# Cave Paleontology Session: Faunas from Cave and Karst Topography: a world-wide view

Session Chairs: Dr. Sharon Weaver and Dr. Jim Mead
Wednesday, June 14, 2022 9am-5:00pm
Location: Brigder-Steel

The discovery of fossils in caves and karst landscapes can be traced back to the beginning of paleontology. This session highlights new developments in this field, with authors contributing a variety of interdisciplinary views on faunal assemblages from around the globe.

## Paleontology Session Schedule

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| 9:00-9:20 | Sharon Weaver | Jefferson's Ground Sloth (*Megalonyx jeffersonii*) from ACb-3 Cave, Colbert County, Alabama |
| 9:20-9:40 | Wang et al. | Evolution and biochronological sequence of Plio-Pleistocene mammalian faunas from Jinyuan Cave at Luotuo Hill in Northeast China |
| 9:40-10:00 | Bushell, Schubert | Fossil Cat Tracks from Chilly Bowl Cave, Arkansas |
| 10:00-10:20 | White, Morgan | Natural traps, shelters or what remains of dinner: Why are fossil pronghorns (Mammalia: Antilocapridae) found in caves? |
| 10:20-10:40 | Morgan, Czaplewski | Cave and Karst Deposits and the North American fossil record of bats (Mammalia: Chiroptera) |
| 10:40-11:00 | Santucci et al. | National Park Service Cave Paleontology: Inventory, Discovery, and Stewardship |
| 11:00-11:20 | Schubert | Fossils from Caves: A Guide to Recognizing, Documenting, and Preserving Paleontological Resources |
| 11:20-11:40 | Socky et al. | The Petra Project: Excavation of a Large Cat Skeleton from Burja Cave (Virginia, USA) |
| 11:40-12:00 | Hastings et al. | The Petra Project: Taphonomy of a New Record of a Large Cat Skeleton from Burja Cave (Virginia, USA) |
| 12:00-1:00 | LUNCH | |
| 1:00-1:20 | Schap et al. | Changes in small mammal community composition over the last 25,000 years across multiple western North American cave localities |
| 1:20-1:40 | Mead et al. | Pleistocene faunas from caves and karst sinkholes, Black Hills, South Dakota |
| 1:40-2:00 | Fox, Johnson | How low should you go? Determining minimum screen size requirements for microfossil acquisition at Wind Cave National Park, South Dakota |
| 2:00-2;20 | Graham, Christine | Taphonomic Implications of Ontogenetic Age Distributions for Field Mice (*Peromyscus* sp.) Populations from Two Debris Cone Deposits, Parker's Pit, Black Hills, SD |
| 2:20-2:40 | Jass et al. | Cave Paleontology and Radiocarbon Dating in the Canadian Rocky Mountains |
| 2:40-3:00 | Lujan | Richards Spur: A Fissure Fill Preserves a Unique Highland Ecosystem from the Early Permian |
| 3:00-3:20 | Shore | A New late Pleistocene/Holocene Fauna from a cave in Uvalde County, Texas |
| 3:20-3:40 | Skwarcan | Review of late Pleistocene and early Holocene vertebrate faunal records from central Texas caves and contextualization within paleoclimatic and archaeological contexts |
| 3:40-4:00 | Carpenter, Mead | Canids from two caves in Grand Canyon National Park, Arizona |
| 4:00-4:20 | Czaplewski et al. | Late Pleistocene vertebrate fauna and guano deposit of La Tetera Cave, Arizona: a preliminary report |
| 4:20-4:40 | Bruce, Mead | Quaternary badger (Taxidea; Mustelidae) from Snake Creek Burial Cave, Nevada |
| 4:40-5:00 | McDonald, Chatters | Cenotes and Sloths: Pleistocene Sloth Diversity on the Yucatan Peninsula, Mexico |

**Paleontology Session Abstracts**
(in alphabetical order by presenting author)

**Quaternary badger (*Taxidea*; Mustelidae) from Snake Creek Burial Cave, Nevada**
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[2]The Mammoth Site, 1800 Hwy 18 BYP, Hot Springs, South Dakota 57747

Here, we report the occurrence of late Quaternary badger (*Taxidea*) fossils from Snake Creek Burial Cave (SCBC) in eastern Nevada, USA. Linear measurements of SCBC badger fossils were recorded and compared to extant badger specimens for size comparison. We provide a map of Quaternary fossil localities across western North America. Sites with badger fossils are concentrated in the Southwest along the US-Mexico border and decrease in number and density from south to north. Some researchers have suggested that *T. taxus* was larger during the Rancholabrean such as several other Ice Age survivors (*Bison*, *Martes*, *Ovis*). Pleistocene-age badger fossils from SCBC do not surpass size ranges observed in extant forms. SCBC has not yielded fossils of *Cynomys*, a known common prey item for extant *Taxidea*, however, colonial ground squirrels, lagomorphs, and arvicoline rodents are among the most common fossil remains recovered from the natural trap deposit. The diet of extant *Taxidea* varies based on its geographic distribution, but its primary prey item is typically the dominant burrowing rodent within a region. Thus we surmise that the main food source of local badgers in the central Great Basin was colonial ground squirrels. Additionally, SCBC has yielded fossils of various other carnivores including other mustelids, wolves, coyotes, foxes, bobcats, and skunks. With such an abundance of small mammals alongside carnivores in this southwestern Lake Bonneville basin, it is apparent that SCBC badgers would have had considerable dietary overlap with all carnivores.

**Fossil Cat Tracks from Chilly Bowl Cave, Arkansas**
Matthew W. Bushell and Blaine W. Schubert
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Preserved cat (Carnivora, Felidae) tracks are relatively uncommon in the fossil record. Felid trackways from Chilly Bowl Cave, Arkansas represent two, large, late Pleistocene cats. Chilly Bowl Cave is located within the Boston Mountains of the Ozarks in northern Arkansas. The identity of these tracks is the subject of this research. Based on size and morphology, the larger trackway could represent *Panthera atrox,* the American lion. These tracks are similar in size to another set of tracks from Missouri assigned to *P. atrox,* and trackways identified as *Panthera spelaea* from Germany. *Panthera atrox* was an especially large cat, estimated to be 25% larger than the modern lion and weighing over 700 lbs (>315 kg). This is the only potential evidence of the species in Arkansas, and the second set of tracks that could represent this extinct species. An additional trackway is also known from the same area in Chilly Bowl Cave. These tracks are smaller than the trackways suggestive of *P. atrox* but are similar to modern and fossil pawprints interpreted to be Pleistocene jaguar, *Panthera onca*. The smaller prints are larger than cougar (*Puma concolor*) tracks with some morphological differences such as shape of the digital pads. The possibility that the smaller tracks were created by an adolescent *P. atrox* is also present. Additionally, both trackways show a distinct difference to those attributed to machairodont sabertooth cats such as *Smilodon* or *Homotherium.* The Chilly Bowl Cave tracks retain the typical sub-triangular or circular interdigital pad of most felines while the “Machairodont tracks” instead have a kidney bean shaped interdigital pad. The tracks from Chilly Bowl Cave represent the first of their kind in the state of Arkansas and contribute to the record of Pleistocene felid tracks of North America.

**Canids from two caves in Grand Canyon National Park, Arizona**
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[2]The Mammoth Site, Hot Springs, South Dakota 57747

The Redwall Limestone formation is a well-known massive cave-forming unit exposed throughout the 277 river miles of the Grand Canyon. In the eastern, up-river region, Stanton's Cave is located 45 m above current Colorado River level in Marble Canyon and was investigated for both archaeological and paleontological remains in the 1970s. Of the many skeletal remains of extinct mountain goat (*Oreamnos harringtoni*), bighorn sheep (*Ovis canadensis*), numerous birds, and small mammals was a fragmented lower jaw of a fox (GRCA 76272) originally identified as the extant gray fox (*Urocyon cinereoargenteus*). Morphological comparisons of this fossil indicate that the mandible is consistent with the red fox (*Vulpes vulpes*) and not the gray fox. Today the red fox is known only in the northwestern-most portion of Arizona, outside of the Grand Canyon. This is the first fossil record of the red fox in the Grand Canyon and for all of Arizona. Shrine Cave located farther down-river from Stanton's Cave was investigated in the 1990s. Typical of the Grand Canyon dry caves, this grotto contained numerous plant, dung, and skeletal remains readily exposed on the surface, some dating to the late Pleistocene. In a crevice in the entrance chamber was a completely mummified carcass of a coyote (*Canis latrans*; GRCA 69062). Radiocarbon dating of a sample of the hide indicates an age of 2,250$\pm$50 yr BP (Beta-80631). Entrance into the cave from the room opening to the side canyon is a shear drop of over 100 m which implies that the coyote may have entered from another opening elsewhere on the mesa.

**Late Pleistocene vertebrate fauna and guano deposit of La Tetera Cave, Arizona: a preliminary report**

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La Tetera is a cave formed in the mid-late Paleozoic limestones of the Rincon Mountains of southern Arizona. The cave was sealed since the late Pleistocene and preserves a small vertebrate fauna reflecting the Rancholabrean NALMA including two extinct large mammals, horse (probably *Equus conversidens*) and giant llama (*Camelops*), as well as an extinct vampire bat (*Desmodus stocki*). Additional recovered biotic remains under study include hackberry endocarps (*Celtis*), charcoal, and bones of toads, large tortoise (*Gopherus*), squamates (at least *Heloderma*, *Phrynosoma, Crotalus*), roadrunner (*Geococcyx*), wren (*Salpinctes*), heteromyid and cricetid rodents, rabbits, *Myotis* sp., and shrew. Further investigation will likely reveal additional biotic remains. Preservation of bone is relatively poor, probably due to as-yet-undetermined, corrosive geochemical processes. Fossils occur as isolated skeletal elements scattered sparsely in several areas of the small cave or those recovered by screening of unconsolidated cave floor sediments (in which the vampire bat is the second most commonly recovered taxon, after toads). A large, stratified paleoguano deposit in one room promises the potential to recover ancient environmental DNA from the bats, their dietary sources, and autochthonous and allochthonous microorganisms. A sample of the guano deposit gave a calibrated radioisotopic age of 23 ka, confirming a late Pleistocene age for the deposit and placing it within late Wisconsinan full glacial time and within Marine Isotope Stage 2. Several of the fossil vertebrates reflect a desertscrub fauna similar to that of the region today.

**How low should you go? Determining minimum screen size requirements for microfossil acquisition at Wind Cave National Park, South Dakota**

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Microvertebrate, invertebrate, and plant fossils less than 1 cm (hereafter microfossils) are critical to understanding many paleontological patterns and processes. Due to their size, microfossils are difficult to detect using conventional field excavation methods and are often acquired by washing and sorting sediments using stacked screens of decreasing mesh size (screening). Screening protocols vary and can have a substantial impact on fossil yields. For example, minimum mesh size of the lowest screen will determine the smallest materials captured. The Museum of Geology houses a large collection of microfossils and microfossil-bearing sediment, but it does not have a standardized microfossil screening protocol. A pilot study was therefore conducted in summer 2021 to determine the minimum mesh size needed to capture all microfossils in the Museum's fossil-bearing matrix. Sediments from the Beaver Creek Rock Shelter, a cultural locality at Wind Cave National Park, were selected for this study due to the abundance of microfossils within. Sediments were washed prior to the experiment and sorted into 4 mesh fractions: >4mm, 4-2mm, 2-1mm, and 1-0.5mm. The four mesh fractions were then picked for microfossils by four student interns. Microfossil abundance, microfossil diversity, and processing time was evaluated per mesh fraction. Results show that processing time increases significantly with decreasing mesh size and that microfossils are present in all mesh fractions down to 1-0.5mm. Contrary to expectations, the smallest (1-0.5mm) mesh fraction captured the greatest abundance of microfossils and the 4-2mm mesh fraction captured the greatest diversity of fossils. This pilot study suggests that sediments down to ~0.5mm must be screened to acquire the full microfossil assemblages at Wind Cave National Park. We plan to refine this study in summer 2022 by experimenting with minimum mesh sizes between 1mm and 0.5mm and applying other techniques to reduce processing time without limiting microfossil acquisition.

**Taphonomic Implications of Ontogenetic Age Distributions for Field Mice (*Peromyscus* sp.) Populations from Two Debris Cone Deposits, Parker's Pit, Black Hills, SD**

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Fossil bones can accumulate in caves in a variety of ways and these modes of deposition can introduce different biases that must be understood before the fossil assemblage can be interpreted. We studied the ontogenetic age distribution of individual specimens of the field mouse, *Peromyscus*, based on tooth wear to determine potential biases from fossil bone assemblages from two different talus cone deposits in Parker's Pit in the Black Hills of SD. Main Cone has accumulated under the modern 12 m vertical pit entrance throughout the Pleistocene and Holocene. The pit trap does not permit escape. The Red Cone has formed in an old, closed entrance with an acute slope that allowed animals to enter and exit the cave. Differences in the age distribution of these two populations is statistically significant. Maine Cone individuals show a wider and generally older age distribution than those from the Red Cone. We interpret these differences as a result of individuals surviving the vertical fall onto the Main Cone and living into old age facilitated by organic debris washed into the cave. The Red Cone population is much younger and probably represents accumulation from predation, possibly by weasels, *Mustela* sp., as independently documented by tooth marks on the bones. Hence, the Main Cone fossil assemblage is derived from a random process (i.e., falling into a pit); whereas, the Red Cone sample is biased by predator selection. Therefore, the entire Main Cone fossil assemblage, not just *Peromyscus*, may represent a random, local sample that can be used for paleoecological analyses. Isotopic studies of other rodent species suggests they were also derived locally which tends to eliminate owl predation. On the other hand, the predator biased Red Cone sample is not amenable to paleoecological interpretations but does provide information on predator-prey interactions.

*Deceased

**The Petra Project: Taphonomy of a New Record of a Large Cat Skeleton from Burja Cave (Virginia, USA)**

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Through the Ice Ages of the Pleistocene Epoch, large cats were a fundamental part of the Appalachian ecosystem, yet there are relatively few records of them. A team of eleven cavers recently extracted an incredible new specimen of a large cat from Burja Cave in southwestern Virginia. The skeleton, nicknamed Petra, was found lying on its left side, with near perfect articulation of nearly every bone element. Left and right limbs were held together and fully extended from the body, and the tail was held straight out from the body. Full preparation in the lab is needed to properly identify Petra, but during fieldwork it appeared most similar to the American Cheetah, *Miracinonyx inexpectatus*. Other known large cats from the Ice Ages of Appalachia include the American Lion (*Panthera atrox*), the Saber-toothed Cat, (*Smilodon* spp.), the Ice Age Jaguar (*Panthera onca augusta*), and ancient members of the living species of Mountain Lion (*Puma concolor*). Of these, *Smilodon* can be ruled out based on the much smaller canines, and the skull shape is not nearly as robust as *P. atrox*. Preparation at the Virginia Museum of Natural History thus far has been largely mechanical, using pin vices under high magnification, but digital and chemical methods are currently being explored. The Petra Project was made possible with the support of the Cave Conservancy of the Virginias, Virginia Department of Conservation and Recreation Division of Natural Heritage, Virginia Museum of Natural History, Science Museum of Minnesota, U.S. Forest Service, and caver volunteers.

**Cave Paleontology and Radiocarbon Dating in the Canadian Rocky Mountains**

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Vertebrate remains and radiocarbon dates from eight new cave deposits (Anticline Arch, Brazeau Cave, Disaster Point Cave, Goat's Nest Cave, Ice Trap Cave, Moose Mountain Cave, Procrastination Pot, and Sheep Catcher Cave) in the Canadian Rocky Mountains highlights the potential of caves to contribute to the Quaternary biological and geological history of higher elevations in mountains and foothills of Alberta. Initial field research at Disaster Point Cave permitted recovery of intact, albeit geologically recent, sedimentary sequences in some cave deposits, and spurred additional investigations at other localities. Subsequent research at other cave sites focused specifically on preliminary sampling of vertebrate remains and radiocarbon dating.

Radiocarbon dates from the new localities and new radiocarbon data from a known sites (e.g., Rat's Nest Cave) range from infinite to modern, but are largely restricted to the Holocene. We interpret the consistency of Holocene ages in most records as a reflection of geologic processes associated with deglaciation, although some variability occurs across the region as a whole. Vertebrate remains recovered from the new localities are consistent with the existing biota of the region, suggesting relatively early post-Last Glacial Maximum establishment of modern biotas at higher elevations for some parts of western Canada. Preliminary evaluation of recovered plant remains highlight a potentially under-evaluated source of palaeoecological data from cave deposits in the Canadian Rocky Mountains.

**Richards Spur: A Fissure Fill Preserves a Unique Highland Ecosystem from the Early Permian**

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The Richards Spur locality north of Lawton, Oklahoma, preserves a unique combination of environments from the early Permian of North America. The majority of sediments from this time and place record life in lowland floodplains. Richards Spur preserves fauna from both a highland environment as well as a cave in an ancient fissure. The highland fauna consists of smaller animals dominated by the captorhinid reptile *Captorhinus aguti* and includes dwarf forms of larger species (*Dimetrodon*, unidentified diadectid). These fossils reveal a full ecosystem with herbivores, predators, and other niches. These fossils were preserved in a cave deposit that bears its own assemblage of suspected cave dwelling forms. These deposits have been commercially mined for limestone since 1932, which is responsible for the fossils coming to light. The quarry remains active to this day. Recent work by Texas Through Time has recovered hundreds of individual fossils as well as rock containing articulated remains. Remains of rare taxa such as *Oromycter* and *Bolosaurus* have been found, as well as exceptional adult and juvenile specimens of the trematopid amphibian *Acheloma*. Continued quarrying of the site promises to expose older deposits, which have the potential for new taxa and data on how this highland ecosystem changed over time.

**Pleistocene faunas from caves and karst sinkholes, Black Hills, South Dakota**

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The Black Hills of southwestern South Dakota are a geological inselberg surrounded by a 'sea' of prairie grasslands that are all part of the extant Northern Great Plains Ecoregion. As such, they are an ideal location to assess the extent of latitudinal, longitudinal and elevation-related biogeographic shifts of animal taxa in response to climatic and environmental changes through the numerous glacial and interglacial regimes of the Quaternary. Although Pleistocene faunas are well known to the west in the Intermountain West region and to the east in glacial and pro-glacial terrains, the Black Hills Pleistocene record was unexplored until the discovery of the Mammoth Site deposit in 1974. The karst sinkhole contains the skeletal remains of at least 60 mammoths (*Mammuthus*) along with lesser amounts of other vertebrates. The age of the deposit is now known to date to about 110,000 years old at the top (culmination) of the sinkhole and approximately 200,000 at the 8 m depth of excavation, but another 13 m of deposit remains to be assessed. The Black Hills are a well-known 'caving paradise' with extensive exposures of karstic limestone. The Mammoth Site research team is collaborating with local cavers to find and better understand the faunas that are being discovered in these caves. Regional karst/cave deposits preserve unique faunal assemblages and chronologies spanning the most recent 300,000 years. On-going research at several caves (Persistence, Wind, Salamander, Parker's Pit, Stage Barn, and others) provide insight into biological changes in the Black Hills from the Ice Age–Recent.

**Cenotes and Sloths: Pleistocene Sloth Diversity on the Yucatan Peninsula, Mexico**

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Knowledge of the fossil record of the tropics is extremely limited reflecting the high rate of decomposition of organic matter and general rarity of conditions that contribute to its preservation as fossils. One of the primary exceptions to this pattern occurs in tropical karstic regions when vertebrate remains accumulate in caves. An excellent example is the Yucatan Peninsula which is an approximately 181,000 km2 (70,000 sq mi) area of low relief, almost entirely composed of porous limestone. Processes ranging from acidic water welling up in a semi-circle around the Chicxulub crater, which outlines impact of an asteroid at the end of the Cretaceous, to brackish water dissolving weaker limestone during elevated sea levels of MIS 5e produced extensive karst and cave systems. During the Pleistocene, with the lowering of sea level resulting from formation of the continental glaciers, the water table of the Yucatan Peninsula also was lower. Many of the caves were then open and accessible to Pleistocene megafauna, either as water sources or potential den sites. With the subsequent decline of the glaciers and rise in sea level many of these cave systems became flooded. The development of SCUBA and improvements in technology for cave diving has permitted the exploration of these flooded caves and the discovery of a diversity of Pleistocene fauna. This includes new species as well as taxa from South America not previously known to be present in North America.

One of the better represented groups found in the caves is the ground sloths. Multiple species and individuals of sloths have been found in the near-coastal cave systems of Quintana Roo. In Outland Cave of the Sac Aktun system, the floors of three primary submerged passages »12 m below sea level converge at a 62 m diameter circular collapse chamber, named Hoyo Negro, that drops to depths up to 50 mbsl. Skeletal material of sloths and other species have been found in this natural trap, 600 m from the nearest entrance when it was a dry cave. Articulated skeletons of sloths have also been found in the individual passages. Sloth remains from the Yucatan include representatives of four families, Megalonychidae, Nothrotheriidae, Mylodontidae and Megatheriidae. With at least two genera, *Nohochichak* and *Xibalbaonyx*, megalonychids are the most common in number of individuals and taxonomic diversity. The single nothrothere is *Nothrotheriops*, best known from dry caves in the southwestern United States, which was not expected to be found in the tropics. A single mylodont sloth is also known. It has not been formally identified, although *Paramylodon* has been previously reported from other caves in the Yucatan. While the megathere, *Eremotherium,* is primarily found in terrestrial deposits there is one record from a cenote in Belize. Currently, five genera of sloths are known from the Yucatan, giving it a higher diversity of Pleistocene sloths than any other location in North or Central America. This diversity may reflect niche portioning of the tropical environment and changes in species ranges as the vegetation upon which sloths fed shifted in distribution in response to changing Pleistocene climates.

## Cave and Karst Deposits and the North American fossil record of bats (Mammalia: Chiroptera)

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Bats are the group of mammals most closely associated with caves. More than half of the 50+ living species of bats from temperate North America (NA) are cave-dwellers in the families Vespertilionidae, Molossidae, Phyllostomidae, and Mormoopidae. Bats that inhabit caves also die in caves, leaving behind their skeletons to become preserved in fossil deposits on the cave floor. During the latter half of the Pleistocene epoch (~1.5 million [Ma] to 10,000 years ago), bats have an excellent fossil record in North American caves, primarily vespertilionids, the most common living bats in temperate NA. A few bats in the other three families are also represented in NA Pleistocene cave deposits, including the extinct vampire bat *Desmodus stocki* (Phyllostomidae), identified from about 10 caves in the southern US. The oldest NA cave deposits containing fossil bats are early to middle Pleistocene (~1.5–0.5 Ma), including an extinct species of free-tailed bat *Tadarida constantinei* (Molossidae) from Hamilton Cave, WV, Mammoth Cave, KY, and Slaughter Canyon Cave, NM. NA Pleistocene cave deposits contain no other extinct bats and otherwise mostly document extant bat species found within their modern ranges. The NA Pleistocene chiropteran fauna tells us little about deep-time bat evolution, such as…When did bats first begin using caves? The majority of NA fossil deposits older than early Pleistocene that contain bats are concentrated in peninsular Florida and are derived from various types of karst deposits, including sinkhole fills, fissure deposits, and isolated sediment pockets. These karst deposits originally formed in caves, but the caves have since been destroyed by erosion. Highlights of the Florida fossil chiropteran record from karst deposits include: Inglis 1A (earliest Pleistocene, ~2 Ma), a fissure fill with seven species of bats, including the oldest NA record of *Desmodus* and the only eastern NA record of the pallid bat *Antrozous*; Thomas Farm (early Miocene, ~18 Ma), a sediment-filled sinkhole containing nine species of bats, including *Primonatalus*, the oldest record of the cave-dwelling, funnel-eared bat family Natalidae; and two Oligocene (~30–28 Ma) fissure fills, I-25 and Brooksville 2, with seven species of bats, including *Koopmanycteris*, the oldest member of the cave-dwelling bat family Mormoopidae, and *Speonycteris* representing an extinct family (Speonycteridae) of primitive cave-dwelling bats. Although caves and karst deposits are widely distributed in NA, these karst regions, except Florida, lack pre-Pleistocene bats. Our suspicion is that older karst deposits with bats exist elsewhere in NA (as on other continents) but have yet to be discovered, and we solicit cavers throughout the US to help us find them.

**National Park Service Cave Paleontology: Inventory, Discovery, and Stewardship**

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The first inventory of paleontological resources associated with National Park Service (NPS) caves was published in 2001. This inventory documented the scope, significance, distribution, and management issues associated with diverse fossils from caves within 35 NPS units. In the two decades since the original inventory was completed, many new and significant fossil discoveries have been made in NPS caves. Highlights include: the first paleontological inventory of Carlsbad Caverns NP, which documented both Permian fossils in cavern bedrock and bones of Quaternary megafauna; reassessments of Quaternary fossils, particularly avifauna, from rock shelters and caves of Channel Islands NP; discoveries of thousands of mummified ice age bats and cranial remains of the extinct Pleistocene American Cheetah at park caves of Grand Canyon NP; documentation of extinct or locally extirpated taxa from caves in Great Basin NP; discoveries of abundant Mississippian fossils, particularly sharks, in cave strata of Mammoth Cave NP and Natchez Trace Parkway; the relocation of the Port Kennedy Bone Cave site in Valley Forge National Historical Park; and an inventory of *Neotoma* middens from caves across the NPS. The rise of photogrammetry as an investigative technique has been key to facilitating study of in situ specimens in these challenging cave settings. Paleontological resources in caves are now considered as a matter of course during any paleontological inventory work in NPS units. We can expect that many more exciting discoveries will be made in the decades to come.

**Changes in small mammal community composition over the last 25,000 years across multiple western North American cave localities**

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Natural Trap Cave (NTC) is an 80-foot deep karst sinkhole located at the base of the Bighorn Mountain range in Wyoming, USA. An exceptional fossil record of microfaunal remains are found from well-stratified layers in the cave stretching back 30,000 years ago, before the end-Pleistocene megafauna extinction, up until a few hundred years ago. While many studies have examined how communities respond to environmental changes

in a single location through time, few have observed how community responses vary across different habitats. We compared standardized richness, evenness, and relative abundances, using NISP (number of individual specimens), of the small mammal communities from NTC, Samwell Cave, Two Ledges Chamber, and Homestead Cave to observe how small mammal communities shifted through time across diverse landscapes. Results from a PCoA found that NTC and Samwell Cave were more similar to each other than to Homestead Cave and Two Ledges Chamber. Despite differences in local environments, open and arid at NTC and closed and forested at Samwell Cave, small mammal accumulation at both these caves are the result of packrat midden collection. Richness and evenness were then compared between NTC and Samwell Cave. We found that evenness decreased at both caves from the Late Pleistocene to the Late Holocene. Richness also decreased through time at Samwell Cave but increased through time at NTC, though this may be influenced by small sample sizes in the Late Pleistocene. High evenness and richness are good indicators of a stable community, meaning small mammal communities may be threatened in the modern.

**Fossils from Caves: A Guide to Recognizing, Documenting, and Preserving Paleontological Resources**

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From large cat tracks to giant ground sloth skeletons, dire wolf dens to packrat middens, and natural traps to massive piles of guano, caves provide a wealth of information about past life. In fact, if it weren't for caves and other fossil bearing karst deposits, our understanding of terrestrial life over time would be severely hampered. Some of this life, such as most of North America's megafauna, went extinct near the end of the Pleistocene Epoch. Other life survived this extinction event, but climatic and environmental changes led to dramatic shifts in animal distributions, and these too are recorded in caves. Of particular interest from a cave perspective, many of the large mammals that are now extinct actually inhabited caves, using them for dens or to extract resources. Thus, the cave life we observe today is depauperate, a reduced fauna that coexists with fossil remnants of its greater diversity, exemplified by bones and other traces from the past. Despite the importance of these paleontological resources for science, most paleontologists that work on cave faunas are not cave explorers themselves. Instead, new discoveries are typically made by cavers and cave divers who encounter remains or traces of animals while exploring or surveying voids in the subterranean world. Although such encounters are relatively common, many of these explorers are uncertain how to record and report paleontological discoveries when they occur. This presentation targets cave explorers, and reviews the general types of fossils found in caves. In addition, standards are provided for recording, reporting, and preserving these resources for future generations and scientific research.

**Review of late Pleistocene and early Holocene vertebrate faunal records from central Texas caves and contextualization within paleoclimatic and archaeological contexts**

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The Edwards and Stockton plateaus in central Texas have been the subject of extensive paleoclimatic, paleoecological, and archaeological investigation since the mid-twentieth century, with the efforts of this work yielding over 700 publications that include information from hundreds of different sites. Of this multitude of localities, 29 are caves containing some sort of late Pleistocene or early Holocene vertebral faunal component. I compiled published data from these vertebrate cave faunas across the Edwards and Stockton plateaus as well as records of invertebrate faunas, palynology, and archaeology from the plateaus. I also compiled

relevant paleoclimate reconstructions from across the state of Texas with the goal of synthesizing those records and reconstructions to understand if and how climate had an impact on the flora, fauna, and past human settlements in central Texas during the late Pleistocene and early Holocene. Though numerous records of vertebrate fauna, invertebrate fauna, pollen, human settlements, and paleoclimate in central Texas exist, only a small percentage are temporally extensive or in well-dated contexts. In addition, the different methods for age constraint (e.g., U-series, radiocarbon, faunal assemblage, archaeological style) and periodization of time make actual comparisons between these records and reconstructions nontrivial. Ultimately, more work to resolve the temporal disparities among these various types of records is needed before plateau-wide comparisons and contextualization can be completed.

**A New late Pleistocene/Holocene Fauna from a cave in Uvalde County, Texas**

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Texas is well known for its great number of limestone caverns. Over the last century a large number have been demonstrated to contain late Pleistocene faunas, including Friesenhahn Cave, Inner Space (Laubach) Cavern, and Eagle Cave. Recent work by Texas Through Time has led to the discovery of a new Pleistocene/Holocene fauna in a cave on Ox Ranch, Uvalde County. The cave consists of a single expansive chamber with a single massive debris cone and a secondary chamber branching off. Presumed Holocene subfossils have been found on and just below the surface. A test pit uncovered older fossils in a deeper layer dated to ca 45.000 year BP through geo luminescence dating. The Holocene remains recovered consist of reptile, avian, and mammal remains consistent with the modern local fauna. Older remains recovered thus far include snake, bat, rodent, and lagomorph. A tooth and limb fragment attributed to Equus sp. (horse) as well as a large unidentified fragment indicate the potential for macro fauna in the assemblage. This new assemblage has the potential to further illuminate our understanding of life in the late Pleistocene of the southern United States and how it has changed through time. Future plans are to excavate the known deposits further as well as search for others in yet unexplored sections of the cave.

**The Petra Project: Excavation of a Large Cat Skeleton from Burja Cave (Virginia, USA)**

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In 2016, deep within Burja Cave, cavers discovered a nearly complete skeleton of a large cat in southwestern Virginia. This specimen, nicknamed Petra by the cavers, would provide a key record for paleontological study, but first it needed to be removed. Multiple methods of excavation were planned; however, preservation was very different from what was anticipated. A hard crust of calcite was deposited onto the skeleton over time and some calcite was deposited within bones as well. While this further solidified the bones, it also made them impossible to separate. Controlled breaks were made to get the skeleton into sections small enough to be safely removed from the cave. Each segment of the skeleton was carefully wrapped in layers of toilet paper and foam, then either placed within a hard case or extra layers of thick foam braced with splints. A team of eleven cavers transported materials and the cat from Burja Cave to its final destination at the Virginia Museum of Natural History, where study of this incredible specimen could begin. The Petra Project would not have been possible without the tremendous support of the Cave Conservancy of the Virginias, the Virginia Department of Conservation and Recreation Division of Natural Heritage, the Virginia Museum of Natural History, the Science Museum of Minnesota, the U.S. Forest Service, and, most importantly, the cavers.

**Evolution and biochronological sequence of Plio-Pleistocene mammalian faunas from Jinyuan Cave at Luotuo Hill in Northeast China**

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The Jinyuan Cave at Luotuo Hill, discovered in 2013, is enormous in size with a sedimentary thickness of over 40 m. Systematic excavations of the Jinyuan Cave deposits conducted by the Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences during the past few years have yielded abundant, diverse, and well-preserved vertebrate fossils from multiple layers. Based on a combination of biostratigraphic and geochronological evidence, the fossil assemblages from Jinyuan Cave are divided into four successive faunas that span the Late Cenozoic (ca. 3.60–0.35 Ma): the Wanghai fauna from upper unit (Middle Pleistocene, 0.78–0.35 Ma), the Jinyuan upper/lower fauna from middle-lower unit (Early Pleistocene, 2.58–0.78 Ma) and the Luotuoshan fauna of the bottommost unit (Late Pliocene, 3.60–2.58 Ma). Accordingly, the mammalian faunal evolution of Jinyuan Cave has also been divided into four temporal stages from the Late Pliocene to the Middle Pleistocene. The diverse fossil assemblages from Jinyuan Cave provide an outstanding opportunity to conduct multidisciplinary studies combining traditional paleontology, paleoanthropology, geochronology, and paleoenvironmental sciences.

**Jefferson's Ground Sloth (*Megalonyx jeffersonii*) from ACb-3 Cave, Colbert County, Alabama**
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Jefferson's Ground Sloth (*Megalonyx jeffersonii*) is one of the most geographically dispersed giant ground sloths with a range from northern Mexico into the Yukon. Many individuals have been discovered of *M. jeffersonii,* but only a handful of sites have contained more than one and even fewer sites from caves. Excavations in the mid-1980s of ACb-3 Cave in Colbert County, Alabama, by the Red Mountain Museum of Birmingham, uncovered the remains of multiple *M. jeffersonii* individuals. The original excavation team suggested as many as sixteen, but a subsequent minimum number of individuals analysis indicated only 7. This, however, still represents a large sample of individuals from one locality. Not only is it unique in number of individuals, but the sloths ranged in age from infant to adult. Now residing at the McWane Center in Birmingham, Alabama, four individuals of *M. jeffersonii* from ACb-3 Cave representing four different age classifications were chosen for study. These individuals were fully prepared, described, and examined for pathologies. The sloths were then compared to one another to determine what morphological changes are exhibited in the osteology from birth through maturity. This included a direct comparison of an infant and adult ground sloth skulls. Statistical morphometric software was used to visually depict these changes in morphology showing a unique shape change in mammalian growth. A nearly complete adult ground sloth was also compared to ground sloths from other North American localities to get a better understanding of how it relates to other *M. jeffersonii*. Due to pathology evidence and the range in age of individuals, ACb-3 Cave may provide the best-known evidence of cave denning and possible maternity use by *M. jeffersonii*.

**Natural traps, shelters or what remains of dinner: Why are fossil pronghorns (Mammalia: Antilocapridae) found in caves?**

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We examine the record of fossil pronghorn (Mammalia: Antilocapridae) bones found in caves throughout the inter-montane western United States and in Mexico, noting the species present and their distribution in time and space. We review previously published explanations for pronghorn fossils found in caves. We then examine population structures, taphonomic factors, preservation biases, and abundance in order to identify patterns in the record which can resolve those different explanations. We focus on Pleistocene (Ice Age) sites known from Arizona, Colorado, Nevada, New Mexico, Texas, Wyoming, and in Mexico for the broader perspective and on three species of pronghorns from late Pleistocene (Rancholabrean) sites in particular for a narrower perspective: the extinct Stock's pronghorn *Stockoceros conklingi* from Papago Springs Cave in Southern Arizona and San Josecito Cave in Nuevo Leon, Mexico, the extant pronghorn *Antilocapra americana* from Natural Trap Cave in Wyoming, and the dwarf pronghorn, *Capromeryx furcifer*, from multiple sites.