UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

MAMMALIAN CAVE FAUNA FROM THE LATE PLEISTOCENE OF THE WESTERN OZARK PLATEAU, OKLAHOMA

A THESIS

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

MASTER OF SCIENCE

By

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Norman, Oklahoma
2018

MAMMALIAN CAVE FAUNA FROM THE LATE PLEISTOCENE OF THE WESTERN OZARK PLATEAU, OKLAHOMA

A THESIS APPROVED FOR THE
DEPARTMENT OF BIOLOGY

BY

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For Charlie

Acknowledgements

Thank you to my committee members Dr. Nicholas Czaplewski, Dr. Richard Cifelli, and Dr. Steven Westrop for your guidance and patience with advising me on this study, and for educating me further in a plethora of paleontological principles in class, laboratory, and field. Thank you to Kyle Davies for your guidance in fossil preparation, and so much more in the vertebrate paleontology lab and at the many excavations you've lead. Thank you, Jennifer Larson, for your continued support and managing the collection in which my specimens were stored. Thank you Dr. Lynn Soreghan for giving this biologist the best experience possible in their first graduate geology course, elements of your teachings have been useful to me since day one. Thank you, Dr. Rosemary Knapp, for believing in me when I could not believe in myself, it means the world and I would not be here without your support.

Thanks to Steve Hensley, manager of the Ozark Plateau National Wildlife Refuge, USDI Fish and Wildlife Service, for permits to collect fossils. Bill May kindly picked the microvertebrates from the screenwashed concentrate; Charles Baker and Hannah Fay mounted many of the microvertebrates on pins for ease of study and handling. John Stonecipher cataloged many hundreds of specimens from the deposit. Don G. Wyckoff helped secure funding for radiometric dating, and Arnold Coldiron provided the funding for the dating. William L. Puckette found the site and aided in specimen collection.

Hugh, Zoe, Mati, and Pip; thank you for welcoming this stranger into your lives. I consider you my family and the miles between us have not lessened the strength you have given me in some of the hardest of times.

Thank you, Jake, John, Sebastian, and Shawn, for our trips to collect rocks and fossils, and the years-long group chat that has taught me so much about geology; among many other things. Your passion is contagious. To have found a group of friends so quickly that spends their free-time nerding out about rocks and fossils made this crazy state feel a little bit like home. Thanks also to Theodore II for taking one for the team.

Mayzie, you're a good girl and the best dog.

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ABSTRACT

The Ozarks are a highland system riddled with caves across multiple states within the South-Central United States. During the late Pleistocene retreat of the North American Laurentide ice sheet, habitat and species composition of this region was indicative of a more temperate climate. Many studies have ascertained a strong boreal influence on late Pleistocene mammalian faunas in the central Ozarks, but less is known of this period in the highland region of Eastern Oklahoma. This study focuses on a site designated as AD-14 located within the Duncan Field Cave Complex of Adair County, Oklahoma which straddles the border of Oklahoma and Missouri and represents the westernmost edge of the Ozark Plateau. Material was collected from muddy deposits in the cave floor where bones were visibly accumulated as a lag deposit. Preliminary dating yielded a conventional radiocarbon age of 12,304± 50 years for this site. Further radiocarbon analysis is needed to determine if this is a temporally mixed or contemporaneous deposit. Here, we introduce the mammalian fauna found in this late Pleistocene accumulation, which is dominated by small mammalian remains. As the Duncan Cave Complex is currently regarded one of the most biologically rich cave an analysis of species has indicated key differences between current and late Pleistocene environments. Extralocal taxa such as bog lemmings, star-nosed moles, meadow jumping mice, and southern red-backed voles were all cohabiting the Ozark Highland ecoregion during this time, indicative of a cooler climate than modern day and giving insight into future species reactions to anthropogenic climate change.

INTRODUCTION

Cave deposits are often a good source of paleobiological data given their propensity to accumulate debris. Most detritus and soft tissue will decompose, but the bones of any animals that may have perished survive and accumulate in various stages of preservation.

During the late Pleistocene retreat of the North American Laurentide ice sheet, habitat and species composition of this region was indicative of a more temperate and slightly boreal climate (Hall, 1988). While the modern-day Ozark Highland ecoregion historically represented a transition from grassland to deciduous forest (before anthropogenic habitat conversion), studies have ascertained a strong coniferous and deciduous woodland influence on late Pleistocene mammalian faunas in the central Ozarks (Hall, 1988; Akersten and McDonald, 1991). Additionally, habitats of the Late Pleistocene varied considerably across the state (Saunders, 1975).

The modern-day Ozark Highland system is pocketed with cave complexes across Oklahoma, Missouri, Arkansas, and Kansas in an area of roughly 48,000 square miles (Adamski et al., 1995). This study focuses specifically on cave AD-14, also known as the Duncan Field Cave Complex. Within this cave, fossils were discovered at OMNH locality V1506 in Adair County, Oklahoma, near the western edge of the Ozark Plateau (Graening, 2007).

This locality has provided a concentrated deposit of various small mammalian fossil remains, which can give an inside look into the habitat and species distribution of the area during time of deposition.

A. Objectives

This study aims to focus on answering just what animals lived during this time period in this particular habitat, both in and around the cave, and what that says about the climate of this time period as the Laurentide ice sheet retreated from the region. As such, my working hypothesis is that species within this locality lived in a time of a cooler climate and the taxa found will corroborate this when compared to the climate of their extant relatives.

BACKGROUND

A. The Late Pleistocene Biome of Eastern Oklahoma

Based on pollen data from cores, during the Late Pleistocene, the eastern portion of Oklahoma, and western portion of the Ozark Highland system were dominated by boreal forest (Delcourt and Delcourt, 1991). During this time, which was the last glacial maximum (the Wisconsinan), the Laurentide ice sheet covered a good portion of North America, extending south to New York and Ohio. This put what is modern-day eastern Oklahoma and western Missouri in a pluvial environment with much cooler conditions than currently are expected of such latitudes. What was previously mixed deciduous forest was replaced by boreal forest spruce and pine (Delcourt and Delcourt, 1991).

A late Pleistocene vertebrate assemblage in Missouri corroborates this, where Schubert noted the strong boreal influence on the mammalian fauna found. This suggested a cool, moist, and equable climate and a habitat mosaic of open coniferous and deciduous forests with intermixed grasslands for the Central Ozarks (2003). Another study (Saunders, 1975) noted many small mammals in Missouri cavity assemblages (*Synaptomys. Sylvilagus, Neotoma* and *Blarina*) which presently occur in habitats that provide cover in coniferous and deciduous forest, borderlands, or steppes. By the end of the Pleistocene, aboriginal peoples had arrived in the Ozark Highland area and, as the boreal forest retreated northward with the glaciers, prehistoric humans likely manipulated large tracts of forest with fire, maintaining the open habitat as a mix of prairie and woodlands (Tyrl et al., 2002).

Current habitats for this region comprise a gradient of grassland to mixed forest as one goes eastward into Missouri and a much warmer climate than the end Pleistocene.

B. Geology

1. GEOLOGICAL SETTING

The region covered by the Ozark Plateau includes areas within the states of Kansas, Arkansas, Oklahoma, and Missouri. The Plateau consisted of three sections: Springfield Plateau, Salem Plateau, and the Boston Mountains. The cave in this study is located within the Springfield Plateau where karst features like caves and sinkholes are common (Adamski et al., 1995).

The Springfield Plateau itself is underlain with caves formed within the Pitkin Limestone and overlain by the Hale Formation, both of which are of Pennsylvanian age, the rock of which the cave system was carved out by the Springfield Plateau aquifer (Fenneman, 1938).

2. CAVE ENTRANCE AND LOCATION

The entrance of the cave was marked by oak and hickory forest and is roughly 403 meters in elevation. The entrance room to the V1506 locality was approximately 76 lateral meters from the entrance to the cave (Fig. 2). The cave was approximately 55°C and contained hibernating tricolored bats (*Perimyotis subflavus*).

The specific vertebrate fossil locality within the cave was originally found by Bill Puckette on June 30, 2003, where he did a brief survey and documentation of the site and collected surface material. He collected a sample of approximately a quarter liter, where he saw bones accumulating in a small drip-hole within the muddy deposits on the floor. This initial discovery would be later documented as within the “Lower Deposit” of the two drip-cups from which material was collected.

AD-14 cave is part of the Duncan Cave Field Complex, in the Eastern Oklahoma Ozarks of Adair County, Oklahoma. The complex comprises around nine miles of passages with multiple rooms and entrances, and is known as one of Oklahoma’s most modern biologically rich cave systems (Graening, 2007; Looney, 1969).

The Sam Noble Oklahoma Museum of Natural History (OMNH) has designated the paleontological locality within the cave as V1506 (Figs. 4 and 6).

MATERIALS AND METHODS

A. Excavation

Excavation was done by personnel of the vertebrate paleontology lab of the OMNH on December 28, 2005, with the aid of William Puckette and Clayton Russell. Two separate areas of unlithified sedimentary deposits (Quaternary) were sampled with small test pits; these were designated as "Upper Deposit" and "Lower Deposit" and were separated by 6-7 m horizontally and less than a meter vertically by a limestone ledge forming a step in the cave floor, but the deposits may originally have been laterally continuous. Microvertebrate bones had accumulated as lag deposits from the sedimentary deposits in two sets of drip-cups on the cave floor. Fossils accumulated as lag on the surface were collected and small test pits were dig in each of the two deposits.

Profile cleaning of the Lower Deposit showed six distinguishable layers that were noted, while the Upper Deposit yielded four units. The profiles of each were measured, sketched, and photographed. Samples of fossiliferous sediment were collected from each unit using trowels, and whisk brooms and placed in plastic bags and vials for transport to the OMNH and later screenwashing. All other samples were collected in plastic gallon zip-top bags from the stratigraphic levels described below. Delicate and partially-intact vertebrate fossils encountered during excavation were placed in vials and labeled with appropriate provenience data. Excavations were not continued to the depth of the Pitkin limestone bedrock.

B. Profile Descriptions

LOWER DEPOSIT (Figs. 1.1 and 5)

Unlithified sedimentary deposits were moist or even saturated because of wet cave conditions. The 2nd and 3rd levels seemed most fossiliferous, though sticky mud obscured this during sampling. In the upper right corner of the top of the 2nd level was found what might represent an animal scat, a pebbly-textured grayish-black ball that was stored in its own separate vial.

1st level – (6.35 mm laminations), densely packed sandy silt/clay, pale grayish tan to brown, dense and not fossiliferous; 4 cm thick.

2nd level – loose, fluffy-airy (like moist cake), but moist silt/clay, soft and with many fossils visible, especially bat wing and finger bones and an occasional rodent long bone, with pebbles scattered especially throughout the top half of the unit and one cobble in the middle of the unit. The top-half was slightly darker gray-brown than the paler gray-brown bottom-half. The bottom-half contained one yellowish-gold clay pebble that might represent decomposing roof fall, possibly derived from the Hale Formation. The top 6 cm of the unit were collected in 2 bags and the bottom 6cm of it in separate bags; ~12 cm thick.

3rd level – loose, fluffly-airy; like 2nd level, but darker brownish-gray. It included a small 1 cm^3 block of black material that might represent a crumbling but wet piece of charcoal or shaly clay pebble derived from the cave walls. At the lower right of this unit was a blackish lens that was also light and fluffy, samples of which were collected in a separate vial as potentially old guano sample. Slightly fossiliferous; 4 cm thick.

4th level – This is a thin zone that seemed transitional between the overlying 3rd and underlying 5th levels; bagged separately; 2cm thick.

5th level – similar to 1st level; pale grayish sandy silt/clay, denser than levels 2nd-3rd-4th, bagged down to 6 cm deep where excavation was discontinued, though unit continues deeper, it is at the next lower walking surface; 6cm thick; not fossiliferous.

6th level – not collected; blackish brown w/ gold swirls – mud-cracked blocks of clay.

Depth to the limestone bedrock unknown.

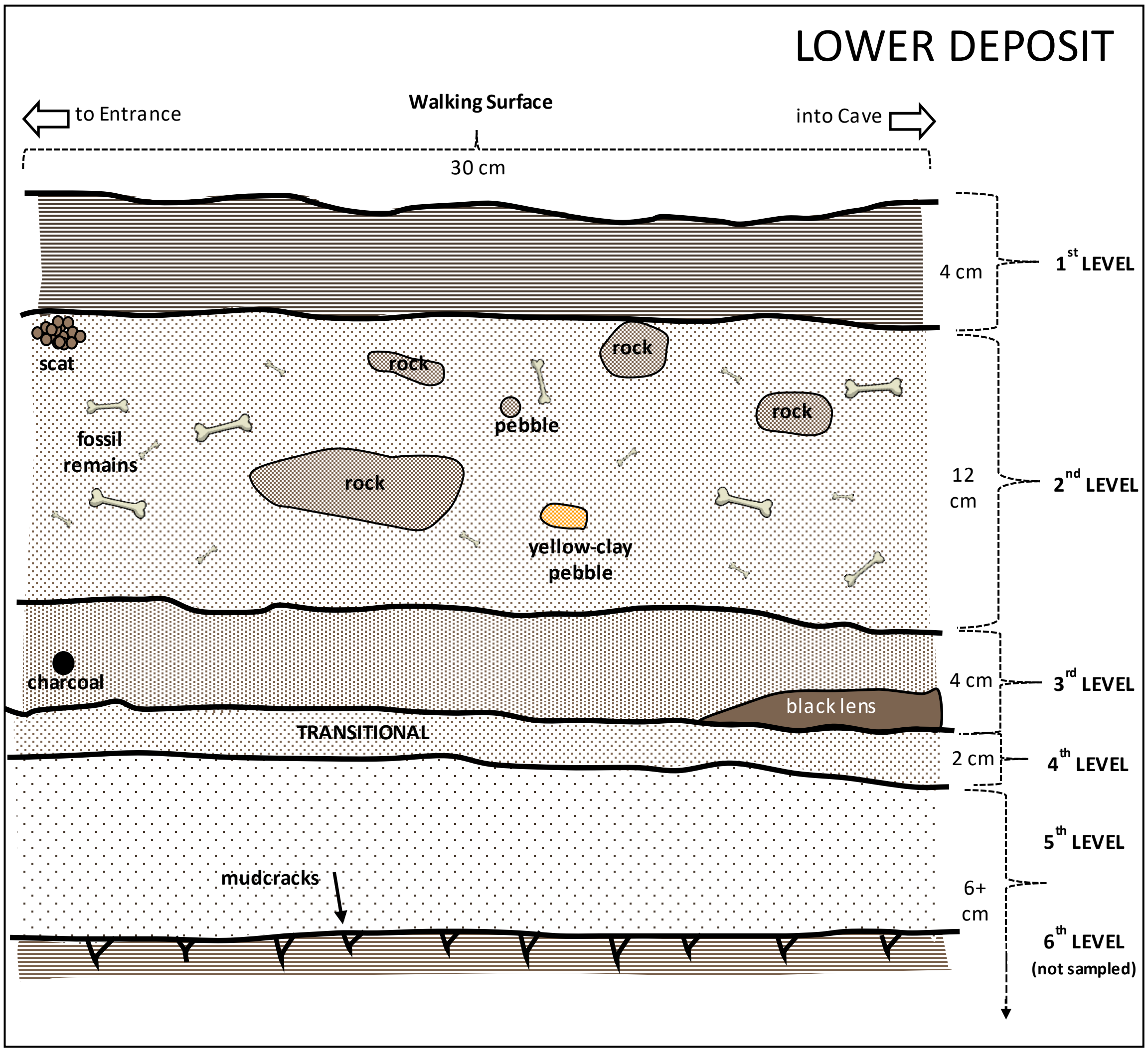

Figure 1.1

Lower Deposit profile cut, facing West Bank of mud deposit.

UPPER DEPOSIT (Figs. 1.2 and 7)

As with the Lower Deposit, the Upper Deposit was profile cleaned, with most good surface specimens being retained before excavation began.

The test pit was smaller than that in the Lower Deposit. This was composed of four distinct levels that were laterally highly variable. Plastic zip-top gallon backs were scarce at this point, so the profile cut material filled one bag, while the other four were used to collect samples from individual levels.

1st level – packed dense brown silt, no visible fossils; 4cm thick.

2nd level – looser, fluffy silt, pale reddish tan with fossil small vertebrate bones. Level 1 peeled easily off to reveal deposits of bone, mixed pale yellowish-white and blackish-brown on this one bedding plane; 3cm thick.

3rd level – darker grayish-brown, mottled with dark gray or blackish spots; loose fluffy silt. 1-2cm thick

4th level – brownish silt with numerous light-gray gravel-sized inclusions; 6+cm thick and continues down

Depth to limestone bedrock unknown.

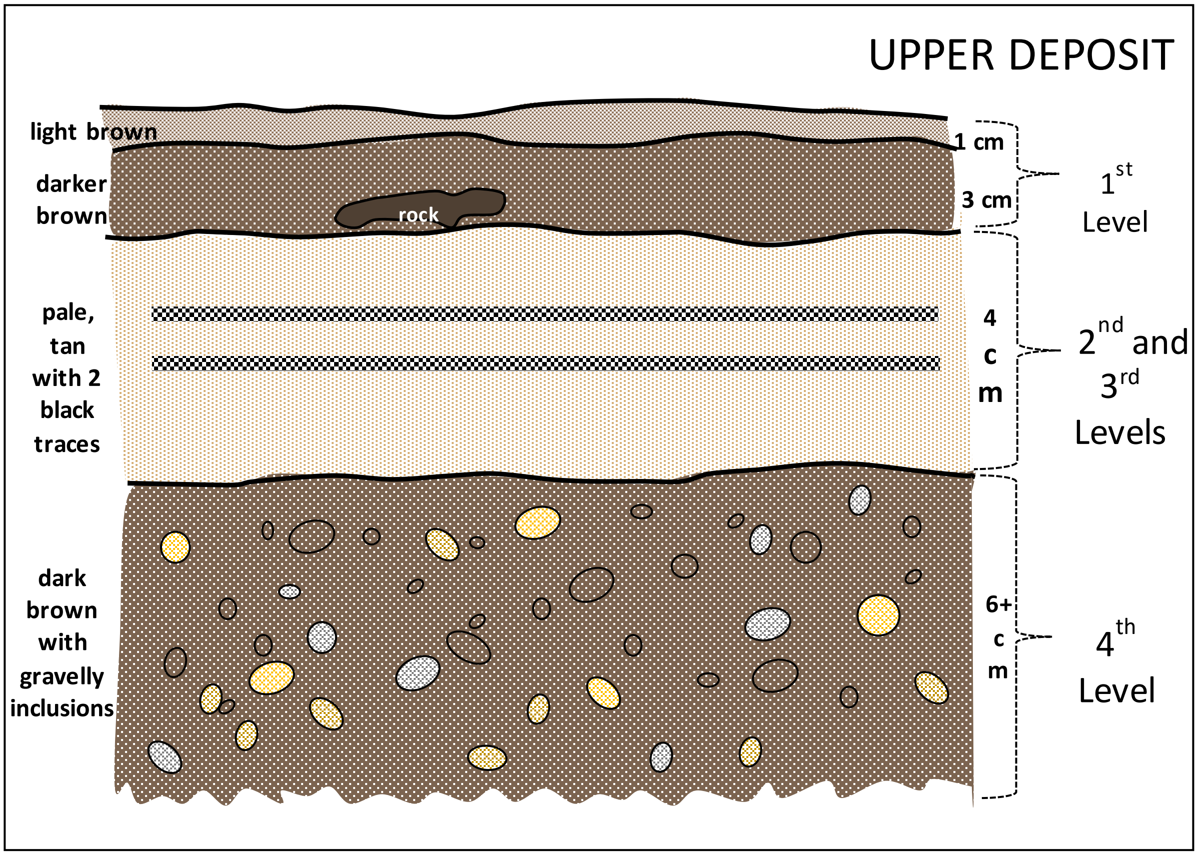

Figure 1.2

Upper Deposit profile cut after collecting a gallon-bag sample.

C. Processing of Fossiliferous Sediment Samples

Material was screen-washed with water in two-part nesting screen-bottomed boxes. Size of screens were 1.5mm for the inner box, and 0.6mm for the outer box as specified by Cifelli et al. (1996). Concentrated material was then dried, and specimens were sorted and catalogued into the OMNH Vertebrate Paleontology collection.

D. Data Selection and Manipulation

Material was heavy in Chiropteran (bat) and rodent remains, especially postcranial skeletal elements containing upwards of hundreds of specimens, including to a lesser extent shrews, moles, Carnivorans, and rabbits. Due to this abundance of skeletal material, and given mammalian remains reliance on craniodental information for a positive identification, dentaries and maxillae (lower and upper jaws) containing teeth were prioritized. Of these specimens, 179 were chosen for this study due to their good state of preservation for use in identification. In most instances, criteria for this included a well-intact maxilla or dentary with a minimum of 2 teeth still present. In a few cases, entire rostra and craniums are present. For some larger animals or those with more distinct and identifiable teeth or bones, singular teeth and postcranial material were used in identification. This can be seen in the cases of *Procyon lotor, Neotoma rodents, Neovison, Condylura cristata,* and *Sylvilagus.*

Species within the genus *Myotis* are small and difficult or unidentifiable to species if incomplete cranial material is present. Species within this large genus in or near the study area today include: *M. septentrionalis, M. ciliolabrum, M. lucifugus, M. griscesens, M. leibii, M. austroriparius,* and *M. sodalis.* Therefore, for the purpose of this study *Myotis* spp. were classified only on size: small and medium.

Since the lag deposit likely does not represent a contemporaneous assemblage of fossils, the relative ages of the sedimentary units are unknown, and cave deposits are likely to represent time-transgressive fossils, a study looking at relative abundance of the taxa was not possible. Instead, my focus was to get as complete a taxonomic sampling of the paleofauna as possible, and examine them for their biogeographic significance. Taxa present as fossils in the cave in the Late Pleistocene were compared with modern taxa of North America. Those taxa no longer present in the region in modern times have special biogeographic significance. These are referred to as extralocal taxa and can give evidence about the habitat and climate of the time-period of deposition.

E. Carbon-14 Dating

Two specimens from the AD-14 V1506 locality were sent to Rafter Radiocarbon Laboratory, Lower Hutt, New Zealand on November 3rd, 2010 for AMS radiocarbon dating. Specimens chosen were dentaries from a *Myodes gapperi* (southern red-backed vole, an extralocal taxon) and *Eptesicus fuscus* (big brown bat, still present in the area today). These two specimens were selected for dating based on recommendations from Stafford et al. (1990) because they were two distinct taxa from the same layer. Before sending, specimens were photographed because they would be destroyed in the dating process. Both specimens originated in the 2nd layer of the Lower Deposit, specifically the lowest 6cm of a 12cm thick level.

F. Species Identification

Specimens were identified using dissection microscopes to illustrate and photograph pieces. These were compared to existing comparative collections within the

OMNH. The utilization of Animal Diversity Web and scientific articles aided in identification, specifically keys provided by Guadin et al.'s 2011 paper on Late Pleistocene bats from Tennessee and Semken and Wallace's key to Arvicoline rodents (2002).

As *Myotis* are often small, fragmented, and morphologically very similar, classification for these down to species was not possible.

RESULTS

A. List of Identified Species

In Table 1.1, all mammalian species identified in this study are listed, as well as their presence in either the Upper or Lower Deposit. Taxa are listed phylogenetically in ascending order.

Taxon	Represented in Upper Deposit	Represented in Lower Deposit
EULIPOTYPHLA		
Talpidae		
Condylura cristata		x
Scalopus aquaticus		x
Scalopus sp.	x	x
Soricidae		
Blarina brevicauda		x
Sorex sp.		x
Cryptotis sp.		x
CHIROPTERA		
Vespertillionidae		
Vespertillioninae		
Eptesicus fuscus	x	x
Perimyotis subflavus	x	x
Myotinae		
Myotis sp. *(small)*	x	x
Myotis sp. *(medium)*	x	x
CARNIVORA		
Canidae		
Urocyon cf. *cineroeargenteus*		x
Procyonidae		
Procyon lotor		x
Mustelidae		
Neovison vison		x
LAGOMORPHA		
Leporidae		
Sylvilagus sp.	x	x
RODENTIA		
Sciuridae		
		x

Taxon	Represented in Upper Deposit	Represented in Lower Deposit
Geomyidae		
Geomys sp.	x	x
Cricetidae		
Arvicolinae		
Myodes gapperi		x
Synaptomys cooperi		x
Microtus sp.		x
Peromyscinae		
		x
Neotominae		
Neotoma sp.		x
Dipodidae		
Zapodinae		
Zapus hudsonius		x

Table 1: *List of species identified in this study and their presence in the Upper and Lower Deposits.*

SPECIES DIVERSITY

Overall the Lower Deposit has both more fossil material and a higher species richness. A majority of fossils found were of Chiropteran remains. Layers in both deposits were not distinct enough, nor the format of the study fit, to determine distribution between layers. There is also no way to determine the age structure of the Upper Deposit as only Lower Deposit fossils were sent in for dating.

NON-MAMMALIAN TAXA

While non-mammalian taxa were not considered for the purpose of this study, remains of them were still found in the deposit. Among those represented are: Anura (frogs), Urodela (salamanders), Serpentes (snakes), and Actinopterygii (bony fish).

B. Carbon-14 Dating

Modern AMS C14 radiocarbon dating was used, rather than conventional. This includes atmospheric data and geolocality.

The *M. gapperi* specimen (AD14-MG; Rafter's R32588/2), was a left dentary containing the incisor (i1) and first and second molars (m1-m2). This sample was lost during processing when the glass tube containing CO2 with the specimen's carbon cracked in the oven, allowing enough CO_2 gas to escape that there was insufficient material to date.

The *E. fuscus* specimen (AD14-EF; Rafter's R32588/1) was a right dentary containing molars two through three (m2-m3). This sample was successful in yielding results with a calibrated radiocarbon age of 12,304 ± 50 years.

DISCUSSION

A. Systematic Paleontology

For the purposes of clarity and brevity, "Upper Deposit" and "Lower Deposit" will use the acronyms "UD" and "LD" respectively.

ORDER EULIPOTYPHLA

Family Talpidae

Condylura cristata

Material – LD OMNH 73940, left maxillary fragment with P2-P3 (Fig. 12); LD OMNH 73951 right m2

Discussion – This species is extralocal for its modern range and is of paleobiogeographical significance.

Scalopus aquaticus

Material – LD OMNH 73950, lower left m2 (Fig.11), 79085; UD OMNH 79084, worn right M1 lacking enamel from much of the labial and occlusal surfaces;

Discussion – This species is within its modern extant range.

Family Soricidae

Blarina brevicauda

Material – LD OMNH 79123, right dentary fragment with i1-m1,

Blarina sp.

Material – LD OMNH 79122, dark brown pigmentation, but pigment is still discernable on the moderately worn teeth.

Discussion —The i2 of OMNH 79123 has no accessory cone posterolingual to the main cusp. This character fits with part of the diagnosis of *Blarina brevicauda*, known from the Conard Fissure of Arkansas (Graham and Semken, 1976). Only two specimens of this genus are present in the material collected from AD-14. This species is within its modern extant range, though along the southwesternmost range boundary.

ORDER CHIROPTERA

Family Vespertilionidae

Eptesicus fuscus

Material – LD OMNH 79102, 79101; UD OMNH 79099, 79100

Discussion – This species was prevalent in both Upper and Lower deposits. Skulls ranged from average to quite large, possibly suggesting increased moisture across their environment at the time, as in this species wing and skull size are positively correlated with environmental moisture (Burnett, 1983). This species is within its modern extant range.

Perimyotis subflavus

Material – LD OMNH 79095, 79096,79097; UD OMNH 79098

Discussion – *Perimyotis subflavus* (tricolored bat, formerly known as the eastern pipistrelle; *Pipistrellus subflavus*) has been shifting or expanding its range for the last few decades (Fitzgerald et al., 1989; Bogan and Cryan, 2000; Geluso et al., 2005); possibly it fluctuates in connection with global or regional climate change. Currently, this species is within its modern extant range.

Sub-Family Myotinae

Myotis spp. (small)

Material – LD OMNH 79062, 79063, 79074, 79073, 79064, 79072, 79065 79066, 79070, 79067, 79068, 79069

Discussion – Assuming they are analogous to *Myotis* species native to the area, it can be said that these genera are within their modern extant range.

Myotis spp. (medium)

Material – LD OMNH 75753, 75519, 75522, 75525, 75861, 75596,75845, 76119, 75719, 75590, 75595, 75581, 75585, 75609, 75669, 75575, 75676, 75614, 75527, 75819, 75517, 75864, 76120, 75841, 75583, 76112, 75804, 79140, 79141, 79061, 79060, 79059, 79058, 79057, 79056, 79049, 79050, 79051, 79052, 79053, 79054, 79055; UD OMNH 79043, 79044, 79045, 79042, 79041, 79040, 79039, 79038, 79036, 79037, 79033, 79034, 79035, 79046, 79047

Discussion – Assuming they are analogous to *Myotis* species native to the area, it can be said that these genera are within their modern extant range.

Corynorhinus sp.

Material – LD OMNH 79158, 79159, 79160, 79161, 79162, 79163, 79164, 79165

Discussion – This genus is within its modern extant range, though it is geographically isolated from the main population.

ORDER CARNIVORA

Family Canidae

Urocyon cf. *cinereoargenteus*

Material – LD OMNH 79092, extremely worn M1, no apomorphic characters preserved. Identification is based on occlusal outline and size.

Discussion – This species is within its modern extant range.

Family Procyoniidae

Procyon lotor

Material – LD OMNH 79127, 79128, 79129, 79130, 79131, 79132, 79133, 79134, 79135, 79136, 79137, 79138, 79139; several teeth, astragalus, and claws.

Discussion – Many large individual raccoon bones were found in the deposit, suggesting this may be a predator accumulation. If this is the case this would present a bias in both the species richness and the contemporaneousness of the sample. This species record is within its modern extant range.

Family Mustelidae

Neovison vison

Material – LD OMNH 79105; M1 (Fig. 9); OMNH 79104, 79103

Discussion – This species is within its modern extant range.

ORDER LAGOMORPHA

Family Leporidae

Sylvilagus sp.

Material – LD OMNH 73946, right p3 (Fig. 11); LD OMNH 79093; UD OMNH 79094

Discussion – This genus is within its modern extant range.

ORDER RODENTIA

Family Sciuridae

Sciurus sp.

Material – LD OMNH 79147, 79148, 79149, 79150, 79151, 79152, 79153, 79154, 79155, 79156, 79157

Discussion – This genus is within its modern extant range.

Family Geomyidae

Geomys sp.

Material – OMNH 73947, P4 abraded and missing anterior enamel plate

Discussion – This genus is within its modern extant range.

Family Cricetidae

Subfamily Arvicolinae

Myodes gapperi

Material— LD OMNH 79087, 79088, 79089, 79090, 79091

Discussion—While the genus was originally known as *Clethrionomys*, Tesakov et al. (2010) referred the species to

Myodes. Therefore, we use the name *Myodes gapperi*. This species is known from cave deposits in other localities in the Ozark Highland dating to the last glacial, e.g., records from Peccary Cave, Arkansas, at about 16,700 ybp (Davis, 1969; Quinn, 1972; Semken, 1984; Stafford and Semken, 1990). This species is extralocal for its modern range and is of paleobiogeographical significance.

Synaptomys cooperi

Material—LD OMNH 79081, L dentary with m1 (Fig. 8)

Discussion – This species' modern range does not extend as far southward as AD-14 Cave, suggesting a cooler climate at the time of deposition. This species is extralocal for its modern range and is of paleobiogeographical significance.

Microtus sp.

Material— LD OMNH 79144, R dentary; OMNH 79145, 79146, maxilla with M1

Discussion – These fossils are within the modern range of the genus.

Subfamily Peromyscinae

Peromyscus sp.

Material – LD OMNH 79087, 79088, 79089, 79090, 79091

Discussion – These fossils are within the modern range of the genus.

Subfamily Neotominae

Neotoma spp.

Material – LD OMNH 79109, 79107, 79106, 79110, 79108, 75408, 75392, 75406, 75410

Description –

Discussion – These fossils are within the modern range of the genus.

Family Dipodidae

Subfamily Zapodinae

Zapus hudsonius

Material – LD OMNH 73941, right dentary with m1-m3; OMNH 73942, right M1; OMNH 73943, left M2 OMNH 73944, right M2; OMNH 73945, left m2; (Fig. 10).

Discussion— *Zapus* prefer open areas of forest having dense grasses (Hadly, 2008), but are also somewhat habitat generalists in regions associated with dense herbaceous vegetation and are unwilling to cross even a small area with little to no cover (Quimby, 1951). This species is extralocal for its modern range and is of paleobiogeographical significance.

B. Etralocal Taxa

Zapus hudsonius

Zapus disjunct distribution of its many geographic isolates in the Rocky Mts. and southwest are relictual from a more widespread distribution during glacial maxima (Hafner 1993).

Condylura cristata

This unexpected specimen represents the southwesternmost record of the star-nosed mole. Previously this unusual species was known from several localities in the eastern United States beyond its modern range; the southwesternmost of these had been in Peccary Cave, Arkansas, where it was found in deposits dated to the last glacial and last glacial maximum (Davis, 1969; Quinn, 1972; Semken, 1984; Stafford and Semken, 1990). The extralimital occurrence of this species in AD-14 Cave in the Oklahoma Ozark Highland is concordant with the radiometric date on a bat jaw from AD-14 that correlates to the last glacial maximum.

Synaptomys cooperi

Myodes gapperi

Red-backed voles in particular indicate a preference for cooler, more mesic forested environments, with dense wooded habitat and understory (Hadly, 2008).

C. Carbon-14 Dating

Due to the failure in one of the two specimens sent in for radiocarbon dating, this study relies on only one date. This establishes that at least one faunal member in one unit of one of the two deposits indicates a late Pleistocene/Rancholabrean/late Wisconsinan glacial age of 12,304± 50 years BP. Although the deposit is most probably diachronous, this date provides a working estimate of the age of the deposit and fauna.

CONCLUSIONS

- The AD-14 cave deposit V1506 fossils are likely not contemporaneous, but a mixed sample due to a variety of material transport including guano deposits, predator deposits, and lag deposits.
- Material has been radiometrically dated to approximately 12,304± 50 radiocarbon years old based on one specimen. As suggested above, unless all of the fossils are contemporaneous, this cannot represent age of the entire sample.
- The presence of extralocal taxa *Zapus hudsonius, Condylura cristata, Synaptomys cooperi, Myodesgapperi* suggest a cooler environment congruent with the pluvial environment to be expected of the Ozark Highland during last glacial maximum.
- The Late Pleistocene in the Ozark Highland ecoregion was a boreal forest as opposed to the modern grassland/deciduous forest biomes of today. Forest dwellers and those with a preference for more northerly environments such as *Condylura cristata* and *Synaptomys cooperi* extended into the region at this time. The presence of *Zapus hudsonius* suggests a period of glacial maximum, as they quickly became relictual populations upon the retreate of the Laurentide ice sheet.
- The extirpation of the extralocal taxa with the retreat of the Laurentide ice sheet suggests they are less generalistic and more susceptible to environmental changes and climate. This suggests they will be the first to become extirpated from their current ranges due to anthropogenic climate change, and may be a useful indicator species for at-risk ecoregions.

- The presence of taxa that still occur in the Ozark Highland cave system of today suggests they are more habitat generalists.

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APPENDICCES

Appendix A. Tables

Table 2: Museum catalogue data for the specimens used in this study.

Catalogue #	ID	Description	Site #	Locality	Collectors	Remarks
79033	Chiroptera	maxilla	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT*
79034	Chiroptera	maxilla	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT*
79035	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT*
79036	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT*
79037	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT*
79038	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT*
79039	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT surface*
79040	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT fr. NW wall*
79041	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT fr. NW wall*
79042	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT fr. NW wall*
79043	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT 4th level w/ light gray gravel inclusions; 6+ cm*
79044	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT 4th level w/ light gray gravel inclusions; 6+ cm*
79045	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT 4th level w/ light gray gravel inclusions; 6+ cm*
79046	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT 4th level w/ light gray gravel inclusions; 6+ cm*
79047	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT 4th level w/ light gray gravel inclusions; 6+ cm*
79049	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT surface*
79050	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT 3rd level ~4cm*
79051	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT 3rd level ~4cm*
79052	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT*
79053	Chiroptera	maxilla	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*UPPER DEPOSIT*

Catalogue #	**ID**	**Description**	**Site #**	**Locality**	**Collectors**	**Remarks**
79054	Chiroptera	maxilla	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT 3rd level ~4cm*
79055	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT 2nd level top 6cm profile cleanings ?guano*
79056	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT 2nd level top 6cm profile cleanings ?guano*
79057	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT 2nd level top 6cm profile cleanings ?guano*
79058	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT 2nd level top 6cm profile cleanings ?guano*
79059	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT 2nd level top 6cm profile cleanings ?guano*
79060	Chiroptera	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT 2nd level top 6cm profile cleanings ?guano*
79061	Chiroptera	rostrum	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT 2nd level top 6cm profile cleanings ?guano*
79062	*Myotis sp.*	maxillae & premaxillae	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT surface*
79063	*Myotis sp.*	maxillae & premaxillae	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT surface*
79064	*Myotis sp.*	maxillae & premaxillae	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT surface*
79065	*Myotis sp.*	maxillae & premaxillae	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT surface*
79066	*Myotis sp.*	maxillae & premaxillae	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT surface*
79067	*Myotis sp.*	maxillae & premaxillae	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT surface*
79068	*Myotis sp.*	maxillae & premaxillae	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT surface*
79069	*Myotis sp.*	maxillae & premaxillae	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT surface*
79070	*Myotis sp.*	maxillae & premaxillae	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT surface*
79071	*Myotis sp.*	maxillae & premaxillae	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT surface*
79072	*Myotis sp.*	rostrum	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT 3rd level ~4cm*
79073	*Myotis sp.*	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT 3rd level ~4cm*
79074	*Myotis sp.*	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	*LOWER DEPOSIT 2nd level bottom berm profile scrapings*

Catalogue #	***ID***	***Description***	***Site #***	***Locality***	***Collectors***	***Remarks***
79075	Peromycinae	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79076	Peromycinae	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79077	Peromycinae	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79078	Peromycinae	maxilla	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level top 6cm profile cleanings ?guano
79079	Peromycinae	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 3rd level
79080	cf. Reithrodintmys	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79081	*Synaptomys cooperi*	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79082	*Geomys sp.*	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	UPPER DEPOSIT fr. NW wall
79083	*Geomys sp.*	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	UPPER DEPOSIT fr. NW wall
79084	*Scalopus sp.*	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	UPPER DEPOSIT
79085	*Scalopus sp.*	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79087	*Myodes sp.*	teeth (7)	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79088	*Myodes sp.*	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79089	*Myodes sp.*	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79090	*Myodes sp.*	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79091	*Myodes sp.*	teeth (3)	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 5th level
79092	cf. *Urocyon cineoargentineus*	singular tooth L M1	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79093	*Sylvilagus sp.*	large bone fragment	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79094	cf. *Sylvilagus*	dentary frag	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	UPPER DEPOSIT
79095	*Perimyotis sp.*	maxilla	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79096	*Perimyotis sp.*	maxilla	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface

Catalogue #	**ID**	**Description**	**Site #**	**Locality**	**Collectors**	**Remarks**
79097	*Perimyotis sp.*	maxilla	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79098	*Perimyotis subflavus*	cranium	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	UPPER DEPOSIT surface
79099	*Eptesicus fuscus*	cranium	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	UPPER DEPOSIT surface
79100	*Eptesicus fuscus*	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	UPPER DEPOSIT cut from wall
79101	*Eptesicus fuscus*	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79102	*Eptesicus fuscus*	L maxilla	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79103	cf. *Neovision*	L maxilla w/ P$\underline{3}$	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79104	cf. *Neovision*	zygomatic arch	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 3rd level darker level ~2.5 cm (down to sandy-silt basal layer_
79105	Mustelid	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level pale 12-14 cm
79106	*Neotoma sp.*	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level top 6 cm
79107	*Neotoma sp.*	L dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level top 6 cm
79108	*Neotoma sp.*	R dentary w/ m2	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 3nd level ~4cm
79109	*Neotoma sp.*	singular tooth m1	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 3nd level ~4cm
79110	*Neotoma sp.*	singular tooth m2	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 3nd level ~4cm
79111	Soricidae (small)	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level top 6cm
79112	Soricidae (small)	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level top 6cm
79113	Soricidae (small)	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level bottom berm surface scrapings
79114	Soricidae (small)	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level bottom berm surface scrapings
79115	Soricidae (large)	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79116	Soricidae (large)	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79117	Soricidae (large)	maxilla	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface

Catalogue #	ID	Description	Site #	Locality	Collectors	Remarks
79118	Soricidae (large)	maxilla	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79119	Soricidae (large)	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level bottom berm surface scrapings
79120	Soricidae (large)	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level bottom berm surface scrapings
79121	*Blarina sp.*	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79122	*Blarina brevicauda*	maxilla	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 3nd level ~4cm
79123	Soricidae (large)	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	UPPER DEPOSIT
79127	*Procyon lotor*	L I3	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79128	*Procyon lotor*	i1 or 2	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79129	*Procyon lotor*	L p4	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79130	*Procyon lotor*	R p3	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79131	*Procyon lotor*	R p2	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79132	*Procyon lotor*	R I3	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79133	*Procyon lotor*	L c1	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79134	*Procyon lotor*	R M1	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79135	*Procyon lotor*	astragalus	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level bottom 6cm profile scrapings
79136	*Procyon lotor*	claw	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 3rd level darker brownish gray ~4cm
79137	*Procyon lotor*	claw	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 3rd level darker brownish gray ~4cm
79138	*Procyon lotor*	C1	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT pale 2nd layer 12-14cm

Catalogue #	ID	Description	Site #	Locality	Collectors	Remarks
79139	*Procyon lotor*	vertebra	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 3rd level darker brownish gray ~4cm
79140	Arvicolinae (Microtine)	L dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level bottom berm profile scrapings
79141	Arvicolinae (Microtine)	L dentary w/ i1-m3	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 3rd level
79142	Arvicolinae (Microtine)	singular molar	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 5th level
79143	Arvicolinae (Microtine)	singular molar	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 5th level
79144	*Microtus sp.*	R dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79145	*Microtus sp.*	maxilla w/ M1	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 3rd level
79146	*Microtus sp.*	maxilla w/ M1	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 3rd level
79147	Sciuridae	edentulous palate fragment	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79148	Sciuridae	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79149	Sciuridae	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79150	Sciuridae	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT surface
79151	Sciuridae	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79152	Sciuridae	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79153	Sciuridae	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79154	Sciuridae	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 4th level
79155	Sciuridae	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 3rd level ~4cm
79156	Sciuridae	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 3rd level ~4cm
79157	Sciuridae	singular tooth	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 3rd level ~4cm
79158	*cf. Corynorhinus*	L maxilla	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT pale 2nd layer 12-14cm
79159	*cf. Corynorhinus*	L maxilla	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT pale 2nd layer 12-14cm

Catalogue #	ID	Description	Site #	Locality	Collectors	Remarks
79160	*cf. Corynorhinus*	R maxilla	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT pale 2nd layer 12-14cm
79161	*cf. Corynorhinus*	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79162	*cf. Corynorhinus*	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79163	*cf. Corynorhinus*	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79164	*cf. Corynorhinus*	dentary	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	LOWER DEPOSIT 2nd level
79165	*cf. Corynorhinus*	rostrum	V1506	AD-14 Pleistocene Cave Adair Co., OK	Czaplewski & Puckette 28 Dec 2005	UPPER DEPOSIT fr. NW wall

Appendix B. Figures

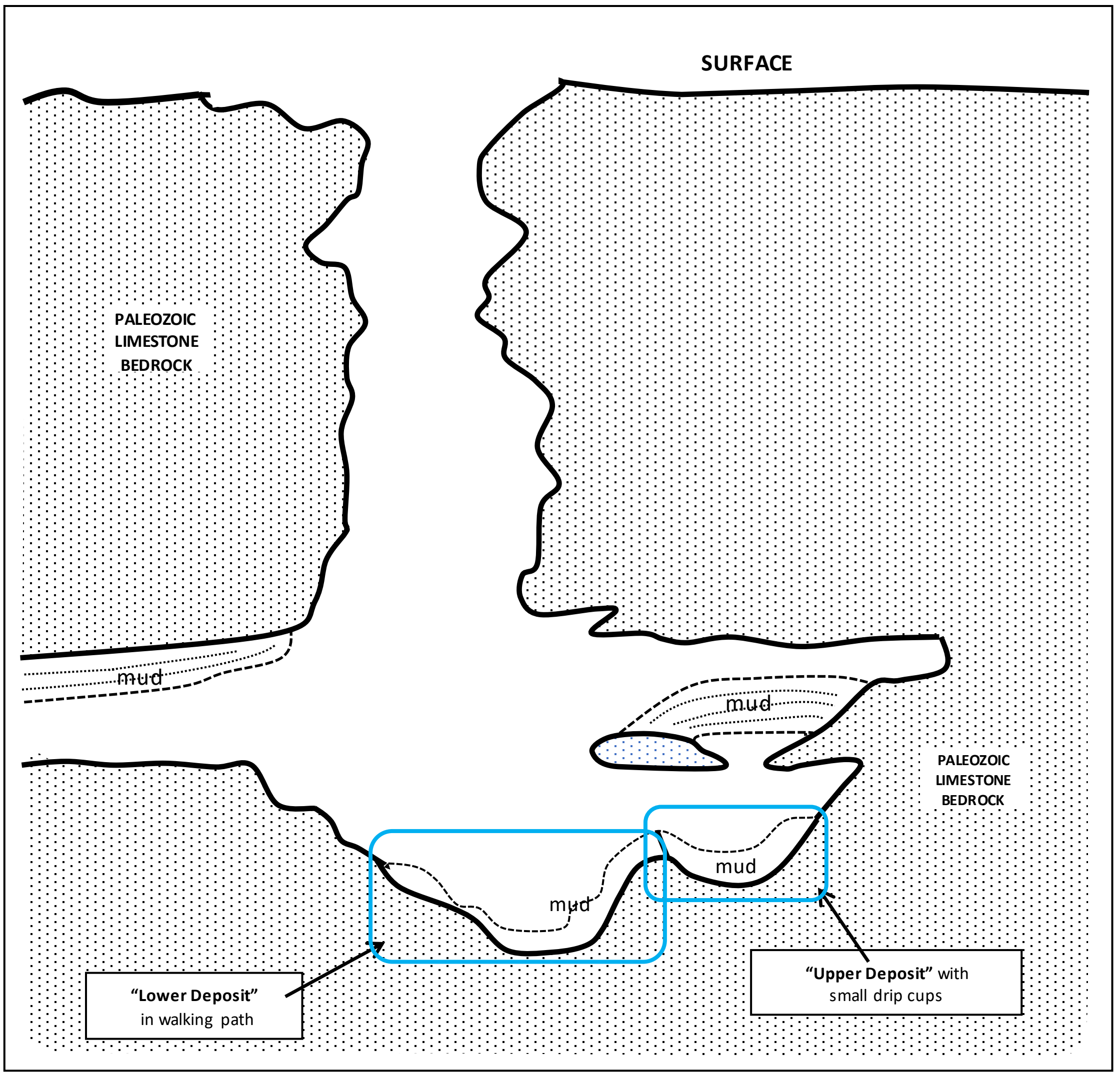


Figure 2

Cross-section of AD-14 Cave Entrance

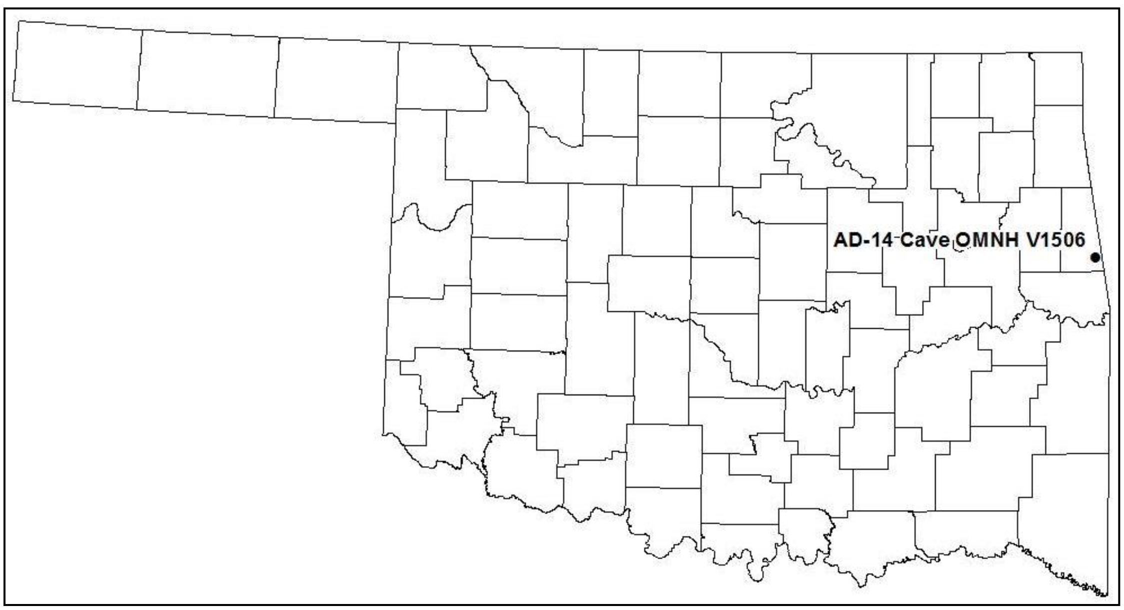


Figure 3

Cave locality within Adair County, Oklahoma, USA

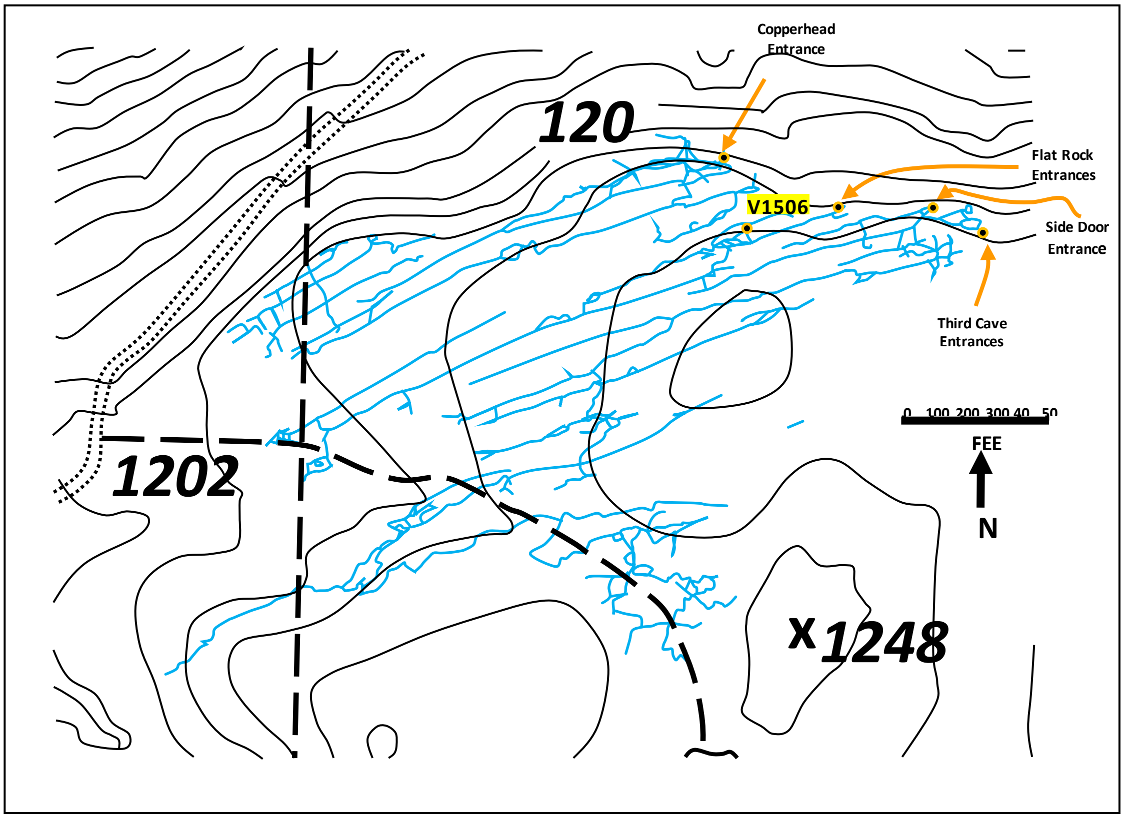


Figure 4

Simplified map of the Duncan Field Cave System overlaid with topographical data and entrances labeled.

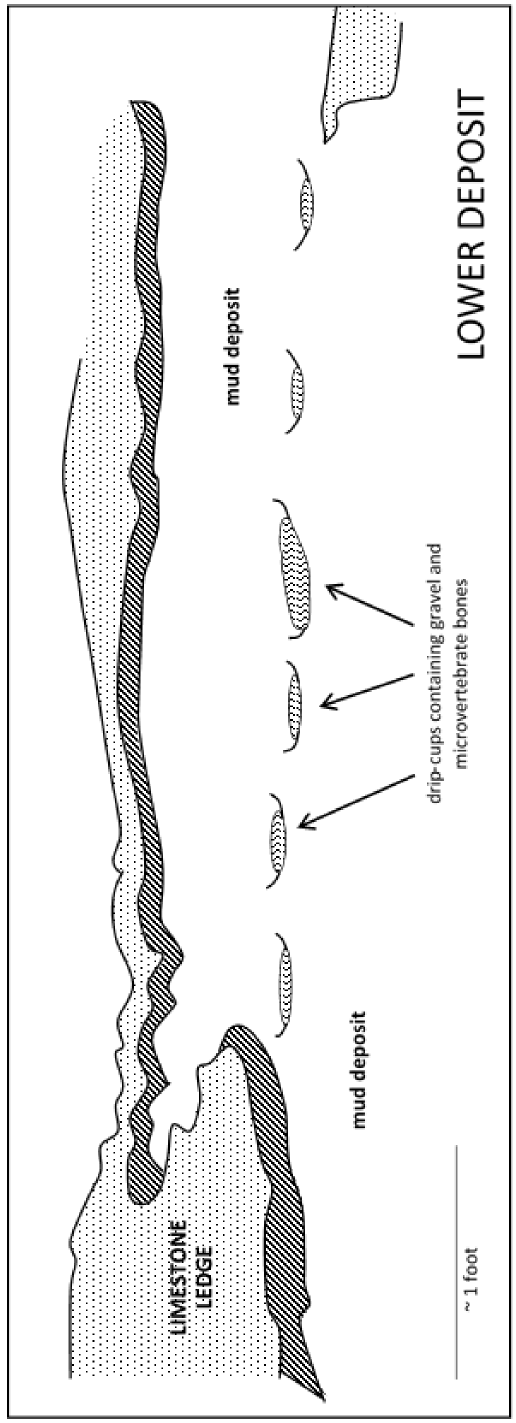


Figure 5

Physical view of the floor of the cave at Lower Deposit

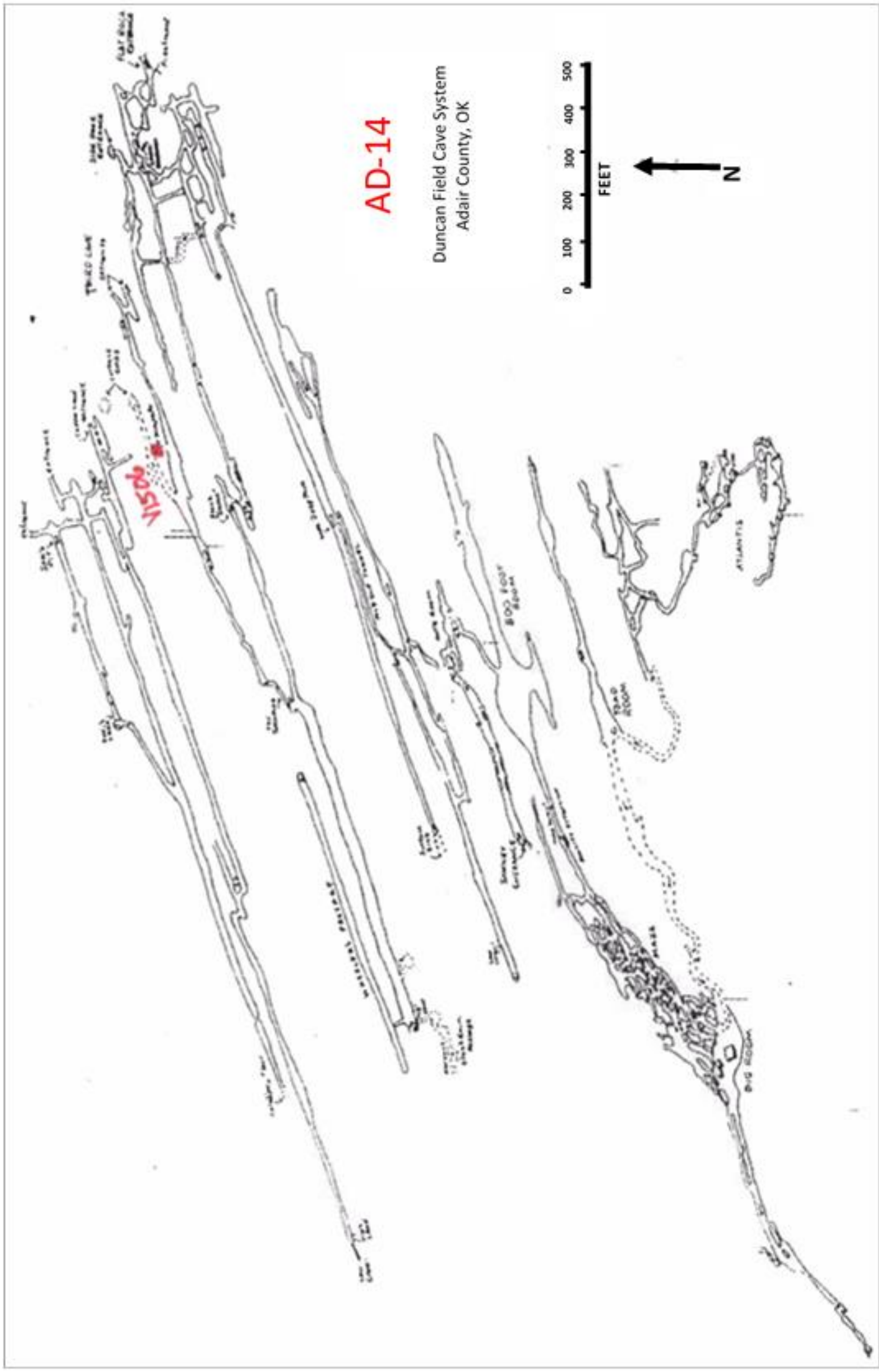


Figure 6

Map of the Duncan Field Cave System in Adair, Co., OK with Cave AD-14 and site locality V1506 labeled.

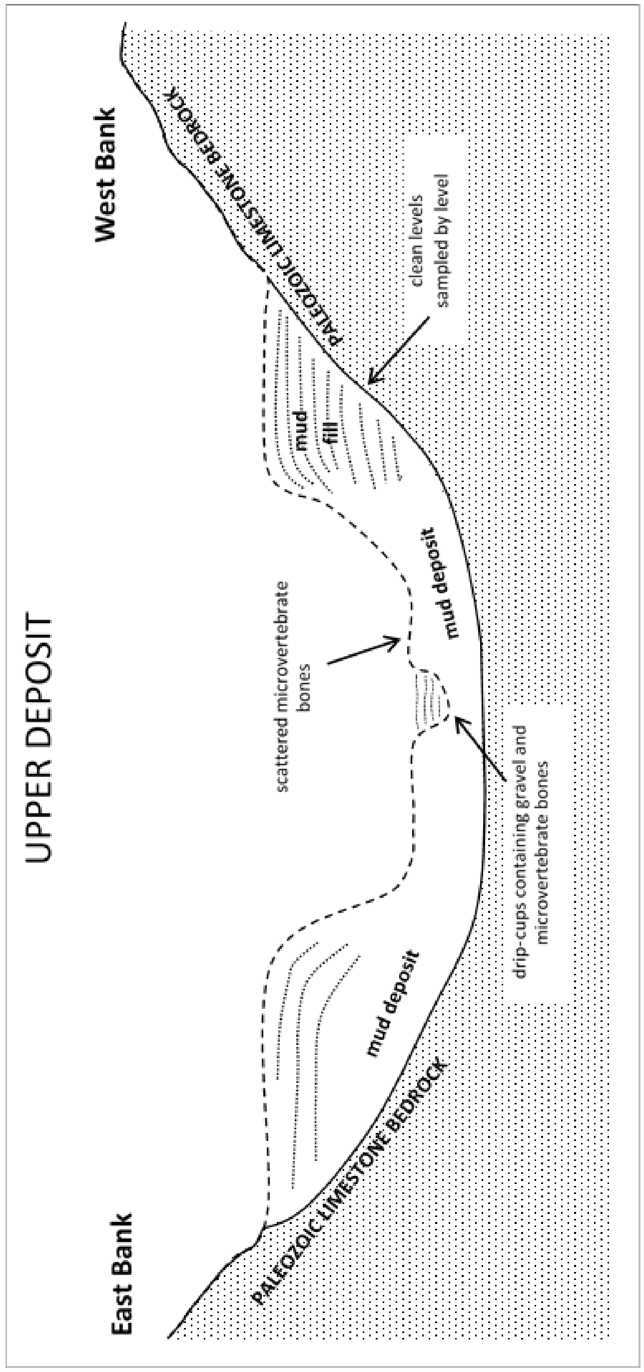


Figure 7

Profile cut of the Upper Deposit, viewed back towards the entrance room.

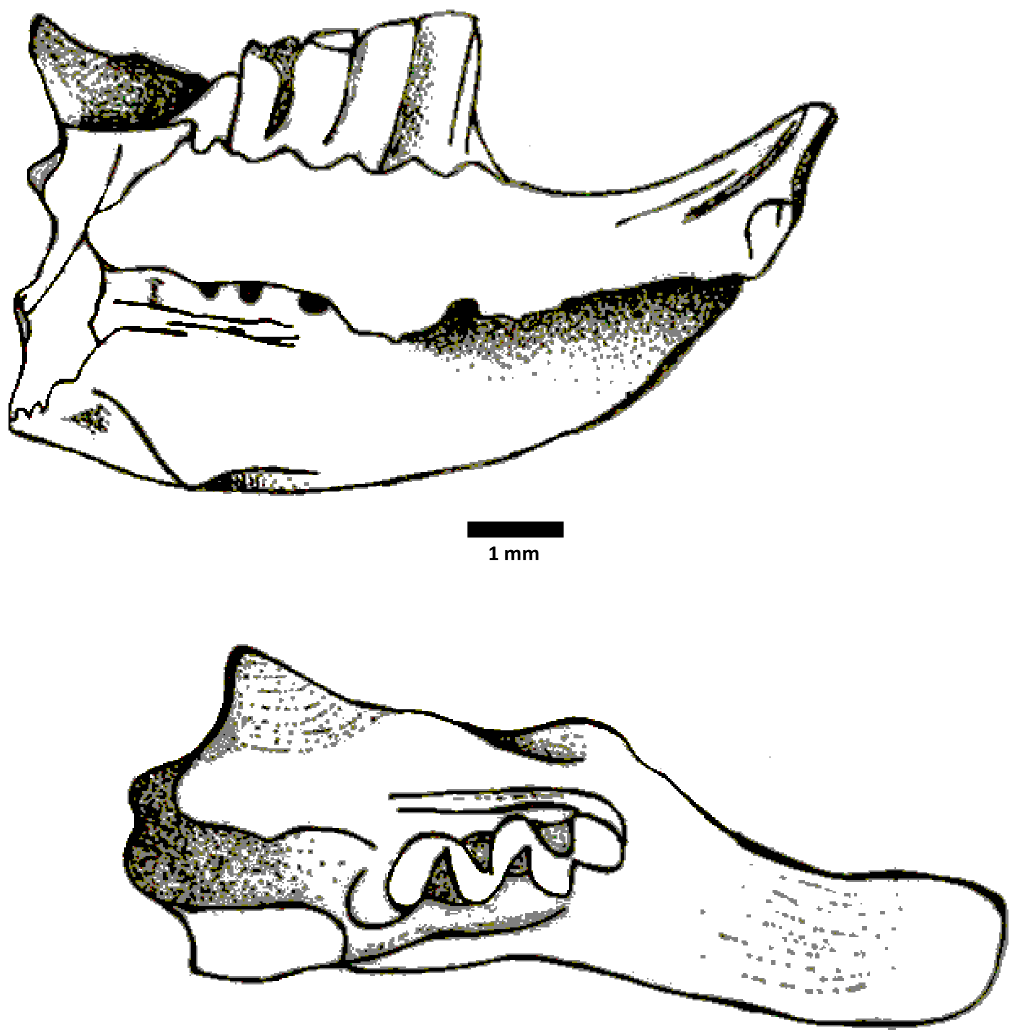


Figure 8

Synaptomys cooperi OMNH 79081

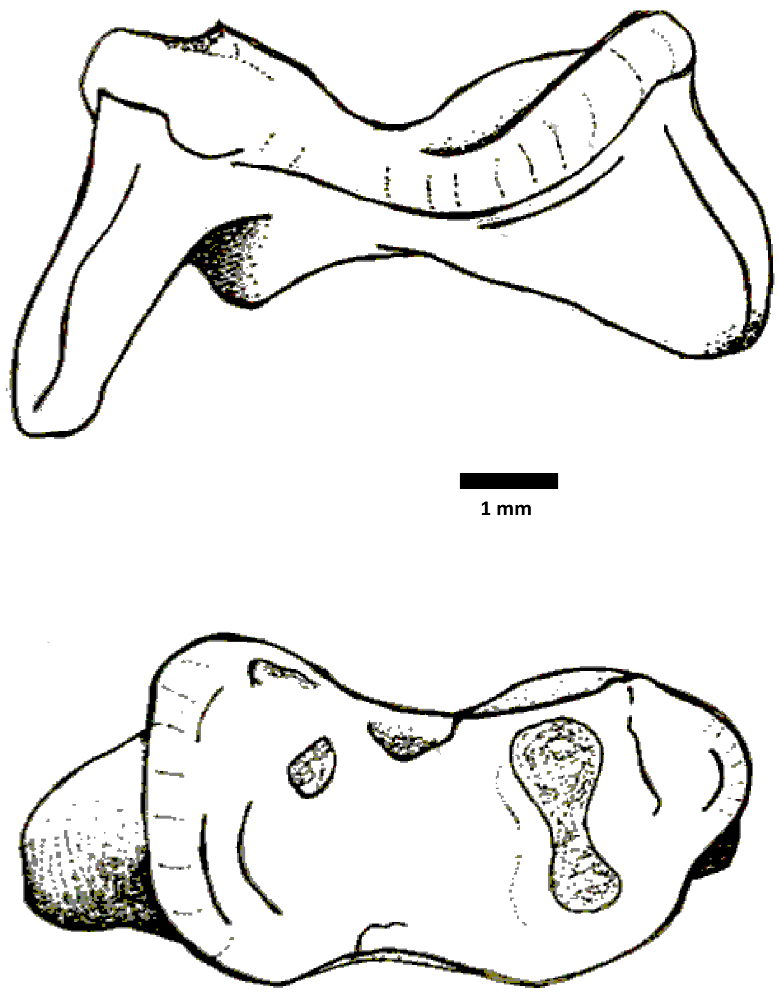
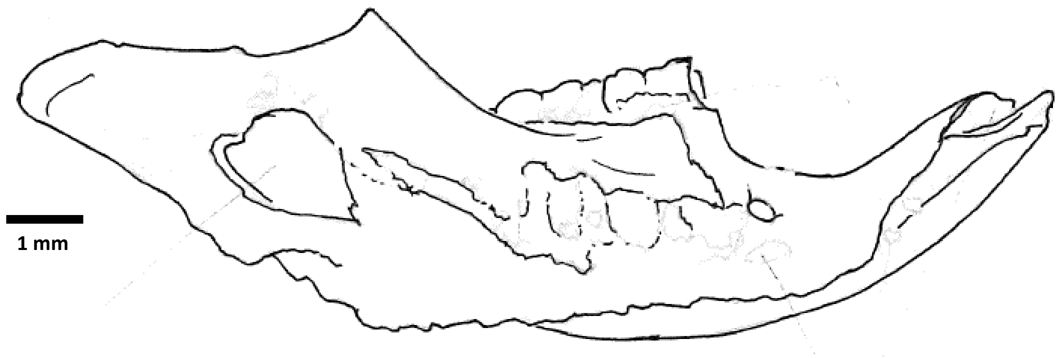
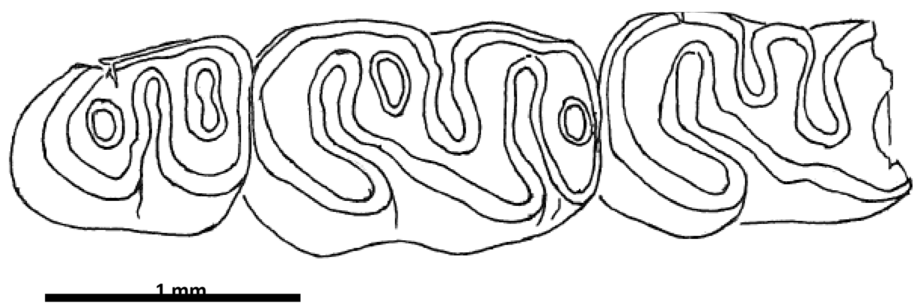


Figure 9

Neovison L M1 OMNH 79105.



73941
Zapus hudsonius R dentary



73942 R M1 | **73944** R M2 | **73943** L M2 | **73945** L m2

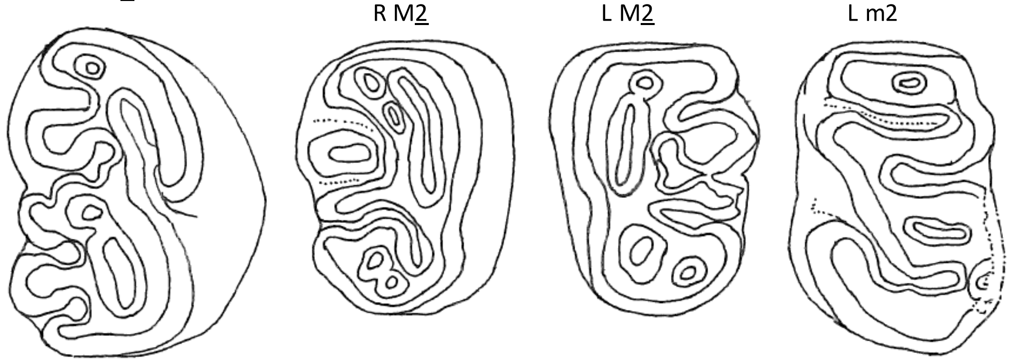


Figure 10
Zapus hudsonius R dentary and singular teeth

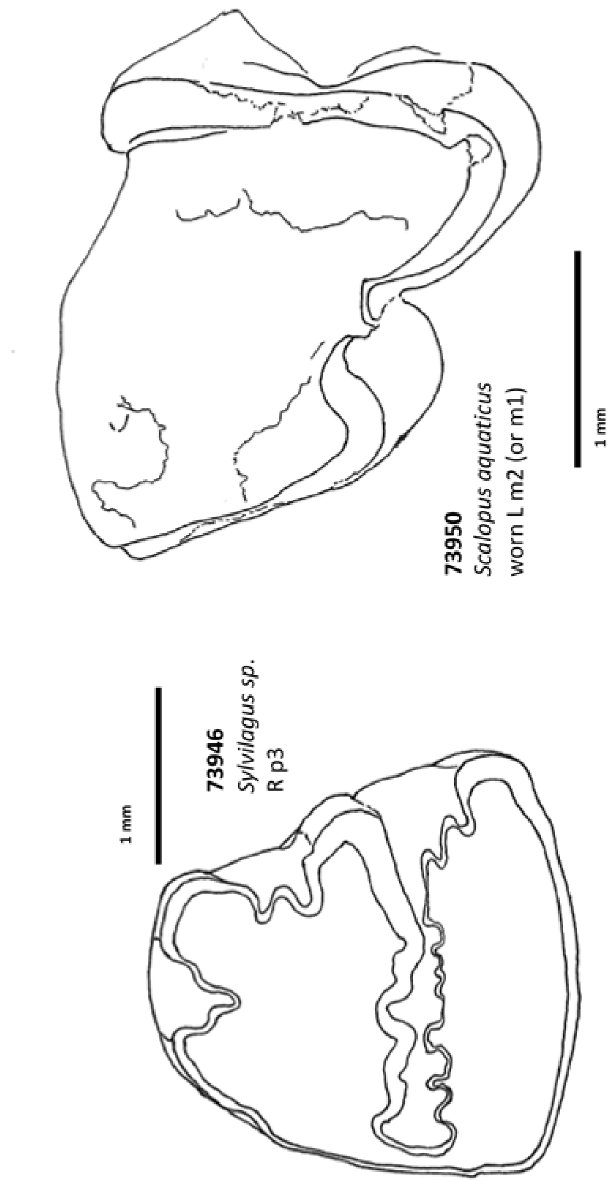


Figure 11

Singular teeth, L m2 (or m1) of *Scalopus aquaticus* and R p3 of *Sylvilagus* sp.

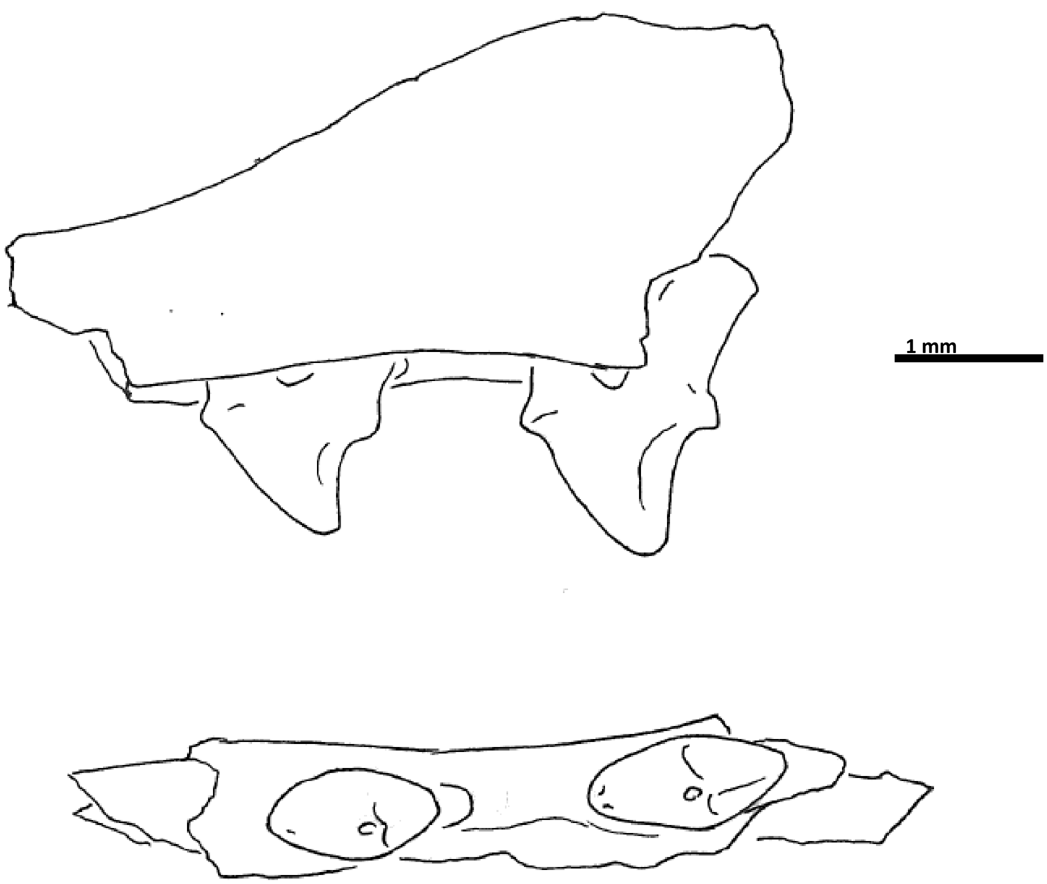


Figure 12
Condylura cristata L maxilla fragment P2-P3 OMNH 73941