and in time and used factor analysis and multivariate regression to determine what combination of factors determined this pattern. H' values were calculated for each station for each month. Twenty-one variables were used in multivariate regression analysis. Since many of these variables were highly correlated, factor analysis was used to lump them into factors (Table 1). Each factor could be scored by expressing it as a linear combination of the variables and these factor scores were used in the regression analysis.

The results of the third section are as follows:

1.) Six factors were extracted from the raw data. These factors accounted for 81.9 per cent of the variance in the original data. Based upon the importance of the variables comprising them, each factor can be given a "name". These are as follows:

Factor 1 - outside temperature

Factor 2 - passage air relative humidity

Factor 3 - flooding rigor

Factor 4 - substrate moisture and organic content

Factor 5 - cave air temperature

Factor 6 - cave morphology

2.) The results of the multivariate regression analysis are shown in Table 2. It can be seen that physical factors have the greatest effect on species diversity and that the effects of these are equal but opposite. Substrate moisture and organic content has the least significant effect on species diversity. Cave morphology serves as a link between the physical and energetic environments of the cave by determining where deposition of organic material will take place. Thus, Factor 6 is intermediate in value between Factors 5 and 3, and Factor 4.

Murray Spring Cave appears to be a physically controlled system. This may not be surprising in view of the fact that the cave is relatively short, floods frequently and has a high amount of deposition of silt and organic debris. However, this is the first time that a study of this type and scope has been carried out on a cave community. Since many of the previous studies of terrestrial cave communities have been carried out in the Mammoth Cave area, the effects and consequences of cave flooding have received less attention than other factors. The present study therefore provides baseline data on the community of a flooding cave system which can be compared with other types of

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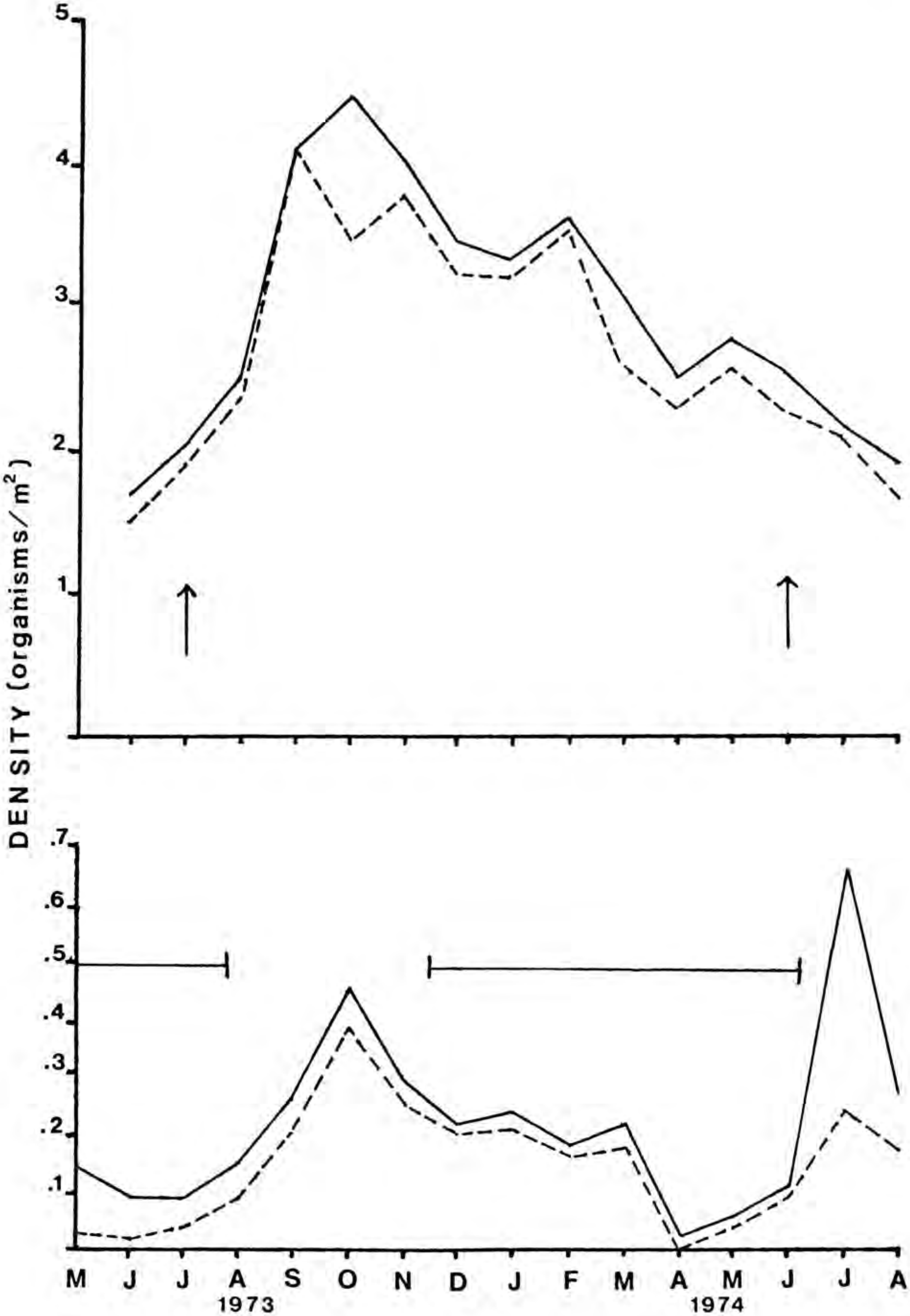
Figure 17: Cumulative monthly abundances (organisms/m^2) for all organisms on the mudbank tops are shown on the top graph. Cumulative monthly abundances for all organisms at the streamside level are shown on the bottom graph. The two vertical arrows on the top graph indicate two individual flood events of the mudbank tops. The horizontal bars on the bottom graph indicate the periods when the streamside stations are regularly inundated by floodwaters. The dashed line shows the abundance of the collembolan Arrhopalites, while the solid line shows the monthly abundance of all other organisms (except Pseudanophthalmus) present at the streamside level.


5
4
3
2
1
DENSITY (organisms/ m²)
.7
.6
.5
.4
.3
.2
.1
M J J A S O N D J F M A M J J A
1973
1974

systems. It also provides the first quantitative relationship between a cave community and its physical and energetic regime, and can provide a springboard for more detailed studies of this type of cave community.

Table 1: A list of the independent variables used in the multivariate regression analysis and the results of factor analysis on the variables. The coefficients represent the weight of each variable in each factor, and the bottom line of the table shows the per cent variance in the data accounted for by each rotated factor. The total variance accounted for by six factors was 81.90%.

KEY: WL = water level
SOH = substrate moisture
SOC = substrate organic content
RHS = substrate relative humidity
RHA = passage air relative humidity
WT = water temperature, and its square (WT^2)
SST = surface substrate temperature and its square (SST^2)
ATS = air temperature at the substrate, and its square (ATS^2)
ATP = passage air temperature, and its square (ATP^2)
AM = air movement
T_1 = average maximum temperature, and its square ($T_1{}^2$)
T_2 = average minimum temperature, and its square ($T_2{}^2$)
ORF = outside rainfall
XS = passage cross-sectional area

VARIABLE	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
WL	.0014	-.0013	.4606	.0242	.0722	.1176
SOH	-.0056	.0039	.0743	.4942	.0043	-.0140
SOC	-.0321	.0200	-.0089	.5032	.0005	.0165
RHS	.0282	.0230	.3064	.0019	-.0303	-.1738
RHA	.0072	.3474	.1900	.0422	-.0475	-.0485
WT	.0568	.2733	.0886	-.0259	.0298	.0892
SST	-.0632	.1038	.1229	.0133	.2044	-.0115
ATS	-.1013	.0823	-.0813	-.0010	.1907	.0107
ATP	-.0723	.1688	-.0755	.0039	.1582	.0058
AM	-.1318	-.0490	-.1484	-.2348	.0906	.1413
T_1	.2770	.0234	-.0344	-.0018	-.1286	-.0083
T_2	.2807	-.0126	.0005	-.0118	-.1175	-.0017
ORF	.0390	-.3550	.2790	-.0276	.0811	.0124
WT^2	.0965	-.0545	.0958	-.0698	.0918	.0543
SST^2	-.0629	-.1437	.1935	.0010	.2591	-.0322
ATS^2	-.0844	-.1064	-.0421	.0126	.2378	-.0470
ATP^2	-.0909	-.1025	-.0554	-.0106	.2320	-.0252
T_1^2	.2741	-.0167	-.0163	-.0138	-.1101	-.0078
T_2^2	.2327	-.0022	.0567	-.0217	-.0624	.0158
STA	.0248	.0110	-.0065	-.0606	-.0099	-.5551
XS	.0250	.0117	.0619	-.0792	-.0334	.5670
Per cent variance accounted for:	22.24	11.49	9.10	8.91	23.23	6.93

Total per cent variance accounted for: 81.90

ANALYSIS 1:

VARIABLE	STA	WL	ORF	ATS^2
BETA	-.0224	-.0046	.0321	.0100
P	<.001	<.001	.02>P>.01	.05>P>.02
CONTRIBUTION TO R^2	.04757	.09447	.00129	.01279
TOTAL R^2	.33819			

ANALYSIS 2:

VARIABLE	FACTOR 5	FACTOR 3	FACTOR 6	FACTOR 4
BETA	.2228	-.2284	.1275	.0881
P	<.001	<.001	<.001	.02>P>.01
CONTRIBUTION TO R^2	.10304	.10128	.03503	.01661
TOTAL R^2	.26141			

Table 2 : Results of multivariate regression analyses using species diversity (H') as the dependent variable and physical parameters from Murray Spring Cave as the independent variables. Species diversity was regressed on raw data (Analysis 1), and on factored data (Analysis 2). BETA is the multiple regression coefficient, and P is the probability that BETA equals zero. A P-value of .05 or less was considered significant. See text for the explanation of each factor and the key accompanying Table 1 for the explanation of the names of the variables used in Analysis 1.

Microbial Ecology of Bat Guano

Mickey W. Fletcher

The purpose of this report is to present a synopsis of my research proposal and some of the tenative findings of my research. A detailed analysis of my findings is not possible at this point because the research is still on-going and a portion of the data collected has not yet been analyzed.

Cave systems have for years been expounded by biospeleologists for their simplicity and ease of study. For the microbial ecologist, cave systems are dreams in reality. Caves provide a set of environmental conditions which would rival many constant-condition laboratory incubators while still having the advantage of being a relatively undisturbed natural system. It was for these reasons, plus my interests in the biology of caves, that I chose a cave for the site of my research.

Bat guano represents one of the major nutrient inputs into cave systems of southern Missouri. It forms the base of a dynamic community of organisms both on a micro as well as macro level. This small but diverse assemblage of organisms utilizes guano on both a direct and/or indirect basis. The organisms, while being diverse and small in number, are representative of cryptozoic organisms commonly found in surface decomposer systems. These reasons, along with the stability of the cave's environment, form the basis for my opinion that bat guano may be used as a model system for the study of decomposition.

Since research devoted exclusively to the microbiology of guano is almost nonexistant, it was the purpose of my research to provide some insight into the significance of microorganisms in the guano community, and also to better define the nature of the chemical environment that guano provides. In past years the significance of microorganisms in decomposer systems in general has been the subject of considerable speculation, especially in regard to their role in determining the presence of invertebrates. It is a question that until present was still unresolved. If the cave represents a model system of decomposition, as I believe, the answer to the question is that the bulk of the invertebrates on guano are dependent upon the presence and action of microorganisms.

The microfloral successions in an organic milieu with infrequent additions of new organics is strongly dependent on the insoluble reserve carbon and on energy sources such as the particulate macromolecules. Except for the existence of the macromolecules, no complex microfloral successions would occur because all the readily available high-energy compounds would be rapidly depleted by the opportunists. It also follows that no invertebrate successions would occur, with the exception of a flurry of opportunists upon the organic addition. If there were no insoluble macromolecules, the importance of guano as a long-term food item in caves would be severely diminished.

In the bat-guano community, a striking series of fungal successional events occur when fresh guano is added. An immediate proliferation of the opportunistic, highly competitive phycomycetes occur. These forms have a high mycelial growth rate coupled with rapid spore germination. These fungi are generally dependent upon the soluble high-energy components of the milieu, particularly the simple carbohydrates and fatty acids. The more complex compounds such as lignin, collulose, chitin, proteins, and lipids are degraded by the exoenzymes of the bacteria, actinomycetes, yeasts, and the slower growing, slower germinating fungi. During the succession of the mycelial fungi, the less obvious but no less important bacteria, actinomycetes, and yeasts are also metabolically active in the organic milieu, each competing for its own niche and food supply.

The general succession of major groups of microorganisms is given in Figure 18 . Bacteria initially dominate fresh guano in terms of numbers and biomass. This is followed by a bacteria-fungi association and later by a bacteria-fungi-actinomycete association. The antibiotic secreting action of this later association, coupled with the gradual drop in the guano pH, may result in a bacteriostatic mechanism which results in decreased numbers of microorganisms for a later period in the successional sequence.

Increased numbers of invertebrates are associated with fresh guano-microfloral associations. The number of invertebrates diminishes when the number of microorganisms decreases, even though the organic content of the guano is equivalent to that of fresh guano. A generalized food web listing the most common components, approximate trophic level, and some of the predator-prey interactions of the guano community is presented in Figure 19.

Pseudoscorpions are in most instances the main predators in the guano community. Pseudoscorpions are commonly found in close proximity to fresh guano-microfloral associations. A note describing some of the behavioral and feeding patterns of the pseudoscorpions is currently in preparation.

At the present time, I am seriously considering continuing the guano research at the Ph.D. level. A large number of questions and hypotheses that I have formulated during the course of my present research are yet to be tested. Furthermore, a number of manipulative experiments could be conducted to obtain an even finer grasp of how the community functions and responds.

Figure 18. Microorganism succession on guano with approximate respect to time.

Time :	———————————	———————————	——————————→
Guano Age :	Fresh	≈1 year	>5 years
Dominant Microflora:			
Bacteria :	——————?		?——————→?
Fungi :	———————	———————	——————→?
Actinomycetes :	—————?		
Total Microbial Population :	10^8	10^4	10^5

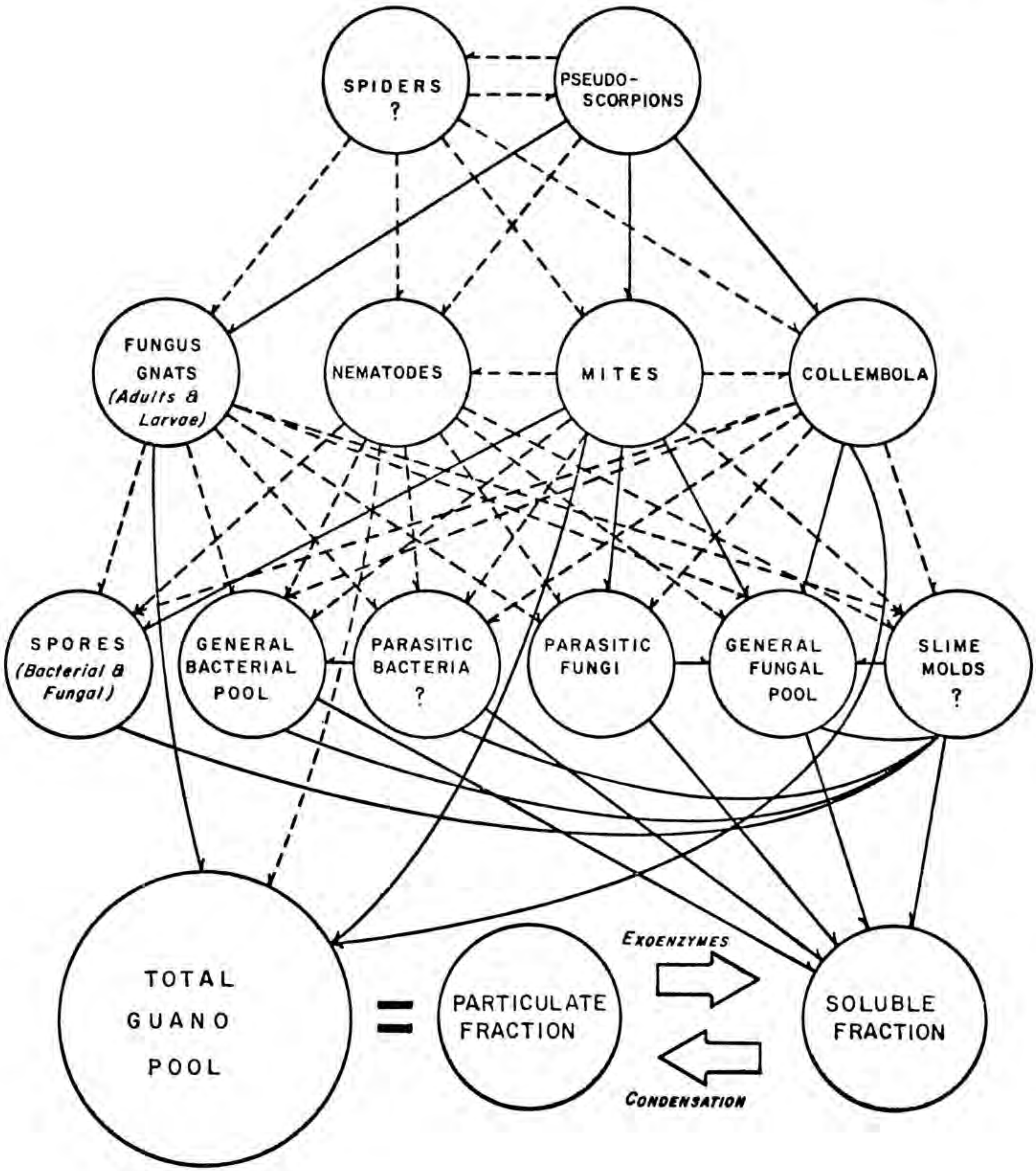


Figure 19 . Generalized food web based on bat guano. Solid lines indicate predator-prey relationships based on observations or direct evidence. Dashed lines represent suspected predator-prey relationships. Question mark indicates occasional or questionable presence of the respective organisms.

Bat Guano Arthropod Communities

Barbara J. Martin

Introduction:

This is a preliminary report on a year-long study of invertebrate community structure on grey-bat guano piles and its relation to rates and patterns of guano renewal.

Energy input into the cave consists of guano, carcasses, and plant detritus, by far the greatest biomass contribution being guano. However, mortality of the young bats during parturition and rearing results in a considerable influx of carcasses during the early summer.

Consequently, although my primary interest is in the successional sequence of invertebrates on the guano, I am also interested in this sequence in comparison with the decomposing carcasses.

Certain parameters of the piles govern the limits of the community structure. The size of a pile determines the carrying capacity for the community. Age and proximity to other piles (source of immigrants), combined with dispersal mechanisms of the guanobites governs the size of the species pool that can potentially colonize any guano pile.

My hypothesis is that, within this context, the pattern and amount of guano renewal are the principal factors determining community structure and the sequence of organisms which replace each other through time following a pulse of guano. Reproductive strategies and dispersal between or within piles are also tied in with this.

Methods:

Rates of guano renewal are being measured by meter-square plastic sheets and by jars. Data from the plastic sheets indicate that areas of light guano input receive anywhere from $3g/m^2$ to $45g/m^2$ per annum. Variance is high both from place to place and through time.

Pitfall traps and Berlese extraction of cores of guano are being used to census guano populations monthly in 4 piles which differ in size, age, and timing of renewal. Pitfall traps beneath bat carcasses are being used to census carrion populations monthly.

Results To Date:

So far the following organisms have been found in direct association with guano. I have used the term "unidentified" for species which I have not yet identified. They are not necessarily new species, although this is a possibility for some of the mites.

20 mites (unidentified, some of which are immatures)
5 flies (Bradysia sp., Leptocera sp., a psychodid, 2 mycetophylids)
several Collembola (1 to 3 species of Arrhopalites, Pseudosinella argentea, and Folsomia candida)
5 beetles (2 staphylinids, 2 carabids, and an unidentified)
1 pseudoscorpion (Hesperochernes occidentalis)
1 millipede (Antriadesmus sp.)

Reproduction and/or immigration would appear to be the obvious response to a pulse of guano. There is evidence of a reproductive response in the many immature pseudoscorpions which have been found in conjunction with high densities of a small oribatid mite in a recently renewed pile. Immigration, whether from deep within the pile or from other piles, is very likely the reason for the species found only on new piles or only on old piles. The former harbors: 2 oribatid mites, the pseudoscorpion, 2 staphylinid beetles, and 3 flies - Bradysia sp., Leptocera sp. and the psychodid; the latter: a tenebrionoid beetle, mycetophylid larvae, and the millipede.

At least the early successional phase of the guano community is based more on fungi than on guano itself. The densities of organisms with low and high densities of an early successional Mucor fungus (4-7 days to appearance of sporangia) differ by 45 fold. Two species of oribatid mites, a Rhagidia mite, Pseudosinnella argentea, and 2 mycetophylid fly species have been frequently observed on or among the sporangia of the Mucor, presumeably feeding.

The carcasses appear to follow the same early successional sequence as the guano (both of fungus and of invertebrates). The Bradysia, Leptocera, and psychodid flies come in at the same time as the Mucor fungus. This is followed by some of the mites, which is, in turn, followed by the appearance of predatory beetles (Staphylinidae and/or Carabidae). Since these carcasses are small and comprise a more easily utilized food source than the guano, they are used up more rapidly. As a result, the later successional sequence of the old guano piles cannot occur on the carcasses. One prominent member of the early guano community (the pseudoscorpion) has not been found on the carcasses. This may be a result of poorer dispersal mechanisms compared to the flies and mites.

Laboratory experiments are being conducted to ascertain predator-prey relations, that is, "who is eating whom or what".

Survey of the Cave Fauna of the Gaudalupe Region, Eddy County, New Mexico

W. Calvin Welbourn

This year has seen a change in goals, with the combining of the entire Guadalupe Region into one project. In the past only Carlsbad Caverns and Guadalupe Mountains National Parks were considered. This change will result in a better understanding of cave fauna in both parks and the region.

In 1975, twenty-four caves were examined for invertebrate cave fauna. Of those, 15 were caves not previously examined. Ten of the caves were in Carlsbad Caverns National Park, six were on Bureau of Land Management land, seven were in the Lincoln National Forest (Guadalupe District) and one was in Guadalupe Mountains National Park. There have been more than 43 caves examined in the Guadalupe Region with 56 species of invertebrates identified. Work is progressing on identification of other specimens. In addition to specimens, information on the temperature and humidity has been gathered on many of these caves.

The cave fauna of the region are dominated by troglophiles, 62.5 percent, with trogloxenes being 14 percent, troglobites 12.5 percent, and the rest accidentals. This is close to the percentages found by Barr and Reddell (1967). The low percentage of troglobitic fauna is probably due to the semi-arid climate of the Chihuahuan desert, although there are more troglobites than previously reported, since the recent discovery of a troglobitic harvestman and new species of possibly troglobitic spider and pseudoscorpion. The only confirmed troglobites in this region are a millipede (Speodesmus tuganbius), a dipluran, and an isopod (Brackenridgia sp.). Two others are possible troglobites: a centipede (Thalkethops grallatrix), and a cave cricket (Ceuthophilus longipes).

Future work will be centered on the lowlands around the Guadalupe Mountains as well as the higher elevations of the mountains. With this survey nearly complete, publication of this material is now the goal.

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Arthropod Fauna of the Guano in the Bat Cave Portion of Carlsbad Caverns

W. Calvin Welbourn

The bat guano deposits of many caves represent an ecosystem different from other cave communities that can contain large numbers of individuals. In order to determine the species composition and seasonal variation of the guano arthropods in Bat Cave, six sites were selected and have been sampled on an approximate monthly basis since February 1975. Five of the sites were in bat guano from Tadarida brasiliensis and one was in cave swallow guano (Petrochalidon fulva). Samples of 110 cm^2, 10 cm deep, were taken from each site and placed in a berlese funnel. The arthropods were separated and identified. Air temperature, soil temperature, relative humidity and location of the bats relative to the sample sites were recorded.

The micro-arthropods recovered from the guano include: mites (two dominant species, but several present), diptera and coleoptera larva, a pseudoscorpion (Dinocheirus) at two sites only, Siphonoptera (fleas) and collembola. Arthropods noted on the surface of the guano were a cave cricket (Ceuthophilus carlsbadensis), Psocopterans, two species of Tenebrionidae, Tineidae (guano moth), Rhadine beetle and hemipterans on the swallow guano.

Each of the sites has received varying amounts of guano this year, with one site receiving none. Most received almost constant guano while the bats were present, and one had guano added for only a short time.

The monthly samples will continue through February 1976. After that time, samples will be less frequent, with most effort placed on identification and determination of exact numbers of each arthropod present. Rates of guano deposits will be determined during the next season.

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Cave Fauna of New Mexico (Excluding Eddy County, New Mexico)

W. Calvin Welbourn

Field work was limited in 1975, with only two caves visited, one of which had not been previously examined for cave fauna. Work centered on identification of material previously collected. To date, nine caves have been examined outside the Guadalupe region, with 37 species of cave fauna found. These 37 species can be broken down into 11 percent troglobites, 46 percent troglophiles, 27 percent trogloxenes, and 16 percent accidentals. Most notable records were a species of spider not previously found in New Mexico and a troglobitic harvestman from a cave in northern New Mexico.

Vulture Cave: A Late Pleistocene Paleoenvironmental Record for the Lower Grand Canyon, Arizona

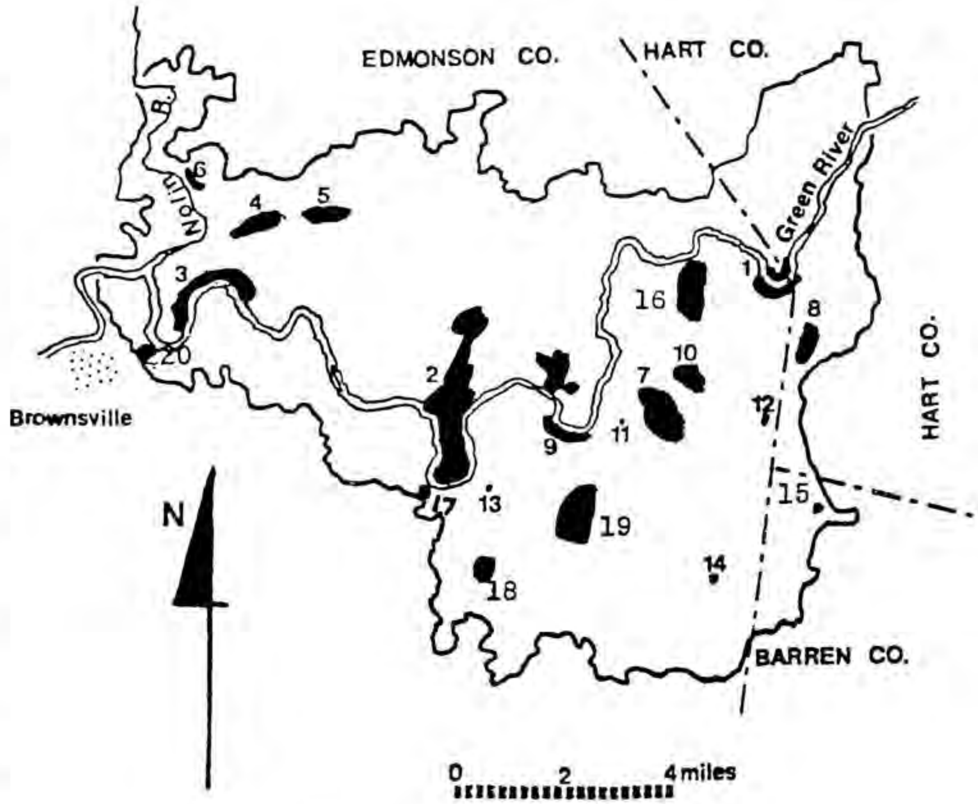
Jim I. Mead

With the help of a Cave Research Foundation grant, work is being continued at Vulture Cave in the Grand Canyon National Park of Arizona. Previous work in the small limestone cave uncovered seven Late Pleistocene age packrat middens.

Packrat (genus Neotoma) middens contain excellent indicators of nearby environments. These rodents bring into their den small bones, teeth and quantities of plant fragments (seeds, leaves, twigs etc.) for use as food and building materials. With stratigraphic control, the Vulture Cave middens are sampled and taken to the Laboratory of Paleoenvironmental Study in Tucson for further flora and fauna identification. The middens are cleaned and a single floral taxon, usually 5 grams of juniper (Juniperus sp.) twigs, is collected and sent to the Laboratory of Isotope Geochemistry, Tucson, for radiocarbon dating. Some middens contain as many as 23 species of plants representing woodland and desert communities. One midden that has a juniper twig radiocarbon data of 13,820 $\pm$ 220 YBP (A-1564), indicates a Late Pleistocene juniper woodland depressed at least 910 meters below the nearest present juniper woodland elevation. Another midden was radiocarbon dated at 17,560 ±350 YBP (A-1603) with juniper twigs and again indicates a juniper woodland depression of at least 910 meters. All combined, the seven juniper-filled middens contain the bones and teeth of (preliminary identification) sloth (Nothrotheriops sp.), camel (Camelops cf. hesternus), Bighorn sheep (Ovis sp.), peccary (cf. Platygonus sp.), packrats (Neotoma cf. lepida; N. cf. stephensi), Black vulture (<u>Coragyps</u> <u>atratus</u>), Turkey vulture (<u>Cathartes</u> <u>aura</u>), Condor (<u>Gymnogyps</u> <u>californianus</u>), Desert tortoise (<u>Gopherus</u> <u>agassizi</u>), and various snakes and lizards occurring with flora elements representing at least 25 plant species.

This summer's field work (August, 1975) revealed five additional juniper-filled middens. Three were indurated surface middens and two were unindurated subsurface middens. Test pits were located in certain tunnel areas within the cave to determine the floor fill depth. Tests indicate a surface unit composed of fine loose sediments mixed together with rodent bones and Late Pleistocene (?) age juniper twigs. Below the surface is a semi-compacted unindurated juniper packrat midden (Unit 2). Unit 3 is a red organic layer, probably bat guano. Unit 4 has an undetermined depth of roof spall, boulders and fine sediments. Laboratory identification of this summer's collections is currently in progress. Samples from each stratigraphic midden layer and other selected samples will be radiocarbon dated.

The Vulture Cave material is proving to be a unique and abundant source of packrat middens, indicating a juniper woodland depression of a minimum of 910 meters along with associated extinct fauna, during a Late Pleistocene time span of at least 13,6000 to 17,200 radiocarbon years before present. Complete work will bring together at least twelve middens with detailed flora and fauna lists accompanied with a minimum of one radiocarbon date from each midden unit.



FOOT SURVEY AREAS

1 Dennison Ferry
2 Turnhole Bend
3 Temple Hill
4 First Creek Hollow
5 Blue Spring Hollow
6 Nolin Rockshelter, MC 29
7 Eaton-Houchins Valley
8 Chestnut Grove Hollow
9 Mammoth Cave Ferry
10 Three Springs Pumphouse
11 Mammoth Cave*
12 Salts Cave*
13 Lee Cave*
14 Bluff Cave*
15 Sand Cave*
16 Three Sisters Hollow
17 Patch Shelter
18 Cedar Sink
19 Sloans Cressing
20 Indian Hill

FIGURE 20: Surveyed Areas in Mammoth Cave National Park

* Cave locations

Archeology

Archeological Activities in the Central Kentucky Area

Patty Jo Watson

Summary Report

CRF archeological activities over the past year included surface survey inside the Park and in the Big Bend area of the Green River 40 miles west of the Park, stratigraphic excavations of rock shelters in both those areas, excavation of a 1 x 2 m trench in Salts Cave Vestibule, recording of prehistoric cultural debris in Mammoth and Salts Caves, investigation of pollen coring potential of First Creek Lake and of two ponds outside the Park.

This work was supported by the Cave Research Foundation, the National Geographic Society, Washington University, and royalties from the book published last year (Watson, ed., 1974).

Work Inside Mammoth Cave National Park

Surface survey - walking over selected areas (usually ravines) in search of rock shelters with traces of archeological material in them - was carried out in some 20 localities (see map). A total of 24 sites was found inside the Park (17 shelters, 6 open sites, and 1 chert outcrop), and 4 more outside the boundaries (2 chert outcrops and 2 shelters). Don Coons and Paul Heller provided information on the locations of a number of these above-ground sites. Several of the sites reported by Douglas Schwartz some 20 years ago were also revisited. Three rock shelters were chosen for stratigraphic excavation in restricted areas to establish their chronological positions and depth of deposit while obtaining flotation samples from each of them.

"Flotation samples" are bags of deposit which are emptied into a specially constructed water-filled container (with fine screens attached) so that the charred plant material floats off, and can thus be relatively easily concentrated and recovered for analysis. Fish bone, rodent bone, and other small items remain in the heavy fraction of the flotation sample, as well as denser botanical material such as hickory nutshell. (For details on the flotation process we employed see Watson, In Press).

The first series of rock shelter excavations was completed in July, 1975. All material found seemingly dates to the Late Woodland period (approximately 1000-1500 years ago), although we have not yet obtained radiocarbon dates for any of these sites. Thus, occupation of the rock shelters tested up through last summer post-dates prehistoric mining and other activity in the big caves (Salts, Mammoth, and Lee), all of which seems to have taken place in the last two millennia B.C. Ken Carstens' Ph.D. dissertation will be concerned with the rock shelter materials and other aspects of surface archeology in Mammoth Cave National Park (Carstens, 1974, 1975; Watson and Carstens, 1975).

Permission has very recently been received from the Department of the Interior to test excavate a few other sites inside the Park (all rock shelters). This will complete our excavation program here, and should furnish a chronological framework as well as biological remains indicating the subsistence patterns followed at different periods of prehistoric occupation.

Excavation in Salts Cave Vestibule resulted in two complete stratigraphic flotation sequences from the new trench (Trench K, immediately adjacent to the south side of Trench J; Watson, ed., 1974, Fig. 11.1, shows the position of Trench J). A stratigraphic series of sediment samples was also taken to recover any micropaleontological remains that might have been washed in (ostracodes, tiny snails, etc.) and that might provide information on the ancient climate in the vicinity of Salts Sink. Greer Price will extract the microfauna from the sediment samples and Richard Yarnell will identify the botanical material from the flotation samples.

Recording of aboriginal debris (especially the location and quantity of squash, gourd, and paleofecal material) was continued in both Salts and Mammoth Caves. The material is documented by notes and sometimes by photos, but is not removed from the caves. The recent CRF surveys of upper passages of Mammoth Cave have been very helpful in giving us stations to tie to. John Wilcox, Pat Crowther, Diana Daunt, and the cartographic crews have, as always, been exceedingly generous in furnishing MS copies of maps and xeroxes of survey books.

Archeological Research Outside Mammoth Cave National Park

A few archeological sites have been investigated in the areas bordering the Park to the south. Some of these have been badly disturbed by relic collectors, but permission to put in small test trenches was obtained for two sites (one at Smith's Grove and one on the Elmore farm near Smith's Grove). The excavations were carried out in September and October, 1975, respectively. The Smith's Grove site has been almost completely destroyed by pot-hunters, but apparently once contained abundant, stratified Middle Woodland occupation debris. The Elmore site is essentially a surface scatter of chipped stone tools and munufacturing debris; once again the remains are quite abundant. We are grateful to Mr. Mills and Mr. Elmore for permission to work at these two sites.

During March and May/June, 1975, Bill Marquardt directed survey and test excavations in the Big Bend region of the Green River some 40 miles west of Mammoth Cave National Park. This work developed from our earlier (spring, 1972, and summer, 1974) excavations at two of the Archaic period Green River shellmounds where we had gone in search of antecedents for the subsistence economy revealed in Salts and Mammoth Cave flotation and paleofecal remains (Marquardt, 1972;

Marquardt and Watson, 1974). Yarnell and his students at the University of North Carolina are working on the botanical material from these shellmounds, and have recently reported finding squash shell fragments there which are some of the earliest cultigens in the eastern United States (ca. 2000 B.C.).

Rock shelters in the uplands near the riverside shellmounds so far all seem later in time (Middle to Late Woodland) than the mounds, and are comparable to shelters investigated by Carstens inside the Park.

Wet Pollen Reconnaissance

Pollen has been recovered from sediments inside Salts Cave and from some of the human paleofecal specimens in both Salts and Mammoth Caves (see chapters by James Schoenwetter and Vaughn Bryant in Watson, ed., 1974). However, for purposes of environmental reconstruction pollen from a wet context (swamp, bog, lake bottom) is far preferable because it is better preserved and more abundant. Surface water in karst terrain is rare but we have begun investigating such potential pollen-coring sites as do exist. In July, 1975, we were visited by an Irish palynologist, Bill Watts, who has been carrying out a long-term paleoenvironmental research project in parts of the southeastern United States. Watts kindly agreed to accompany us to possible coring spots in the Mammoth Cave National Park vicinity and advise us on their probable status for our purposes. First Creek Lake inside the Park was found to be a very poor prospect, but two ponds to which Ron Wilson guided us outside the Park seemed more promising (Brushy Knob Pond and 100 Acre Pond - see Figure 19). We intend to pursue our search for other likely places and to attempt to core Brushy Knob Pond (100 Acre Pond has a thick layer of very recent slopewash in it which makes it less desirable than the Brushy Knob site).

Figure 21: Test coring in Brushy Knob Pond, July 28, 1975. Front to back: Bill Watts, Pat Watson. Photo by Louise Robbins.

Other Analyses and Research

Diana Patch is conducting a study of the mussel remains from the shellmound sites and some of the rock shelter excavations. The work will be described in her senior honors thesis (Department of Anthropology, Washington University).

Gail Wagner is studying the charred botanical material from the major rock shelter excavation (Blue Spring Hollow shelter). These data will form a part of her Master's thesis (Department of Anthropology, Washington University).

Mary Elizabeth King (Texas Tech University) is continuing her analyses of textile and vegetable fiber remains from Salts and Mammoth Caves (see her preliminary report in Watson, ed., 1974).

Louise Robbins (University of North Carolina, Greensboro) is analyzing the human skeletal material from both the shellmounds and the rock shelters (see her account of human skeletal remains from Salts Cave and Mammoth Cave in Watson, ed., 1974), and Steve Ward (Washington University Dental School) has begun a detailed study of the dental wear patterns and tooth microstructure of these skeletons.

Further parasitological analyses of the paleofecal material in Salts Cave have been begun by Sharon Patton (University of Kentucky). Earlier studies by Elizabeth Dusseau and Gary Fry are reported in Watson, ed., 1974.

Summary and Future Plans

The data being recovered in and near Mammoth Cave National Park and in the Logansport / Big Bend area of the Green River west of the Park are of local significance for understanding the culture history of this part of western central Kentucky. They are of more general significance, too, in that we have some of the best evidence (both qualitatively and quantitatively) in eastern North America for the details of prehistoric diet at a time period that happens to coincide with the introduction into this region of tropical cultigens (squash and gourd, originally domesticated in Mexico several thousand years B.C. and traded or otherwise diffused north from there) in combination with the use of native North American cultigens (sunflower, sumpweed, perhaps chenopod). The main reason our botanical evidence is so good is the context provided for it by the big dry caves. Paleofecal material is rarely preserved except in caves or rock shelters, and seldom in any great quantity even there. Not only do we have this very abundant paleofecal "data bank", but also we have associated occupational sediments containing a great deal of charred plant material.

We intend to continue work on the archeology of the central Kentucky karst, focussing on Mammoth Cave National Park, and on the region of the western coalfields centering on the Big Bend of the Green River.

Our major objectives are to recover as much information as possible on the prehistoric lifeways of this area and to delineate the process whereby cultivated plants were introduced and assimilated into the local prehistoric economy.

Estimated duration of current projects:

(1) Surface archeology of Mammoth Cave National Park, present phase - August, 1976
(2) Salts Cave Vestibule excavations - Now completed
(3) Recording prehistoric cultural debris inside MCNP caves - Because of the extent and abundance of the material, this could go on almost indefinitely. We will continue working at it for at least two or three more years.
(4) Archeological investigations in the Big Bend/Green River area - We plan to continue working here for the next several years, both in the shellmound sites along the river and in the upland rockshelters.

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History and Economics

Economic Geography of the Mammoth Cave Regional Saltpetre Industry

Duane DePaepe

The analysis of Mammoth Cave National Park area nitre caves exemplifies the circa 1812 saltpetre industry as an important pioneer economic activity in a locational context. The initial investigation phase focused on the formulation of a card file "data bank" resulting from a search and recording of all important early Mammoth Cave area reports and maps describing mining features and the underground landscape of the period. With this completed as a research base, detailed field investigation progresses toward eventual interpretational objectives.

Regional Investigations

A trip to Salts Cave failed to identify conclusive nitre mining features, although some removal of clay by digging stick was noted. No mattock marks could be found. It was concluded that because of the breakdown-covered floor, widespread saltpetre mining was not practical, despite a dripping spring at the cave entrance. The investigation covered Upper Salts to the Pike-Chapman entrance.

Hundred Dome (Coach) Cave, now part of the Park-Mammoth development, contains an extensive rock-stacked, nitre mined avenue and the recent commercialization of the cave uncovered vat timbers in the entrance vestibule. What seems to be another vat is buried under recent entrance room collapse reportedly caused by dynamiting the entrance because of a whiskey still operation.

The saltpetre cave near Cedar Spring contains vats of similar construction to those in Mammoth Cave. Stone bridges, ramps and trails may originate at least in part from nitre mining although it probably is not possible to separate these features from a later commercial attempt. Of particular interest are hundreds of tally notches found on the walls and ceilings in intensively mined areas. Mattock marks are found in abundance (about 2½ inches wide, rounded blade), identical to those in Long (MCNP) and Wyandotte and Summnerville Saltpetre Caves in Indiana. A mattock handle was discovered under the air chamber of one of the vats. There is evidence of rock sifting and shallow pit mining in floor breakdown. The multiple mining features in these caves are forming a recognizable, consistent pattern with those in Mammoth Cave.

Surface Reconnaissance

Surface work included the finding of a round iron kettle, with nesting rim, that dates pre-1916 from the old Mammoth Cave Hotel. The kettle, now in the Craft Shop, may be an original nitre kettle. The park artifact collection contains a wood shovel and an iron auger with extension, but both items do not seem to date from the saltpetre era. The photo and negative file was searched but did not reveal any new data on the mining ruins, although it did establish the tools and methods of CCC digging efforts in the cave. Supplemental data on CCC diggings, at which time the rock stacking was removed from the Narrows, was supplied by Lyman Cutliff. Ellis Jones of Cave City identified the type of oil lamp employed by the circa 1812 miners.

Mammoth Cave Observations

In Mammoth Cave, CCC earth removing tools found in Audubon Ave. were tested in order to compare the marks produced with known saltpetre tools. In addition, a portion of the cave known to have not been used by the miners, from the Frozen Niagara entrance to Mary's Vineyard, was searched for dig sites and rock removal and stacking, again for comparison purposes in order to competently identify nitre mining patterns.

Detailed measurements were taken, including mortice angles and positions, of pump frame timbers in Booth's Amphitheatre and the Rotunda to establish hydrostatic head relationships. After this survey was made, it was discovered that two large framing timbers in the Rotunda were "left over" after all of the other pieces were accounted for. It may be that these were carried in from the entrance pump frame. Widespread dry rot on these timbers further suggests this. Several large pieces of vat drain, of different design from in-situ drains, may represent the smaller vats which were in the vestibule of the cave. Similar examples of this type of drain are found in situ in small vats in Tennessee nitre caves. Measurements suggest the Rotunda pump tower to have functioned on a level with that of the pipes in the Narrows. One piece of vat intake valve was identified in the Rotunda, and similar valves were found in vat trough drains. Seemingly mysterious, large, half-round wooden objects, suggesting cart wheels, were proven to be trough ends. Rock-stacked trailways partially exposed under the beds of floor breakdown caused by mining, adjacent to the Rotunda on Broadway, were noted to have been used by the miners to pile rocks after the earth sifting operation.

After surveying the wooden architecture in Booth's Amphitheatre it was found that the composite in-situ nitre works do not correlate with previous ideas and early lithographs of how the pump frame, drainage tank and vats functioned. More study and survey is needed in this area as it is more complex than originally conceived.

An incomplete search for nitre dig sites along Main Cave to Blackall Ave. found little evidence because of massive floor breakdown. Cyclops' Gateway, which was near the Main Cave turn-around point of the ox cart road, was extensively mined and rock stacking lines the passage. Harvey's Ave. was probably "pit mined" in breakdown debris, but no rock stacking was found. A corn cob was found near the area where this passage once connected to the Methodist Church. Only questionable evidence could be found in Main Cave cut-around passages, including Proctor's Arcade. Blackall Ave. was searched but later diggings, possibly for Indian mummies, has erased any sign of nitre mining.

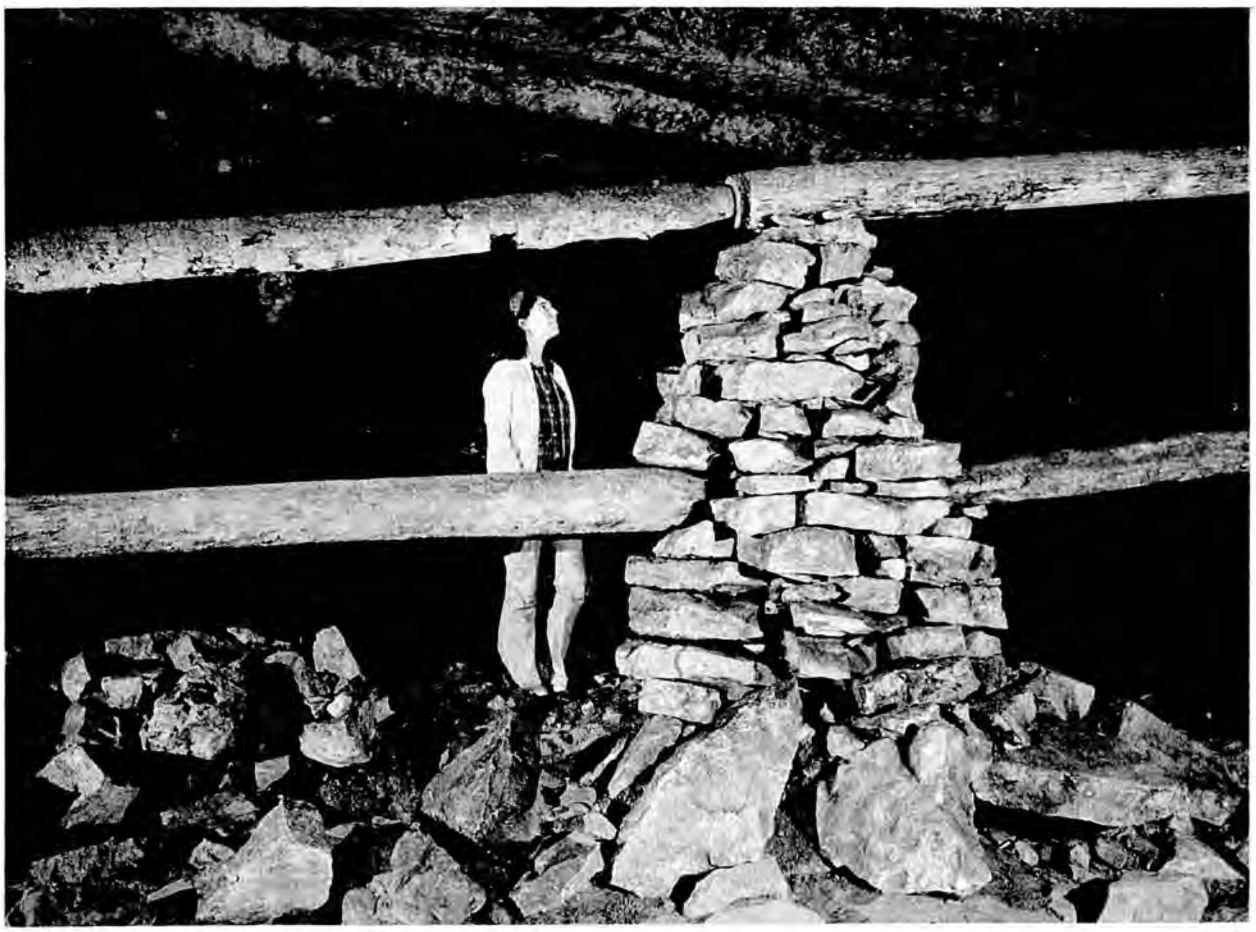

Figure 22: Pipes in Broadway, Mammoth Cave, constructed of hollowed-out logs reinforced with iron bands, for conveying water to and from nitrate leaching vats in the early 1800's. Photo by Pete Lindsley and Art Palmer.

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Management and Publications

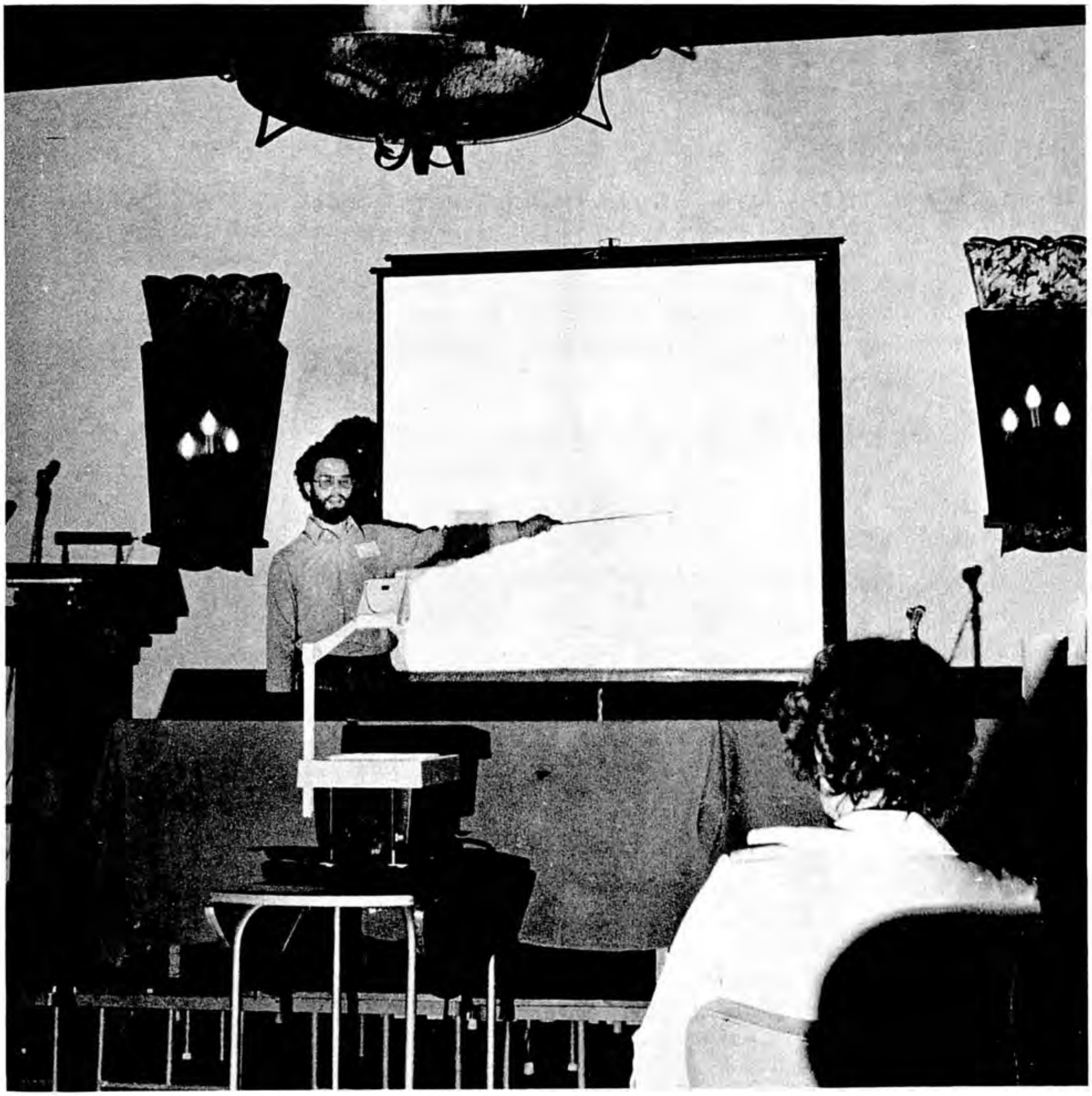

Figure 23: Cave Management Symposium, Albuquerque, N.M., October, 1975. Jack Hess making his presentation on Hydrology and Geology. Photo by Pete Lindsley.

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Management

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Field Station	Robert O. Eggers, Roger L. McMillan
Log Keeper	Jennifer A. Anderson
Personnel	L. Greer Price
Safety	Norbert M. Welch
Vertical Supplies	Charles F. Hildebolt
Supplies	Tomislav M. Gracanin

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Many of the functions of the Foundation are managed through operating committees, usually chaired by a director. The present list of committees, their function, and their membership follows.

RESEARCH COMMITTEE: Functions to coordinate all sponsored research within the Foundation, to initiate new projects, to review proposals and fellowship applications, and to coordinate back-up support from personnel and the field stations. By definition, all persons conducting research projects under Foundation sponsorship are members of the Research Committee.

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Warren Cal Welbourn

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Dorothy M. Corcoran
Gordon L. Smith
William P. Bishop
Philip M. Smith

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Thomas L. Poulson, Chairman
John W. Hess, Jr.
Horton H. Hobbs III
Bethany Jean Grover Wells
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Richard A. Watson
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Philip M. Smith
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Personnel

General Statistics

Number of JVs as of November, 1974	321
Attrition	-63
Continuing JVs	258
New JVs -- Kentucky Area	78
New JVs -- Guadalupe Area	13
Number of JVs as of November, 1975	349

These are broken down as follows:

Members (79, of which 7 are not JVs)	72
Central Kentucky Area JVs	145
Guadalupe Area JVs	56
Archeologists	54
Biologists	22

The big news this year on the Personnel front has been the publishing of the Second Edition of the CRF Personnel Manual, edited by Jack Freeman. The manual was distributed to all personnel, and fairly widely outside the foundation. It received good reviews in several caving periodicals.

Expeditions this year have been of comfortable size, if anything a little too small for greatest efficiency. In response, a number of new JVs have recently been accepted, and the Thanksgiving Expedition was a good-sized affair, with more than 50 participants.

The archeology projects have been very active and have greatly expanded their personnel, as have the biologists (though to a preportionately lesser degree). Though fewer JVs have been active in the cartographic program, the constant presence of Diana Daunt and Don Coons at the Park, together with a number of other JVs now living quite close by, have led to quite a few mini-expeditions. These people have formed one of the nucleus groups planned for last year, and other groups are forming in Columbus and in Washington, DC.

The publication of the new book, The Longest Cave, is sure to produce another surge of applications for joint venture status, so now is a good time to sign up people we really want, before the deluge.

The National Cave Management Symposium

A symposium on cave management was held October 6 - 10, 1975, in Albuquerque, New Mexico, sponsored jointly by the National Park Service, National Forest Service, Bureau of Land Management, Cave Research Foundation, and National Speleological Society. The goals were to exchange data on caves and cave management, and to improve communications between cave owners, speleologists, cave managers and cavers. It was hoped that cave management techniques and policies would be upgraded to better protect our virtually non-renewable cave resources. CRF members Cal Welbourn and John McLean were on the planning committee.

Publications

Books

John P. Freeman (editor), Personnel Manual, Cave Research Foundation, Yellow Springs, Ohio, 1975, (2nd edition).

Richard A. Yarnell, Early Plant Husbandry in Eastern North America. In Christopher Pebbles, ed., Festschrift for James B. Griffin, in press.

Articles and Theses

Articles

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T.C. Kane (1975) Reproductive strategy of Neaphaenops tellkampfii (Coleoptera: Carabidae). Am. Zool. 15: 793.

T.C. Kane, R.M. Norton and T.L. Poulson (1975) The ecology of a predaceous troglobitic beetle, Neaphaenops tellkampfii (Coleoptera: Trechinae). I. Seasonality of food input and early life history stages. Int. J. Speleol. 7: (in press).

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S.G. Wells (in press) The geomorphic evolution of the sinkhole plain in the Mammoth Cave region, Kentucky. Annals of the Assoc. of American Geographers.

Theses

Kenneth C. Carstens (1974) Archeological surface reconnaissance of Mammoth Cave National Park Kentucky, M.A. in Anthropology, Washington Univ., St. Louis, Missouri.

Ernst H. Kastning (1975) Cavern development in the Helderburg Plateau, east-central New York, M.A. in Geology, Univ. of Connecticut, Storrs, Connecticut.

Papers at Professional Meetings

73rd Annual Meeting of the American Anthropological Association (Mexico City, Mexico, November, 1974).
William H. Marquardt and Patty Jo Watson
"The Green River, Kentucky, shellmound archeological project."

40th Annual Meeting of the Society for American Archeology (Dallas, Texas, May, 1975).
Kenneth C. Carstens
"Surface archeology in the Mammoth Cave National Park, Kentucky."

AIBS Meetings (Corvallis, Oregon, August, 1975).
Thomas C. Kane
"Reproductive strategy of *Neaphaenops tellkampfii* (Coleoptera: Carabidae)."

Mid-Western Archaeological Conference Symposium (University of Michigan, October, 1975).
Patty Jo Watson
"In pursuit of prehistoric subsistence: a comparative account of some contemporary flotation techniques."

International Association of Hydrogeologists, 12th International Congress (Huntsville, Alabama, September, 1975).
Rane L. Curl
"The dissolution kinetics of calcite in carbonic acid."
Derek C. Ford
"Cave systems and groundwater hydrologic organization in limestones."
Derek C. Ford and James F. Quinlan
"Karst of Canada."
Angelo I. George (North Shore Task Force)
"Cave development north of the Green River at Mammoth Cave National Park is strongly influenced by recharge from a filled Pennsylvanian paleo-valley."

Russell S. Harmon
"The chemical and isotopic composition of carbonate groundwaters, nature of bedrock dissolution in karst terrains."
Keith G. Kirk and Henry Rauch
"The application of the tri-potential method of resistivity prospecting for ground-water exploration and land use planning in karst terrains."
Arthur N. Palmer
"Effect of continental glaciation on karst hydrology, northeastern U.S.A."
Arthur N. Palmer
"Structural control of ground-water flow and cave development in Mammoth Cave National Park, Kentucky, U.S.A."
Richard L. Powell
"Joint patterns and solution channel evolution in Indiana."
Richard L. Powell
"Lateral unloading of isotropic rock as a process of solution channel enlargement."
James F. Quinlan, Michael R. McCann, William M. Andrews and John A. Branstetter
"Heavy metals and optical brighteners as ground water tracers in the Central Kentucky Karst: implications concerning regional hydrology
John Thrailkill
"Relative solubilities of limestone and dolomite."
Elizabeth L. White
"Surface water hydrology in carbonate basins within the Appalachians."
William B. White
"Role of solution kinetics in the development of karst aquifers."

National Cave Management Symposium (Albuquerque, New Mexico, October, 1975).
Cal Welbourn - Moderator cave resources session
"Visitor Management through physical controls."
Roger Brucker
"Caves and Caving - an overview."
Jack Hess
"Hydrology and geology."
Carol Hill
"Minerology."
Thomas Poulson
"Biology."
John McLean
"Classification systems of caves."
John Corcoran and James Hardy
"Computer use in cave mapping."
Alan Hill
"Acoustical holography."
Roger Brucker
"The Mammoth/Flint Ridge link-up expedition."
John McLean
"Cave climate."

Talks

Jack Hess

"The Central Kentucky Karst" Southern Nevada Grotto of the N.S.S. in Las Vegas, Nevada, October, 1975.

Arthur N. Palmer

"Geology of Mammoth Cave, Kentucky" Talk presented for the National Park Service, Mammoth Cave National Park, Kentucky, July, 1975.

Patty Jo Watson

"Archeology of the Mammoth Cave area" Luncheon talk at the University of Cincinnati given as Taft Lecturer, May, 1975.

"Prehistoric subsistence patterns at Mammoth Cave and the Green River shell mounds" Visiting lecturer series, Dept. of Anthropology, University of Tennessee, Knoxville, Tennessee, November, 1975.

Cal Welbourn

"Cave fauna of Carlsbad Caverns National Park" National Park Service Seasonal Training Session, Carlsbad Caverns National Park, June, 1975.

Appendix

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