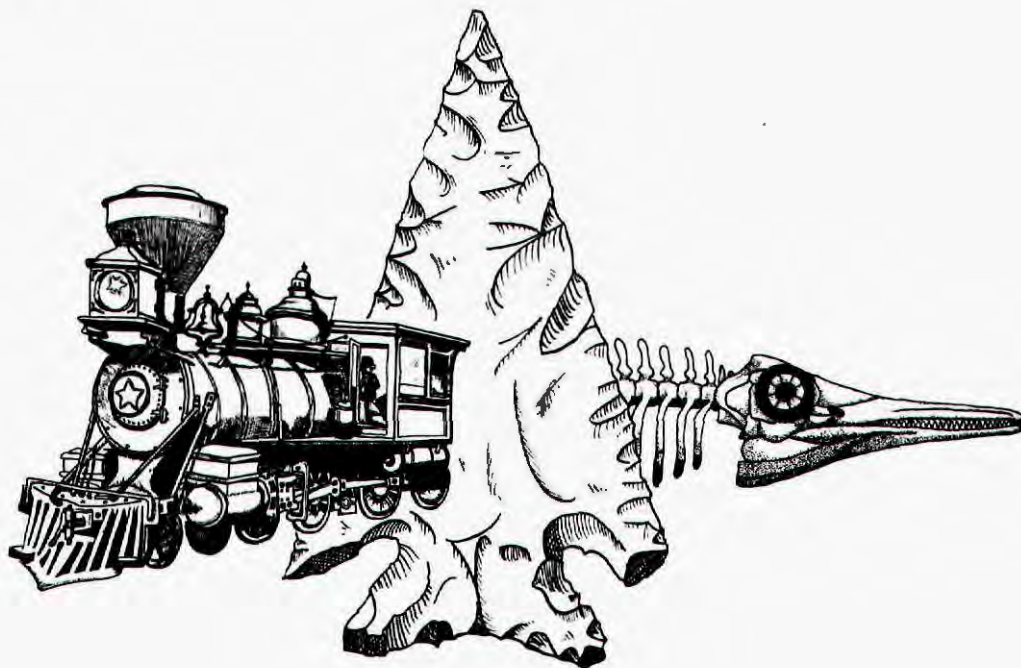U.S. DEPARTMENT OF THE INTERIOR
Bureau of Land Management
NEVADA

PALEONTOLOGICAL INVESTIGATIONS
AT MINERAL HILL CAVE

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and
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CHAPTER 1

Mineral Hill Cave: An Introduction

Bryan Hockett

Mineral Hill Cave has attracted the attention of miners, explorers, surveyors, and scientists for more than 130 years. This report focuses on the paleontological significance of the cave. A diverse suite of bones from extinct and extant mammals, birds, reptiles, and fish have been recovered from the clay sediments inside Mineral Hill Cave since the mid-1970's. The bulk of the scientific excavations, however, were recently completed by the Elko Field Office of the Bureau of Land Management between 1997-2000.

In the mid-1980's, about the time I was beginning graduate studies in anthropology, I read an article published in 1980 in *Quaternary Research* entitled "Cave Sites, Faunal Analysis, and Big Game Hunters of the Great Basin: A Caution", by Kelly McGuire. In that paper, which was actually completed in 1978, McGuire argued that although he found split and broken bones of extinct large mammals mixed with charcoal in a cave known as Mineral Hill Cave, all indications suggested to him that the bones and charcoal were deposited naturally inside the cave rather than by human hunters.

In historical perspective, this interpretation was significant for a number of reasons. Among them was the fact that McGuire was directly challenging some of the methods used by archaeologists at the time to interpret the role that "Paleoindian" hunters played in the deaths of now-extinct large mammals such as mammoths, camels, and horses. In the early to mid-1900's, it was commonly argued that split large mammal long bones must have been broken open by human hunters for their fatty marrow, and if charcoal was present alongside the bones, then this was proof positive that humans had killed, butchered, cooked, and consumed the flesh of these animals.

In Mineral Hill Cave, however, McGuire found abundant split long bones from large, extinct mammals, as well as charcoal, but he uncovered no artifacts. In the absence of some of the stone tools that assuredly would have been left behind by human hunters, McGuire argued instead that all of the bone and charcoal had been deposited naturally inside the cave, and were subsequently thoroughly mixed together by burrowing marmots. This interpretation brought an immediate rejoinder from Gruhn and

Bryan (1981), who rebuked McGuire's conclusions and argued that Great Basin archaeologists should not 'write-off' Mineral Hill Cave as a potential site that preserves evidence for the killing and butchering of extinct large mammals in the Great Basin.

Since these publications, Mineral Hill Cave has been largely ignored by archaeologists, but not by paleontologists. Whether Mineral Hill Cave preserved evidence that the earliest inhabitants of the Great Basin killed extinct megafauna was not vital to its importance as a paleontological site. The cave provided an important locale for the presence of now extinct llama and horse, as well as an extralocal record of pika in the central Great Basin (e.g., Lundelius et al. 1982; Harris 1985; Grayson 1993).

In fact, it was the presence of large-headed llama in the central Great Basin that attracted my attention to the site in the mid-1980's more so than the debate about whether or not humans had killed these animals. My direct involvement with Mineral Hill Cave certainly would not have occurred had I not taken a job with the Elko District of the Bureau of Land Management in 1991. In 1995, I set out with a Global Positioning System (GPS) unit to find this cave that had fascinated me for over a decade. Later that same day, I picked out a limestone ridge located on the steep face of a hill that was completely surrounded by pinyon and juniper trees, and began walking along its base. Within 30 minutes, I stumbled upon a small opening that plunged steeply downward into what appeared to be total darkness. I had found Mineral Hill Cave.

The first chamber of the cave was large, spacious, dark, and cold. Near the base of the opening, to my left, I discovered McGuire's original 1m x 2m unit that he had excavated in 1975. The corners of his unit were still marked with wooden stakes and large nails as if the original team of scientists had recently departed. Next to this unit was a large pit; based on the irregular nature of the pit and the pile of clay sediment lying next to it, I surmised that this hole was probably excavated by looters. I found out later, talking to Kelly McGuire, that this pit did not exist in 1975 when he excavated the 1m x 2m unit.

Two circumstances occurred that day that led to a deeper involvement in the paleontological

investigation of Mineral Hill Cave. After entering the large looter's pit, I noticed several bones protruding from one of the side walls. Among them were a complete proximal phalanx of a large camel and a second phalanx of a horse. It was apparent that the cave continued to possess potentially significant fossils. Second, while crawling into the deeper chambers of the cave system later that same day, I found two horse phalanges lying on the surface. McGuire (1980) had mapped Mineral Hill Cave as a single large chamber about 60 feet (18 meters) in length; yet the cave actually consisted of a series of five interconnected chambers that totaled over 200 feet (90 meters) in length. The discovery of bones of extinct horses lying on the surface some 150 feet into the cave system suggested that its paleontological resources may have remained largely unexplored.

For the next four years, I guided periodic excavations in Mineral Hill Cave. The excavation procedures are described in further detail below. It will be sufficient here to merely mention that the excavations were slow, tedious, and back-breaking; yet the rewards were well worth the effort. Mineral Hill Cave contains one of the most diverse Late Pleistocene faunal assemblages excavated to date in the Great Basin. With 55 Accelerator Mass Spectrometry (AMS) radiocarbon dates on bones, plus another eight AMS dates on charcoal and plant macrofossils, Mineral Hill Cave becomes one of the best-dated Pleistocene-aged cave sites in North America. Mineral Hill Cave also contains significant Holocene-aged fossils, primarily dating to the relatively cool and wet Neoglacial Period of 2,000 – 4,500 BP, but also of the relatively hot and dry period of 7,000 – 8,300 BP.

This volume explores more deeply the history of exploration of Mineral Hill Cave; the excavations undertaken between 1997-2000 by the BLM; detailed descriptions of the fossils and their relationships to other fossil localities from Nevada and surrounding regions; and finally the significance of the cave's paleontological treasures for understanding climatic and paleobiogeographic changes in the Great Basin over the past 50,000 – 70,000 years.

History of Exploration

Mineral Hill Cave is located in the Sulphur Spring Range in the southern Pine Valley region of central Nevada (Figure 1). The cave rests at 6,800 feet (2,060m) in elevation within a dense stand of pinyon-

juniper (*Pinus monophylla-Juniperus osteosperma*) trees (Figure 2). The historic mining town of Mineral Hill lies approximately one mile to the north, from which the cave derives its namesake.

Figure 1. General location of Mineral Hill Cave

Figure 2. The limestone ridge that houses Mineral Hill Cave. The trees are single needle pinyon and Utah juniper. The understory is dominated by big sagebrush (Artemesia tridentata).

The Mineral Hill mining district was discovered in 1868 (Lincoln1982). The first descriptions of

Mineral Hill Cave come from a prospector in September, 1869, and from a surveyor in November, 1869. The September 8, 1869 edition of the Elko Independent newspaper has the following notation:

> From J. K. Sutterley who returned yesterday from Mineral Hill, we learn that an immense limestone cave was discovered in a mountain two miles south of that place. The principle cave is about two hundred feet in length and about fifty feet in width and height. The sides, floor and roof are literally studded with stalactites formed from the dripping of water from overhead. From the floor of the main cave there is a narrow passage way which leads down into a second cave not so large as the first, but which is very similar to it in general appearance. The lower cave had not been fully explored at the time Mr. Sutterley left and its further examination may reveal new subterranean wonders still more remarkable than those already discovered.

A government surveyor's notes, dated November, 1869, contained the following passage:

> On the NE side of Cave Hill is the entrance to quite an extensive cave. It consists of three chambers laying in a N. & S. direction and sloping down at an angle of about 3 degrees from the horizontal. These chambers are connected by very narrow and low passageways. The first and main chamber is about 100 feet long by 60 feet wide, with perpendicular walls and an arched roof 20 feet high. From the roof are suspended innumerable stalactites of carbonate of lime, which under the influence of a strong light produce a magnificently variegated and most intense reflection.

Two years later, during the Wheeler Survey, George M. Wheeler visited the cave and made the following notation (quoted from McLane 1973:4):

> A cave eroded by water from mountain limestone was visited near Mineral Hill, similar to one in Cave Valley (1869), although of less extent. The orifice leads into a large chamber fully 60 feet in width by 70 feet in length, and from 40 to 50 feet in height. This chamber leads along the main channel about 150 feet, then apparently closing, the sides being covered with brilliant crystallizations.

Additional information about the early exploration of Mineral Hill Cave is found in the cave itself. Explorers wrote and carved their names on the boulders and on the walls and ceilings of the various chambers for decades (Figure 3). The earliest writings may pre-date by 13 years the "discovery" of the cave by miners in 1869. The earliest name and associated date is that of "Daniel Gayles" dated 1856. Other early names and dates include "A. Bourdou" dated 1870, "A. Casamayon" dated 1870, "Charlie H. Wall" dated 1870, and four names inscribed in 1871: "Oddie Smyth", "Katie Bunr", "Col. Coles", and "Hamilton Coles".

Figure 3. The main historic rock art boulder in chamber 1.

The historic writings inside the cave contain at least one name and date from almost every decade of the 20th century. Another recent exploration of Mineral Hill Cave of note other than McGuire's was made by Alvin McLane in June of 1972. McLane (1973:5) wrote:

We found the cave much as described by Wheeler... The cave is formed very irregularly with a linear distance of 271 feet. Contrary to the Wheeler Survey, we measured the first room at 52 feet wide and 82 feet long, and nowhere did we find the ceiling over 20 feet high. On the walls and the ceiling of this room is a vast deposit of moon-milk, the largest that I have ever seen. An 1870 date is carved in this soft material. The cave contains unspectacular decorations, and the rear portion contains aragonite.

Current Investigations

Excavation Strategy, Site Stratigraphy and Chronology

In 1997, a team was assembled consisting of myself, David Madsen (then of the Utah Geological Survey), David Rhode (Desert Research Institute, Reno), Paul Buck (Desert Research Institute, Las Vegas), Bob Elston (then of Intermountain Research and the University of California, Davis), and Alberta White (currently of the Northeastern Nevada Museum). The goals of the initial investigations were two-fold: determine the stratigraphic integrity of the cave's deposits, and determine if additional significant fossils were preserved in the back portion of the cave.

Although McGuire (1980) found charcoal associated with the bones of extinct fauna, he did not submit any organic samples for C-14 dating. McGuire (1980) argued that marmots had thoroughly churned the sediments in the front chamber, and therefore the charcoal found up to 1.5m below the current ground surface was likely disturbed into these levels from above. The side walls of the current looters pit in the front chamber contained small flecks of charcoal throughout the unit, which was about 1.5m in depth. In order to investigate the stratigraphic integrity of these deposits, we first

cleaned and straightened the wall that had produced the camel and horse phalanges. We then mapped what could have been separate stratigraphic units, based primarily on color and variations in the sizes of the limestone clasts encased in the clays that formed the bulk of the cave sediments (Figure 4). As McGuire (1980) noted, the sediments in the front chamber were not well stratified.

Figure 4. Bob Elston ponders possible stratigraphic breaks in one of the side walls of the looters pit in chamber 1, which is located less than 1m from McGuire's original 1m x 2m unit.

Based on our assessments, we subdivided the side wall deposits into four possible stratigraphic units. We then excavated a 1m by 50cm unit into these sediments, and collected and bagged charcoal and bone samples separately based on these divisions for C-14 analysis. The sediments were screened through 1/4" and 1/8" mesh screens.

This strategy produced two significant results. First, it confirmed McGuire's (1980) interpretation that the sediments in the front chamber lacked stratigraphic integrity. Table 1 and Appendix I display the results of three charcoal samples submitted for radiocarbon analysis from this test unit. Each sample was independently aged twice, using different laboratories, in order to confirm the age of the charcoal samples.

Table 1. Results of C-14 analysis of charcoal samples collected from Test Pit 2, chamber 1.

Sample	Age (BP)	Sample No.
Stratum 3, Level 1	1,289 ± 113	DRI-3423
Stratum 3, Level 1	1,263 ± 74	DRI-3421
Stratum 3, Level 2	645 ± 82	DRI-3422
Stratum 3, Level 2	620 ± 60	ETH-18337
Stratum 4	620 ± 50	CAMS-43072
Stratum 4	600 ± 50	CAMS-42818

As Table 1 indicates, these dates are generally in reverse chronological order, and all samples are Late Holocene in age. Further, this Late Holocene charcoal was mixed with bones of extinct mammals that returned AMS dates in excess of 40,000 BP. In the past, marmots were abundant in and near Mineral Hill Cave, and it appears that they probably contributed to the mixed nature of the sediments in chamber 1.

Second, screening the clays and eboulis was not particularly successful. The majority of medium-to-large-sized bones were recovered, but the high clay content of the sediments adhered to, and indeed concealed, many of the small bones. It was therefore decided that any additional excavations in the cave would require the removal of all sediment in buckets to be taken to the laboratory for water screening through a series of fine mesh screens.

The second major goal of the first year of excavation exceeded expectations. McGuire's original 1m x 2m test unit was designated Test Pit 1 (or "TP1"), and the identifiable bones that he had recovered were later relabeled in the lab as deriving from either TP1a or TP1b, each corresponding to one of the two 1m x 1m subunits. The test unit excavated into the side walls of the looters pit in the front chamber, described above, was designated "TP2". In 1997, a 1m x 1m unit was excavated in the back chamber of the cave (chamber 5), and was designated "TP3" (see Figure 5 for the layout of the five chambers defined here).
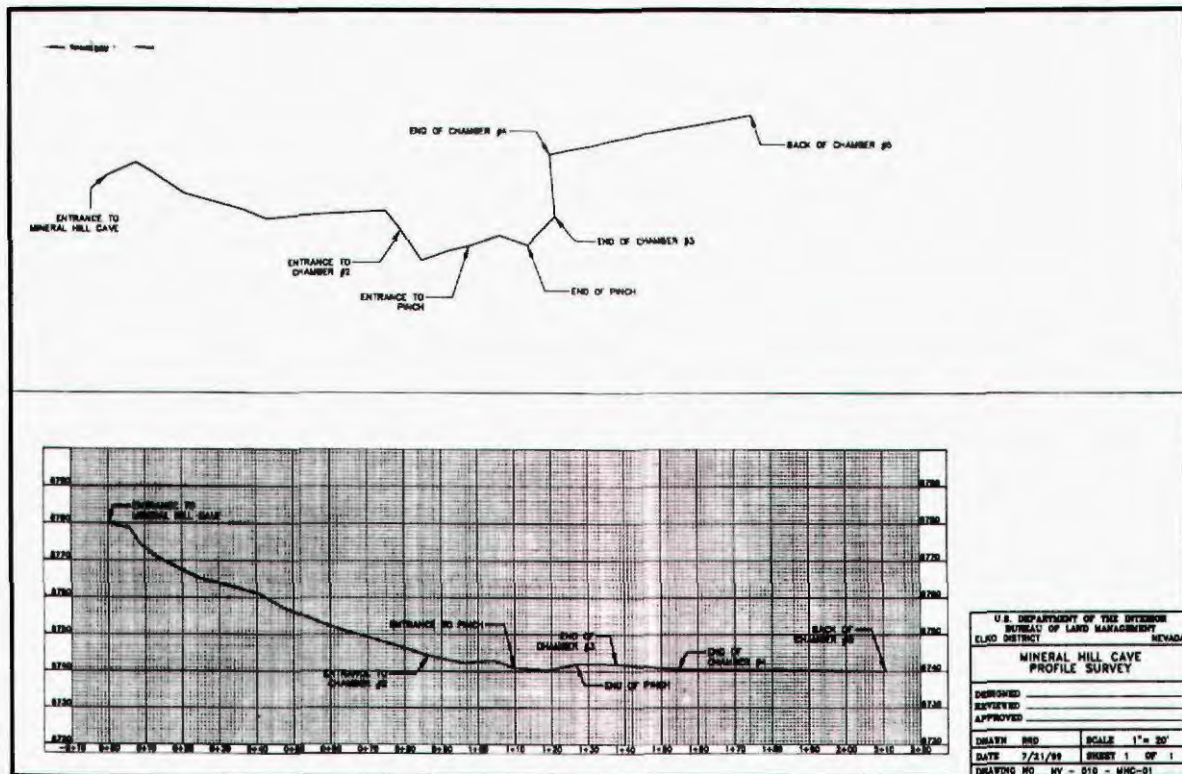
Figure 5. General layout of Mineral Hill Cave showing the entrance and termination of the five chambers (top), and the slope of the cave from the front chamber to the back of the cave (bottom).

TP3 produced the greatest concentration of bones of any of the nine test pits excavated by McGuire and BLM. Excavations were concentrated in this area between 1998-2000, and the original 1m x 1m unit was gradually expanded to approximately 3m x 3m in size. The sediments in TP3 were also unstratified and contained extremely abundant quantities of marmot bones. In contrast to TP1 and TP2, however, a thick layer of woodrat dung and plant macrofossils covered a large portion of the surface at the end of the cave system in chamber 5. Similar to the front chamber, charcoal was discovered amongst the bones of extinct and extant species in TP3.

Four plant macrofossil specimens and one charcoal specimen were sent for C-14 analysis (Table 2 and Appendix I). All of the plant macrofossils returned dates that were essentially modern, and the charcoal sample, which was independently dated twice, was about 2,300 to 2,400 years old.

Table 2. C-14 samples obtained on plant macrofossils and charcoal from Test Pit 3, chamber 5.

Sample	Age (BP)	Sample No.
TP3 (charcoal)	2,400 ± 40	CAMS-42820
TP3 (charcoal)	2,300 ± 70	CAMS-43073
TP3 (plant)	50 ± 70	Beta-130508
TP3 (plant)	40 ± 50	Beta-130511
TP3 (plant)	modern	Beta-130509
TP3 (plant)	modern	Beta-130510

These data suggested that the sediments were also disturbed in chamber 5, and that Holocene-aged materials may have been periodically flushed into the cave by water. These Holocene-aged organic materials could have been flushed into the cave in a number of ways. As Figure 5 illustrates, the current entrance to Mineral Hill Cave is about 40 feet (12 meters) higher than the back chamber. It is possible that heavy rainfall could have flushed recent material through the cave system from chamber 1 to chamber 5, where it accumulated into a thick layer and became mixed with Pleistocene and Holocene-aged bones. Indeed, during the summer of 2001, tens of thousands of acres burned in the Sulphur Spring Range from lightening-induced fires, including the trees surrounding Mineral Hill Cave. During a visit to the cave shortly after the burn, two large woodrat nests that had been built near the entrance had burned into piles of charcoal and gray ash. Several weeks later, after a relatively moderate rainfall event, I visited the cave again and found that water had flushed the charcoal and ash from these burned middens into the front chamber. This process, then, probably accounts for the presence of some of the Holocene-aged charcoal in the cave. It is also possible, however, that charcoal was deposited in the various chambers by Native Americans exploring the cave with torches.

Chambers 3, 4, and 5 also contain "chimneys" of silts and clays that were deposited underneath fissures in the roof of the cave. These fissures probably once connected to the surface such that organic material and sediments could have been flushed into the back chambers from above. This process could also account for the deposition of organic material, including both charcoal and bones, into the back chambers of the cave. This may also account for the various degrees of weathering seen on the bones from TP3 in chamber 5. Most of the bones recovered from the cave were fresh-looking regardless of their age, although those bones that dated to greater than 30,000 BP were generally stained or mottled black with manganese, while Holocene-aged bones lacked this coloration. However, split long bones from TP3 varied from fresh to weathered to extensively water-worn (Figure 6).

The fresh-looking bones were probably deposited directly in the cave soon after the death of these animals. The weathered bones had clearly been defleshed and exposed to sunlight before being deposited into the cave. Some of the water-worn bones were so polished that they appeared to have been deposited directly in a streambed. These latter bones may have been flushed back and forth inside the back chamber for hundreds, and possibly for thousands of years before finally resting within drier silts and clays.

Supporting this interpretation is a small section of the sediments in chamber 5 that contained an 80cm-thick profile of thin strata deposited by episodic periods of water infiltration followed by a standing pool or pond of water (Figure 7). This section contained the only stratified deposits found in Mineral Hill Cave, and it represents a small section of the original clays laid down by water but not destroyed by later episodes of water infiltration or by burrowing marmots. These stratified layers were generally free of bones, but a complete *Camelops hesternus* (Yesterday's camel) proximal phalanx was

recovered from the middle of this section. The camel bone returned a C-14 date of ca. 46,500 BP, suggesting that water was infiltrating and ponding in chamber 5 either during or after this date. This time frame falls within stadial stage 3 recently defined by Bischoff and Cummins (2001) for the east-central Sierra Nevada/Owens Lake region. Bischoff and Cummins (2001) also suggested that this period of glacial advance (ca. 49,000 – 45,100 BP) marked the beginning of a change from earlier cold and dry glacial advances to cold and wet stadials. These thin strata, then, may have been laid down during one or more of the three cold and wet stadials defined by Bischoff and Cummins (2001): stage 3 (49,000 – 45,100 BP); stage 2 (42,800 – 39,000 BP); or stage 1 (30,500 – 15,000 BP).

measured approximately 1m x 1m in size, except for TP3 which measured about 3m x 3m, and TP7, which was a narrow trench (approximately 50cm in width and 3m in length). None of the sediments except those in TP8 displayed intact, stratified deposits.

Following the first season of fieldwork, it became apparent that establishing a radiocarbon chronology for the fossils recovered from the cave would require the AMS dating of individual bone specimens, provided that adequate organic material was preserved within the bones. The first series of bones was submitted to Tom Stafford of Stafford Research Labs in Boulder, Colorado. The radiocarbon analysis revealed that the bones from Mineral Hill Cave contained amino acids suitable for dating.

Figure 6. Large mammal shaft fragments in various degrees of preservation from TP3, chamber 5. The two bones on the bottom row, far right have been extensively polished by water. The four bones to the left of these water-polished bones display extensive split-lined weathering cracks, and were defleshed and exposed to sunlight before being deposited in the cave. The remaining bones were probably deposited in the cave shortly after the death of these animals, perhaps by carnivores.

Figure 7. Thin strata near Test Pit 3 in chamber 5. Note the darker and lighter sections. The darker lenses probably contain greater amounts of organic debris. The white material at the base of the profile are calcite crystals that appear to represent bedrock. The top of the profile is present ground surface. This section is about 80cm deep.

In addition to the three units already mentioned, five additional units were excavated in the cave. TP4 was placed in chamber 5 next to TP3; TP7 was placed in the center of chamber 5; TP8 was placed into the stratified, thin sediments in chamber 5; TP5 was excavated in chamber 2; and TP6 and TP9 were excavated in chamber 1. All of the units

We surmised that the current temperature and humidity regime inside the cave was probably present for at least the past 50,000 years: presently, each chamber in Mineral Hill Cave maintains a relatively constant 45-47 degrees F temperature with 90-94% humidity throughout the year. In many respects, the conditions inside the cave are not unlike that in a refrigerator, and these conditions have

preserved the fossils remarkably well. As a result, we sought as much funding as possible in order to AMS date as many bone specimens as feasible.

Because of the richness of the fossils in terms of numbers of species present, the dating strategy focused on the submission of samples from as many different species as possible in order to try to establish some degree of species contemporaneity. Although this issue is dealt with in greater degree in Chapter 10, it may be noted here that 57 different bone specimens, representing 33 different species, were submitted for AMS dating. Of the 57 bone specimens submitted, 55 (96%) retained adequate amounts of organic material suitable for radiocarbon dating. We were unable to obtain dates on a sagebrush vole (*Lemmiscus curtatus*) mandible and a cutthroat trout (*Oncorhynchus clarki*) vertebra. The 55 dates ranged from ca. 2,000 BP to >50,000 BP, with the majority of dates ranging between ca. 29,000 and >50,000 BP (Table 3 and Appendix I).

In some respects, the number of dates obtained from each time period listed in Table 3 represents a biased sample. Bones of extinct animals were chosen more frequently for C-14 dating than those of extant animals. Nevertheless, many samples from extant animals, such as bobcat, red fox, badger, golden eagle, prairie falcon, short-eared owl, and raven returned dates in excess of 10,000 BP, and many of these dated to the middle Wisconsinan. Among the Pleistocene-aged samples, the vast majority of dates cluster between 30,000 and >50,000 BP. Thus, the bulk of bone deposition in the cave probably occurred during the early and middle Wisconsinan (ca. 75,000 – 30,000 BP) and again during the Holocene.

Table 3. Number of radiocarbon dates from Mineral Hill Cave associated with general time periods and climatic phases. The Pleistocene phases follow Bischoff and Cummins (2001).

AGE (BP)	# SAMPLES	CLIMATE	Epoch/Glacial Designation
49,000 - >	10	cool/dry	Middle/Early Wisconsinan
45,000 – 49,000	4	cool/wet	Middle Wisconsinan
43,000 – 45,000	2	cool/dry	Middle Wisconsinan
39,000 - 43,000	4	cool/wet	Middle Wisconsinan
30,000 – 39,000	11	cool/dry	Middle Wisconsinan
15,000 – 30,000	5	cold/wet	Late Wisconsinan
10,500 – 15,000	2	cool/dry	Late Wisconsinan
8,300 – 10,500	2	cool/moist	Early Holocene
4,500 – 8,300	9	hot/dry	Middle Holocene
2,000 – 4,500	6	cool/moist	Late Holocene

It is possible that some of the bones are much older than 50,000 years, and date to the early Wisconsinan or the Sangamonian Interglacial of ca. 125,000 – 75,000 BP (Marine Isotope Stage [MIS] 5). Uranium-Thorium dating of 24 speleothem samples revealed that stalactites and stalagmites have been forming in Mineral Hill Cave for more than 350,000 years, the limit of this dating technique (Denniston 1999). Eleven of the 24 samples returned dates in excess of 350,000 BP. The remaining 13 dates are displayed in Table 4.

Based on these samples, there were at least four periods of increased speleothem growth inside Mineral Hill Cave: 1) sometime greater than 350,000 BP; 2) approximately 200,000 BP, which may correspond to the Penultimate Interglacial of MIS 7;

3) approximately 100,000 - 150,000 BP, which may correlate with the beginning of the Late Pleistocene and the Last Interglacial of MIS 5; and 4) approximately 6,000 – 7,000 BP, which may mark the beginnings of climatic amelioration following the hot/dry conditions of the early middle Holocene. None of the speleothems dated to the relatively intense period of bone deposition between 30,000 and 50,000 BP.

Whether the cave was open to the surface prior to 350,000, 225,000, or 125,000 years ago to allow bones to be deposited inside is unknown; the cave may have been an underground, sealed cavern at these early stages of speleothem formation. As discussed in more detail below, the animals identified suggest a Rancholabrean Land Mammal Age, or post

400,000 BP age for the faunal assemblage. No animals were identified that are known to have gone extinct prior to the end of the Irvingtonian Land Mammal Age before ca. 400,000 BP. Thus, we can more confidently conclude that the oldest bones recovered from Mineral Hill Cave probably date between 400,000 and 50,000 BP.

Table 4. U-Th ages of stalactite and stalagmite samples from Mineral Hill Cave. In addition to these, 11 samples dated to greater than 350,000 BP.

AGE (BP)
251,000 ± 62,000
200,000 ± 30,000
193,500 ± 22,000
180,000 ± 25,000
157,600 ± 12,000
154,600 ± 23,000
149,500 ± 17,000
145,000 ± 35,000
114,300 ± 25,500
104,300 ± 18,000
7,050 ± 450
6,320 ± 500
100 ± 100

Identification Strategies

The carnivore, large mammal, and lagomorph remains recovered from Mineral Hill Cave were identified through direct comparison with collections of recent and fossil specimens housed at the Elko BLM and various institutions across the country. The Elko BLM maintains a comparative collection of recent mammalian skeletons such as bison, mountain sheep, pronghorn, mule deer, American red deer (elk), puma, bobcat, coyote, red fox, marmot, jackrabbit, cottontail etc. In addition, various bones from the cave were taken to the Page Museum (La Brea Tar Pits) [RLB] and the Los Angeles County Museum [LACM] in Los Angeles, California; to the American Museum of Natural History in New York [AMNH]; to the Philadelphia Academy of Natural Sciences in Pennsylvania [ANSP], and to the Denver Museum of Natural History [DMNH] in Colorado. The Page Museum was instrumental in the identification of many of the Mineral Hill Cave carnivores, artiodactyls, and perissodactyls. The

LACM was instrumental in the identification of the Mineral Hill Cave perissodactyls and mountain deer (*Navahoceros*) specimens. The LACM houses large collections of bones from both of these groups, particularly specimens recovered from the famous San Josecito Cave site in central Mexico. The LACM also had a complete specimen of African cheetah that we used to compare to a probable "North American cheetah" metatarsal recovered from Mineral Hill Cave. At the AMNH, we took advantage of that facilities large collections of recent animals such as bear and puma to assist in the identification of some of the Mineral Hill Cave carnivore remains. In Philadelphia, the ANSP houses important collections of short-faced bear and short-faced skunk, as well as recent specimens of bear, which assisted greatly in the identification of the Mineral Hill Cave carnivores. In addition to the collections, the staff at each of these facilities greatly assisted our efforts, and we acknowledge that assistance here and in the Acknowledgements section of this report.

Finally, we were able to meet with Elaine Anderson and Greg McDonald at the DMNH in the Spring of 2002. One week before her death, we had the privilege of showing E. Anderson some of the rare but important specimens from Mineral Hill Cave, such as the *Brachyprotoma* mandible and she was able to confirm our identification of these specimens.

Before traveling to Denver, Eric Dillingham and I discussed at some length how we should designate species or subspecies for specific identifications. For example, for the Mineral Hill Cave bison remains that pre-dated 10,000 BP, should we use *Bison bison*, *Bison bison antiquus*, or *Bison antiquus*? For mountain sheep, do we use *Ovis canadensis*, *Ovis canadensis catclawensis*, or *Ovis catclawensis*? While today these taxonomic nomenclature issues are less ambiguous with certain species such as mountain sheep than they once were, there seems little agreement in the literature for some mammals such as bison. We posed this question to Elaine Anderson. Regarding bison and sheep, she did not hesitate in responding: "*Bison bison, Ovis canadensis*"; "If you line Pleistocene and Holocene specimens up, you see size overlap among them". This is in general agreement with our findings based on the size of Pleistocene and Holocene specimens that we measured, and information available in the published literature (see further details in chapters 3 and 10). Although the recovery of ancient sequences of protein (osteocalcin) and DNA hold promise in resolving phylogenetic relationships (e.g., Nielsen-Marsh et al.

2002), the systematic relationship of the pre-40,000 BP bison from MHC to modern bison in North America remain unresolved.

We also discussed with E. Anderson the issue of two possible species of short-faced skunk in North America: *Brachyprotoma obtusata* in the east, and *Brachyprotoma brevimala* in the west. Again, her response was without hesitation: "One species, *Brachyprotoma obtusata*". Because so many of these issues involving taxonomic nomenclature remain unresolved in the open literature, we have chosen here to generally follow Anderson's advice and be placed under the rubric of "lumpers" rather than "splitters". We therefore have chosen to be conservative in our designation of species from animals such as bison and mountain sheep.

We acknowledge, however, an observation that many paleontologists have earlier noted: while the size ranges of Pleistocene and Holocene bones of the same animal such as mountain sheep often overlap, the means of the Pleistocene specimens are generally larger than the means of the Holocene specimens. This means that there were often greater numbers of relatively large-sized animals during the Pleistocene, but that the largest known recent specimens may reach or nearly reach the size of the largest known Pleistocene specimens.

The identification of the reptiles, birds, and fish from MHC are discussed in chapters 6, 7, and 8, respectively.

Species Identified

At least 64 genera and 74 species are represented at Mineral Hill Cave (Table 5). These included mammals, birds, reptiles, and fish. The carnivores and large mammals were identified by B. Hockett and E. Dillingham (Chapter 3); the lagomorphs by B. Hockett (Chapter 4); the rodents by D. Schmitt and B. Hockett (Chapter 5); the reptiles by M. Hollenshead (Chapter 6); the birds by S. James (Chapter 7); and the fish by J. Broughton (Chapter 8).

Table 5. The animals identified at Mineral Hill Cave.

SPECIES	COMMON NAME
Antilocapra americana	Pronghorn
Bison bison	Bison
Ovis canadensis	Mountain sheep
Camelops hesternus	Yesterday's camel
Hemiauchenia macrocephala	Large-headed llama
Navahoceros fricki	Mountain deer
Odocoileus sp.	Mule/White-tailed deer
Equus cf. *occidentalis*	Western horse
Equus cf. *conversidens*	Mexican ass
Canis latrans	Coyote
Canis lupus	Wolf
Vulpes vulpes	Red fox
cf. *Miracinonyx trumani*	North American cheetah
Lynx rufus	Bobcat
cf. *Ursus arctos*	Brown bear
Taxidea taxus	Badger
Mustela erminea	Ermine
Mustela frenata	Long-tailed weasel
Mustela vision	Mink
Brachyprotoma obtusata	Short-faced skunk
Spilogale putorius	Spotted skunk
Mephitis mephitis	Striped skunk
Ochotona princeps	Pika
Brachylagus idahoensis	Pygmy rabbit
Lepus spp.	Hare
Sylvilagus sp.	Cottontail rabbit
Myotis spp.	Bat
Sorex sp.	Shrew
Marmota flaviventris	Yellow-bellied marmot
Spermophilus beldingi/elegans	Belding's ground squirrel
Spermophilus lateralis	Golden-mantled squirrel
Spermophilus townsendii	Townsend's ground squirrel
Tamias minimus	Least chipmunk
Erethizon dorsatum	Porcupine
Thomomys bottae	Southern pocket gopher
Thomomys talpoides	Northern pocket gopher
Perognathus parvus	Great Basin pocket mouse

Lemmiscus curtatus	Sagebrush vole
Microtus spp.	Meadow vole
Neotoma cinerea	Bushy-tailed woodrat
Neotoma lepida	Desert woodrat
Peromyscus maniculatus	Deer mouse
Oncorhynchus clarki	Cutthroat trout
Crotaphytus sp.	Collard lizard
Gambelia sp.	Leopard lizard
Cnemidophorus sp.	Whiptail
Phrynosoma hernandezi/douglasi	Mountain/Pigmy Short horned lizard
Phrynosoma platyrhinos	Desert horned lizard
Uta sp.	Side-Blotched lizard
Sceloporus sp.	Spiny lizard
Eumeces sp.	Skink
Pituophis melanoleucus	Pine-Gopher snake
Masticophis sp.	Whipsnake (Coachwhip)
Coluber constrictor	Racer
Rhinocheilus lecontei	Long-nosed snake
Thamnophis sp.	Garter snake
Hypsiglena torquata	Night snake
Crotalus sp.	Rattlesnake
Charina bottae	Rubber boa
cf. *Buteogallus fragilis*	Fragile eagle
Aquila chrysaetos	Golden eagle
Buteo jamaicensis	Red-tailed hawk
Asio flammeus	Short-eared owl
Falco mexicanus	Prairie falcon
Falco sparverius	American kestrel
Centrocercus urophasianus	Sage grouse
cf. *Dendragapus obscurus*	Blue grouse
Tympanuchus phasianellus	Sharp-tailed grouse

Cygnus columbianus	Tundra swan
Corvus corax	Raven
Gymnorhinus cyanocephala	Piñon jay
Pica pica	Black-billed magpie
Turdus migratorius	American robin
Zenaida macroura	Mourning dove

CHAPTER 2

Paleoenvironmental Context for Mineral Hill Cave

Bryan Hockett

General Patterns

This chapter explores more fully the paleoenvironmental context of Mineral Hill Cave. This context includes previous research on Pleistocene faunal assemblages in western North America, as well as past studies of both faunal and floral remains in the Great Basin, with emphasis on the central and northern Great Basin subregions. As Grayson (1993) summarized, the Great Basin can be defined based on hydrology, physiography, floristic associations, or similarity of prehistoric artifacts. The Great Basin will be defined here hydrographically: it is that region of western North America that exhibits internal drainage basins with no outlet to the sea. This region is also known as the Intermountain West because it is roughly bounded to the west by the Sierra Nevada Mountains along the Nevada-California border and to the east by the Wasatch Range in central Utah. The northern boundary is irregular, and is located near the Nevada-Idaho border to the east and southern and central Oregon to the west. The southern boundary, also highly irregular, abuts the Colorado Plateau region (Figure 8).

Figure 8. Location of Mineral Hill Cave within the hydrographic Great Basin.

A variety of proxy data have been examined in order to reconstruct past climatic regimes throughout the globe. These data include pollen cores, oxygen isotopes, sediment cores, lakeshore features, glacial features, faunal remains, changes in the earth's orbit around the sun, variations in the tilt of the earth's axis (e.g., Shackelton 1977, 1987; Williams et al. 1998), and, in western North America, plant macrofossils preserved in fossil woodrat middens (e.g., Betancourt et al. 1990). A plethora of specialized terms have been used to define specific periods of time that each represent individual climatic events or patterns. The terms used most often throughout the remaining chapters of this volume are outlined in Table 3 in the previous chapter and in Table 6 below; they are also briefly described below.

The Quaternary Period consists of the Pleistocene and Holocene Epochs. The beginning of the Quaternary corresponds to an overall cooling of the earth beginning about 1.8 million years ago that triggered a series of glacial cycles that may have "ended" approximately 10,000 years ago. These glacial cycles were interrupted by relatively warm interglacial cycles. These warm and cold cycles affected the ratios of specific oxygen isotopes in the oceans (e.g., Shackelton 1977). Based on these isotopes, the Quaternary has been divided into a series of 22 glacial and interglacial cycles, called Oxygen Isotope Stages (OIS) or Marine Isotope Stages (MIS) (see Table 6). In general, the odd-numbered stages represent interglacial cycles while even-numbered stages represent glacial cycles. An exception to this general rule, however, is seen in MIS 3 (ca. 59,000 – 24,000 BP), which appears to be a time of increasingly warmer temperatures compared to the previous MIS 4, but it was still a relatively cool period if compared to stronger interglacial cycles such as MIS 7c and MIS 5e. Nevertheless, these stages provide a general framework for relative cold and warm conditions in the oceans across the northern hemisphere during the past two million years that are often closely correlated, albeit imperfectly, with changes in sediment loads and terrestrial floral and faunal associations.

Table 6. Correlation of Land Mammal Ages, Marine Isotope Stages, and general climatic terms used in this report.

Age (BP)	Land Mammal Age	MIS	Climate Terms
2,000			Modern
4,500			Neoglacial Late Holocene
8,300			Middle Holocene
10,000	Recent	1	Early Holocene
18,000			Glacial Max
24,000		2	Late Wisconsinan
59,000		3	Mid-Wisconsinan
71,000		4	Early Wisconsinan Glacial
128,000		5	Late Pleistocene Sangamonian Interglacial
186,000		6	Glacial
245,000		7	Penultimate Interglacial
303,000		8	Glacial
339,000		9	Interglacial
362,000		10	Glacial
400,000	Rancholabrean		
423,000		11	Interglacial
478,000		12	Glacial
736,000		19	Middle Pleistocene
1,800,000	Irvingtonian	22	Early Pleistocene Early Quaternary

The Pleistocene-Holocene boundary is generally set at ca. 10,000 BP. By definition, the beginning of the Holocene implies that the Pleistocene "Ice Ages" ended, and therefore the Holocene does not simply represent a modern interglacial cycle; however, not all researchers agree with this assessment. Whatever the case may be, the Pleistocene (ca. 1.8 million to 10,000 years ago) was a period of shifting glacial and interglacial cycles of widely varying intensity. Typically, glacial cycles lasted between roughly 40,000 and 100,000 years, perhaps controlled largely by variations in the earth's orbit and the tilt of its axis. Interglacial cycles typically lasted for much shorter time periods. The Pleistocene has been divided into three stages based on variations in the earth's climate and polarity. The Early or Lower Pleistocene dates to ca. 1.8 million to 750,000 years ago, and encompasses MIS's 20-22. Overall, the earth was in a very cool period, and the earth's polarity was reversed (the Matuyama polarity) from the current situation. The switch to "normal" polarity (the Brunhes polarity) marks the beginning of the Middle Pleistocene at ca. 750,000 years before present (BP). The beginning of the Middle Pleistocene roughly corresponds to the MIS 19 interglacial, and ends with the beginning of the MIS 5 interglacial. The Late Pleistocene, then, begins with MIS 5, and ends 10,000 years ago, with the beginning of MIS 1.

The marine oxygen isotope record is too coarse-grained to adequately separate relatively short periods of warm/cool and wet/dry cycles during the Pleistocene or the Holocene. Cooler and warmer phases within each MIS is best interpreted through other proxy data such as fluctuations in CO_2 preserved in glacial ice, plant macrofossils preserved in fossil woodrat middens, pollen records, and faunal remains.

In general, these data suggest that the Holocene can also be divided into three general periods for the Great Basin. The Early Holocene (ca. 10,000 – 8,300 BP) was relatively cool and moist compared to current conditions, but not as cool as the preceding Pleistocene. The Middle Holocene (ca. 8,300 – 4,500 BP) was relatively warm and dry; the period between ca. 8,300 and 7,000 BP was one of the hottest and driest times recorded in the Great Basin over the past two million years, and this millennium-and-a-half had a profound impact on plant and animal distributions, as discussed in more detail below. The Late Holocene (ca. 4,500 to present) was cooler and wetter than the preceding Middle Holocene. The Late Holocene, however, has witnessed significant variability in climate. The early portion of the Late Holocene, from ca. 4,500 to 2,000 BP, is known as the Neoglacial in the Great Basin. This period was characterized by relatively cool and

wet climatic conditions. Between ca. 1,600 and 800 BP, a winter precipitation pattern appears to have been supplanted by a summer precipitation pattern. A relatively short but intense drought is seen across much of the western United States about 800 BP. In contrast, a relatively short but intense cold snap occurred about 350 BP across much of the northern hemisphere, collectively known as the Little Ice Age.

All of these climatic trends affected plant and animal distributions in the Great Basin, including human populations. While space does not permit more detailed discussions here, a number of recent works have been published that summarize these data (e.g., Kurtén and Anderson 1980; Lundelius et al. 1982; Harris 1985; Heaton 1990; Grayson 1993, 1994; Graham and Lundelius 1994; Williams et al. 1998; Madsen 2000; Madsen et al. 2001; Benson et al. 2002; Schmitt et al. 2002; Wigand and Rhode 2002).

The Pleistocene of North America witnessed the evolution of new mammal species, the extinction of others, and the migration of species into the region from Asia. As a result, specific time periods are characterized by the presence of mammal species that were not present previously in the fossil record. These are the so-called "Land Mammal Ages" (Savage 1951; Hibbard et al. 1965). In North America, the Irvingtonian Land Mammal Age begins about the same time as the Quaternary Period/Pleistocene Epoch (see Table 6). Three hallmark events of the Irvingtonian include the migration of the mammoth (*Mammuthus* sp.) and hare (*Lepus* sp.) from Asia into North America, and the *in-situ* evolution of the muskrat genus *Ondatra* (Kurtén and Anderson 1980).

The Irvingtonian is supplanted by the Rancholabrean Land Mammal Age, which is traditionally set at approximately 400,000 years ago. The most distinguishing mammal that sets the Rancholabrean apart from the Irvingtonian is the presence of bison (*Bison*) at this time. This approximate date actually lies within interglacial MIS 11 (Table 6); it may be more probable that bison migrated to North America from Asia during MIS 12 (ca. 425,000-475,000 BP) or MIS 10 (ca. 360,000-340,000 BP). Whatever the case, bison are not present in Irvingtonian faunal assemblages. In addition, there are many other species that migrated from Asia to North America at various times during the Rancholabrean, and these species also assist in placing Pleistocene-aged paleontological sites within one of these two Land Mammal Ages. These

relatively late arriving mammals include the brown bear (*Ursus*), North American reindeer, or caribou (*Rangifer*), mountain sheep (*Ovis*), and mountain goat (*Oreamnos*). The presence of these animals in paleontological sites of North America signal a Rancholabrean age for the assemblage. It is also important to note, however, that many mammals, such as the horse (*Equus*), deer (*Odocoileus*), and llama (*Hemiauchenia*) were present in both the Irvingtonian and Rancholabrean, and may not be a good indication of Land Mammal Age.

Biotic Change in the Great Basin During MIS's 2 and 3

As noted in chapter 1, many of the fossils from Mineral Hill Cave date between 30,000 and >50,000 BP. Because many of the Pleistocene dates range between about 30,000 and 45,000 BP, the majority (and perhaps all) of these fossils may be Wisconsinan in age (MIS's 2-4; 71,000 – 10,000 BP). The Wisconsinan is defined as the last general glacial cycle in North America. Cooler conditions, beginning about 70,000 to 75,000 years ago, followed the interglacial (but widely fluctuating) cycle of MIS 5. MIS 4, dated to approximately 71,000 BP, was quite cool across the northern hemisphere. MIS 3, dated between about 59,000 and 24,000 BP, was a period of millennial-scale fluctuations between cooler and warmer temperatures that are sometimes referred to as "Dansgaard-Oeschger cycles" (for recent summaries, see d'Errico and Goñi 2003; Huntley et al. 2003). Overall, however, MIS 3 was relatively cool. MIS 2, often called "Late Glacial Maximum" or "LGM", is dated between about 24,000 and 17,000 BP, and witnessed the greatest advance of continental and mountainous ice sheets of any time during the Wisconsinan. The post-17,000 BP climatic trend has been toward warming, except for the last millennial-scale cold snap of the Pleistocene known as the Younger Dryas, dated between ca. 11,500 – 10,500 BP.

Based on terrestrial sediment loads into Owens Lake created by glacial surges in the east-central Sierra Nevada's, as well as overflow of Owens Lake into subsequent lake basins, Bischoff and Cummins (2001) recently subdivided the Wisconsinan glacial cycle into 13 distinct glacial advances and retreats. These cycles are probably close proxies for general climatic conditions occurring in the central Great Basin over the past 75,000 years. Their research also highlights the importance of terrestrial records for

interpreting changes in flora and fauna. In general, the stages outlined in Biscoff and Cummins (2001) generally match the marine record in terms of MIS's and millennial-scale events, but not precisely. For example, the accepted date for the boundary between the early and middle Wisconsinan is approximately 59,000 BP, or the boundary between MIS 4 and MIS 3. While Bischoff and Cummins (2001) found that this date correlates with one of their glacial stadials (either stadial 4 or 5), this stadial was unremarkable in relation to the two glacial stadials that occurred both before and after. Instead, a more significant change in the terrestrial record occurred at stadial 3, dated 49,000 – 45,100 BP. Between ca. 78,000 – 49,000 BP, the glacial pulses of the Wisconsinan in the east-central Sierra Nevada's were relatively mild, and seemed to be caused by low summer temperatures and relatively dry conditions. A rather dramatic change occurred beginning about 49,000 BP in which the periodic low summer temperatures were combined with increased precipitation, causing the glacial cycles of 49,000 – 45,100 BP, 42,800 – 39,000 BP, and 30,500 – 15,000 BP to be of greater intensity. In addition, the post-49,000 BP record seems to be correlated with the advent of millennial-scale fluctuations in climate. Further, while the marine record suggests a date of 24,000 BP for the onset of glacial cycle MIS 2, the terrestrial record suggests this phenomenon was well underway by 30,500 BP (Bischoff and Cummins 2001).

In the northern Great Basin, the effects of the widely-fluctuating MIS 3 and Biscoff and Cummins' (2001) stadial 3 on the biotic and abiotic environments are just beginning to be understood. The majority of paleoenvironmental reconstructions in this region post-date MIS 3, and indeed most of them post-date the LGM. Nevertheless, recent syntheses such as Wigand and Rhode (2002) are beginning to fill in missing pieces of the paleoenvironmental history of the Great Basin during this earlier stage. In general, the entire northern Great Basin witnessed relatively cool conditions during MIS's 4-2. A period of cool and increasingly wet conditions is recorded in the northern Great Basin beginning with the last glacial cycle at ca. 30,500 BP. This caused lake systems to rise across the central and northern Great Basin. Millennial-scale cool but somewhat dry conditions occurred until the onset of MIS 2, ca. 24,000 BP. This latter phase saw a return to a cool and wet climate that once again caused lakes to rise.

There are two important proxy records close to the Mineral Hill Cave region that date to MIS 3 (middle Wisconsinan). One is the Top of the Terrace woodrat midden located in an upland setting on the western flanks of the Goshute Mountains, approximately 100 miles to the northeast of the cave (Rhode 1998, 2000; Wigand and Rhode 2002). In these records, Utah juniper twigs are present before ca. 46,000 BP, but then absent until they re-emerged during the Holocene. The presence of Utah juniper together with cool/mesic species such as currant and cinquefoil suggests that relatively cool and moist conditions prevailed in northeastern Nevada at this time. This cool and wet phase may correspond to Bischoff and Cummins' (2001) stadial 3 (49,000 – 45,100 BP). After ca. 41,000 BP, these cool/mesic species were replaced by cool/dry forms such as limber pine trees and fernbush. These data suggest relatively cool and dry conditions from about 40,000-28,000 BP, which generally correlates with Biscoff and Cummins' (2001) interstadial 1 (39,000 – 30,500 BP). The ca. 40,000-28,000 BP pollen record from the Ruby Marshes, located only 30 miles to the east of Mineral Hill Cave, suggests a shallow lake surrounded by sagebrush steppe at this time (Thompson 1992). These data corroborate an interpretation of cool and dry conditions for about 10,000 years near the end of MIS 3.

Toward the end of MIS 3, by about 30,000 BP, lake levels began to rise in the northeastern Great Basin. The Top of the Terrace woodrat midden records an increase in Spruce trees and a reappearance of currant and cinquefoil with dramatic declines in limber pine and fernbush between 28,000-20,000 BP. The Ruby Marshes document increasing lake levels by at least 23,000 BP and continuing to at least 14,000 BP. These data suggest that relatively cool and wet conditions prevailed between 28,000-14,000 BP, which correlates rather well with Biscoff and Cummins' (2001) stadial 1 (30,500 – 15,000 BP). Limber pine returns in low-elevation woodrat middens of the northern Bonneville Basin after ca. 14,000 BP, signaling drier conditions; this corresponds to a general lowering of lake levels following the highstands of ca. 15,000 BP, with lake stabilization or slight rise in lake levels during the Younger Dryas of ca. 11,500 – 10,500 BP (Oviatt et al. 2003). A variety of proxy data from the south (e.g., southern New Mexico and southern California) may corroborate these general climatic patterns, although precision in the dating of these Mid-Wisconsinan records is a recurring problem (e.g., Harris 1993; Anderson et al. 2002).

Similar to the vegetation records, well-dated faunal records from MIS 3 and earlier are rare in the central and northern Great Basin. Comparisons of the species identified from Mineral Hill Cave with existing fossil collections from the Great Basin and surrounding regions are presented in Chapters 3-9. Here, however, it is worth noting that the American Falls Local Fauna from southern Idaho dates to the MIS 5 Sangamonian interglacial. This interglacial fauna contains the remains of, among many other animals, giant ground sloth (*Megalonyx* and *Paramylodon*), mammoth (*Mammuthus*) and mastodon (*Mammut*), horse (*Equus*), perhaps two species of bison (*Bison*), camel (*Camelops*), llama (*Hemiauchenia*), reindeer (*Rangifer*), pronghorn (*Antilocapra*), mountain sheep (*Ovis*), and a variety of carnivores including wolf (*Canis lupus*), coyote (*Canis latrans*), short-faced bear (*Arctodus simus*), sabre-toothed cat (*Smilodon fatalis*), lion (*Panthera leo*), puma (*Puma concolor*), bobcat (*Lynx rufus*), and lynx (*Lynx canadensis*) (Pinsof 2000). The nearby Massacre Rocks locality (McDonald 1998) may be of equivalent age, and it contains a similar faunal assemblage to American Falls.

In east-central Utah, the Silver Creek Local Fauna probably dates to the early to middle Wisconsinan, or MIS 4 or early MIS 3 (Miller 1976). Some of the animals identified from this locality include dire wolf (*Canis dirus*), coyote, sabre-toothed cat, lynx, mammoth, horse, camel, pronghorn, and bison.

In western Nevada, a variety of paleontological locales situated along the shorelines of Pleistocene Lake Lahontan (Dansie et al. 1988) appear to date to the transitional period between MIS 3 and MIS 2, approximately 25,000-28,000 BP. The most common large mammals identified from this period are camel, horse, bison, and mammoth. At the Poker Brown Crossing site, in particular, the remains of over 80 individual camels, 50 horses, three bison, and 10 mammoths have been recovered. These animals evidently died after becoming trapped in clay sediments around a spring source, which led Dansie et al. (1988:186) to suggest that these animals were being drawn to a critical water source during an arid climatic period. As noted above, current paleovegetation and glacial cycle records suggest that the period between ca. 40,000-30,000 BP was more arid than the periods before and after this stretch of time. If Dansie et al.'s (1988) interpretation is correct, then it is possible that these sites date a significant large mammal die-off during the arid

period before the onset of generally cold and wet conditions marking the last glacial cycle. This die-off, corresponding to the end of Bischoff and Cummins' (2001) interstadial 1, may correlate with a similar die-off recorded in the Beringian region (Leonard et al. 2000; Barnes et al. 2002). The potential significance of this die-off is discussed further below and in Chapter 10 in relation to Mineral Hill Cave.

Dating of Biotic Changes At Mineral Hill Cave

As noted above and in chapter 1 (Table 3), the majority of Pleistocene-aged radiocarbon dates from Mineral Hill Cave cluster within MIS 3. Within this cluster, however, those that are younger than 50,000 BP cluster between about 30,000-48,000 BP. Some of the Mineral Hill Cave dates, then, are associated with the relatively cool and wet period preceding 41,000-39,000 BP, while others are associated with the relatively cool and dry period preceding LGM (Table 7, following page). Significantly, no extinct animals date younger than 31,000 BP at Mineral Hill Cave.

There are at least two possible explanations for the patterning of dates within the Pleistocene at Mineral Hill Cave. First, it is possible that the cool and dry period of 41,000-28,000 BP caused major stresses on the large mammal populations in the central Great Basin. If this interpretation is correct, then the lack of now-extinct large mammals such as camel, llama, and horse after ca. 31,000 BP may be a consequence of naturally declining populations on the landscape that did not recover during the succeeding MIS 2/LGM.

Another possible explanation is that the cold and wet climatic conditions of LGM rendered the cave largely uninhabitable to carnivores. As is detailed in chapter 3, the majority of large mammal remains recovered from Mineral Hill Cave consisted of lower leg and foot bones. This pattern is typical of faunal assemblages created by carnivore scavenging, in which limb bones are carried from a kill site to a den or feeding locale (Binford 1981). The generally drier climate of 41,000-28,000 BP may have allowed carnivores to den inside the cave more frequently, and consequently they may have accumulated large numbers of bones at this time. Conversely, the wet

climate of LGM times may have filtered large quantities of water through the cave system; this microenvironment may not have been conducive to carnivore denning. The section of laminated clays in chamber 5 described in chapter 1 (Figure 7) were deposited sometime after 46,500 BP, the AMS date retrieved on a camel phalanx that was found embedded in these deposits. It may be the case that the laminated clays were deposited during MIS 2 following the colder and drier period at the end of MIS 3, in which case the back chamber of the cave would have been essentially a cold pond uninhabitable to mammalian carnivores. This explanation, however, does not fully account for the fact that no extinct large mammals dated to the latest Pleistocene following LGM (ca. 15,000 – 10,000 BP), while dates from this time period were obtained on extant animals such as pronghorn, bobcat, and badger.

Table 7. Animals with AMS dates at Mineral Hill Cave subdivided by eight general climatic regimes.

>50,000	49,000- 39,000	39,000- 30,000	30,000- 15,000	15,000- 10,500	10,500- 8,300	8,300- 4,500	4,500- 2,000
cool/dry	cool/wet	cool/dry	cold/wet	cool/dry	cool/moist	warm/dry	cool/moist
*Llama *Deer +Bison Pronghorn *Horse +Pika *Cheetah +Red fox Owl Falcon	*Llama *Camel +Bison *Horse +Red fox +Marmot Raven	*Llama *Deer +Bison *Horse Sheep +Pika Hare +Pygmy rabbit Golden eagle	Bobcat +Marmot Collard lizard	Pronghorn Badger	Bobcat +Brown bear	Sheep Spotted skunk +Marmot Hare Bushytailed woodrat Northern pocket gopher Sage grouse Collard lizard	Spotted skunk Long-tailed weasel Bushytailed woodrat Porcupine

*extinct

+extralocal; no modern or historic records of animal occurring in the immediate area surrounding the cave

CHAPTER 3

Systematic Paleontology of the Mineral Hill Cave
Carnivores, Perissodactyls, and Artiodactyls

Bryan Hockett and Eric Dillingham

This chapter discusses the carnivores and large mammals identified from Mineral Hill Cave (MHC). Where applicable, additional details are presented below regarding specific identifications. If the identifications were relatively secure but not without reservations, they were designated as "cf." for "compares favorably to". For each species, information is presented on other paleontological and archaeological sites where the same or similar species

has been identified. These comparisons focus primarily on sites located within the state of Nevada, but other regional locales are included for a broader context.

The locations of the important sites mentioned in the text below are shown on Figures 9 and 10. Figure 9 shows these sites with modern political boundaries; Figure 10 without them.
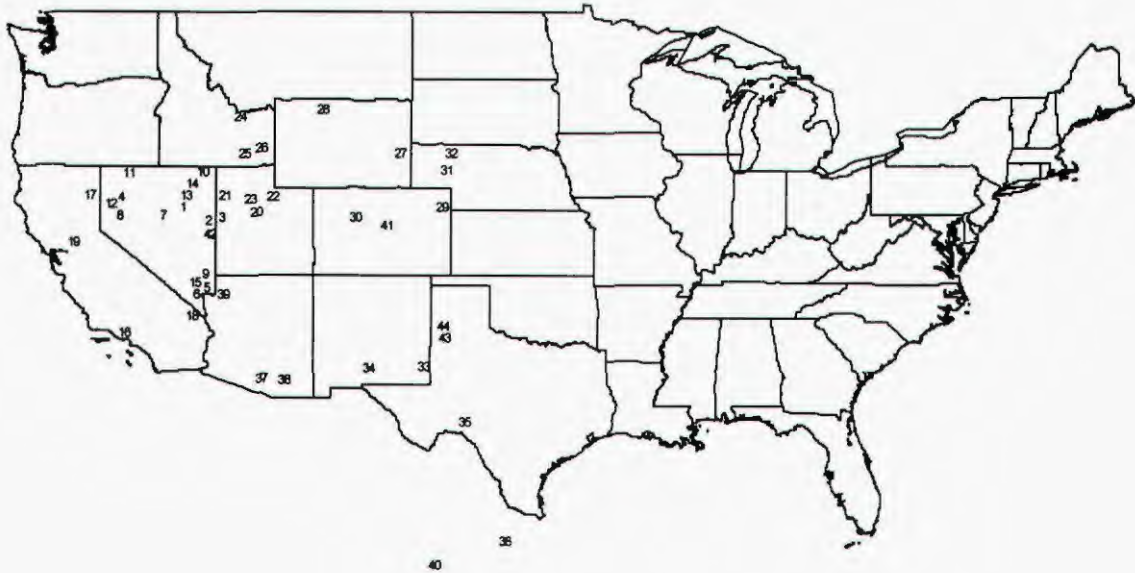
Figure 9. General location of major sites mentioned in chapter 3: (1) Mineral Hill Cave; (2) Smith Creek Cave; (3) Crystal Ball Cave; (4) Crypt Cave; (5) Gypsum Cave; (6) Tule Springs; (7) Gatecliff Shelter; (8) Hidden Cave; (9) Mormon Mountain Cave; (10) Deer Creek Cave; (11) Last Supper Cave, Hanging Rock Shelter; (12) Wizard's Beach; (13) James Creek Shelter; (14) Pie Creek Shelter; (15) Pintwater Cave; (16) Rancho La Brea; (17) Potter Creek Cave; (18) Kokoweef Cave, Antelope Cave; (19) Arco Arena; (20) Lake Bonneville; (21) Danger Cave; (22) Silver Creek; (23) Homestead Cave; (24) Jaguar Cave; (25) Rainbow Beach, Massacre Rocks; (26) American Falls; (27) Little Box Elder Cave; (28) Natural Trap Cave; (29) Selby, Dutton; (30) Haystack Cave; (31) Broadwater, Lisco; (32) Gordon, Rushville, Hay Springs; (33) Burnet Cave, Dry Cave; (34) Shelter Cave; (35) Cueva Quebrado; (36) San Josecito Cave; (37) Ventana Cave; (38) Deadman Cave; (39) Rampart Cave, Vulture Cave; (40) Aquascalientes; (41) Porcupine Cave; (42) Owl Cave No. 2, Snake Creek Burial Cave; (43) Slaton; (44) Canyon

Figure 10. General location of major sites mentioned in this chapter without reference to political boundaries except the border of the United States and Canada: (1) Mineral Hill Cave; (2) Smith Creek Cave; (3) Crystal Ball Cave; (4) Crypt Cave; (5) Gypsum Cave; (6) Tule Springs; (7) Gatecliff Shelter; (8) Hidden Cave; (9) Mormon Mountain Cave; (10) Deer Creek Cave; (11) Last Supper Cave, Hanging Rock Shelter; (12) Wizard's Beach; (13) James Creek Shelter; (14) Pie Creek Shelter; (15) Pintwater Cave; (16) Rancho La Brea; (17) Potter Creek Cave; (18) Kokoweef Cave, Antelope Cave; (19) Arco Arena; (20) Lake Bonneville; (21) Danger Cave; (22) Silver Creek; (23) Homestead Cave; (24) Jaguar Cave; (25) Rainbow Beach, Massacre Rocks; (26) American Falls; (27) Little Box Elder Cave; (28) Natural Trap Cave; (29) Selby, Dutton; (30) Haystack Cave; (31) Broadwater, Lisco; (32) Gordon, Rushville, Hay Springs; (33) Burnet Cave, Dry Cave; (34) Shelter Cave; (35) Cueva Quebrado; (36) San Josecito Cave; (37) Ventana Cave; (38) Deadman Cave; (39) Rampart Cave, Vulture Cave; (40) Aquascalientes; (41) Porcupine Cave; (42) Owl Cave No. 2, Snake Creek Burial Cave; (43) Slaton; (44) Canyon

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We begin the systematic paleontology with a discussion of the Mineral Hill Cave carnivores, followed by the Perissodactyls and Artiodactyls.

Class Mammalia

Order Carnivora

Family Felidae

cf. *Miracinonyx trumani*
North American Cheetah

MATERIAL RECOVERED. metatarsal V

C-14 Age. TP4-1 [> 50,000 BP]

DISCUSSION. The large felid fifth metatarsal from MHC was identified based on a combination of size and morphology, with the latter taking precedence. Based on comparisons with a variety of living and extinct felids, the metatarsal was clearly too large to belong to small felids such as bobcat (*Lynx rufus*) or lynx (*Lynx canadensis*), yet it was too small to belong to the North American lion, *Panthera leo*. The specimen was therefore likely to belong to the extinct North American cheetah (*Miracinonyx* spp.), fossil jaguar (*Panthera onca*), or fossil puma/cougar (*Puma concolor*). The size of the specimen was of limited utility in narrowing its possible affiliation to one of these three cats. Table 8 lists metatarsal V measurements for two species of North American cheetah, fossil and recent pumas, fossil jaguars, recent African cheetahs, and the MHC specimen. Based on these measurements, the MHC specimen is generally longer and broader proximally than recent pumas, but it shares the characteristic greater length to breadth ratios seen in African cheetahs and the extinct North American cheetah (e.g., Martin et al. 1977; Adams 1979; Morgan and Seymour 1997). However, this characteristic alone is inadequate to identify the metatarsal.

The morphology of the MHC specimen, however, clearly aligns it within the puma-cheetah lineage. Paleontological and immunological data suggest that fossil and recent pumas and cheetahs are more closely related to one another than to other felids such as lynx, lion, and jaguar (Adams 1979; Collier and O'Brien 1985), although Martin et al. (1977) suggested that the morphological similarities between the skeletons of fossil pumas and cheetahs were the result of convergent evolution. Whatever

biological relationships occur between pumas and cheetahs, we found several characteristics of the fifth metatarsal that may help to distinguish between them.

Martin et al. (1977) noted that African cheetahs and the extinct North American cheetah (*Miracinonyx trumani*) both possessed relatively straight metatarsals. Additionally, Adams (1979) noted that the muscle scars on the limb bones of both animals were remarkably similar. These characteristics are thought to be related to the restructuring of the limbs for propulsion rather than for climbing. Related to these observations, we found three characteristics that generally distinguish the fifth metatarsals of *Miracinonyx* from those of *Puma*: 1) the proximal one-half of the diaphysis of *Miracinonyx* fifth metatarsals tend to be strongly triangular in shape; most of the specimens of *Puma* that we examined were round – those that were triangular-like were not as sharply triangular as those of *Miracinonyx*; 2) the Irvingtonian-aged *Miracinonyx* specimens we examined from Port Kennedy Cave were all straighter than recent *Puma* specimens; put the other way, *Puma* fifth metatarsals tend to curve more deeply than those of *Miracinonyx*; and 3) every *Puma* specimen we examined displays a muscle scar on the posterior side of the diaphysis, approximately one-third of the way up the length of the bone from the end of the distal epiphysis. This muscle scar was absent on the Port Kennedy Cave *Miracinonyx* specimens, as well as the specimen of African cheetah that we examined. Of these three characters, the muscle scar may be the most diagnostic, and may relate to an adaptation geared toward running rather than climbing and darting. Together, these three characteristics appear to adequately distinguish *Miracinonyx* fifth metatarsals from those of *Puma*.

Figure 11 shows the fifth metatarsal from MHC. The proximal one-half of the diaphysis of the MHC specimen is strongly triangular in shape; it is relatively straight; and it possesses no muscle scar on the posterior side of the bone near its base. These three characteristics suggest that the MHC specimen belongs to the extinct North American cheetah rather than to a fossil puma.

The early form of the North American cheetah, *M. inexpectatus*, first occurs in late Blancan deposits, but was extinct by the late Irvingtonian or early Rancholabrean (Van Valkenburgh et al. 1990; Morgan and Seymour 1997). Although the metatarsal from MHC produced a limiting date of > 50,000 BP, given that the assemblage as a whole appears to be Rancholabrean in age, the bone is tentatively

identified here as the Rancholabrean North American cheetah *M. trumani*.

The type specimen of *M. trumani* comes from Crypt Cave in western Nevada, radiocarbon dated to ca. 19,750 BP (Orr 1969). The *M. trumani* specimens from Natural Trap Cave, Wyoming generally date between ca. 11,000 and 13,000 BP (Martin and Gilbert 1978). Emslie (1986) identified a medium-sized felid phalange at Haystack Cave, Colorado as *M. trumani*, radiocarbon dated between ca. 12,000 and 15,000 BP. If the MHC identification is correct, then it represents the oldest known specimen of *M. trumani* in North America. Currently, *M. inexpectatus* is unknown west of Colorado, and *M. trumani* is unknown east of Colorado (Anderson 1996). There remains a gap in dating between the latest *M. inexpectatus* and the earliest *M. trumani*: the MHC specimen may help close that gap.

Table 8. Mean metatarsal V measurements of M. inexpectatus, M. trumani, Puma concolor, Panthera onca, A. jubatus, *and the Mineral Hill Cave specimen.*

	n	Length	Proximal Breadth	Distal Breadth	Length/ Proximal Breadth	Length/ Distal Breadth
M. inexpectatus[1]	1	117.3	16.7	17.1	7.0	6.9
M. inexpectatus[2]	2	-	15.2	-	-	-
M. trumani[3]	6	110.7	-	14.9	-	7.4
Puma concolor (fossil)[4]	4	-	16.3	-	-	-
Puma concolor (recent)[5]	2	-	15.2	-	-	-
Puma concolor (recent)[6]	8	84.9	13.5	12.4	6.3	6.8
Panthera onca[7]	4	107.2	-	16.1	-	6.7
A. jubatus[8]	3	95.8	13.3	13.0	7.2	7.4
M. trumani[9]	1	105.0[10]	15.6[11]	-	6.7	-

[1]Hamilton Cave; Irvingtonian; Van Valkenburgh et al. (1990)
[2]Port Kennedy Cave; Irvingtonian; this report
[3]Natural Trap Cave; Rancholabrean; Van Valkenburgh et al. (1990)
[4]Cutler, Dry Cave, Potter Creek Cave; Rancholabrean; Morgan and Seymour (1997); K. Seymour (personal communication letter to B. Hockett, March 22, 2000)
[5]Morgan and Seymour (1997)
[6]Continental United States; Recent; this report
[7]Cumberland Cave, Coleman II A, Conard Fissure; Irvingtonian; (Kurtén 1973)
[8] K. Seymour (personal communication letter to B. Hockett, March 22, 2000)
[9]Mineral Hill Cave; Rancholabrean; this report
[10]minimum estimate
[11]worn

Figure 11. The cf. Miracinonyx trumani metatarsal V (1) and cf. Ursus arctos proximal phalanx (2) from Mineral Hill Cave. Note the strongly triangular proximal region and the lack of a tuberosity/muscle scar on the distal, posterior side of the cheetah metatarsal.

Lynx cf. *rufus*
Bobcat

MATERIAL RECOVERED. five mandibles (one adult, four subadult); eight isolated teeth (three subadult Pm^4, two adult Pm^4, one subadult mandibular canine, one adult mandibular canine, one adult maxillary canine); one innominate (acetabular fossa +); one patella; one distal tibia; one calcaneus; one proximal ulna

C-14 AGE. TP3-151 (adult mandible [30,310 ± 170 BP]); TP3-170 (subadult mandible [9,640 ± 40 BP])

DISCUSSION. Bobcat is one of the most common small carnivores recovered in Irvingtonian and Rancholabrean sites throughout western North America (Anderson 1984). All of the small cat remains from MHC compare favorably with the bobcat. The presence of four subadult mandibles provides evidence that bobcats probably used MHC as a den. All of the subadult mandibles were found in the back chamber of the cave, which would suggest that this area may have been more open or once received greater air exchange with the outside compared to current conditions. The two dates reported above suggest that bobcats have been occupying this region of Nevada for at least the past 30,000 years.

Bobcat remains are ubiquitous in Pleistocene and Holocene caves and rockshelters throughout central and northern Nevada, including Deer Creek Cave (Ziegler 1963), Gatecliff Shelter (Grayson 1983), Crystal Ball Cave (Heaton 1985), Hidden Cave (Grayson 1985), Snake Creek Burial Cave (Heaton 1987), Last Supper Cave and Hanging Rock Shelter (Grayson 1988), James Creek Shelter (Grayson 1990), and Homestead Cave (Grayson 2000). They are also present in the Early Holocene levels of Pintwater Cave (Hockett 2000) in southern Nevada.

Family Ursidae

cf. *Ursus arctos*
Brown Bear

MATERIAL RECOVERED. proximal phalanx

C-14 Age. TP5-01-1 [9,960 ± 50 BP; 9,710 ± 40 BP]

DISCUSSION. The identification of the MHC bear phalanx was based primarily on the size of this bone compared to other proximal phalanges of brown (*Ursus arctos*), black (*Ursus americanus*) and giant short-faced (*Arctodus simus* and *Arctodus pristinus*) bear specimens, as well as the age of the bone. The MHC bear phalanx was compared to proximal phalanges of brown bears labeled as "kodiak" (*Ursus arctos arctos*) at the AMNH and the ANSP, brown bears labeled as "grizzly" at the AMNH, black bears on file at the AMNH and the ANSP, Rancholabrean short-faced bears from RLB, and Irvingtonian short-faced bears from Port Kennedy Cave on file at the ANSP. Table 9 presents the results of these data.

The proximal phalanx from MHC (Figure 11) is either a 2nd, 3rd, or 4th digit. The measurements displayed in Table 9 are from a mixture of 2nd-4th

digits, and are only designed to show general trends in the size of the proximal phalanges of these bears. However, the MHC phalanx morphologically matched well with various specimens of extinct *Arctodus* and extant brown and black bears, so we could not make a tentative identification based on morphology.

As Table 9 indicates, the length, as well as the proximal and distal widths of bear proximal phalanges generally decrease in size along the following gradient: short-faced bear - kodiak brown bear -grizzly brown bear - black bear. Merriam and Stock (1925) published length and proximal widths of two *Arctodus* proximal phalanges from Rancho La Brea, and these measurements closely match the maximum values we obtained from 20 measured specimens from the site. In general, proximal phalanges tend to be larger in *Arctodus* than *Ursus arctos*, but overlap exists. Thus, neither size nor morphology clearly distinguishes proximal phalanges from these two genera.

Black bear proximal phalanges also overlap in size with those of brown bears, but this overlap tends to be stronger among specimens labeled "grizzly" than those labeled "kodiak". In addition, there is no overlap between those labeled "grizzly" and those labeled "*Arctodus*": within the brown bears, only those labeled "kodiak" overlap the *Arctodus* specimens. There is a slight overlap in the lengths of proximal phalanges between the largest black bears and the smallest *Arctodus*.

In comparison, the bear phalanx from MHC is larger than any of the black bear or "grizzly" bear measurements, but overlaps with both "kodiak" brown bear and *Arctodus* measurements. The MHC specimen dates to the earliest Holocene, and thus it is not likely to be Arctodus, as no specimens from this animal have been found in the Great Basin that post-date ca. 11,200 BP (Gillette and Madsen 1992). It is therefore likely that the MHC phalange belongs to either a brown or black bear. Kurtén (1967) noted that Pleistocene brown and black bears achieved larger size than their Holocene descendants, but both underwent rapid diminution at the close of the Pleistocene. Given these data, and given that the MHC phalanx overlaps in size with *Arctodus*, the specimen is identified as "compares favorably" with the brown bear, although the possibility that it belongs to a black bear cannot be completely discounted. DNA analysis may be able to solve this question.

Pleistocene and Holocene bear remains are generally rare in Nevada. Ziegler (1963) identified a brown bear tooth from Deer Creek Cave in northeastern Nevada near the Idaho border. Emslie and Czaplewski (1985) reported the discovery of at least five individual bears from Labor-of-Love Cave near Ely in east-central Nevada. One specimen was identified as giant short-faced bear, three as black bear, and one tibia was identified as brown bear. Reliable dates have not been obtained from this site, but Emslie and Czaplewski (1985) argued that the cave was sealed approximately 12,000 years ago, and therefore the bear bones likely pre-date that date. If this is the case, then the brown bear tibia from Labor-of-Love represents one of the earliest brown bear specimens known from the contiguous United States. Data suggest that brown bears migrated into eastern Beringia during MIS 3 or 4, but did not migrate further southward into the contiguous United States until after ca. 12,000 BP (Agenbroad and Mead 1986; Cox 1992; Matheus 1995). Brown bear was also identified from Hidden Cave, western Nevada, in strata dating between ca. 7,000-10,000 BP (Grayson 1985). Brown bear was apparently identified in Smith Creek Cave, east-central Nevada (Miller 1979:292). The brown bear phalanx from MHC is the second such specimen dated to the early Holocene of Nevada, and the first dated to this time period in the central Great Basin.

Late Pleistocene specimens of bear are relatively common in other parts of the Great Basin, although most of these have been identified as short-faced bear. Heaton (1988) reported on a specimen of brown bear from Porcupine Cave, at an elevation of 9,250 feet in the Uinta Mountains of western Utah that dated to 10,600 BP. Nelson and Madsen (1987) reported on a Pleistocene specimen of black bear from along the ancient shoreline of Lake Bonneville, Utah. Grayson (2000) identified a single black bear bone from Homestead Cave, Utah, C-14 dated at ca. 8,200 BP. To the north of the hydrographic Great Basin, Kurtén and Anderson (1974) reported on several bones of brown bear from Jaguar Cave, southern Idaho, C-14 dated to between 10,370 and 11,580 BP. Lundelius (1984) reported on a short-faced bear from Cueva Quebrada, Texas, C-14 dated between 12,000 and 14,000 BP. As mentioned, remains of giant short-faced bear are relatively common in the Great Basin and surrounding regions (Merriam and Stock 1925; Schultz and Howard 1935; Kurtén 1967; McDonald and Anderson 1975; Kurtén and Anderson 1980; Nelson and Madsen 1983, 1987; Emslie and Czaplewski 1985; Akersten and McCrady

1990; Gillette and Madsen 1992; Scott and Cox 1993; Richards et al. 1996; Madsen 2000).

Kurtén and Anderson (1974) were the first to report an association of brown bear with short-faced bear south of Alaska at Little Box Elder Cave, Wyoming. Although brown and short-faced bears may have both been present near Labor-of-Love Cave in eastern Nevada during the latest Pleistocene, the

youngest definitive date on *Arctodus* from the Great Basin is between 11,200 and 11,400 BP (Gillette and Madsen 1992). Gobetz and Martin (2001), however, recently reported on a possible early Holocene short-faced bear from Kansas.

Table 9. Proximal phalanx measurements (mm) of Arctodus, Ursus, *and the Mineral Hill Cave specimen.*

	Length			Proximal breadth			Distal breadth		
	n	mean	range	n	mean	range	n	mean	range
Arctodus simus[1]	20	50.1	42.8-65.5	20	25.9	20.6-34.8	20	19.0	16.4-25.2
Arctodus pristinus[2]	9	54.3	45.5-60.5	14	25.8	22.7-28.5	12	19.1	16.9-20.2
Ursus arctos (kodiak)[3]	11	49.0	43.2-51.5	11	26.2	20.9-30.2	11	18.2	15.3-22.4
Ursus arctos (grizzly)[3]	6	39.9	37.9-41.8	6	19.1	16.1-20.7	6	14.0	12.6-15.1
Ursus americanus[4]	16	38.2	31.8-47.0	16	17.9	14.5-21.6	16	13.4	10.7-16.9
cf. *Ursus arctos*[5]	1	47.2	-	1	24.7	-	1	16.6	-

[1]Rancho La Brea, California; Rancholabrean; this report
[2]Port Kennedy Cave, Pennsylvania; Irvingtonian; this report
[3]Alaska; Recent; this report
[4]Continental United States; Recent; this report
[5]Mineral Hill Cave; Rancholabrean; this report

Family Canidae

Canis lupus
Gray Wolf

MATERIAL RECOVERED. M$_1$

C-14 AGE. unknown

DISCUSSION. A complete lower first molar of a juvenile gray wolf (Figure 12) was recovered in MHC. This specimen was compared to adult coyote (*Canis latrans*) and adult and subadult dire wolf (*Canis dirus*) at the Page Museum in Los Angeles. The deciduous tooth from MHC was much smaller than those of the dire wolf, yet it was much larger than adult coyote teeth.

Table 10 lists various mandibular measurements of recent and Rancholabrean-aged canids, including the gray wolf, coyote, red fox (*Vulpes vulpes*) and gray fox (*Urocyon cinereoargenteus*). These four canids grade in size from large to small, and we have found minimal overlap in dental measurements between them, although some overlap does exist. As Table 10

shows, the lower first molar from MHC fits within the size range of Alaskan gray wolves, but is beyond the range of recent or fossil coyotes reported here. Considering that the specimen is deciduous and it is being compared to adult teeth in Table 10, the specimen is securely attributed to gray wolf.

Figure 12. Gray wolf deciduous M$_1$ from MHC.

Gray wolf remains are uncommon in Pleistocene and Holocene sites in Nevada and the Great Basin. Wolf may be present in the Pleistocene

deposits of Gypsum Cave in southern Nevada (Harrington 1933:192), but it is possible that this specimen is dire wolf. Gray wolf may also be present in Deer Creek Cave, northeastern Nevada (Ziegler 1963:17). Heaton (1985) identified several gray wolf specimens from Crystal Ball Cave, east-central Nevada, and Nelson and Madsen (1986, 1987) identified a gray wolf maxilla from along the shoreline of Pleistocene Lake Bonneville in Utah. These specimens are probably late Pleistocene in age. More recently, Hockett (2000) reported on a gray wolf terminal phalanx from Pintwater Cave. This specimen was recovered from Unit 3, stratum 8, C-14 dated to ca. 32,000 BP.

Grayson (1985) reported on three gray wolf specimens from Hidden Cave, western Nevada, that were C-14 dated to ca. 3,600 – 3,800 BP. Grayson (1988) later identified 18 gray wolf bones scattered throughout the Holocene sequence in Danger Cave. Grayson (1988) also identified a single gray wolf ulna from an undated context at Last Supper Cave, northwestern Nevada. In addition, Hockett (1997) reported on the identification of a gray wolf patella

from Pintwater Cave that was recovered from Unit 5, stratum 3. The stratum above this level (stratum 2) in Unit 5 was C-14 dated to ca. 6,200 BP (Buck et al. 1997:25, Table 2). This gray wolf specimen is probably Early Holocene in age. Grayson (2000) also recently reported on a single wolf specimen from Homestead Cave that was C-14 dated between 5,300 and 3,400 BP.

These data suggest that wolves have been present in the southern, central and northern Great Basin regions throughout the last 30,000 years, although in relatively small numbers. Unfortunately, the gray wolf tooth from MHC is undated, but based on the wealth of C-14 dates retrieved from the cave, this specimen likely dates to either the Late Pleistocene or the Neoglacial.

Late Pleistocene gray wolf was also reported from Jaguar Cave, Idaho, C-14 dated between ca. 10,000 – 11,500 BP (Kurtén and Anderson 1972), and from Burnet Cave, New Mexico (Schultz and Howard 1935).

Table 10. Mandibular tooth measurements of Canis lupus, Canis latrans, Vulpes vulpes, *and* Urocyon cinereoargenteus *from Little Box Elder Cave, Jaguar Cave, Mineral Hill Cave, and recent specimens.*

	Alveolar Length (C-M$_3$)			Length M$_1$			Width M$_1$		
	n	mean	range	n	mean	range	n	mean	range
Canis lupus[1]	1	106.7	-	2	31.0	30.7-31.3	2	10.0	9.9-10.1
Canis lupus[2]	7	113.2	109.0-121.5	7	26.5	24.2-29.4	7	10.4	9.4-11.4
Canis lupus[3]	-	-	-	1	25.7	-	1	10.1	-
Canis latrans[1]	1	97.0	-	-	-	-	-	-	-
Canis latrans[4]	-	-	-	11	22.3	21.2-25.3	10	8.3	7.5-9.4
Canis latrans[5]	4	95.2	90.1-101.3	4	22.0	20.0-23.7	4	8.2	7.2-9.0
Canis latrans[6]	1	99.9	-	1	21.3	-	1	8.5	-
Vulpes vulpes[1]	8	66.0	60.7-70.7	57	15.0	13.2-16.6	57	5.5	4.6-6.3
Vulpes vulpes[2]	3	70.6	69.0-74.1	4	15.6	14.8-16.7	4	6.2	5.7-6.6
Vulpes vulpes[6]	2	69.0	67.4-69.7	-	-	-	-	-	-
Urocyon cinereoargenteus[5]	1	58.5	-	1	11.5	-	1	5.0	-

[1]Little Box Elder Cave; Rancholabrean; Anderson (1968)
[2]Alaska; Recent; Anderson (1968)
[3]Mineral Hill Cave (subadult specimen) ; Rancholabrean; this report
[4]Jaguar Cave; Rancholabrean; Kurtén and Anderson (1972)
[5]Nevada; Recent; this report
[6]Mineral Hill Cave (adult specimen(s)); Rancholabrean; this report

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Canis latrans
Coyote

MATERIAL RECOVERED. one mandible (with M_1); six canines; one Pm_2; one maxilla fragment (with Pm^4-M^1); three Pm^3; three M^2; one atlas; four caudal vertebrae; one metapodial

C-14 AGE. unknown

DISCUSSION. Table 10 above, as well as Tables 11-16 below display various mandibular and maxillary tooth measurements of wolf, coyote, red fox, and gray fox. As mentioned above, there is minimal overlap in size between the medium-sized coyote and the large red fox. Unlike a number of extant ungulate species, small to medium-sized canids such as the coyote and red fox did not achieve significantly larger bodies during the Late Pleistocene (Anderson 1968, 1996). The data outlined in Tables 10 - 16 were used to separate individual teeth and mandible/maxilla fragments of coyote and red fox.

Coyotes appear in the fossil record of North America during the Irvingtonian (Anderson 1996), and are one of the most ubiquitous species identified in Rancholabrean deposits throughout the western United States (Anderson 1984). In Nevada, coyote remains have been identified from Tule Springs (Mawby 1967), South Fork Shelter (Heizer et al. 1968), Smith Creek Cave (Miller 1979), Gatecliff Shelter (Grayson 1983), Crystal Ball Cave (Heaton 1985), Hidden Cave (Grayson 1985), Owl Cave No. 2 (Turnmire 1987), Last Supper Cave (Grayson 1988), Hanging Rock Shelter (Grayson 1988), James Creek Shelter (Grayson 1990), Homestead Cave (Grayson 2000), Pintwater Cave (Hockett 2000), and Sunshine Well (Huckleberry et al. 2001) to name a

few. To the north, coyote remains were common in the American Falls, Idaho, fauna dated between 80,000 and 130,000 BP (Pinsof 2000), and at Rainbow Beach, Idaho, C-14 dated between ca. 20,000 – 30,000 BP (McDonald and Anderson 1975). Although ubiquitous in Late Pleistocene deposits in western North America, coyote remains are often outnumbered by those of the red fox at this time, as seen in MHC, Jaguar Cave, Idaho (Kurtén and Anderson 1972), and Little Box Elder Cave, Wyoming (Anderson 1968).

Canis spp.
Wolf/Coyote

MATERIAL RECOVERED. three mandible fragments; one canine; one metapodial fragment

C-14 AGE. unknown

DISCUSSION. These five specimens all appear too large to be fox, but they are too fragmentary to be positively identified as either gray wolf or coyote. However, one of the mandible fragments is from a young canid in which the canine had not erupted above the gum line. The depth of the mandible below Pm_2 in this specimen measures about 19.0mm, near the upper limit of the coyote (see Table 16). Comparative specimens were not available to make a positive identification of this specimen, but it is possible that it belonged to a young wolf. The remaining specimens are probably coyote.

Table 11. C-Pm₄ tooth measurements of recent Canis latrans and Urocyon cinereoargenteus, and the three Vulpes vulpes mandibles from Mineral Hill Cave.

	Alveolar Length (C-Pm₄)		
	n	mean	range
Canis latrans[1]	4	60.0	57.7-63.7
Vulpes vulpes[2]	3	44.3	42.4-46.8
Urocyon cinereoargenteus[1]	1	38.3	-

[1] Nevada; Recent; this report
[2] Mineral Hill Cave; Rancholabrean; this report

Table 12. Pm$_2$-M$_3$ tooth measurements of recent Canis latrans *and* Urocyon cinereoargenteus, *and* Rancholabrean Canis latrans *and* Vulpes vulpes *mandibles from Jaguar Cave and Mineral Hill Cave.*

	Alveolar Length (Pm$_2$-M$_3$)		
	n	mean	range
Canis latrans[1]	4	73.6	70.0-78.5
Canis latrans[2]	10	74.6	69.0-78.0
Canis latrans[3]	1	78.5	-
Vulpes vulpes[2]	9	55.8	52.0-60.0
Vulpes vulpes[3]	2	55.2	53.9-56.5
Urocyon cinereoargenteus[1]	1	42.0	-

[1]Nevada; Recent; this report
[2]Jaguar Cave; Rancholabrean; Kurtén and Anderson (1972)
[3]Mineral Hill Cave; Rancholabrean; this report

Table 13. Pm^4 tooth measurements of Canis latrans, Vulpes vulpes, *and* Urocyon cinereoargenteus *from Little Box Elder Cave, Jaguar Cave, Mineral Hill Cave, and recent specimens.*

	Length Pm^4			Width Pm^4		
	n	mean	range	n	mean	range
Canis latrans[1]	6	19.4	17.9-20.5	6	10.1	9.3-10.8
Canis latrans[2]	1	20.0	-	1	9.8	-
Vulpes vulpes[3]	4	13.9	13.0-14.8	4	7.5	7.1.8.0
Vulpes vulpes[4]	44	13.3	11.8-15.1	43	6.9	5.4-8.4
Vulpes vulpes[5]	3	13.9	13.3-14.6	-	-	-
Vulpes vulpes[2]	1	14.3	-	1	7.7	-
Urocyon cinereoargenteus[1]	2	11.2	11.1-11.2	2	4.2	4.2-4.3

[1]Nevada; Recent; this report
[2]Mineral Hill Cave; Rancholabrean; this report
[3]Alaska; Recent; Anderson (1968)
[4]Little Box Elder Cave; Rancholabrean; Anderson (1968)
[5]Jaguar Cave; Rancholabrean; Kurtén and Anderson (1972)

Table 14. M¹ tooth measurements of Canis latrans, Vulpes vulpes, *and* Urocyon cinereoargenteus *from Little Box Elder Cave, Jaguar Cave, Mineral Hill Cave, and recent specimens.*

	Length M^1			Width M^1		
	n	mean	range	n	mean	range
Canis latrans[1]	5	12.6	11.7-13.4	5	16.2	15.4-17.7
Canis latrans[2]	2	12.9	12.6-13.1	2	15.9	15.7-16.1
Vulpes vulpes[3]	4	9.8	8.7-10.8	4	13.5	12.0-14.0
Vulpes vulpes[4]	48	6.9	7.1-10.3	47	12.3	10.3-14.3
Vulpes vulpes[5]	-	-	-	4	12.4	11.5-13.0
Urocyon cinereoargenteus[1]	2	7.5	7.3-7.6	2	10.4	10.1-10.6

[1]Nevada; Recent; this report
[2]Mineral Hill Cave; Rancholabrean; this report
[3]Alaska; Recent; Anderson (1968)
[4]Little Box Elder Cave; Rancholabrean; Anderson (1968)
[5]Jaguar Cave; Rancholabrean; Kurtén and Anderson (1972)

Table 15. M² tooth measurements of Canis lupus, Canis latrans, Vulpes vulpes, *and* Urocyon cinereoargenteus *from Little Box Elder Cave, Jaguar Cave, Mineral Hill Cave, and recent specimens.*

	Length M^2			Width M^2		
	n	mean	range	n	mean	range
Canis lupus[1]	-	-	-	1	14.7	-
Canis latrans[2]	6	7.7	7.4-7.9	6	11.3	10.0-12.4
Canis latrans[3]	2	8.2	7.0-9.3	2	11.3	10.5-12.1
Vulpes vulpes[4]	4	5.4	4.5-5.9	4	8.8	8.3-9.3
Vulpes vulpes[5]	24	4.7	3.0-6.7	24	8.0	7.0-9.4
Vulpes vulpes[3]	1	5.8	-	1	7.9	-
Urocyon cinereoargenteus[2]	2	5.0	4.6-5.3	2	6.8	6.7-6.9

[1]Jaguar Cave; Rancholabrean; Kurtén and Anderson (1972)
[2]Nevada; Recent; this report
[3]Mineral Hill Cave; Rancholabrean; this report
[4]Alaska; Recent; Anderson (1968)
[5]Little Box Elder Cave; Rancholabrean; Anderson (1968)

Table 16. Depth of mandible at Pm$_2$ of Canis latrans, Vulpes vulpes, and Urocyon cinereoargenteus from Mineral Hill Cave and recent specimens.

	Depth at Pm$_2$		
	n	mean	range
Canis latrans[1]	4	17.1	16.0-18.8
Canis latrans[2]	1	19.4	-
Vulpes vulpes[2]	5	12.2	11.0-13.5
Urocyon cinereoargenteus[1]	1	9.5	-

[1]Nevada; Recent; this report
[2]Mineral Hill Cave; Rancholabrean; this report

Vulpes vulpes
Red Fox

MATERIAL RECOVERED. six mandibles (three edentulous, one fragment with Pm$_4$ and partial M$_1$, one fragment with PM$_2$ and partial Pm$_3$, and one fragment with Pm$_2$ and partial Pm$_4$); one maxilla fragment with Pm^4 and M^2; one sacrum; one humerus

C-14 AGE. TP1a-08-8 (maxilla fragment [39,200 ± 1,200 BP]); TP3-147 (mandible [> 50,000 BP])

DISCUSSION. As noted above, Tables 10-16 display various tooth measurements for the wolf, coyote, red fox, and gray fox. Red fox tooth measurements tend to lie between those of the coyote and gray fox, and gray fox mandibles tend to have more widely-spaced teeth than the red fox (Anderson 1996). The six mandibles and one maxilla fragment identified above match the size and form of the red fox, as does the complete sacrum and the humerus (Table 17). McGuire (1980) reported that the gray fox was present in the MHC assemblage; however, we found no elements that match those of *U. cinereoargenteus*.

At least three individuals of red fox are represented by the six mandibles based on side (three left and three right), although tooth measurements and horizontal rami depths suggest that five to six individuals are present. The two red fox specimens dated from MHC are at least ca. 40,000 years old.

The red fox was once thought to have entered North America during the middle of the Rancholabrean, ca. 125,000 BP (Anderson 1984), but Anderson (1996) recently identified late Irvingtonian-aged red fox remains from Porcupine Cave, Colorado. Red fox has been reported from a number of Pleistocene localities in Nevada, including Smith Creek Cave (Miller 1979), Crystal Ball Cave (Heaton 1985), Snake Creek Burial Cave (Heaton 1987), and Sunshine Well (Huckleberry et al. 2001) all in east-central Nevada, and in Hidden Cave (Grayson 1985) in western Nevada. Red fox was also identified in Holocene deposits at Gatecliff Shelter (Grayson 1983) and Hidden Cave (Grayson 1985) in central Nevada, Last Supper Cave (Grayson 1988) in northwestern Nevada, and James Creek Shelter (Grayson 1990) in northeastern Nevada. Heaton (1985) noted that red fox was probably much more common in the Great Basin during the Pleistocene, and that this animal has been losing its range to the gray fox throughout the Holocene.

In nearby regions, red fox was identified along the shoreline of Pleistocene Lake Bonneville (Nelson and Madsen 1987), at Danger Cave (Grayson 1988) along the Nevada-Utah border, and at

Homestead Cave (Grayson 2000) in central Utah. Red fox was also recovered from the American Falls, Idaho locality (Pinsof 2000), and was one of the most common carnivores identified at Jaguar Cave, Idaho (Kurtén and Anderson 1972). Red fox was present in the Late Pleistocene deposits of Burnet Cave, New Mexico (Schultz and Howard 1935).

Table 17. Humerus measurements of Canis lupus, Canis latrans, *and* Vulpes vulpes *from Jaguar Cave and Mineral Hill Cave.*

	Mid-Shaft Breadth			Distal Width		
	n	mean	range	n	mean	range
Canis lupus[1]	-	-	-	1	44.5	-
Canis latrans[1]	1	10.6	-	1	27.7	-
Vulpes vulpes[1]	4	7.3	6.5-8.1	3	19.4	18.4-21.1
Vulpes vulpes[2]	1	7.8	-	1	19.0[3]	-

[1]Jaguar Cave; Rancholabrean; Kurtén and Anderson (1972)
[2]Mineral Hill Cave; Rancholabrean; this report
[3]estimated

Family Mustelidae

Brachyprotoma obtusata
Short-Faced Skunk

MATERIAL RECOVERED. mandible

C-14 Age. Unknown

DISCUSSION. Mandibles of the extinct short-faced skunk, *Brachyprotoma obtusata*, are relatively easy to distinguish from other species of skunks due to their short, massive structure, crowded/overlapping premolars, and curved tooth rows (Figure 13; Table 18; also see Hall 1936; Anderson 1996). The MHC specimen, however, is unique because instead of crowded premolars, the 2nd premolar never developed (Figure 13). Thus, the dental formula for the MHC *Brachyprotoma* mandible from C-M is $C_1:Pm_2:M_2$, rather than the $C_1:Pm_3:M_2$ seen in most other species of skunk, including the short-faced skunk. The number of lower premolars on this specimen, therefore, match the number of upper premolars seen on all other *Brachyprotoma* skulls from North America, the latter feature unique to this genus of skunk.

This situation, however, is not entirely unexpected, and does not imply that a new species is present (E. Anderson, personal communication, 2002). For example, Hall (1936:91) specifically noted that the lower premolars of the genus *Mustela* may number either two or three, the same situation seen in the *Brachyprotoma* specimen from MHC. Perhaps the best statement on the morphological variability of mustelid teeth comes from Anderson (1968:42), citing the work of Hall (1946), in her discussions of the variability of badger (*Taxidea taxus*) teeth:

> ... the cusps on the talonid of M_1 may number two, three, four, or five, and comparable variation exists in P^4 and M^1.

Figure 13. Mandibles of the short-faced skunk, Brachyprotoma *(upper) and the spotted skunk,* Spilogale *(center and lower) from MHC. Note the short, broad nature of the* Brachyprotoma *specimen.*

The only aspect open to interpretation regarding the short-faced skunk mandible from MHC, then, is the species designation. *Brachyprotoma* is known from Irvingtonian and Rancholabrean contexts in both the eastern and western United States (Anderson 1996). Hall (1936) initially concluded that all of the eastern specimens belonged to a single genus, and referred them to *B. obtusata*. Heaton (1985) identified a short-faced skunk skull from Crystal Ball Cave in east-central Nevada, and argued that it represented a new species, *B. brevimala*. Mead and Mead (1989) later retained Heaton's species identification in their review of Pleistocene mustelids of the Great Basin. However, Anderson (1996) referred all eastern and western specimens, including those of Irvingtonian and Rancholabrean age, to a single species, *B. obtusata*. We discussed and examined the MHC specimen with Elaine Anderson at the Denver Museum of Natural History during the Spring of 2002. Anderson reiterated that it was her belief that all of the short-faced skunk material she has examined, including the MHC specimen, should be identified under a single species. Given this, and considering that there are no "*brevimala*" mandibles

known to exist in North America, we have chosen here to refer to the MHC specimen as *B. obtusata*.

The MHC specimen is only the 4th known occurrence of this animal in Rancholabrean deposits in western North America, and the second known occurrence in the state of Nevada (Heaton 1985; Anderson 1996). Because of the small size and importance of this specimen, it was not damaged for radiocarbon dating. However, the mandible possesses the distinctive coloration (polished, light-yellow with black speckles) that many of the MHC bones exhibit. In most other cases, bones with this coloration returned C-14 dates in excess of 30,000 BP. It is unlikely that this specimen dates younger than 30,000 to 40,000 BP.

The short-faced skunk is probably closely related to the spotted skunk, *Spilogale putorius*, and the two are often found together in Pleistocene contexts (Kurtén and Anderson 1980). However, as described below, all of the *Spilogale* specimens from MHC may be Holocene in age, and therefore the association of these two genera at this site may be accidental.

Table 18. Mandible measurements of short-faced and spotted skunk from Hall (1936) and Mineral Hill Cave.

	n	Length of M_1	n	Posterior border of Pm_4 to anterior border of canine	n	Alveolar length $(C-M_2)$
B. obtusata[1]	11	7.2	9	8.8	9	-
B. obtusata[2]	1	6.2	1	8.7	1	15.8
S. putorius[2]	7	7.5	6	10.1	5	21.0

[1]Irvingtonian; Hall (1936)
[2]Mineral Hill Cave; Rancholabrean; this report

Spilogale putorius
Spotted Skunk

MATERIAL RECOVERED. seven mandibles

C-14 AGE. TP1b-012-3 (left mandible [6,600 ± 40 BP]); TP3-340 (left mandible [3,020 ± 50 BP])

DISCUSSION. The spotted skunk mandibles identified from MHC matched the size and morphology of comparative specimens (see Figure 13; Table18). At least four individuals were identified. Two specimens, one from the front chamber (TP1b-012-3) and one from the back chamber (TP3-340) were C-14 dated. Both specimens date to the Middle to Late Holocene. Based on the condition and coloration of the other four mandibles, all of the *Spilogale* remains from MHC are likely Holocene in age. Spotted skunk remains are relatively common in the caves of the Great Basin, especially during the Holocene (Mead and Mead 1989). In Nevada, *Spilogale* has been reported from Smith Creek Cave (Miller 1979), Gatecliff Shelter (Grayson 1983), Hidden Cave (Grayson 1985), Last Supper Cave (Grayson 1988), Snake Creek Burial Cave (Mead and Mead 1989), and Pintwater Cave (Hockett 1997). *Spilogale* was present at Homestead Cave, Utah, beginning about 8,200 BP (Grayson 2000), and was recovered from Deadman Cave, Arizona (Mead et al. 1984).

Mephitis mephitis
Striped Skunk

MATERIAL RECOVERED. partial skull, including maxillae

C-14 AGE. unknown

DISCUSSION. Striped skunk remains are easily identified based on their large size (Figure 14). The MHC specimen is most likely Holocene in age as it does not display the coloration typical of the Pleistocene-aged bones. Previous striped skunk remains have been restricted to the northern one-half of the state, such as at Gatecliff Shelter (Grayson 1983), Hidden Cave (Grayson 1985), and Last Supper Cave (Grayson 1988) (see also Mead and Mead 1989). MHC adds another locality for the Holocene distribution of this species. Striped skunk dating between 12,000 and 14,000 BP was reported from Cueva Quebrada, Texas (Lundelius 1984).
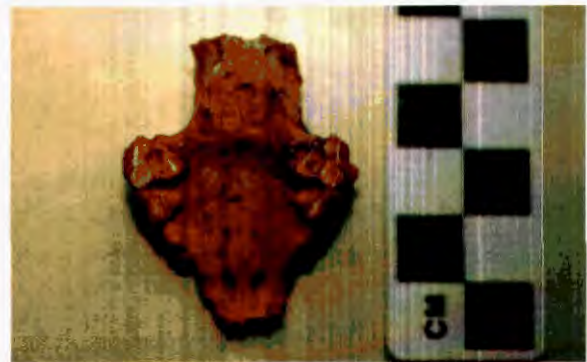
Figure 14. Striped skunk partial skull from MHC.

Mustela frenata
Long-Tailed Weasel

MATERIAL RECOVERED. three mandibles

C-14 AGE. TP3-341 (right mandible [3,950 ± 50 BP])

DISCUSSION. The mandibles of *M. frenata* were distinguished from those of the ermine, *M. erminea*, primarily based on the broader, more curved horizontal rami of the former (Figure 15). Table 19 shows that the length of the lower first molar overlaps in these two species. Long-tailed weasels are relatively common in Late Pleistocene and Holocene deposits of northern Nevada and the northern Great Basin (Mead and Mead 1989). They have been reported from Smith Creek Cave (Miller 1979), Hidden Cave (Grayson 1985), Snake Creek Burial Cave (Heaton 1987; Mead and Mead 1989), Danger Cave, Last Supper Cave, and Hanging Rock Shelter (Grayson 1988), and James Creek Shelter (Grayson 1990). They were present throughout the depositional sequence at Homestead Cave, Utah, from ca. 11,300 to 1,000 BP (Grayson 2000).

Figure 15. Long-tailed weasel (left) and ermine (right) mandibles from MHC. Note the broader, more curved horizontal ramus on the long-tailed weasel specimen.

One of the MHC specimens dates to the Neoglacial period of the Late Holocene. Based on the condition and coloration of the other two specimens, all of the *M. frenata* specimens from MHC are probably Holocene in age.

Mustela erminea
Ermine

MATERIAL RECOVERED. one mandible; partial skull (with maxillae)

C-14 AGE. unknown

DISCUSSION. As noted above, the horizontal rami of *M. erminea* tend to be thinner and straighter than those of *M. frenata*. The ermine skull recovered from MHC is illustrated in Figure 16.

The ermine has been previously identified in only four caves in Nevada: Smith Creek Cave (Miller 1979), Owl Cave #1 (Turnmire 1987), and Snake Creek Burial Cave (Mead and Mead 1989) in east-central Nevada, as well as Pintwater Cave (Hockett

2000) in southern Nevada. The Pintwater Cave specimen was recovered from a level C-14 dated to ca. 10,100 BP (Hockett 2000). Based on the condition and coloration of the MHC specimens,

these probably date to the early Late Holocene. Ermine was also recovered from the Late Pleistocene deposits of Homestead Cave, Utah (Grayson 2000).

Figure 16. Mink (left) and ermine (right) partial skulls from MHC.

Table 19. Mean mandible measurements of the ermine and long-tailed weasels from Little Box Elder Cave and Mineral Hill Cave.

	n	Length M_1	n	Alveolar Length (C-M_2)
M. frenata[1]	36	5.2	18	15.0
M. frenata[2]	2	5.8	2	17.0
M. erminea[2]	1	5.4	1	-

[1]Little Box Elder Cave; Rancholabrean; Anderson (1968)
[2]Mineral Hill Cave; Rancholabrean; this report

Mustela vision
Mink

MATERIAL RECOVERED. one partial skull (edentulous)

C-14 AGE. unknown

DISCUSSION. McGuire (1980) originally reported and identified this specimen, and we concur with his original findings (Figure 16). Mink are uncommon occurrences in the Late Pleistocene and Holocene caves of Nevada and the Great Basin (Mead and Mead 1989). They have been reported from Smith Creek Cave (Miller 1979), Crystal Ball Cave (Heaton 1985), Hidden Cave (Grayson 1985), and Snake Creek Burial Cave (Mead and Mead 1989), as well as Homestead Cave (Grayson 2000) and Sunshine Well

(Huckleberry et al. 2001). Based on coloration, the MHC specimen could have considerable antiquity. Two puncture marks on the skull suggest that this animal fell prey to a larger carnivore or to a large raptor.

Taxidea taxus
Badger

MATERIAL RECOVERED. two skull fragments, two mandibles, two maxillae, two thoracic vertebrae, one femur, one humerus

C-14 AGE. TP3-283 (left mandible [11,290 ± 50 BP])

DISCUSSION. Badgers are one of the most common mustelids found in Pleistocene and Holocene caves throughout western North America (Anderson 1968; Mead and Mead 1989). One of the MHC badger mandibles dates to the Late Pleistocene (see Figure 17), and some of the other specimens may have much greater antiquity. The measurements of the MHC badger bones closely match those from Little Box Elder Cave, Wyoming (see Table 20).

Badger is reported from numerous sites in central and northern Nevada (Grayson 1988; Mead and Mead 1989; Grayson 1990) south to New Mexico (Schultz and Howard 1935).

Table 20. *Various tooth measurements of badger from Little Box Elder Cave (Anderson 1968) and Mineral Hill Cave (this report).*

	Little Box Elder Cave		Mineral Hill Cave	
	n	mean	n	mean
Alveolar length (C-M^1)	7	39.9	1	39.3
Length M^1	9	11.1	1	12.6
Width M^1	9	10.3	1	10.5
Alveolar length (C-M$_2$)	10	51.1	2	49.4

Figure 17. *Partial maxilla (upper) and mandible (lower) of badger from MHC. The mandible returned a date of ca. 11,300 BP.*

Mustelidae

MATERIAL RECOVERED. 15 fibulae; one terminal phalanx

C-14 AGE. unknown

DISCUSSION. These bones were not identified beyond the family level. Based on their relatively large size, the majority of them probably belong to skunks and badgers.

Order Perissodactyla

Family *Equidae*

Identifying Pleistocene horse remains to species is a complex task, not the least of which is the problem of consistency amongst paleontologists in taxonomic nomenclature. Three relatively recent attempts to sort through the milieu of Pleistocene horse taxonomy are Winans (1989) and Azzaroli (1995, 1998). Winans (1989) focused only on metric data obtained from skulls, mandibles, and metapodials. Azzaroli (1998) considered both quantitative and qualitative measures. We have chosen here to generally follow Azzaroli (1998) (see Table 21).

For our discussion of the *Equus* remains from MHC, seven species of Pleistocene horse seem especially relevant. Four of these seven are relatively large forms: *E. excelsus*, *E. occidentalis*, *E. mexicanus*, and *E. simiplicatus*. The three relatively smaller forms are *E. fraternus*, *E. conversidens*, and *E. francisci*. As Table 21 shows, Azzaroli (1998) considered *E. scotti* a junior synonym of *E. excelsus*, and *E. pacificus* a junior synonym of *E. mexicanus*, and thus we have adopted the former names throughout the discussions that follow.

Two of the seven *Equus* species used here are the "stilt-legged" horses: the large *E. simiplicatus* and the smaller *E. francisci*. Both of these stilt-legged horses are known from Irvingtonian deposits, and *E. francisci* is also known from the Rancholabrean. The limbs of these horses consist of long, slender metapodials (see Table 24). Based on the data displayed in Table 24, it is the length of the metacarpal that helps to distinguish the large stilt-legged horse from any other known species of *Equus*. However, it is the proximal breadth (and perhaps the distal breadth) that distinguishes small, stilt-legged metacarpals from those of small and large stout-legged horses.

Metric data on metacarpals, phalanges, and upper muzzles form the core data with which the MHC horse bones can be tentatively identified (see Tables 22 - 25). These are the *Equus* elements recovered from MHC that offered the best opportunity for identification to the species level.

Table 21. General correlation of horse groups between Winans (1989) and Azzaroli (1998)

General Type	Age	Winans (1989)	Azzaroli (1998)
large, stout-legged	Early Blancan	*E. simplicidens*	?
large, stout-legged	Late Blancan to Early Rancholabrean	*E. scotti*	*E. excelsus*[1] *E. niobrarensis*[2]
large, stout-legged	Rancholabrean	*E. laurentius*	*E. occidentalis* *E. mexicanus*[3]
small, stout-legged	Late Irvingtonian to Rancholabrean	*E. alaskae*	*E. conversidens* *E. fraternus*
large, stilt-legged	Irvingtonian	*E. francisci*	*E. semiplicatus*
small, stilt-legged	Irvingtonian to Rancholabrean	*E. francisci*	*E. francisci*

[1]also includes *E. scotti*
[2]also includes *E. hatcheri*
[3]also includes *E. pacificus*

Table 22. Proximal phalanx measurements (mm) of E. occidentalis, *?*E. fraternus, *?*E. francisci, *and* E. conversidens *from various Pleistocene localities throughout western North America and Mexico, including Mineral Hill Cave.*

	Length			Proximal breadth			Distal breadth		
	n	mean	range	n	mean	range	n	mean	range
E. occidentalis[1]	30	93.2	83.8-106.3	30	59.3	51.3-64.8	30	50.1	45.8-53.5
Equus sp. (large horse)[2]	2	90.6	86.7-94.4	2	59.1	56.2-62.0	1	51.0	-
Equus sp. (large horse)[3]	8	79.7	74.9-83.0	8	57.0	51.5-59.1	9	45.8	43.0-47.9
?E. fraternus[4]	7	84.4	78.5-89.0	6	48.1	38.8-55.7	8	37.9	31.3-42.3
Equus sp. (small horse)[3]	7	79.3	72.4-87.6	4	42.8	40.5-45.3	6	34.8	33.7-36.6
Equus sp. (small horse)[5]	5	74.7	72.0-76.8	4	38.7	38.1-39.7	5	35.0	33.2-37.5
E. conversidens[6]	30	78.5	72.2-84.0	30	45.9	39.8-50.8	30	38.7	34.8-43.1
E. conversidens[7]	6	77.1	71.7-88.7	5	39.0	35.9-43.7	6	35.8	33.1-38.1
E. conversidens[8]	6	81.0	78.3-87.2	7	46.2	35.8-49.0	6	43.0	37.0-40.3
E. conversidens[9]	3	80.0	77.0-82.0	2	40.0	39.6-40.5	2	34.7	34.3-35.0
E. conversidens[10]	16	75.6	71.1-84.4	12	41.6	35.8-48.6	16	36.7	32.4-43.9

[1]Rancho La Brea, California; Rancholabrean; this report
[2]Rainbow Beach, Idaho; Rancholabrean; McDonald and Anderson (1975)
[3]Cueva Quebrada, Texas; Rancholabrean; Lundelius (1984)
[4]Slaton and Canyon, Texas; Irvingtonian; Dalquest and Hughes (1965)
[5]Crystal Ball Cave, Nevada; Rancholabrean; Heaton (1985)
[6]San Josecito Cave, Mexico; Rancholabrean; this report
[7]Little Box Elder Cave, Wyoming; Rancholabrean; Anderson (1967)
[8]Dry Cave, New Mexico; Rancholabrean; Harris and Porter (1980)
[9]Jaguar Cave, Idaho; Rancholabrean; Kurtén and Anderson (1972)
[10]Mineral Hill Cave; Rancholabrean; Hockett and Dillingham (this report)

Table 23. Central phalanx measurements (mm) of E. occidentalis, E. excelsus/scotti, *?E.* francisci, *?E.* fraternus, *and* E. conversidens *from various Pleistocene localities throughout western North America and Mexico, including Mineral Hill Cave.*

	Length			Proximal breadth			Distal breadth		
	n	mean	range	n	mean	range	n	mean	Range
E. occidentalis[1]	30	49.8	44.9-54.0	30	54.7	50.2-57.9	30	49.1	43.5-53.0
E. occidentalis[2]	6	54.5	52.0-57.5	9	56.6	54.7-59.9	8	50.7	46.0-54.4
Equus sp. (large)[3]	3	53.0	51.4-55.6	3	58.3	55.2-62.8	3	52.5	51.0-55.5
Equus sp. (large)[4]	6	38.7	36.7-40.3	6	54.1	47.2-57.5	4	50.4	48.7-51.1
?E. excelsus (large)[5]	1	51.8	-	1	62.0	-	1	57.1	-
Equus sp. (small horse)[4]	5	32.7	26.8-34.8	6	39.5	36.1-42.2	5	36.4	33.7-39.4
Equus sp. (small horse)[5]	6	40.5	36.5-45.2	5	39.7	31.9-44.0	5	34.6	31.1-39.1
?E. fraternus[6]	8	43.7	39.0-47.0	8	43.9	37.1-50.9	8	40.2	34.5-45.8
E. conversidens[7]	30	44.7	41.1-47.8	30	43.6	38.7-47.4	30	38.1	34.3-41.4
E. conversidens[8]	8	42.7	40.5-44.1	6	42.7	39.0-47.3	6	38.7	34.4-41.3
E. conversidens[9]	5	43.4	41.5-45.4	5	42.5	40.5-44.8	5	38.9	36.9-42.2
E. conversidens[2]	7	42.8	38.3-50.8	9	42.8	39.7-46.6	9	37.9	33.3-42.4

[1]Rancho La Brea; Rancholabrean; this report
[2]Mineral Hill Cave; Rancholabrean; this report
[3]Rainbow Beach, Idaho; Rancholabrean; McDonald and Anderson (1975)
[4]Cueva Quebrada, Texas; Rancholabrean; Lundelius (1984)
[5]Crystal Ball Cave, Nevada; Rancholabrean; Heaton (1985)
[6]Slaton and Canyon, Texas; Irvingtonian; Dalquest and Hughes (1965)
[7]San Josecito Cave, Mexico; Rancholabrean; this report
[8]Little Box Elder Cave, Wyoming; Rancholabrean; Anderson (1967)
[9]Dry Cave, New Mexico; Rancholabrean; Harris and Porter (1980)

Table 24. Metacarpal measurements (mm) of E. occidentalis, ?E. fraternus, E. conversidens, E. francisci, *and* E. simiplicatus *from various Pleistocene localities throughout western North America, including Mineral Hill Cave.*

	Length			Proximal breadth			Distal breadth		
	n	mean	range	n	mean	range	n	mean	range
E. occidentalis[1]	1	257	-	1	58.9	-	1	57.0	-
E. occidentalis[2]	-	-	-	-	-	-	1	54.6	-
E.occidentalis/mexicanus[3]	109	248	221-269	110	57.9	44.9-67.9	103	53.1	42.6-58.7
E. excelsus[4]	2	232	231-234	2	54.7	54.2-55.1	2	50.9	50.7-51.0
E. excelsus[3]	139	234	204-275	138	51.9	38.9-59.0	132	49.1	40.3-56.5
Equus sp. (large horse)[5]	2	244	243-244	2	54.7	53.0-56.4	2	51.4	51.2-51.5
Equus sp. (large horse)[6]	3	235	231-237	3	54.3	47.7-58.9	3	50.9	48.5-52.4
E. fraternus[7]	-	-	214-217	-	-	44.5-46.0	-	-	42.5-44.5
?E. fraternus[8]	5	225	218-233	5	49.7	45.0-53.4	5	45.9	43.5-49.0
E. conversidens[1]	3	237	216-259	3	47.5	44.3-50.3	2	47.2	45.8-48.5
E. conversidens[9]	5	228	217-235	5	46.5	44.1-49.5	5	42.7	39.4-45.8
E. conversidens[10]	1	219	-	1	43.8	-	-	-	-
E. conversidens[11]	1	213	-	-	-	-	-	-	-
E. conversidens[5]	2	226	226-226	2	52.0	49.0-55.0	2	46.6	44.4-48.8
E. conversidens[2]	1	221	-	1	42.1	-	1	39.5	-
E. conversidens[3]	51	225	207-263	51	47.8	42.7-52.6	51	42.4	38.9-47.1
Equus sp. (small horse)[6]	2	230	223-237	1	44.4	-	1	39.7	-
E. francisci[12]	1	235	-	1	31.4	-	-	-	-
E. simiplicatus[13]	1	287	-	1	54.0	-	1	45.5	-

[1]Rancho La Brea; Rancholabrean; this report
[2]Mineral Hill Cave; Rancholabrean; this report
[3]Winans (1989)
[4]Aguascalientes, Central Mexico; Early Rancholabrean; Mooser and Dalquest (1975)
[5]Rainbow Beach, Idaho; Rancholabrean; McDonald and Anderson (1975)
[6]Cueva Quebrada, Texas; Rancholabrean; Lundelius (1984)
[7]Pool Branch, Florida; Irvingtonian/Rancholabrean; Azzaroli (1998)
[8]Slaton and Canyon, Texas; Irvingtonian; Dalquest and Hughes (1965)
[9]Dry Cave, New Mexico; Rancholabrean; Harris and Porter (1980)
[10]Blackwater Draw, New Mexico; Rancholabrean; Harris and Porter (1980)
[11]Papago Springs, Arizona; Rancholabrean; Harris and Porter (1980)
[12]Wharton County, Texas; Irvingtonian; Lundelius and Stevens (1970)
[13]Rock Creek, Texas; Irvingtonian; Azzaroli (1998)

Table 25. Upper muzzle breadth (mm) of E. mexicanus/pacificus, E. excelsus, *and* E. occidentalis, *including Mineral Hill Cave.*

	Breadth		
	n	mean	range
E. mexicanus[1]	1	81	-
E. excelsus[1]	2	74	71-77
E. excelsus[2]	14	81	73-89
E. occidentalis[3]	2	84	81-86
E. occidentalis[4]	1	87	-
E. occidentalis/mexicanus[2]	28	82	68-93
E. conversidens[2]	4	75	58-88

[1]Sheridan Beds, Nebraska; Irvingtonian; Azzaroli (1998)
[2]Winans (1989)
[3]Rancho La Brea; Rancholabrean; Azzaroli (1998)
[4]Mineral Hill Cave; Rancholabrean; this report

Heaton (1985) identified the small horses from Crystal Ball Cave along the Nevada/Utah border as *E. conversidens*. However, as Tables 22 and 23 indicate, the proximal and central phalanges of the small horses from Crystal Ball Cave are smaller than those that can more confidently be assigned to *E. conversidens*. The small *Equus* phalanges from Crystal Ball Cave, in fact, may be from the stilt-legged horse *E. francisci*. Thus, we have chosen here to simply list these bones as "small horse" in the absence of more convincing data regarding their affiliation. Heaton (1985) identified the large horse from Crystal Ball Cave as *E. scotti*, referred to here and in Table 23 as *E. excelsus*. The latest *E. excelsus/E. scotti* specimens known in western North America may be from the Sangamonian of American Falls, Idaho, at ca. 100,000 BP (Pinsof 2000). If that is the case, then at least some of the Crystal Ball Cave fauna may date in excess of 100,000 years.

Dalquest and Hughes (1965) also assigned a number of *Equus* metacarpals and phalanges from several sites in Texas to *E. conversidens*. Table 24 shows that the metacarpals from these sites are much broader than those of *E. conversidens*. In addition, the proximal and central phalanges from Texas also seem too large to fit with those of *E. conversidens*. These data corroborate the conclusion drawn by Azzaroli (1998) that a skull from one of these Texas

localities matches more closely with *E. fraternus* than with *E. conversidens*. Azzaroli (1998) also noted that the Texas phalanges appeared to be too large to assign them to *E. conversidens*. Azzaroli (1998) suggested they may belong to the large stilt-legged horse, *E. simiplicatus*, a justifiable suggestion since the Texas faunal material published by Dalquest and Hughes (1965) is most likely Irvingtonian in age. However, the comparisons outlined in Table 24 suggest that the limb bones from these Texas localities are too short to be *E. simiplicatus*, but too stout (and perhaps too old) to be *E. conversidens*. As a result, the Texas material published by Dalquest and Hughes (1965) is provisionally assigned here to *E. fraternus* in order to maintain consistency with Azzaroli (1998). However, it is still possible that the limb bones from these Texas localities represent a relatively large form of *E. conversidens*, as Winans (1989) did not recognize *E. fraternus* separate from *E. conversidens*, and Azzaroli (1998) himself noted that while *E. fraternus* tended to display features of the skull that were larger than *E. conversidens*, both of these small, stout-legged horses tended to have similar-sized limb bones.

Lundelius (1984) relied on Winans' measurements, classification scheme, and advice in order to identify the large and small horses from Cueva Quebrada, Texas, as *E. scotti* and *E. francisci*,

respectively. However, as Table 24 shows, the small stilt-legged Irvingtonian horse metacarpal from Wharton County, Texas, measured only 31.4mm in proximal breadth, while those small horse specimens from Cueva Quebrada averaged 44.4mm. The Cueva Quebrada material dates to the latest Rancholabrean, which suggests that either small stilt-legged horses became substantially more robust through time or the small horses from Cueva Quebrada are not closely affiliated with the Irvingtonian stilt-legged horse *E. francisci*. Because of these apparent discrepancies, the small horses from Cueva Quebrada are simply listed as *Equus* (small) in Tables 22-24. If the large horses from Cueva Quebrada are *E. scotti*, then this site would represent the only terminal Rancholabrean locale in North America for this species, based on Azzaroli's (1998) classifications. Thus, Tables 22-24 above simply refer to the large horses from Cueva Quebrada as *Equus* (large).

The other two large horses considered here, *E. occidentalis* and *E. mexicanus*, are both known from the Rancholabrean of California (Azzaroli 1998). Azzaroli (1998) describes both as exhibiting thick muzzles, and of the three specimens he illustrated, *E. occidentalis* had the broadest upper muzzle of the two. Winans (1989) placed both of these Rancholabrean-aged large, stout-legged horses into the species *E. laurentius*. Upper muzzle breadth is described in greater detail in Table 25 and in the discussions below.

Equus cf. *occidentalis*
Extinct Western Horse

MATERIAL RECOVERED. One skull fragment (upper muzzle); one distal metacarpal; 10 central phalanges

C-14 AGE. TP3-87 (central phalanx [45,700 ± 1000 BP]); TP3-128 (upper muzzle [42,420 ± 820 BP])

DISCUSSION. Most of the MHC *Equus* bones consisted of foot elements. As with many other Late Pleistocene sites in western North America, at least two species of horse are present in the MHC collection: a large form and a small form. As noted above, cranial elements (including teeth) and postcranial elements such as metapodials have been instrumental in the identification of Pleistocene horses (e.g., Dalquest and Hughes 1965; Anderson 1967; Lundelius and Stevens 1970; Kurtén and

Anderson 1972; Dalquest 1979; Harris and Porter 1980; Woodburne and Sondaar 1988; Azzaroli 1998). A complete upper muzzle and a distal metacarpal served as the focus of the identification of the large form of horse.

Azzaroli (1998:12) noted that one of the hallmark characteristics of *E. occidentalis* was the presence of 'massive praemaxillaries', or massive upper muzzles. Although sample sizes are small, the data in Table 25 suggest that *E. occidentalis* may have had the broadest upper muzzle of any of the large horse species that occupied western North America. *E. excelsus* was extinct by the Early Rancholabrean. There is, however, some overlap in this feature between *E. occidentalis* and *E. mexicanus*. The MHC specimen, however, measured one centimeter greater than the largest of the two measurements that could be obtained from Azzaroli (1998) for *E. occidentalis*. Thus, the upper muzzle from MHC compares favorably with *E. occidentalis*.

Metacarpal measurements from several species of Pleistocene horses from across western North America are displayed in Table 24. Again, sample sizes are extremely limited. The MHC specimen is worn and undoubtedly measured greater than the 54.6mm displayed in Table 24 during the life of this horse. Unfortunately, the measurements published in Winans (1989) "mix" specimens previously identified as *E. occidentalis* with those of *E. mexicanus*. Nevertheless, the "worn" 54.6mm measurement clearly identifies the specimen as a large form of horse; assuming that only one species of large horse is present in the MHC assemblage, this specimen is also provisionally assigned to *E. occidentalis*. Figure 18 shows this specimen together with the *E. conversidens* metacarpal described below.

Figure 18. Distal ends of metacarpals of E. conversidens *(left) and* E. occidentalis *(right) from MHC.*

Tables 22 and 23 display length and proximal/distal breadth measurements for proximal and central phalanges of *E. occidentalis* and a number of other horse species from the published literature. Based on our measurements of *E. occidentalis* from Rancho La Brea and *E. conversidens* from San Josecito Cave, Mexico, as well as other published data, we were able to clearly separate the proximal and central phalanges of the large form of horse from the small form at MHC, provided that the bones were not too worn or broken. We were not able, however, to clearly separate the terminal phalanges using metric data. Published measurements of Pleistocene horse phalanges clearly indicate that those of the fore foot are usually larger than those of the hind foot (e.g., Dalquest and Hughes 1965; Harris and Porter 1980). However, in many Pleistocene locales, including MHC, *Equus* phalanges cannot be separated into fore and hind elements with certainty (Anderson 1967). As a result, the measurements shown in Tables 22 and 23 are based on averages and ranges of a mixture of fore and hind foot bones.

Overall, proximal phalanges of *E. occidentalis* generally measure greater than 84mm in length, 51mm in proximal breadth, and 45mm in distal breadth. The proximal phalanges *of E. conversidens* typically measure less than these three

critical values, although there is slightly more overlap between the lengths of these bones. There is quite a bit of overlap between the ranges of *E. occidentalis* and the *E. fraternus* specimens from Texas, but the means are substantially larger in the former. Based on these criteria, none of the unworn *Equus* proximal phalanges from MHC could be confidently assigned to the larger form of horse.

For the central phalanges, we found that *E. occidentalis* and *E. conversidens*/*E. fraternus* greatly overlap in the ranges of the lengths of these bones, although the means are again substantially larger in the former. However, there is less overlap between the proximal and distal breadths of the large and small horses. The central phalanges of *E. occidentalis* tend to measure greater than 50mm in proximal breadth and 43mm in distal breadth, while those of *E. conversidens* tend to measure less than these two critical values. Central phalanges from MHC that exceeded 50mm in proximal breadth and 43mm in distal breadth were assigned to *E. occidentalis*. Ten central phalanges clearly belong to large horses, and they are provisionally assigned to *E. occidentalis*. Figure 19 shows various specimens of horse phalanges, as well as the complete *E. conversidens* metacarpal, recovered from MHC.

Figure 19. E. conversidens *complete metacarpal (top row, left), as well as* Equus *proximal phalanges (top row), central phalanges (middle row), and terminal phalanges (bottom row) from MHC. All of the proximal phalanges appear to be from* E. conversidens. *The first four central phalanges are from a large horse, while the next four are from a small horse. The first two terminal phalanges are probably from a large horse, while the remaining five are probably from a small horse.*

These data indicate that at least three individuals of large horse were recovered from MHC. *Equus* remains, both large and small, are ubiquitous in Late Pleistocene deposits in Nevada (Jefferson et al. 1999). Dansie et al. (1988) reported on a complete large horse from the shoreline of Pleistocene Lake Lahontan in western Nevada. This specimen was radiocarbon dated to ca. 25,500 BP, about 15,000 to 20,000 years younger than the C-14 dated MHC large horses. Dansie et al. (1988) identified the specimen as *Equus* cf. *pacificus*, although no measurements of the skeleton were published. Large horses identified as *E. occidentalis* have been reported from Astor Pass in the Smoke Creek Desert of northwestern Nevada (Merriam 1915) and Gypsum Cave in southern Nevada (Stock 1931). Other notable localities that have produced large horse remains include Crystal Ball Cave (Heaton 1985) and Smith Creek Cave (Miller 1979) in east-central Nevada, and Tule Springs (Mawby 1967) in southern Nevada. *Equus* remains, including large horses are also commonly found in Late Pleistocene locales in the American Southwest, such as Deadman, Rampart, and Stanton's caves in Arizona (Mead 1981; Mead et al. 1984), and Burnet Cave, New Mexico (Schultz and Howard 1935).

Equus cf. *conversidens*
Extinct Mexican Ass

MATERIAL RECOVERED. One metacarpal; 20 proximal phalanges; nine central phalanges

C-14 AGE. TP3-133 (central phalanx [>46,400 BP]); TP2-4-1 (proximal phalanx [35,080 ± 280 BP])

DISCUSSION. Based on the discussions above, Table 24 indicates that the complete metacarpal of a small form of horse recovered from MHC compares favorably with *E. conversidens*. It is clearly not from a "stilt-legged" form of small horse such as *E. francisci*. The MHC metacarpal is both shorter and much broader than the stilt-legged horse. The measurements do, however, fit rather nicely with other *E. conversidens* metacarpals, albeit at the small end of this range. As a result, this bone is provisionally identified as *E. conversidens*. This specimen is illustrated in Figures 18 and 19.

Based on the criteria discussed above for separating the proximal and central phalanges of large and small horses, 20 proximal phalanges and nine

central phalanges clearly belong to a small form of horse (Tables 22 and 23; also see Figure 19). The sizes of these 29 phalanges also match those of previously identified *E. conversidens* from western North America. These 29 phalanges, therefore, are provisionally assigned to *E. conversidens*.

These data suggest that at least five individuals of small horse were recovered from MHC. *E. conversidens* has been identified in Nevada from Astor Pass (Merriam 1915) and Gypsum Cave (Stock 1931). Like the large horses, small horses are a ubiquitous component of Late Pleistocene assemblages throughout Nevada (Jefferson et al. 1999) and south into New Mexico (Schultz and Howard 1935) and Mexico (Mooser and Dalquest 1975).

Equus spp.
Extinct Horse

MATERIAL RECOVERED. Seven teeth (two incisors, one canine, one M^2, one M^3, two fragments); one skull fragment; eight vertebrae; two proximal femora; four proximal tibiae; four calcanei; 10 astragali; 25 carpals; two sesamoids; one metapodial; eight lateral metapodials; five proximal phalanges; one central phalanx; 16 terminal phalanges

C-14 AGE. TP3-92 (carpal [31,130 ± 200 BP])

DISCUSSION. No attempt was made to separate these 94 *Equus* elements into large and small forms. They clearly represent both large and small forms, with elements of the small horse more common than the large form. Seventy-eight of these 94 bones are from the limbs and feet. Many more elements of the fore and hind limbs and feet were recovered than from the axial skeleton, which suggests that the majority of these bones were carried or dragged into the cave by scavenging carnivores.

Order Artiodactyla

Family Camelidae

Camelops hesternus
Yesterday's Camel

MATERIAL RECOVERED. one subadult molar fragment; one tooth fragment; one vertebra fragment;

one distal femur; two astragali; one innominate fragment; one metapodial fragment; two fibulae; one cuboid; one scaphoid; one magnum; two unciforms; one mesoectocuneiform; two pisiforms; three sesamoids; two proximal phalanges; two central phalanges

C-14 AGE. TP3-41 (pisiform [48,900 ± 3,100 BP]); TP8-1 (proximal phalanx [46,550 ± 1,100 BP]); TP2-SL-1 (proximal phalanx [44,600 ± 3,000 BP])

DISCUSSION. A minimum of two individual camels (*Camelops hesternus*) are present in the MHC assemblage: one adult and one subadult. Camel bones are considerably larger than those of the large-headed llama, *Hemiauchenia macrocephala* (see Figure 20).

First phalanx and astragalus measurements

of the camelids from MHC were compared to those available in the published literature, and are reported in Tables 26 and 27. All of the MHC large camelids match the size and morphology of the *C. hesternus* specimens from RLB and other locales. The first phalanges of the hind limb are considerably longer and more stout than those of the forelimb in *Camelops* (Webb 1965). Both of the *Camelops* first phalanges from MHC are probably from the forelimb, which has slightly depressed their mean averages compared to other localities that contain phalanges from the fore and hind limbs. The only species of Rancholabrean camel identified from Nevada and the Great Basin has been *C. hesternus*, and thus the large camelid bones from MHC are assigned to this species.

Figure 20. Proximal phalanges of Camelops *(first two bones on the left) and* Hemiauchenia *(final two bones) from MHC.*

Dalquest (1990:296) recently noted that *Camelops* is "...present in almost every Pleistocene local fauna from North America with an adequate collection of large mammals...". Camel bones were relatively common in the MHC collection compared to other large mammals, although they were much

less abundant than those of the small horse. *Camelops* remains have been reported from almost

every major Pleistocene locale emphasized in this report, including Gypsum Cave (Harrington 1933), Burnet Cave (Schultz and Howard 1935), Tule Springs (Mawby 1967), Jaguar Cave (Kurtén and

Anderson 1972), Rainbow Beach (McDonald and Anderson 1975), Silver Creek (Miller 1976), Smith Creek Cave (Miller 1979), Vulture Cave, Arizona (Mead and Phillips 1981), Cueva Quebrada (Lundelius 1984), Crystal Ball Cave (Heaton 1985), Hidden Cave (Grayson 1985), Snake Creek Burial Cave (Mead and Mead 1985), Lake Bonneville (Nelson and Madsen 1987), Owl Cave No. 2 (Turnmire 1987), Wizard's Beach (Dansie et al. 1988), Kokoweef Cave (Reynolds et al. 1991), Sunshine Well, Nevada (Jones et al. 1996), Grass Valley, Nevada (James 1997), Massacre Rocks (McDonald 1998), Arco Arena (Hilton et al. 2000), and Sunshine Well (Huckleberry et al. 2001).

Despite their abundance, few camel remains in Nevada are securely dated, although many of the localities mentioned above probably date between ca. 20,000 and 10,000 BP. Mead et al. (1982), however, recovered *Camelops* remains from a woodrat midden near Smith Creek Cave that was C-14 dated to ca. 13,500 BP. The few camel bones, as well as hair, recovered from Smith Creek Cave are about 11,000 years old (Miller 1979). A camel bone was directly C-14 dated to ca. 11,400 BP at Sunshine Well (Huckleberry et al. 2001). The three *Camelops* bones submitted for C-14 analysis from MHC all dated between ca. 45,000 and 50,000 BP.

Table 26. Camelops *and* Hemiauchenia *astragali measurements from various fossil localities, including Mineral Hill Cave.*

	Astragalus – greatest length			Astragalus – greatest width		
	n	mean	range	n	mean	range
Camelops sp.[1]	5	71.5	-	-	-	-
Camelops sp.[2]	62	73.0	-	-	-	-
Camelops hesternus[3]	2	87.9	87.7-88.1	2	62.6	59.6-65.6
Camelops hesternus[4]	7	83.1	82.6-83.6	-	-	-
Camelops hesternus[5]	18	86.2	80.5-91.9	18	57.9	55.3-64.6
Camelops hesternus[6]	1	80.1	-	-	-	-
Hemiauchenia sp.[1]	33	59.0	-	-	-	-
Hemiauchenia sp.[2]	6	64.0	-	-	-	-
H. macrocephala sp.[7]	7	60.5	56.0-64.4	7	41.4	37.6-44.3

[1]Nebraska; Late Blancan; Breyer (1974)
[2]Nebraska; Irvingtonian; Breyer (1974)
[3]Selby-Dutton, Colorado; Rancholabrean; Graham (1981)
[4]Lamb Spring, Colorado; Rancholabrean; Graham (1981)
[5]Rancho La Brea; Rancholabrean; Webb (1965)
[6]Mineral Hill Cave; Rancholabrean; this report; Note: specimen water-worn
[7]Mineral Hill Cave; Rancholabrean; this report

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Table 27. Camelops *and* Hemiauchenia *proximal phalanx measurements from various fossil localities, including Mineral Hill Cave.*

	Greatest length			Proximal Transverse Breadth			Distal Transverse Breadth		
	n	mean	range	n	mean	range	n	mean	Range
Camelops sp.[1]	127	111.0	93.0-128.0	127	40.0	-	-	-	-
Camelops hesternus[2]	6	112.2	105.1-122.3	6	44.3	41.0-50.9	6	35.2	32.7-40.0
Camelops hesternus[3]	4	118.2	109.0-125.5	3	42.8	40.0-45.1	2	30.7	29.3-32.0
Camelops hesternus[4]	16	114.5	103.0-127.0	16	46.1	42.0-52.0	16	38.0	34.0-42.0
Camelops hesternus[5]	2	115.5	114.0-117.0	3	38.0	32.0-43.0	2	28.5	28.0-29.0
Camelops hesternus[6]	7	122.3	112.1-132.7	7	45.2	43.1-49.5	6	36.4	34.6-40.8
Camelops hesternus[7]	2	121.1	107.6-134.5	2	47.4	46.8-48.0	2	38.9	37.7-40.1
Camelops hesternus[8]	2	108.8	105.5-112.1	2	42.5	41.9-43.0	2	34.6	33.9-35.3
H. macrocephala sp.[8]	1	96.8	-	1	26.8	-	1	24.2	-
Hemiauchenia sp.[1]	10	110.0	-	10	34.0	-	-	-	-
H. macrocephala[5]	1	100.0	-	2	25.5	23.0-28.0	1	22.0	-
H. macrocephala[9]	1	95.0	-	1	26.5	-	2	24.6	24.5-24.6

[1]Nebraska; Irvingtonian; Breyer (1974)
[2]Selby-Dutton, Colorado; Rancholabrean; Graham (1981)
[3]Lamb Spring, Colorado; Rancholabrean; Graham (1981)
[4]Rancho La Brea; Rancholabrean; Webb (1965); Note: forelimb and hindlimb phalanges combined in this table
[5]Crystal Ball Cave, Nevada; Rancholabrean; Heaton (1985)
[6]Rainbow Beach, Idaho; Rancholabrean; McDonald and Anderson (1975)
[7]Little Box Elder Cave, Wyoming; Rancholabrean; Indeck (1987)
[8]Mineral Hill Cave; Rancholabrean; this report
[9]Nebraska; Late Blancan; Breyer (1974)

Hemiauchenia macrocephala
Large-headed Llama

MATERIAL RECOVERED. one M_1; two tooth fragments; one proximal femur; one innominate fragment; one distal humerus; one proximal ulna; two proximal metatarsal fragments; two proximal metacarpal fragments; one proximal metapodial fragment; one distal metapodial fragment; one calcaneus; eight astragali; one cuneiform; three naviculars; five proximal phalanges

C-14 AGE. TP1b-06-1 (proximal phalanx [>50,000 BP]); TP3-37 (distal humerus [39,230 ± 1,330 BP]); TP3-50 (navicular [36,320 ± 320 BP])

DISCUSSION. This long-legged small camelid was originally reported from MHC by McGuire (1980), who illustrated a complete first phalanx.

Additional specimens of llama were recovered during recent excavations. A minimum of two individual llamas are represented in the MHC collection (see Tables 26-27; Figure 20).

The genus *Tanupolama* (e.g., Breyer 1974) is now subsumed under the genus *Hemiauchenia* (e.g., Kurtén and Anderson 1980; Dalquest 1990). This genus has been present in North America since the Late Blancan; the only Rancholabrean species identified from the Great Basin is *H. macrocephala*, and thus the MHC llama material is assigned to this species. The sizes of the MHC proximal phalanges and astragali match other *Hemiauchenia* specimens from western North America (see Tables 26 and 27).

Hemiauchenia is often associated with *Camelops* in western North America, but llama remains are relatively rare in the Great Basin compared to those of the camel. Of the 17 localities listed in the previous section that have yielded bones of

Camelops, only three have also produced bones of *Hemiauchenia*: Smith Creek Cave (Miller 1979), Crystal Ball Cave (Heaton 1985), and Kokoweef Cave (Reynolds et al. 1991). No localities are known from Nevada that have produced llama remains without those of camel.

Heaton (1985:380) suggested that *Hemiauchenia* preferred higher and more rugged terrain than *Camelops*. In support of this interpretation, he noted that camel bones outnumber llama bones at the lower elevation Crystal Ball Cave, but that this situation was reversed at Smith Creek Cave, which is located near the top of a steep canyon. Indeed, Kokoweef Cave is located in rugged terrain as well, and many of the sites listed above that contain *Camelops* remains but lack those of the llama are located in or near valley floors. MHC is located at 7,000 feet in elevation in a transitional zone between the valley floor below and steeper terrain to the northeast. It is perhaps not surprising, therefore, that *Camelops* and *Hemiauchenia* bones were present in about equal numbers in MHC.

The llama remains from MHC represent the oldest securely-dated *Hemiauchenia* specimens from Nevada. The three bones analyzed returned C-14 dates in excess of 35,000 BP, essentially contemporaneous with the *Camelops* specimens from the cave.

Family Cervidae

cf. *Navahoceros fricki*
Mountain Deer

MATERIAL RECOVERED. one proximal phalanx; one central phalanx

C-14 AGE. TP3-3 (central phalanx [>50,000 BP]); TP4-10 (proximal phalanx [37,830 ± 440 BP])

DISCUSSION. The intermediate-sized cervid phalanges from MHC compare favorably with those of the extinct mountain deer, *Navahoceros fricki* (see Figure 21). This identification represents the first known occurrence of *Navahoceros* in Nevada, and only the second known occurrence in the Great Basin. The other known Great Basin occurrence is from central Utah (Nelson and Madsen 1987), and together the MHC and Utah specimens represent the northern-most distribution of the genus (see Blackford 1995:109, Figure 55). There has been long-standing speculation that *Navahoceros* is present in the collections from Little Box Elder Cave, Wyoming (Kurtén 1975; Kurtén and Anderson 1980), but this possibility has not yet been confirmed (see Blackford 1995:34).

Figure 21. [Left]: Central phalanges of Navahoceros *(left) and modern mule deer (right). [Right]: Proximal phalanges of* Navahoceros *(left) and modern mule deer (right).*

Navahoceros was defined by Kurtén (1975) as a large cervid intermediate in size between the larger red deer of the genus *Cervus* and the smaller mule deer and white-tailed deer of the genus *Odocoileus*. Kurtén (1975) also noted that *Navahoceros* possessed relatively short, stocky lower limbs adapted to rocky, steep terrain: hence the common name "mountain deer". Kurtén (1975) further suggested that *Navahoceros* was more closely related to the Old World reindeer and New World reindeer ["caribou"] (genus *Rangifer*) than to the genus *Odocoileus*, an interpretation later upheld by Webb (1992) and Blackford (1995).

As a demonstration of the intermediate size of *Navahoceros*, both Kurtén (1975) and Blackford (1995) published various limb bone proportions of mountain deer and other fossil and recent cervids, including the North American red deer ["elk" or "wapiti"] (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*). The MHC phalanges were thought to be intermediate in size between mule deer and red deer, and therefore may belong to *Navahoceros*. However, neither Kurtén (1975) nor Blackford (1995) published measurements of cervid phalanges; rather, these studies focused on comparisons of upper limb bones. In the United States, another intermediate-sized cervid (genus *Sangamona*) appears to be restricted to the central and eastern part of the country (Kurtén 1975; Kurtén and Anderson 1980). West of the continental divide, reindeer were able to move southward into southern Idaho during the Late Pleistocene (Anderson and White 1975), but there is no evidence that they ever penetrated into present-day Nevada or Utah. Indeed, direct comparisons were made of the proximal and central cervid phalanges from MHC with modern specimens of *Rangifer* from Alaska. On morphological grounds alone, the MHC cervid phalanges were clearly not reindeer.

For this study, we measured 30 proximal and 30 central phalanges of *Navahoceros* from San Josecito Cave on file at the LACM, as well as modern specimens of *Cervus elaphus*, *Odocoileus hemionus*, and *Odocoileus virginianus*, and compared these measurements to the phalanges from MHC (see Tables 28 and 29). These data show that cervid phalanges grade from small to large in the following manner: *Odocoileus-Navahoceros-Cervus*. Proximal

and central phalanges of *Navahoceros*, then, are also intermediate in size between *Odocoileus* and *Cervus*. The two large cervid phalanges from MHC are overall too large to fit within the size range of *Odocoileus*, but they are too small to be *Cervus*. These bones therefore compare favorably with *Navahoceros*.

All of the confirmed cases of *Navahoceros* except one are from sites located along the Rio Grande River and southward into Mexico (Blackford 1995), including those from Cueva Quebrada, Texas (Lundelius 1984) and the probable specimens from Burnet Cave, New Mexico originally assigned to "*Rangifer fricki*" (Schultz and Howard 1935). The exceptions are the Lake Bonneville shoreline specimens from central Utah (Nelson and Madsen 1987), and two possible localities in southern California: Antelope Cave (Reynolds et al. 1991) and Irvingtonian deposits within Anza Borrego Desert State Park (Blackford 1995).

It may also be worth noting that Heaton (1985:380) recovered a cervid proximal phalanx from Crystal Ball Cave that was "...intermediate in size between *Cervus* and *Odocoileus*". Heaton (1985) listed the length of the phalanx as 60.2mm, which is within 1/10 of a millimeter of the largest *Navahoceros* first phalanges we measured from San Josecito Cave, but almost a full millimeter less than the smallest value we report for *Cervus* in Table 28. These data corroborate Heaton's (1985) statement that the Crystal Ball Cave specimen is intermediate between *Cervus* and *Odocoileus*; although Heaton tentatively identified the bone as *Cervus elaphus*, it is possible that it belonged to *Navahoceros*.

The Anza Borrego specimens, as well as others from near Las Cruces, New Mexico, are the only examples of Irvingtonian-aged *Navahoceros* from North America or Mexico (Blackford 1995). All of the remaining Rancholabrean localities which have associated C-14 dates range between 11,000 and 22,000 BP (Blackford 1995:21, Figure 3). The proximal phalanx from MHC is greater than 50,000 years old, and the central phalanx returned a date of approximately 38,000 BP. These data indicate that mountain deer inhabited southern Pine Valley, Nevada, for at least 10 millennia prior to the onset of the Late Wisconsinan glacial cycle.

Table 28. *Proximal phalanx measurements of Recent North American red deer (Cervus elaphus), Rancholabrean mountain deer (Navahoceros fricki) from San Jocesito Cave and Mineral Hill Cave, and Recent mule deer (Odocoileus hemionus) and white-tailed deer (Odocoileus virginianus).*

	Greatest length			Proximal Transverse Breadth			Distal Transverse Breadth		
	n	mean	range	n	mean	range	n	mean	Range
Cervus elaphus[1]	5	66.4	61.0-69.7	5	24.7	23.7-25.5	5	24.1	23.2-24.7
Navahoceros fricki[2]	30	54.7	49.8-60.1	30	22.3	20.1-24.6	30	19.1	16.3-23.5
Navahoceros fricki[3]	1	54.4	-	1	19.2	-	1	17.6	-
Odocoileus hemionus[1]	5	51.0	46.8-54.0	5	16.4	15.5-17.4	5	14.2	13.5-15.3
Odocoileus virginianus[4]	1	58.9	-	1	18.1	-	1	15.1	-

[1]Nevada; Recent; this report
[2]San Jocesito Cave, Mexico; Rancholabrean; this report
[3]Mineral Hill Cave; Rancholabrean; this report
[4]Minnesota; Recent; this report

Table 29. *Central phalanx measurements of Recent North American red deer (Cervus elaphus), Rancholabrean mountain deer (Navahoceros fricki) from San Jocesito Cave and Mineral Hill Cave, and Recent mule deer (Odocoileus hemionus).*

	Greatest length			Proximal Transverse Breadth			Distal Transverse Breadth		
	n	mean	range	n	mean	range	n	mean	Range
Cervus elaphus[1]	5	48.2	45.5-50.5	5	23.9	23.5-24.2	5	20.8	18.7-22.3
Navahoceros fricki[2]	30	41.5	37.9-47.5	30	21.1	18.3-25.3	30	17.6	15.3-19.8
Navahoceros fricki[3]	1	45.1	-	1	20.9	-	1	16.1	-
Odocoileus hemionus[1]	4	33.3	31.9-35.7	4	14.3	13.7-14.9	4	11.5	10.9-12.2

[1]Nevada; Recent; this report
[2]San Jocesito Cave, Mexico; Rancholabrean; this report
[3]Mineral Hill Cave; Rancholabrean; this report

Odocoileus sp.
?Mule Deer

MATERIAL RECOVERED. One Pm$_4$; one skull fragment; one calcaneus; one carpal; three metatarsal fragments

C-14 AGE. unknown

DISCUSSION. Seven cervid specimens from MHC match in size and morphology with *Odocoileus*. These specimens likely belong to mule deer, *O. hemionus*. There have been no confirmed

Rancholabrean occurrences of the white-tailed deer, *O. virginianus*, in Nevada. Although it has been widely reported that *O. virginianus* was identified at Deer Creek Cave (e.g., Jefferson et al. 1999), Ziegler (1963:18) identified all of the deer remains from that site as *Odocoileus* sp., and simply noted the possibility that some of the cervid remains could belong to white-tailed deer. The age of the MHC *Odocoileus* specimens is unknown, but based on their coloration, this genus was probably sympatric with *Navahoceros* prior to 30,000 BP in southern Pine Valley.

Family Antilocapridae

Antilocapra americana
Pronghorn

MATERIAL RECOVERED. One M^2; two thoracic vertebrae; two innominate fragments; one distal humerus; one proximal ulna; one distal radius; three calcanei; two astragali; one lunar; two distal metapodials; one metapodial fragment; seven proximal phalanges; three central phalanges

C-14 AGE. TP3-96 (proximal phalanx [>50,000 BP]); TP2-SL-8 (calcaneus [16,810 ± 50 BP]); TP1b-09-3 (13,150 ± 50 BP])

DISCUSSION. All of the MHC antilocaprid material are from a large pronghorn, and compare most favorably with the extant *Antilocapra americana* (see Tables 30-32; Figure 22).

Figure 22. [Left]: Pronghorn metapodials from recent (left) and MHC (right). [Center and Right]: Central and proximal pronghorn phalanges from recent (top) and MHC (bottom).

Capromeryx, the diminutive pronghorn, has been reported from Smith Creek Cave (Miller 1979), but Harris (1985:128) considered this identification erroneous. *Tetrameryx* may be present at Tule Springs (Mawby 1967), and *Stockoceros* is relatively common in the American southwest, Texas, and portions of Mexico (Kurtén and Anderson 1980; Lundelius 1984). *Tetrameryx* is also reported from Burnet Cave, New Mexico (Schultz and Howard 1935). The antilocaprid material from MHC, however, is significantly larger than comparative specimens from either *Capromeryx* or *Stockoceros* (see Tables 30-32). In fact, the antilocaprid material from MHC is slightly but not significantly larger, on average, than recent pronghorn specimens, a pattern that was also noted at Natural Trap Cave (Chorn et al. 1988).

No definitive Rancholabrean specimens of *Tetrameryx* are known from central or northern Nevada. Indeed, all of the other Late Pleistocene antilocaprid material from the surrounding region have been identified as *Antilocapra americana*, including Jaguar Cave (Kurtén and Anderson 1972), Rainbow Beach (McDonald and Anderson 1975), Silver Creek (Miller 1976), Crystal Ball Cave (Heaton 1985), Owl Cave No. 2 (Turnmire 1987), and Homestead Cave (Grayson 2000); the modern pronghorn is also present in the Smith Creek Cave assemblage (Miller 1979). Pronghorn have apparently occupied the region surrounding MHC for some time, judging by the proximal phalanx that returned a date in excess of 50,000 BP. The other two dates obtained on pronghorn bones were late Wisconsinan, and ranged between ca.13,000 and 17,000 BP.

*Table 30. Proximal phalanx measurements of Recent pronghorn (*Antilocapra americana*) and Rancholabrean pronghorn from Mineral Hill Cave, and* Stockoceros *from Cueva Quebrada.*

	Greatest length			Proximal Transverse Breadth			Distal Transverse Breadth		
	n	mean	range	n	mean	range	n	mean	Range
Antilocapra americana[1]	7	52.7	50.9-54.6	7	13.8	13.4-14.3	7	12.7	12.1-13.2
Antilocapra americana[2]	6	53.7	50.7-56.8	5	15.0	14.4-15.9	5	13.2	12.9-13.6
Stockoceros sp.[3]	6	41.3	39.1-44.4	6	12.2	11.2-13.2	-	-	-

[1]Nevada; Recent; this report
[2]Mineral Hill Cave; Rancholabrean; this report
[3]Cueva Quebrada, Texas; Rancholabrean; Lundelius (1984)

*Table 31. Central phalanx measurements of Recent pronghorn (*Antilocapra americana*) and Rancholabrean pronghorn from Mineral Hill Cave, and* Stockoceros *from Cueva Quebrada.*

	Greatest length			Proximal Transverse Breadth			Distal Transverse Breadth		
	n	mean	range	n	mean	range	n	mean	Range
Antilocapra americana[1]	7	30.2	27.9-32.7	7	13.1	12.4-14.0	7	10.8	9.9-11.7
Antilocapra americana[2]	3	32.5	32.3-32.7	3	13.3	13.1-13.5	3	11.1	11.0-11.3
Stockoceros sp.[3]	10	25.8	24.2-27.1	9	10.8	10.1-11.6	-	-	-

[1]Nevada; Recent; this report
[2]Mineral Hill Cave; Rancholabrean; this report
[3]Cueva Quebrada, Texas; Rancholabrean; Lundelius (1984)

Table 32. Postcranial measurements of recent and fossil pronghorns. All measurements are based on mean values.

	Capromeryx minor[1]	*Stockoceros conklingi*[1]	*Antilocapra americana*[2]	*Antilocapra americana*[3]	*Antilocapra americana*[4]
Calcaneus – L	48.6	66.5	-	75.2	81.8
Calcaneus - PTB	12.6	19.1	-	23.8	26.8
Astragalus – L	22.2	31.1	-	35.5	40.5
Astragalus - GW	12.8	18.9	-	22.4	26.5
Metapodial - DTB	-	23.8	29.0	28.0	28.7

L = greatest length; GW = greatest width; PTB = proximal transverse breadth; DTB = distal transverse breadth

[1]Shelter Cave, New Mexico; Rancholabrean; Stock (1932)
[2]Natural Trap Cave, Wyoming; Rancholabrean; (Chorn et al. 1988)
[3]Recent; Stock (1932); this report
[4]Mineral Hill Cave; Rancholabrean; this report

Family Bovidae

Ovis canadensis
Mountain Sheep

MATERIAL RECOVERED. one skull fragment; three mandibles (Pm$_2$-M$_3$; Pm$_3$-M$_2$; PM$_4$-M$_1$); one M$_1$; one M$_2$; one M^1; three thoracic vertebrae; one cervical vertebra; one scapula (glenoid fossa); six distal humeri; two radii (one proximal, one distal); eight distal tibiae (seven distal, one distal epiphysis); one patella; four calcanei; seven astragali; 10 carpals; three distal metacarpals; one distal metatarsal; three distal metapodials; 15 proximal phalanges; two central phalanges; two distal phalanges

C-14 AGE. TP3-81 (proximal phalanx [38,830 ± 430 BP]); TP2-2 (distal humerus [32,970 ± 680 BP]); TP4-3 (mandible [8,110 ± 50 BP]); TP6-36 (mandible [6,930 ± 50 BP]); TP3-1 (mandible [4,540 ± 50 BP])

DISCUSSION. Bones of mountain sheep were second in abundance to those of *Equus* in MHC. They are relatively easy to identify with appropriate comparative collections. The five dates obtained suggest a long history of occupation of the Sulphur Springs Range by mountain sheep. The oldest sheep bone dated is about 40,000 years old; the three mandibles roughly dated to the Early, Middle, and Late Holocene, respectively.

Much has been written about the Pleistocene and Holocene distribution of mountain sheep in western North America, including the Great Basin (Hibbard and Wright 1956; Stokes and Condie 1961; Stock and Stokes 1969; Harris and Mundel 1974; Shackelton 1985; Emslie 1986; Indeck 1987; Wang 1988; Lawler 1996). This discussion has centered on the validity of a Pleistocene species of mountain sheep, *Ovis catclawensis*, defined from a partial mandible and skull recovered from Catclaw Cave in Arizona (Hibbard and Wright 1956). Hibbard and Wright (1956) argued that the width of the cheek teeth of the Catclaw Cave specimen was beyond the range of Holocene-aged mountain sheep, and so warranted a new species designation. Others (e.g., Stokes and Condie 1961) concurred with this assessment. Geist (1971) then argued that favorable ecological conditions probably accounted for their large size during the Pleistocene; climatic deterioration at the end of the Pleistocene led to their diminution.

Harris and Mundel (1974) subsequently argued that there was size overlap between Pleistocene-aged mountain sheep and recent specimens, and thus the Pleistocene forms were best seen as a subspecies of *O. canadensis*. Others have since generally concurred with this latter interpretation (e.g. Emslie 1986; Indeck 1987; Wang 1988; Lawler 1996).

Our analysis of the mountain sheep remains from MHC also indicates that there is size overlap between Pleistocene and recent specimens, although an overall size diminution occurred sometime during the Holocene (see Figure 23). Most researchers assume that this size reduction occurred in the Early Holocene, but our data from MHC may suggest that this process was more complex, and may have occurred at different times in different regions of the west.

Figure 23. Recent and fossil (MHC) postcranial remains of mountain sheep. From left to right (the larger specimen on the left of each group is from MHC; the smaller specimen is from a recent specimen): proximal phalanges; central phalanges; carpal; humerus. Note the large size of the fossil specimens from MHC.

Regarding postcranial material of *O. canadensis*, Lawler (1996:15, Appendix) published metacarpal and metatarsal measurements of mountain sheep from Natural Trap Cave and recent specimens from Wyoming and Montana. He found significant size overlap between the Rancholabrean and recent material: in fact, the greatest length of one of the recent sheep metacarpals from Montana measured only about 1cm less than the greatest length of the Natural Trap Cave specimens. Put another way, these data suggest that some modern male mountain sheep are attaining the same size as some of the largest males who lived 10,000 to 20,000 years ago. Wang (1988) earlier came to a similar conclusion: ratios of postcranial lengths indicated that there were no appreciable differences in locomotor habit between Pleistocene and recent mountain sheep.

Three mountain sheep mandibles were identified and dated from MHC. Metric data for these specimens, as well as some of those available in the published literature from western North America, are displayed in Tables 33-38. Postcranial measurements of the MHC mountain sheep are displayed in Table 39, and illustrated in Figure 23.

The MHC mandibles are all Holocene in age. One mandible (TP4-3) dates to about 8,100 BP. Recent studies suggest that the faunal turnover from a cooler, more mesic assemblage of animals to a warmer, more xeric assemblage occurred by about 8,300 BP in both the northern (Grayson 2000) and southern (Hockett 2000) Great Basin. Thus, this specimen dates to the early portion of the warm and dry Middle Holocene in the Great Basin. MHC specimen TP6-36 dates to about 6,800 BP, which is near the end of the hottest and driest period of the Middle Holocene. Finally, MHC specimen TP3-1 dates to about 4,500 BP, which is the generally accepted beginning of the wetter and cooler Neoglacial period in the Great Basin (Grayson 1993).

Tables 33-38 suggest that tooth dimensions, and in particular tooth widths, were generally greater in the Pleistocene specimens compared to modern specimens. However, there is size overlap amongst the tooth measurements from MHC and the Pleistocene specimens. Tables 34-37 display cheek tooth widths from the Rancholabrean-aged specimens, the three MHC mandibles, and recent specimens from Nevada. These data suggest that *O. canadensis* near MHC maintained tooth dimensions similar to their Pleistocene ancestors throughout the Early and Middle Holocene. This is striking considering that the period 8,300 to 7,000 BP is one of the warmest and driest millennium-and-a-half recorded during the entire Quaternary. Yet the tooth dimensions of the 6,800 BP specimen from MHC matches those of the type specimen of "*O.*

catclawensis" from the Pleistocene of Arizona. It is not until the onset of the Late Holocene, during a time of increasing moisture and decreasing temperatures, and therefore a time presumably more favorably to mountain sheep populations than the preceding Middle Holocene, that we see a rather dramatic decline in the size of the MHC mountain sheep. It is recognized that this is based on a single specimen, but considering the data displayed in Table 38 as a whole, it may suggest that the overall diminution of mountain sheep body size did not occur in the central Great Basin until 4,000 to 5,000 years ago.

If this interpretation is correct, then these data have a couple of important implications. First, these data support the interpretation that the Pleistocene and Holocene sheep of the Great Basin are best classified as a single species. Second, the data may suggest that size diminution in Great Basin mountain sheep was not caused entirely by environmental factors. Broughton (1994), and more recently McGuire et al. (2003), suggest that human foragers in the Great Basin increasingly focused their subsistence activities on the hunting of artiodactyls sometime between 4,000 and 5,000 BP. This pattern continued to at least 700 BP in the central Great Basin, as indicated by Horizon 2 at Gatecliff Shelter (Thomas and Mayor 1983). Similar patterns in the intensity of mountain sheep hunting are seen at Pie Creek Shelter north of Elko, beginning about 4,500 BP and continuing to at least 1,300 BP (McGuire et al. 2003).

Interestingly, Thomas and Mayer (1983:377-378, Figures 194-195) published astragali length and width ratios for modern desert bighorn sheep (*O. canadensis deserti*), modern Rocky Mountain bighorn (*O. canadensis canadensis*), and the sheep from Horizon 2 at Gatecliff Shelter, C-14 dated to ca. 700 BP. The lengths of the modern desert bighorn ranged from about 27-31mm, and those of Rocky Mountain bighorn ranged from about 22-35mm, with most of the latter ranging from 31-35mm. Thus, the Rocky Mountain bighorn astragali tended to be larger than those of the desert bighorn. Because the Gatecliff Shelter astragali ranged from about 26-32mm, Thomas and Mayor (1983) argued that they probably represented the subspecies represented by desert bighorn populations. In comparison, the lengths of the MHC astragali averaged 45mm, and ranged from about 38-49mm. Thus, all of the MHC astragali measured above the modern limit for Rocky Mountain bighorn published by Thomas and Mayor (1983). The MHC sheep astragali probably all date between about 40,000 and 5,000 years ago, and these

data suggest again that substantial size diminution did not occur in populations of mountain sheep in the region surrounding Pine Valley, Nevada, until sometime after 5,000 BP. Size diminution of mountain sheep across western North America during the Holocene may have a complex history, may vary in scale and timing from one region to another, and may have multiple causes, including the interaction of ecological changes and prehistoric human behavior.

Mountain sheep apparently entered North America by at least 100,000 years ago (Kurtén and Anderson 1980). Previously, the oldest securely dated mountain sheep remains from Nevada were from Pintwater Cave north of Las Vegas, C-14 dated to about 32,000 BP (Hockett 2000). Some of the MHC specimens date to about 40,000 BP, rendering them the oldest securely dated mountain sheep remains in Nevada. The single specimen of *O. canadensis* from Hidden Cave probably dates between 10,000 and 20,000 BP (Grayson 1985). Other probable Late Pleistocene specimens from Danger Cave, Last Supper Cave, Crystal Ball Cave, Morman Mountain Cave, Smith Creek Cave, Deer Creek Cave, and Gypsum Cave are not securely dated, but some of the specimens from all of these sites are likely Late Pleistocene in age (Harrington 1933; Ziegler 1963; Miller 1979; Jefferson 1982; Heaton 1985; Grayson 1988). Mountain sheep are conspicuously absent from the Tule Springs site north of Las Vegas.

In nearby regions, *Ovis canadensis* are the most common remains identified from late Pleistocene deposits surrounding the Great Salt Lake (Nelson and Madsen 1987), but mountain sheep are conspicuously absent from the Silver Creek Local Fauna C-14 dated in excess of 40,000 BP (Miller 1976). Mountain sheep first appear in the Homestead Cave, Utah, sequence beginning in the Early Holocene/Middle Holocene transition, ca. 8300 BP (Grayson 2000). Likewise, mountain sheep are common in late Pleistocene deposits in Jaguar Cave, southern Idaho (Kurtén and Anderson 1972), but absent in the Massacre Rocks Local Fauna dated in excess of 70,000 BP (McDonald 1998) and the Rainbow Beach Local Fauna C-14 dated to 21,000 BP (McDonald and Anderson 1975). It is therefore possible that mountain sheep first entered Nevada about 40,000 years ago. Mountain sheep appear in the Late Pleistocene assemblages of the Grand Canyon between ca. 10,000 and 20,000 BP (Mead et al. 1981).

Table 33. Ovis canadensis *alveolar tooth measurements from Catclaw Cave, Little Box Elder Cave, Natural Trap Cave, Burnet Cave, Mineral Hill Cave, and recent specimens.*

	Alveolar Length (Pm$_2$-M$_3$)			Alveolar Length (Pm$_3$-M$_2$)		
	n	mean	range	n	mean	range
Ovis canadensis[1]	-	88.3	87.1-90.7	-	-	-
Ovis canadensis[2]	3	87.9	86.9-88.9	3	53.5	51.9-56.0
Ovis canadensis[3]	1	101.0	-	-	-	-
Ovis canadensis[4]	-	95.0	-	-	-	-
Ovis canadensis[5]	11	103.8	100.8-108.0	-	-	-
Ovis canadensis[6]	1	104.0	-	-	-	-
Ovis canadensis[7]	1	92.3	-	2	58.3	55.1-61.5

[1]Wyoming; Recent; Indeck (1987)
[2]Nevada; Recent; this report
[3]Catclaw Cave, Arizona; Rancholabrean; Hibbard and Wright (1956)
[4]Little Box Elder Cave; Rancholabrean; Indeck (1987)
[5]Natural Trap Cave, Wyoming; Rancholabrean; Wang (1988)
[6]Burnet Cave, New Mexico; Rancholabrean; Schultz and Howard (1935)
[7]Mineral Hill Cave; Holocene; this report

Table 34. Ovis canadensis *Pm$_3$ tooth measurements from Catclaw Cave, Natural Trap Cave, Mineral Hill Cave, and recent specimens.*

	Length Pm$_3$			Width Pm$_3$		
	n	mean	range	n	mean	range
Ovis canadensis[1]	3	9.4	9.2-9.7	3	5.9	5.3-6.3
Ovis canadensis[2]	-	-	-	1	8.5	-
Ovis canadensis[3]	-	-	-	11	9.4	8.9-9.9
Ovis canadensis[4]	2	10.3	9.0-11.5	2	7.0	5.4-8.6

[1]Nevada; Recent; this report
[2]Catclaw Cave, Arizona; Rancholabrean; Hibbard and Wright (1956)
[3]Natural Trap Cave, Wyoming; Rancholabrean; Wang (1988)
[4]Mineral Hill Cave; Holocene; this report

Table 35. Ovis canadensis Pm_4 tooth measurements from Catclaw Cave, Dry Cave, Mineral Hill Cave, and recent specimens.

	Length Pm_4			Width Pm_4		
	n	mean	range	n	mean	range
Ovis canadensis[1]	3	11.1	10.8-11.6	3	7.4	7.0-7.7
Ovis canadensis[2]	-	-	-	1	9.8	-
Ovis canadensis[3]	-	-	-	1	9.8	-
Ovis canadensis[4]	3	31.1	12.2-14.9	3	9.3	7.7-10.2

[1]Nevada; Recent; this report
[2]Catclaw Cave, Arizona; Rancholabrean; Hibbard and Wright (1956)
[3]Dry Cave, New Mexico; Rancholabrean; Harris and Mundel (1974)
[4]Mineral Hill Cave; Holocene; this report

Table 36. Ovis canadensis M_1 tooth measurements from Catclaw Cave, Dry Cave, Natural Trap Cave, Little Box Elder Cave, Mineral Hill Cave, and recent specimens.

	Length M_1			Width M_1		
	n	mean	range	n	mean	range
Ovis canadensis[1]	3	14.7	13.6-15.9	3	9.1	8.9-9.3
Ovis canadensis[2]	-	-	-	-	8.6	7.8-9.1
Ovis canadensis[3]	-	-	-	1	11.0	-
Ovis canadensis[4]	1	14.1	-	1	10.5	-
Ovis canadensis[5]	-	-	-	11	10.9	10.2-11.4
Ovis canadensis[6]	-	-	-	1	11.5	-
Ovis canadensis[7]	-	-	-	-	10.5	9.7-11.1
Ovis canadensis[8]	3	17.5	15.6-19.7	3	10.6	9.3-11.4

[1]Nevada; Recent; this report
[2]Wyoming; Recent; Indeck (1987)
[3]Catclaw Cave, Arizona; Rancholabrean; Hibbard and Wright (1956)
[4]Dry Cave, New Mexico; Rancholabrean; Harris and Mundel (1974)
[5]Natural Trap Cave, Wyoming; Rancholabrean; Wang (1988)
[6]Lake Bonneville Gravels, Utah; Rancholabrean; Stokes and Condie (1961)
[7]Little Box Elder Cave, Wyoming; Rancholabrean; Indeck (1987)
[8]Mineral Hill Cave; Holocene; this report

Table 37. Ovis canadensis M_2 tooth measurements from Catclaw Cave, Dry Cave, Natural Trap Cave, Little Box Elder Cave, Mineral Hill Cave, and recent specimens.

	Length M_2			Width M_2		
	n	mean	range	n	mean	range
Ovis canadensis[1]	3	18.8	17.1-19.7	3	9.7	9.2-10.1
Ovis canadensis[2]	-	-	-	-	8.7	7.9-9.4
Ovis canadensis[3]	-	-	-	1	12.5	-
Ovis canadensis[4]	1	20.1	-	1	12.2	-
Ovis canadensis[5]	-	-	-	11	12.0	11.0-12.5
Ovis canadensis[6]	1	22.0	-	1	12.5	-
Ovis canadensis[7]	-	-	-	-	11.4	10.9-11.7
Ovis canadensis[8]	2	20.2	19.5-20.9	2	11.2	9.9-12.5

[1]Nevada; Recent; this report
[2]Wyoming; Recent; Indeck (1987)
[3]Catclaw Cave, Arizona; Rancholabrean; Hibbard and Wright (1956)
[4]Dry Cave, New Mexico; Rancholabrean; Harris and Mundel (1974)
[5]Natural Trap Cave, Wyoming; Rancholabrean; Wang (1988)
[6]Lake Bonneville Gravels, Utah; Rancholabrean; Stokes and Condie (1961)
[7]Little Box Elder Cave, Wyoming; Rancholabrean; Indeck (1987)
[8]Mineral Hill Cave; Holocene; this report

Table 38. Mandibular tooth measurements for Ovis canadensis from the Late Pleistocene to Recent.

	Western U.S. (10,000-20,000 BP)[1]	TP4-3 (8,000 BP)[2]	TP6-36 (6,800 BP)[3]	TP3-1 (4,500 BP)[4]	Nevada (Recent)
Width Pm_3	9.3	-	8.6	5.4	5.9
Width Pm_4	9.8	10.2	9.9	7.7	7.4
Width M_1	10.9	11.4	11.0	9.3	9.1
Width M_2	12.0	-	12.5	9.9	9.7

[1]Data compiled from Tables 33-37 in this report; Rancholabrean
[2]Mineral Hill Cave; Early Holocene/Middle Holocene transition
[3]Mineral Hill Cave; Middle Holocene
[4]Mineral Hill Cave; Early Late Holocene

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Table 39. Postcranial measurements of Ovis canadensis from Mineral Hill Cave.

	Greatest Length	Proximal Breadth	Proximal Depth	Distal Breadth	Distal Depth
humerus[1]	-	-	-	47.5	36.5
radius[2]	-	49.6	25.1	42.8	31.8
tibia[3]	-	-	-	38.7	29.6
calcaneus[4]	83.9	-	-	-	-
astragalus[5]	45.0	-	-	-	-
metacarpal[6]	-	-	-	36.7	23.1
metatarsal[7]	-	-	-	37.1	24.8
proximal phalanx[8]	58.4	19.8	22.8	19.0	15.9
central phalanx[9]	36.0	20.7	20.4	14.7	17.3

[1] n = 6; range DB = 36.1-51.5; range DD = 31.4-42.3
[2] n = 1 each
[3] n = 6; range DB = 34.3-43.4; range DD = 24.8-33.2
[4] n = 1
[5] n = 7; range = 38.3-48.9
[6] n = 3; range DB = 36.2-36.9; range DD = 23.0-23.2
[7] n = 1
[8] n = 12; range GL = 51.9-64.1; range PB = 16.7-22.8; range PD = 20.1-26.4; range DB = 16.5-22.8; range DD = 14.3-18.2
[9] n = 2; range GL = 34.4-37.6; range PB = 19.3-22.0; range PD = 19.6-21.1; range DB = 13.3-16.0; range DD = 16.5-18.0

Bison bison
Bison

MATERIAL RECOVERED. two skull fragments; one M^1; one tooth fragment; two carpals; one metacarpal epiphysis; one calcaneus epiphysis; two sesamoids; three proximal phalanges; six central phalanges; three distal phalanges

C-14 AGE. TP3-88 (central phalanx [> 50,000 BP]); TP3-4 (distal phalanx [43,080 ± 730 BP]); TP3-140 (sesamoid [31,880 ± 570 BP])

DISCUSSION. The majority of bison bones recovered from MHC were foot elements. Table 40 compares the size of these bones to those of *Bison bison antiquus* from Rancho La Brea (Miller and Brotherson 1979) (also, see Figures 24-26). These data suggest that the MHC bison had extremely large feet. Almost all of the foot elements from MHC exceed the mean values of the RLB bison; one distal phalanx, in particular, measured 6mm longer than any measured from RLB, and the MHC specimen is quite worn (see Figure 25). Miller (1976) noted that there is size overlap in postcranial elements of *B. latifrons*, *B. b. antiquus*, and *B. b. bison* (see also Kurtén and Anderson 1980:337). Thus, we identify the large bovids from MHC simply as *B. bison*, and note that they had very large feet.
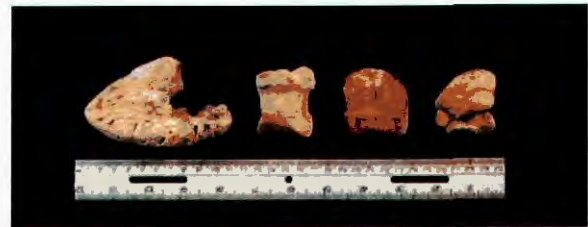
Figure 24. Bison foot elements from MHC: (left to right): terminal phalanx; central phalanx; carpal; carpal.

Figure 25. Terminal phalanges from modern cow (left) and bison from MHC (right).
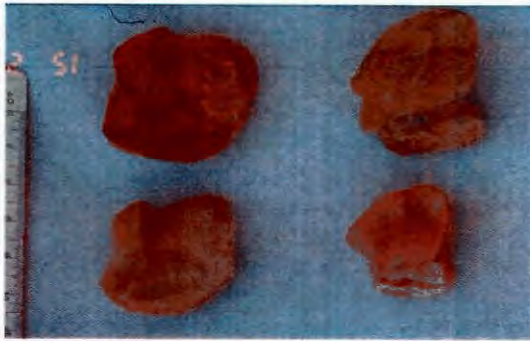
Figure 26. Bison carpals from MHC (top row) and modern specimen (bottom row).

McGuire (1980) identified a large bovid first phalanx (TP1a-010-1) as shrub ox (*Eucheratherium* sp.). This is the only specimen identified as shrub ox from his original report. Our analysis indicates, however, that this bone is from the hind leg of a bison: the measurements of this specimen fall within the upper range of *B. b. antiquus*, and thus it does not possess the shorter, more slender phalanges of the shrub ox. There were no shrub ox remains identified from MHC in the present analysis.

Three of the MHC bison bones were C-14 dated; all dated older than ca. 32,000 BP. *B. latifrons* is

typically more abundant in late Pleistocene assemblages pre-dating the Sangamonian (older than ca. 70,000 BP) (Kurtén and Anderson 1980), although the Late Wisconsinan Rainbow Beach Fauna of Idaho contained bones of this species dating to about 21,000 BP (McDonald and Anderson 1974). *B. b. antiquus* is thought to have emerged from a second migration of bison from Eurasia about 100,000 BP, rather than evolving from the indigenous *B. latifrons* populations within North America at that time (Kurtén and Anderson 1980). However, up to four species of bison may have occupied the southeastern Idaho landscape during the past 100,000 years (McDonald 1998), further complicating bison evolution in North America. These uncertainties make it unclear whether *B. b. antiquus* is restricted to Wisconsinan faunas, or whether it may extend back into the Sangamonian. If the large bovids from MHC belong to *B. b. antiquus* (as bone measurements suggest), and if this subspecies or species was restricted to the late Sangamonian and Wisconsinan, then the limiting date on the central phalanx (TP3-88) may approximate the true date of this bone. Unfortunately, this interpretation remains purely speculative at this time.

Pleistocene-aged bison remains are relatively common in many areas of western North America (Guthrie 1970; Kurtén and Anderson 1980), but surprisingly rare in Nevada. Bison are notably absent in the Crystal Ball Cave assemblage (Heaton 1985), but they are relatively common at Tule Springs (Mawby 1967) in southern Nevada. Bison may be present in Smith Creek Cave, but are scarce (Miller 1979). Bison is also rare in the latest Pleistocene and early Holocene deposits of Hidden Cave, western Nevada (Grayson 1985) and Danger Cave (Grayson 1988) along the Nevada-Utah border. Bison are more common in Pleistocene deposits of southern Idaho and central Utah (e.g., Stokes et al. 1966; Hopkins et al. 1969; McDonald and Anderson 1975; Miller 1976; McDonald 1998). Large bison remains were also recovered from Burnet Cave, New Mexico (Schultz and Howard 1935) and Cueva Quebrada, Texas (Lundelius 1984).

Table 40. Comparison of mean measurements of bison foot elements from Rancho La Brea and the large bovids from Mineral Hill Cave.

	Rancho La Brea			Mineral Hill Cave		
	n	mean	range	n	mean	range
unciform – anterior/posterior length	109	42.2	36.0-51.0	1	47.8	-
unciform – transverse width	109	39.4	35.0-47.0	1	45.4	-
unciform - height	109	31.7	28.0-36.0	1	36.3	-
magnum – anterior/posterior length	126	45.3	40.0-52.0	1	45.7	-
magnum – transverse width	126	48.5	42.0-60.0	1	49.1	-
magnum - height	126	28.1	25.0-33.0	1	30.5	-
proximal phalanx – length[1]	561	74.0	63.0-85.0	2	77.2	76.0-78.4
proximal phalanx – transverse width[1]	561	39.0	30.0-48.0	2	37.3	34.6-39.9
central phalanx – length	555	49.9	43.0-60.0	5	53.5	50.5-56.5
central phalanx – transverse width	555	38.6	30.0-50.0	5	39.6	36.8-41.9
distal phalanx – length	337	85.7	70.0-101.0	3	95.9	89.2-107.2
distal phalanx – transverse width	337	33.2	27.0-41.0	2	41.4	37.7-45.1

[1]Miller and Brotherson (1979) separated measurements of fore and hind phalanges; because this determination could not be made for the MHC phalanges, the measurements from Rancho La Brea have been pooled together, with estimated mean values, in this table. For example, Miller and Brotherson (1979) published the mean value for the length of the proximal phalanx of the forelimb as approximately 73.0mm, and that of the hindlimb as approximately 75.0mm; the estimate given above pools these means and is presented as "74.0mm".

CHAPTER 4

Mineral Hill Cave Lagomorphs

Bryan Hockett

The Order Lagomorpha includes the pikas, rabbits, and hares. All three types of lagomorphs were recovered from MHC. Collectively, lagomorph remains, and in particular those of rabbits and hares, were very abundant in the cave. Approximately 2% of the leporid (rabbit and hare) bones displayed puncture marks (see Hockett and Haws 2002). This percentage compares favorably with that previously identified for raptor nest and carnivore scat assemblages (e.g., Hockett 1989, 1991, 1995, 1996, 1999; Hockett and Haws 2002). Thus, the majority of leporid bones were probably deposited in the cave by small carnivores and raptors, or possibly accumulated by these predators near the cave and subsequently deposited into the cave by water. The foxes, coyotes, wolves, and bobcats recovered from MHC all could have contributed to the accumulation of lagomorph bones.

Class Mammalia

Order Lagomorpha

Family Ochotonidae

Ochotona princeps
Pika

MATERIAL RECOVERED. 34 mandibles; one maxilla

C-14 AGE. TP3-148 (mandible [>50,000 BP]); TP3-247 (mandible [34,050 ± 260 BP])

DISCUSSION. McGuire (1980) originally added MHC to the list of Nevada localities that have produced prehistoric records of pika outside of their current distribution. Mead (1986) listed MHC as a pika-producing locality in his summary of the Quaternary distribution of this animal in North America. More recently, Mead and Spaulding (1995) summarized the known pika-producing localities in the Intermountain West, the majority of which occur in ancient woodrat (*Neotoma* spp.) middens within the state of Nevada. Hockett (2000) recently discussed the Late Pleistocene and Early Holocene distribution of pika at Pintwater Cave and the northern Mojave Desert.

Extralocal pika remains and those from lower elevation settings within their current distribution are generally restricted to deposits that pre-date ca. 7,000 BP (Grayson 1983; Mead and Spaulding 1995; Hockett 2000). Pika are relatively common in caves, rockshelters, and woodrat middens in northern, central, and southern Nevada between 50,000 and 7,000 BP (e.g., Mead 1986:166, Table 1; Mead and Spaulding 1995:169, Table 1; Hockett 2000:265).

Two pika mandibles from MHC were submitted for C-14 dating. One possessed the characteristic coloration (dark brown, manganese stained) of other bones that invariably pre-dated 30,000 BP; the other was much fresher-looking, and was thought to possibly date to the latest Pleistocene or the Holocene (Figure 27). The dark-colored mandible dated beyond the current limits of radiocarbon dating, and the "fresh-looking" bone dated to about 34,000 BP. Thus, pika was established near MHC by at least 50,000 years ago; their latest occurrence in the vicinity of the cave presumably dates to the Early Holocene, but this possibility remains unknown.

Figure 27. Pika mandibles from MHC.

Family Leporidae

Lepus spp.
Jackrabbit

MATERIAL RECOVERED. 18 mandibles; 16 maxillae; 43 innominates; eight sacra; 45 femora; 76 tibiae; five scapulae; 34 humeri; 53 radii; 43 ulnae; 82 calcanei; 36 astragali

C-14 AGE. TP3-264 (mandible [35,270 ± 300 BP]); TP3-346 (mandible [7,980 ± 60 BP])

DISCUSSION. These large leporids are easily distinguished from snowshoe hare (*Lepus americanus*), cottontail rabbits (*Sylvilagus* spp.), and pygmy rabbits (*Brachylagus idahoensis*) based on size. However, there is considerable overlap in the alveolar lengths and size of the postcrania between the white-tailed jackrabbit (*L. townsendii*) and the black-tailed jackrabbit (*L. californicus*) (e.g., Grayson 1983, 1985, 1988). However, Heaton (1985:353, Figure 4) suggests that alveolar lengths greater than 18.5mm probably indicates the presence of *L. townsendii*. A total of nine of the 18 *Lepus* mandibles possessed complete alveolar lengths. Of these, two measured greater than 18.5 mm (18.8mm and 19.4mm). These mandibles indicate that white-tailed jackrabbits are likely present in the MHC faunal assemblage; black-tailed jackrabbits are probably present as well.

Two jackrabbit mandibles were submitted for C-14 analysis. One mandible is approximately 35,000 years old, the other about 8,000 years old. Bones of *Lepus* are ubiquitous throughout the Pleistocene and Holocene caves of the western United States, and MHC is no exception. Approximately 20 *Lepus* bones display small to medium-sized puncture marks, undoubtedly caused by the carnivores and/or raptors that dined on these animals.

Sylvilagus spp.
Cottontail Rabbit

MATERIAL RECOVERED. 61 mandibles; 18 maxillae; 34 innominates; four sacra; 29 femora; 103 tibiae; two scapulae; 33 humeri; 21 radii; 22 ulnae; 64 calcanei; 15 astragali

C-14 AGE. unknown

DISCUSSION. The vast majority of the medium-sized leporid remains from MHC probably belong to Nuttall's cottontail (*Sylvilagus nuttalii*). There is overlap, however, in the size of cottontail rabbits and snowshoe hares, so some of these bones could belong to the latter. Nevertheless, considering the fact that the cave lies at approximately 7,000 feet in elevation, and considering that many of the bones accumulated during cooler climatic phases compared to current conditions surrounding the cave, the majority of these bones are probably Nuttall's cottontail. Cottontail bones are also ubiquitous components of the caves and rockshelters of western North America. Cottontail bones tend to outnumber jackrabbit bones in the Pleistocene and Early Holocene deposits of the Intermountain West, whereas this pattern is often reversed beginning in the Middle Holocene as the climate became more xeric (Grayson 1977; 2000). Jackrabbit and cottontail bones were about equally abundant in MHC, perhaps reflecting the fact that Pleistocene, Early Holocene, Middle Holocene, and Neoglacial-aged bones were recovered.

Brachylagus idahoensis
Pygmy Rabbit

MATERIAL RECOVERED. five femora; two tibiae; one ulna

C-14 AGE. TP3-477 (tibia [31,530 ± 240 BP])

DISCUSSION. Bones of pygmy rabbit are rather easy to identify based on their diminutive size. Only eight of the several thousand leporid remains, however, were positively identified as pygmy rabbit. Remains of *B. idahoensis* are relatively common in Late Pleistocene and Early Holocene deposits throughout the central and northern Great Basin (Ziegler 1963; Grayson 1977, 1983, 1985, 1988, 1990, 2000; Mead et al. 1982; Heaton 1985; Turnmire 1987; Huckleberry et al 2001; McGuire et al. 2003). Bones of pygmy rabbit have also been reported from the Silver Creek (Miller 1976) and Rainbow Beach (McDonald and Anderson 1975) localities in Utah, as well as Jaguar Cave (Kurtén and Anderson 1972) in Idaho. The specimen C-14 dated at MHC establishes this animal in Pine Valley prior to 30,000 BP.

Leporidae
Rabbits and Hares

MATERIAL RECOVERED. 46 maxillae fragments; 40 isolated teeth; four patellae; 151 vertebrae; 22 carpals/tarsals; 667 metapodials; 496 phalanges; 75 ribs

C-14 AGE. unknown

DISCUSSION. These 1,000+ bones were not identified beyond the family level; they belong to both jackrabbits and cottontails.

CHAPTER 5

Mineral Hill Cave Rodents

Dave N. Schmitt and Bryan Hockett

A moderately diverse set of rodents were identified from MHC. However, the numbers of rodent bones present, while numbering in the hundreds, is atypical of the thousands of specimens that typically accumulate under raptor roosts. Thus, many of the smaller rodents (small squirrels, mice, woodrats etc.) probably died naturally inside the cave. We have arbitrarily broken this chapter into large (marmots and porcupines) and small (mice, rats, squirrels, gophers, chipmunks, voles) rodents.

Large Rodents:

The most abundant rodent, and the most abundantly identified remains in the entire cave, was that of the marmot. The number of marmot bones identified compared to those of other rodent species, however, is biased. Marmot bones are large and easy to identify. As a result, all of the marmot remains recovered from the cave were identified and counted. In contrast, only the skulls, mandibles, and maxillae of the small rodents such as woodrats and mice were identified.

As noted in chapter 1, marmots probably had a profound impact on the stratigraphic integrity of the cave sediments. Marmots were once very abundant inside and outside of the cave, and they clearly negatively impacted the cave's stratigraphy. Many of the marmot bones were entirely intact with no signs of predator damage; in addition, many specimens of young animals are present. This situation is indicative of young animals that probably died inside burrows, a situation one of us (B. Hockett) encountered at Haystack Cave in the Gunnison Basin of Colorado in the mid-1980's. Nevertheless, many marmots also fell prey to carnivores. Similar to the rabbit and hare bones, nearly 2% of the marmot bones display puncture marks caused by carnivore teeth or raptor beaks and talons.

Class Mammalia

Order Rodentia

Family Sciuridae

Marmota flaviventris
Yellow-bellied Marmot

MATERIAL RECOVERED. 435 mandibles; 143 maxillae; 141 innominates; 10 sacra; 169 femora; 201 tibiae; 41 scapulae; 166 humeri; 91 radii; 158 ulnae; 45 calcanei; 48 astragali; 68 metapodials

C-14 AGE. TP3-8 (mandible [42,350 ± 1,140 BP]); TP1a-012-2 (mandible [18,290 ± 60 BP]); TP3-15 (mandible [5,640 ± 40 BP])

DISCUSSION. The most common mammalian remains recovered from MHC were those of the marmot (Figures 28-30). The yellow-bellied marmot (*Marmota flaviventris*) is the sole species of marmot that currently inhabits Nevada and the Great Basin (Hall 1946). The hoary marmot (*Marmota caligata*) is currently restricted to parts of Idaho, Montana, Washington, and Alaska, as well as parts of western Canada (Barash 1989). *M. flaviventris* is mainly distributed south of the hoary marmot's range, although hoary and yellow-bellied marmots are sympatric in some areas, such as the Flint Creek Range in Montana (Barash 1989).

Figure 28. Two marmot mandibles from MHC.
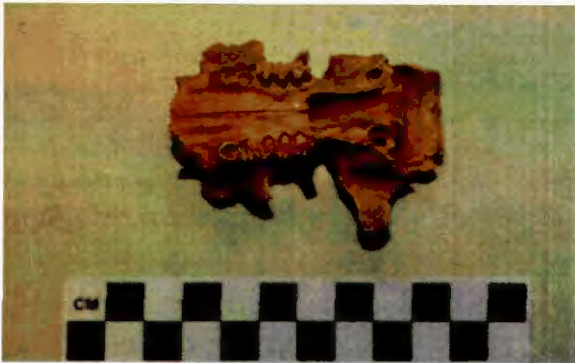
Figure 29. Partial marmot skull with maxillae from MHC.

Figure 30. Marmot postcranial remains from MHC.

During the Pleistocene and portions of the Holocene, marmots were widespread throughout Nevada, from west-to-east and south-to-north (e.g., Ziegler 1963; Miller 1979; Heaton 1985; Grayson 1985, 1988; Reynolds et al. 1991b). At Homestead

Cave, Utah, marmots are present in the earliest deposits (ca. 11,300 BP), but disappear after ca. 5500 BP (Grayson 2000). Marmots were present during the Late Pleistocene in surrounding regions to the south such as the Grand Canyon area, but disappear from these faunal assemblages between ca. 11,000 and 15,000 BP (Mead et al. 1981).

Ziegler (1963:16) noted that due to the proximity of Deer Creek Cave to *M. caligata* populations in central Idaho, this site could preserve evidence of an extended southern distribution for the hoary marmot during the Late Pleistocene. Despite the cave's proximity to the modern distribution of hoary marmots, however, Ziegler (1963) noted that all of the marmot remains compared favorably with *M. flaviventris*. Although there has been continuing speculation that hoary marmot remains may be found further south during the Pleistocene, Mead et al. (1982:19) considered it "unlikely" that *M. caligata* occupied the Great Basin at this time. Studies such as Indeck's (1987) at Little Box Elder Cave, Wyoming, have concluded that *M. flaviventris* maintained (and greatly expanded) its current distribution during the Pleistocene, and that yellow-bellied marmots were on average slightly larger than their modern descendants.

It therefore seems unlikely that *M. caligata* occupied southern Pine Valley during the Late Pleistocene, especially considering the lack of evidence for the hoary marmot north of the cave and closer to their modern distribution, such as at Deer Creek Cave and Jaguar Cave. Nevertheless, a sample of mandibles and maxillae were measured and compared to those of modern hoary and yellow-bellied marmots, as well as those reported from Late Pleistocene contexts in Little Box Elder Cave, Wyoming (Indeck 1987), and Owl Cave No. 2, eastern Nevada (Turnmire 1987).

Table 41 displays these results. The MHC marmot alveolar lengths are within the range of modern and fossil *M. flaviventris*. Based on the Little Box Elder Cave *Marmota* measurements, Indeck (1987) argued that a single population of yellow-bellied marmots, consisting of slightly larger individuals on average compared to modern populations, inhabited that part of Wyoming during the Late Pleistocene. A similar situation appears to have existed during the Late Pleistocene of southern Pine Valley, Nevada.

Table 41. Marmot tooth row measurements from various Rancholabrean and Recent assemblages, including samples from Mineral Hill Cave.

	Alveolar length - mandible			Alveolar length - maxilla		
	n	mean	range	n	mean	range
M. caligata[1]	-	22.5	20.9-24.6	-	22.6	21.0-24.7
M. caligata[2]	-	-	-	88	22.5	21.0-24.4
M. flaviventris[1]	-	19.7	14.8-21.6	-	19.8	14.9-21.7
M. flaviventris[2]	-	-	-	92	20.2	17.3-22.3
M. flaviventris[3]	14	18.4	17.1-19.6	8	20.0	15.7-22.0
M. flaviventris[4]	168	20.4	16.8-24.2	54	21.8	19.6-24.6
M. flaviventris[5]	1	21.2	-	3	22.0	21.5-22.9
M. flaviventris[6]	85	20.3	18.5-22.5	20	20.9	19.0-22.8

[1]Recent; Guilday and Adam (1967)
[2]Recent; data compiled from Turnmire (1987:67-68, Table 3)
[3]Nevada and Oregon; Recent; this report
[4]Little Box Elder Cave, Wyoming; Rancholabrean; Indeck (1987)
[5]Owl Cave No 2, Nevada; Rancholabrean; Turnmire (1987)
[6]Mineral Hill Cave; Rancholabrean and Holocene; this report

Family Erethizontidae

Erethizon dorsatum
Porcupine

MATERIAL RECOVERED. two mandibles; one palate with maxillae; one atlas; one innominate; one femur, one tibia; one fibula; two ulnae

C-14 AGE. TP3-146 (mandible [3,890 ± 110 BP])

DISCUSSION. Much of the porcupine remains from MHC appear to be Neoglacial in age, and the one C-14 date is from the early phases of this climatic regime. The MHC porcupine was of similar size to modern animals (Table 42). Porcupine have rarely been reported from Pleistocene deposits in Nevada. Porcupine remains may be Pleistocene in age at Smith Creek Cave (Miller 1979) and Deer Creek Cave (Ziegler 1963). They have been reported from Holocene contexts at Gatecliff Shelter (Grayson 1983), Danger Cave, Last Supper Cave, and Hanging Rock Shelter (Grayson 1988), and James Creek Shelter (Grayson 1990). Porcupine was reported from the Pleistocene deposits in Jaguar Cave (Kurtén and Anderson 1972).

Table 42. Porcupine tooth row measurements from Mineral Hill Cave and Recent specimens.

	Alveolar length - mandible			Alveolar length - maxilla		
	n	mean	range	n	mean	range
E. dorsatum[1]	8	29.3	27.0-30.3	5	26.7	25.8-27.4
E. dorsatum[2]	2	30.6	28.6-32.6	1	26.3	-

[1]Oregon; Recent; this report
[2]Mineral Hill Cave; Holocene; this report

Small Rodents. We examined 1,101 small rodent specimens and identified 737 bones to species and 244 specimens to genera; the remaining 120 specimens are fragmentary microtine skulls and mandibles that could not be identified beneath Subfamily. The types and numbers of identified specimens are presented below along with discussions on modern small-mammal distributions, their occurrence in regional archaeological and paleontological sites and, where pertinent, methods employed in species identification. Two woodrat mandibles and a pocket gopher maxilla were subject to radiocarbon assay (see below) and the C-14 ages of the remaining MHC small rodents are unknown.

Family Sciuridae

Tamias sp.
Chipmunks

MATERIAL RECOVERED. three mandibles

Tamias cf. *minimus*
Least Chipmunk

MATERIAL RECOVERED. three mandibles

Tamias minimus
Least Chipmunk

MATERIAL RECOVERED. one mandible

DISCUSSION. As its name suggests, least chipmunks are diminutive mammals and represent the smallest chipmunk of the species. Two additional species - the Uinta chipmunk (*T. umbrinus*) and cliff chipmunk (*T. dorsalis*) - also occur in the MHC vicinity (Hall 1946), but these animals are larger than *T. minimus* and the identified specimens listed above. However, two edentulous mandible fragments identified to genera are slightly larger than modern *T. minimus* and likely represent either the Uinta or cliff chipmunk. Least chipmunk remains have been recovered from late Pleistocene deposits at Homestead Cave (Grayson 2000) and have been reported in Holocene and undated deposits throughout the central and eastern Great Basin (Grayson 1983, 1990; Heaton 1985; Mead et al. 1982; Schmitt and Lupo 2002).

Spermophilus sp.
Ground Squirrels

MATERIAL RECOVERED. 41 mandibles; 10 maxillae

Spermophilus cf. *beldingi/elegans*
Belding's or Wyoming Ground Squirrel

MATERIAL RECOVERED. 18 mandibles; six maxillae

Spermophilus beldingi/elegans
Belding's or Wyoming Ground Squirrel

MATERIAL RECOVERED. 65 mandibles; 24 maxillae

Spermophilus cf. *lateralis*
Golden-Mantled Ground Squirrel

MATERIAL RECOVERED. five mandibles

Spermophilus lateralis
Golden-Mantled Ground Squirrel

MATERIAL RECOVERED. 12 mandibles; six maxillae

Spermophilus cf. *mollis* (=*townsendii*)
Townsend's Ground Squirrel

MATERIAL RECOVERED. five mandibles

Spermophilus mollis (=*townsendii*)
Townsend's Ground Squirrel

MATERIAL RECOVERED. three mandibles

DISCUSSION. Each of the ground squirrels identified in the MHC collection is found currently in the area (Hall 1981; Zeveloff and Collett 1988). Given the difficulty in distinguishing the remains of *S. beldingi* from *S. elegans*, and our lack of sufficient comparative materials, we made no attempt to further identify these specimens. Elsewhere in the region, Grayson (1990) identified large numbers of *S. beldingi/elegans* specimens in the Holocene deposits at James Creek Shelter.

While *S. lateralis* may inhabit rocky slopes adjoining low elevation grassland and sagebrush communities, they prefer high elevation settings

extending from pinyon-juniper forests to above the timberline (Bartels and Thompson 1993) and their presence in MHC is not surprising. In contrast, *S. mollis* occupy mountain foothills but are conspicuous residents of low elevation habitats containing sagebrush and xerophytic shrubs (e.g., Rickart 1987). Townsend's ground squirrels have been reported in low desert contexts across the region (e.g., Grayson 1985; Schmitt et al. 2002) and, like MHC, *S. lateralis* and *S. mollis* occur together in a number of upland and semi-upland sites, including Gatecliff Shelter (Grayson 1983), James Creek Shelter (Grayson 1990), and Smith Creek Cave (Mead et al. 1982; Miller 1979).

Family Geomyidae

Thomomys sp.
Smooth-toothed Pocket Gophers

MATERIAL RECOVERED. 144 mandibles; three maxillae

Thomomys bottae
Botta's Pocket Gopher

MATERIAL RECOVERED. two maxillae

Thomomys cf. *talpoides*
Northern Pocket Gopher

MATERIAL RECOVERED. six maxillae

Thomomys talpoides
Northern Pocket Gopher

MATERIAL RECOVERED. four mandibles; 53 maxillae

C-14 AGE. TP3-561 (maxillae [8,110 ± 50 BP])

DISCUSSION. Both of these geomyids can be found today in southern Pine Valley. Townsend's pocket gopher (*T. townsendii*) also occurs in the MHC vicinity (Hall 1946), but this species is larger than modern *T. bottae* and *T. talpoides* and the gopher specimens from MHC. The abundance of *T. talpoides* compared to *T. bottae* at MHC was anticipated since *T. talpoides* is a montane species found largely in regional high valleys and mountains. Northern pocket gophers have been reported in Holocene deposits in other upland and semi-upland

contexts across the northern and central Great Basin (Dalley 1976; Grayson 1988; Heaton 1985), and *T. bottae* are common in sites in regional mountain foothills and valleys (e.g., Grayson 1985, 2000; Schmitt et al. 2002). Our identifications of *T. bottae* and *T. talpoides* crania and mandibles largely employed p4 and rostral morphology discussed in Thaeler (1980).

Family Heteromyidae

Perognathus sp.
Pocket Mouse

MATERIAL RECOVERED. four mandibles

Perognathus parvus
Great Basin Pocket Mouse

MATERIAL RECOVERED. seven mandibles; one maxillae

DISCUSSION. Two species of pocket mice - *Perognathus parvus* and the diminutive *P. longimembris* (little pocket mouse) - are found in the MHC vicinity (Hall 1946, 1981). Our identification of pocket mouse materials was based on specimen size and, when present, dental and cranial morphology (see Grayson 1985). Since *P. longimembris* characteristically occupy low deserts and *P. parvus* inhabit grasslands and range into altitudes significantly higher than those tolerated by *P. longimembris* (e.g., Grayson 2000), it is not surprising that *P. parvus* is the only species present at MHC. Skeletal remains of *P. parvus* have been recovered from Hidden Cave (Grayson 1985), Gatecliff Shelter (Grayson 1983), Swallow Shelter (Dalley 1976), and Smith Creek Cave (Miller 1979). In northwestern Utah *P. parvus* have been reported in terminal Pleistocene/early Holocene deposits in some low elevation contexts, but these and other taxa adapted to montane and/or mesic settings became extinct as middle Holocene desertification took hold (Grayson 2000; Schmitt et al. 2002).

Family Muridae

Microtine

MATERIAL RECOVERED. 72 mandibles; 48 maxillae

DISCUSSION. These skeletal remains are fragmentary and/or lack molars and we could not confidently identify them to taxonomic genera.

Microtus sp.
Meadow Voles

MATERIAL RECOVERED. six mandibles

DISCUSSION. Both the montane vole (*M. montanus*) and long-tailed vole (*M. longicaudus*) occur across much of northern and central Nevada (Hall 1946). A third species, the meadow vole (*M. pennsylvanicus*), occurs today in moist woodlands and meadows north and east of MHC (Hall 1981), but it is possible that the geographic range of this animal once extended across the northern Great Basin. Although *M. longicaudus* are a montane or "boreal" species (Brown 1971; see also Grayson 1993:170-177) and *M. montanus* can be found in more arid, low elevation contexts, their geographic ranges overlap and both species might be represented in the MHC small-mammal fauna. Montane and/or long-tailed voles are common components of Pleistocene and Holocene faunas across the region (e.g., Grayson 1983, 1985, 1990, 2000; Heaton 1985; Hockett 2000; Huckleberry et al. 2001; Miller 1979).

cf. *Lemmiscus* (=*Lagurus*) *curtatus*
Sage Vole

MATERIAL RECOVERED. seven mandibles

Lemmiscus (=*Lagurus*) *curtatus*
Sage Vole

MATERIAL RECOVERED. 78 mandibles

DISCUSSION. *Lemmiscus curtatus* are found currently in the MHC vicinity (Hall 1946; Zeveloff and Collett 1988). As its name suggests, sage voles are most often found in habitats dominated by sagebrush (notably big sagebrush [*Artemisia tridentata*]) and tend to be most abundant in settings with cool and wet summers and warm winters (Carroll and Genoways 1980; Hall 1946). Sage vole remains have been recovered from late Pleistocene/early Holocene deposits at the Sunshine Locality in Long Valley (Huckleberry et al. 2001), Homestead Cave (Grayson 2000), and Camels Back Cave (Schmitt et al. 2002), and they have been

reported in Holocene and undated deposits in upland and semi-upland contexts across the region (e.g., Grayson 1983, 1988; 1990; Heaton 1985). Our assignment of edentulous mandible fragments to *L. curtatus* was based on the location of mandibular foramina (after Grayson 1983:117).

Neotoma sp.
Woodrats

MATERIAL RECOVERED. 32 mandibles; one maxillae

Neotoma cf. *cinerea*
Bushy-tailed Woodrat

MATERIAL RECOVERED. 52 mandibles; 11 maxillae

Neotoma cinerea
Bushy-tailed Woodrat

MATERIAL RECOVERED. 242 mandibles; 101 maxillae

C-14 AGE. TP3-344 (mandible [3,030 ± 50 BP]); TP3-388 (mandible [5,970 ± 40 BP])

Neotoma lepida
Desert Woodrat

MATERIAL RECOVERED. one maxillae (with M2 and M3)

DISCUSSION. Bushy-tailed woodrats occur across much of northern and central Nevada and characteristically occupy boreal habitats on Great Basin mountains and mountain foothills (e.g., Brown 1971; Grayson 1993; but see Grayson and Madsen 2000). Desert woodrats are also found in the MHC vicinity (Hall 1946), but these mammals largely occupy arid, low elevation settings.

We examined the morphology of M1 to separate the two species and measured alveolar and molar occlusal lengths in order to distinguish *N. cinerea* from the more diminutive *N. lepida* (after Grayson 1983, 1988). Table 43 presents lengths of MHC and modern *Neotoma* mandibles and maxillae possessing complete alveoli. Given the location of MHC, it is not surprising that all of the identified specimens are larger than modern *N. lepida* and all fall securely within the range of modern *N. cinerea*.

Similarly, comparing the occlusal lengths of molars retained in fragmentary alveoli with modern specimens (Table 44) indicates that the majority of the cave's woodrat specimens represent *N. cinerea*, except for a single *N. lepida* maxilla collected from TP6. The remaining MHC woodrat bones identified as *N. cinerea* are robust neonate mandibles and maxillae with alveolar lengths exceeding 8.75 mm. While the complete taphonomic histories of the MHC rodent fauna remain unknown, the large numbers of woodrat specimens representing all age classes and relative skeletal completeness of recovered parts

lends support to our contention that many of the MHC small rodents died naturally inside the cave. Elsewhere in the region, *N. cinerea* remains are reported from James Creek Shelter (Grayson 1990), Smith Creek Cave (Miller 1979; Mead et al. 1982), Swallow Shelter (Dalley 1976), Crystal Ball Cave (Heaton 1985) and other sites in upland or semi-upland settings. These woodrats have also been identified in terminal Pleistocene/early Holocene deposits in low elevation caves in western Utah (Grayson 1988, 2000; Schmitt et al. 2002).

Table 43. Woodrat tooth row measurements for modern and Mineral Hill Cave specimens.

	Alveolar length – mandible			Alveolar length - maxilla		
	n	mean	range	n	mean	range
N. lepida[1]	28	8.18	7.6-8.6	23	8.40	7.8-8.6
N. lepida[2]	-	-	-	50	na	7.7-8.8
N. cinerea[1]	125	10.07	9.3-11.5	34	10.23	9.4-11.4
N. cinerea[2]	-	-	-	48	na	9.1-10.8
N. cinerea[3]	129	9.94	9.2-11.2	55	9.95	9.1-10.8

[1]Recent; Grayson (1988:Table 4)
[2]Recent; (Hall 1946:Table 18)
[3]Mineral Hill Cave; this report

Table 44. Woodrat molar measurements (occlusal lengths) for modern specimens and Mineral Hill Cave mandible and maxilla fragments retaining teeth.

		Occlusal length – mandibular			Occlusal length - maxillary		
		n	mean	range	n	mean	range
N. lepida[1]	m1	26	3.00	2.73-3.33	26	3.09	2.90-3.46
	m2	26	2.63	2.37-2.82	26	2.38	2.22-2.57
	m3	26	1.67	1.33-2.01	26	1.70	1.43-2.22
N. lepida[2]	m2	-	-	-	1	2.38	2.38
	m3	-	-	-	1	1.88	1.88
N. cinerea[1]	m1	37	3.51	3.01-4.04	37	3.59	3.19-4.27
	m2	37	3.02	2.75-3.28	37	2.85	2.48-3.09
	m3	37	2.15	1.52-2.57	37	2.30	1.75-2.73
N. cinerea[2]	m1	23	3.59	3.02-4.06	36	3.56	3.30-3.83
	m2	3	3.01	2.98-3.03	-	-	-

[1]Recent; Grayson (1988:Table 4)
[2]Mineral Hill Cave; this report. The two *N. lepida* molars are from a single skull fragment (one identified specimen).

Peromyscus sp.
White-footed Mice

MATERIAL RECOVERED. two mandibles

Peromyscus maniculatus
Deer Mouse

MATERIAL RECOVERED. 23 mandibles; one maxillae

DISCUSSION. There are three species of *Peromyscus* in the MHC vicinity today. The largest of these, the pinyon mouse (*P. truei*), is a montane species that characteristically inhabits moist- to-semi-arid rocky settings containing pygmy conifers (Hall 1946, 1981). The canyon mouse (*P. crinitus*) is well-adapted to more xeric Great Basin environs and largely occur in rocky habitats ranging from desert pavement to craggy outcrops on mountain spines (Johnson and Armstrong 1987). Similarly, the deer mouse occurs throughout the Great Basin, but this generalist is more widespread; it can be found in a variety of habitats extending across most of North America (Hall 1981:670-683) and it has been identified in archaeological and paleontological deposits throughout the Great Basin (e.g., Grayson 1985, 1990, 2000; Heaton 1985; Schmitt and Lupo 2002).

Our identification of the MHC mouse crania and mandibles relied on molar characteristics and comparisons of modern *Peromyscus* mandibular alveolar lengths with the MHC specimens. As shown in Table 45, all but one of the MHC alveoli fall securely within the middle-to-upper range of modern *P. maniculatus* specimens, and each of the MHC *Peromyscus* mandibles is larger than modern *P. crinitus* (see Grayson 1985:146-148). In all cases where molars were present our quantitative assignments of specimens to *P. maniculatus* were corroborated by occlusal morphology. The single MHC specimen identified to genera (Table 45) may represent *P. truei*, but Hall (1946:Table 16) reports a few *P. maniculatus* alveolar (albeit maxillary) lengths exceeding 4.0 mm and it may simply represent a robust deer mouse.

Table 45. White-footed mouse mandibular tooth row measurements for modern and Mineral Hill Cave specimens.

	Alveolar length – mandible		
	n	mean	range
P. maniculatus[1]	23	3.44	3.22-3.77
P. maniculatus[2]	23	3.64	3.42-3.79
Peromyscus sp.[2]	1	3.88	3.88

[1]Recent; Grayson (1985:Figure 42)
[2]Mineral Hill Cave; this report

CHAPTER 6

Mineral Hill Cave Reptiles

Marci Hollenshead

Analyses of late Quaternary reptiles in the Great Basin began in the late 1970s. Sites at which the reptiles were studied cluster around the eastern and western portions of the Great Basin. Since little is known of the north-central Great Basin reptilian fauna, this study provides a unique opportunity to reconstruct the late Pleistocene and Holocene local reptilian fauna and compare biogeographic changes with the other known Great Basin sites.

Identifications of the reptile remains from Mineral Hill Cave are based on morphologic characters presented in published data and comparisons with osteological specimens from the lizard collection at the Laboratory of Quaternary Paleontology, Northern Arizona University.

The MHC reptile specimens were given a BLM catalog number (i.e., TP3-545) as well as a Northern Arizona University, Quaternary Sciences Program (NAUQSP) catalog number. The BLM catalog number generally refers to one particular fossil (i.e., a *Crotaphytus* sp. left dentary) with the main exception being the snake vertebrae, which were given one number per taxon. Each taxon (i.e., *Crotaphytus* sp.) was given one NAUQSP number. The MHC fossil reptiles are housed at NAUQSP.

Figures 31-39 define the terminology and illustrate the measurements used. All specimens are catalogued at NAUQSP. **Abbreviations—ATV,** anterior trunk vertebrae; **CL,** centrum length; **DA,** measures the anterior to posterior tooth row length; **DB,** measures the height of the dentary at the midpoint on the lingual side; **DC,** measures the width of the dentary at the midpoint on the ventral side; **DD,** measures the length of the Meckel's canal constriction on the lingual side of the dentary; **L,** left; **MA,** measures the posterior to anterior toothrow length of the maxilla; **MB,** measures from the highest point of the dorsal maxillary projection to the toothrow; **MC,** measures the anterior tip to highest height of the dorsal projection of the maxilla; **MTV,** mid-trunk vertebrae; **NA,** not available; **NAW,** neural arch width; **PO,** postzygapophyseal facet; **PR,** prezygapophyseal facet; **PTV,** posterior trunk vertebrae; **QA,** measures the greatest dorsal-ventral length of the quadrate; **QB,** measures the greatest medial-lateral breadth of the quadrate; **QC,** measures the length of the ventral base of the quadrate; and **R,** right. **Locality Abbreviations: CHC,** Council Hall Cave; **CBC,** Crystal Ball Cave; **DC,** Danger Cave; **GRS,** Gatecliff Rock Shelter; **HRS,** Hanging Rock Shelter; **HC,** Hidden Cave; **LC,** Ladder Cave; **LSC,** Last Supper Cave; **MHC,** Mineral Hill Cave; **SCC,** Smith Creek Cave; and **SCBC,** Snake Creek Burial Cave.
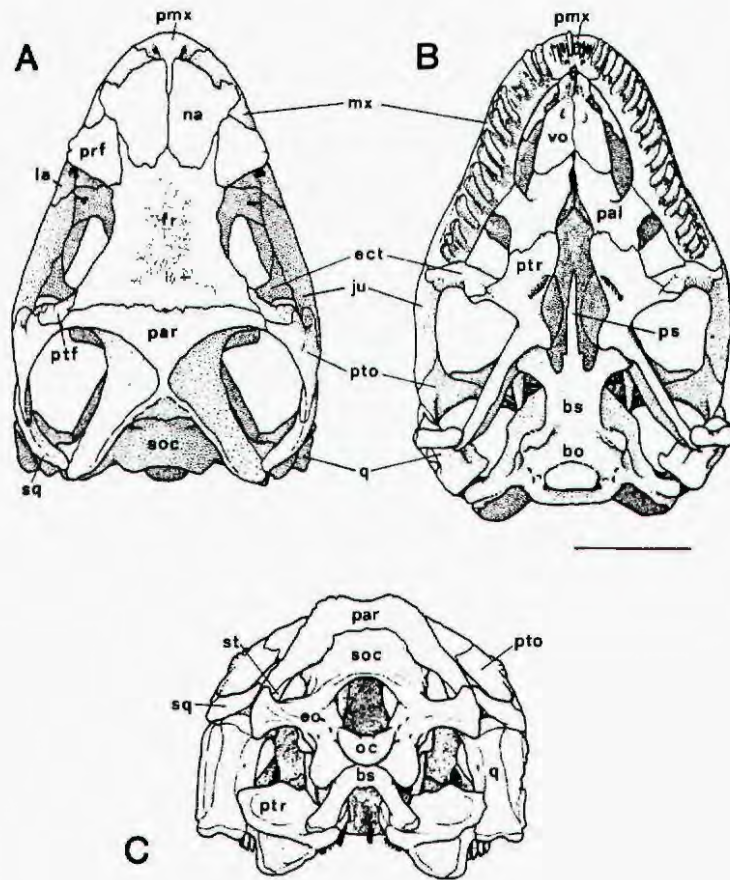
Figure 31. Dorsal (A), ventral (B), and posterior view (C) of a lizard skull. **Abbreviations**—*bo, basioccipital;* **bs,** *parabasisphenoid;* **ect,** *ectopterygoid; eo, exoccipital-opisthotic;* **fr,** *frontal;* **ju,** *jugal;* **la,** *lacrimal;* **mx,** *maxilla;* **na,** *nasal; oc, occipital condyle;* **pal,** *palatine;* **par,** *parietal;* **pmx,** *premaxilla;* **prf,** *prefrontal;* **ps,** *parasphenoid rostrum;* **ptf,** *postfrontal;* **pto,** *postorbital;* **ptr,** *pterygoid; q, quadrate; soc, supraoccipital; sq, squamosal; st, supratemporal; and vo, vomer. Scale equals 10 mm. Modified from de Queiroz (1987).*
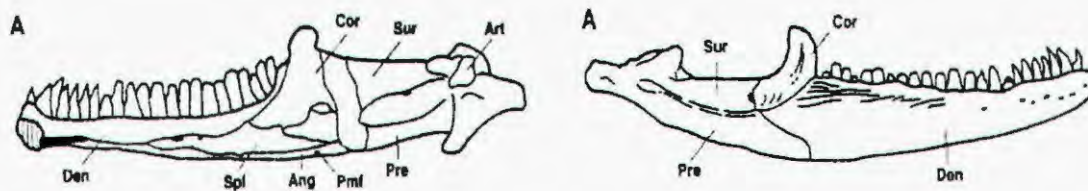
Figure 32. Lingual view (A) and labial view (B) of a lizard mandible. **Abbreviations**— **Ang**, angular; **Art**, articular; **Cor**, coronoid; **Den**, dentary; **Pmf**, posterior mylohyoid foramen; **Pre**, prearticular; **Spl**, splenial; **Sur**, surangular. Modified from de Queiroz (1987).
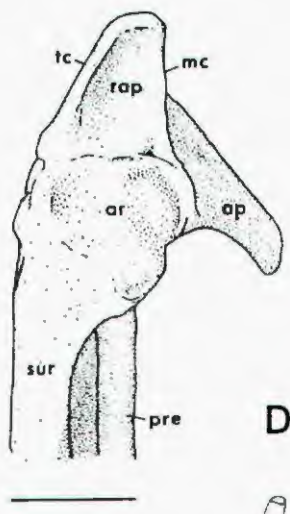
Figure 33. Dorsal view of posterior end of a right mandible. **Abbreviations**—**ap**, angular process; **ar**, articular; **mc**, medial crest; **pre**, prearticular; **rap**, retroarticular process; **sur**, surangular; and **tc**, tympanic crest. Scale equals 0.5 cm. Modified from de Queiroz (1987).
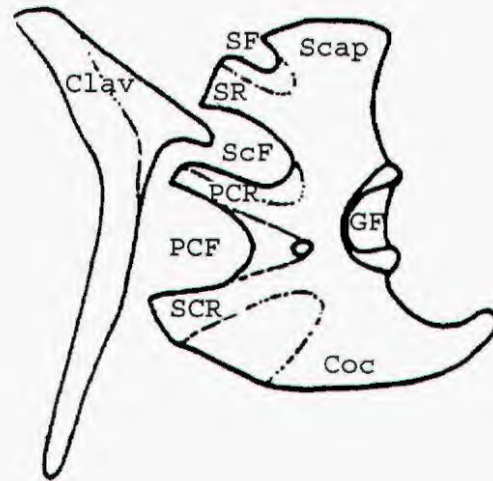
Figure 34. Clavicle and scapulocoracoid of a lizard. *Abbreviations—Clav*, clavicle; *Cor*, coracoid; *GF*, glenoid fossa; *PCF*, primary coracoid fenestra; *PCR*, primary coracoid ray; *Scap*, scapular shaft; *SF*, scapular fenestra; *SR*, scapular ray; *ScF*, scapulocoracoid fenestra; *SCR*, secondary coracoid ray. Modified from Etheridge (1964).
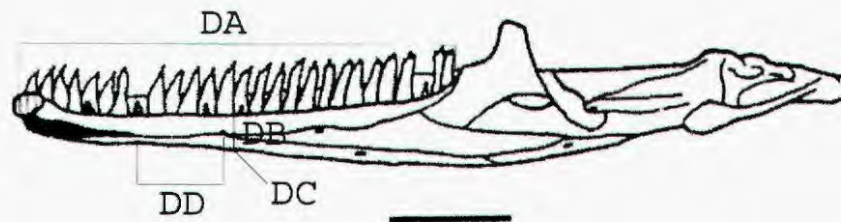
Figure 35. Lingual view of lizard mandible showing measurements discussed in text. DD shows the Meckel's canal. Modified from McGuire (1996). Scale equals 5 mm.
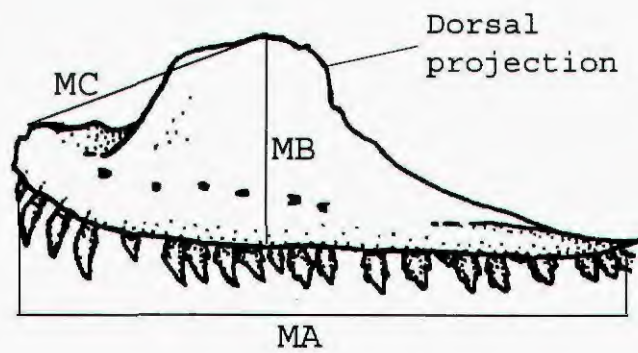
Figure 36. Labial view of a left maxilla showing measurements and structures discussed in text. Modified from de Queiroz (1987).
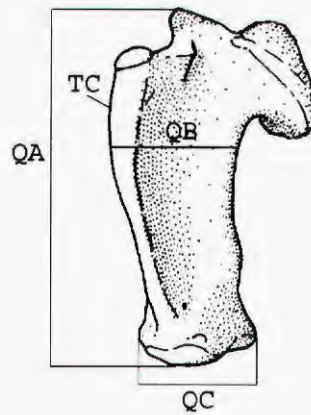
Figure 37. A posterolateral view of the quadrate showing measurements and terms used in text. Modified from de Queiroz (1987).
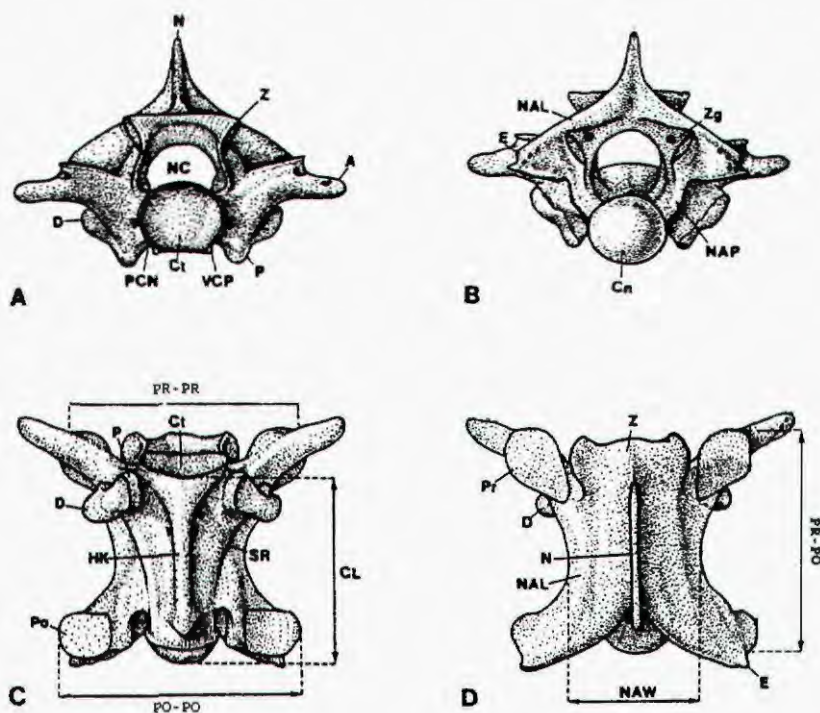
Figure 38. Anterior (A), posterior (B), ventral (C), dorsal (D) view of a snake MTV. **Abbreviations**—*A, accessory process; CL, centrum length; Ct, cotyle; Cn, condyle; D, diapophysis; E, epizygapophyseal spine; HK, hemal keel (hypapophysis); N, neural spine; NAL, neural arch lamina; NAP, neural arch pedical; NAW, neural arch width; NC, neural canal; P, parapophysis; PCN, paracotylar notch; Po, postzygapophyseal facet; PO-PO, width across postzygapophyses; Pr, prezygapophyseal facet; SR, subcentrum ridge; VCP, ventrolateral cotylar process; PR-PO, measurement across the pre- and postzygapophyses; PR-PR, width across prezygapophyses; Z, zygosphene; and ZG, zygantrum. Modified from LaDuke (1991).*

ACCESSORY PROCESS

CRENATE   CONCAVE   CONCAVE WITH
MEDIAN TUBERCLE

CONVEX   NOTCHED CRENATE

ZYGOSPHENE FROM ABOVE

CUNATE   GLADIATE   OBLONG   OBLANCEOLATE   SPATUATE

HAEMAL KEEL
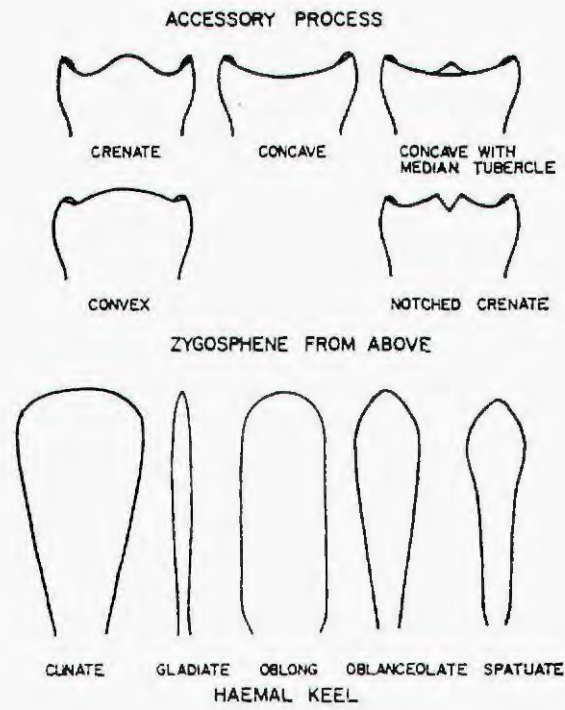
Figure 39. Range of variability in shape of the vertebral structures with terms from the text. Modified from Auffenberg (1963).

Numbers in parentheses specify the number of MHC specimens. Common names and spelling of Latin names of reptiles follow Frank and Ramus (1996), unless otherwise noted.

Class Reptilia

Order Squamata

Suborder Sauria

Family Crotaphytidae

Crotaphytus sp.
Collared lizard

MATERIAL RECOVERED. NAUQSP 14204 [R dentary (TP3-457, 460, 487, 524; TP6-132-33, 136, 138-40, 160, 262), L dentary (TP3-458, 465, 467, 482, 484, 486, 488, 490, 497, 522; TP6-137, 142, 151, 155-6, 159, 180, 260), frontal (TP3-545; TP6-312(2)), R maxilla (TP3-452, 492, 494, 527, 530; TP6-148, 153), L maxilla (TP3-451, 495, 529), parietal (TP3-466, 491, 493; TP6-161, 167, 297), pterygoid (TP3-542; TP6-304, 308(3), 342), surangular, articular, prearticular (TP3-541(2)), surangular and articular (TP6-305)].

C-14 AGE. TP6-132 [right dentary (6,320±40 yr B.P. (Cal BP 7330 to 7230; Beta-145833))]; TP6-133 [right dentary (29,240±350 yr B.P.; not calibrated; Beta-145834))].

DISCUSSION. Several skull elements from *Crotaphytus* were recovered from MHC; the dentary being the most common. Weiner and Smith (1965) and McGuire (1996) describe the osteology of Crotaphytidae. I found no characters on any of the elements that would allow differentiation of the currently accepted nine species of *Crotaphytus*.

The robust dentary of *Crotaphytus* and the fossils have subheterodont, pleurodont dentition. The anterior half of the dentary bears blunt to slightly recurved, unicuspid teeth and the posterior half consists of wide, tricuspid teeth. The dentary of the carnivorous crotaphytine, *Gambelia,* has strongly recurved teeth throughout the dentary. Seventy-five percent of the *Gambelia* toothrow is comprised of unicuspid teeth that grade into a triconodont form. The Meckel's canal of *Crotaphytus* opens medially and constricts at the 8th tooth for about 2-3 tooth spaces (Figs. 40, 41). The Meckel's canal in *Gambelia* remains constricted for about 7-8 tooth spaces, whereas *Crotaphytus* and the fossils show a shorter constriction on the canal. Measurements (toothrow length and depth of dentary at mid-length) indicate no difference in size of the dentary (Weiner and Smith 1965). The number of dentary teeth is the same for both genera (Robison and Tanner 1962). *Crotaphytus* can be differentiated from other lizards by dentition. Many sceloporines (Phrynosomatidae) show a similar dentition pattern (unicuspid anterior and tricuspid posterior); however, the teeth in even the largest species of *Sceloporus* (*S. magister* and *S. poinsettii*) show slender, pillar-like teeth versus the wide, blunt to recurved dentition of the crotaphytines and the fossils.

The maxilla of *Crotaphytus* and the fossils extends caudally at a constant angle to where it articulates with the jugal at the anterior portion of the orbit. The maxilla and jugal flare out, terminating in a prominent lateral projection. The dorsal projection of the nasal process of the maxilla is square in shape at the contact between the nasal and prefrontal bones. McGuire (1996) noted that the transition from unicuspid to tricuspid teeth typically starts about the 8th tooth space from the anterior part of the maxilla. The shape of the external nares differs in *Crotaphytus* and *Gambelia*, creating a diagnostic feature found on the maxilla. The shape of the nares creates a right angle on the maxilla in *Crotaphytus* and the fossils and an obtuse angle in *Gambelia*. The portion of the maxilla contacting the prefrontal and nasal bones is square in *Crotaphytus* and the fossils versus rounded in *Gambelia*. Robison and Tanner (1962) found significantly lower tooth space counts on the maxilla for *Crotaphytus*. However, the MHC *Crotaphytus* sp. specimens did not exhibit significantly lower maxillary tooth space counts, which may reflect the small sample size (Table 46).

Table 46. Maxillary tooth space counts for Crotaphytus *sp. and* Gambelia *sp.*

Source	Crotaphytus *sp.*	Gambelia *sp.*
MHC	18-21 (n=6)	17 (n=1)
Weiner and Smith (1965)	14-20 (n=29)	17-22 (n=36)
McGuire (1996)	14-22 (n=49)	15-24 (n=45)

Figure 40. Lingual view of a fossil (TP6 138; top left) and modern (NAUQSP-JIM 99; top right) Crotaphytus *right dentary. Lingual view of a fossil (TP3 494; bottom left) and modern (NAUQSP-JIM 99; bottom right) right maxilla of* Crotaphytus. *Scale equals 10 mm.*

Figure 41. Lingual view of fossil (TP6 164; top left) and modern (NAUQSP-JIM 112; top right) left dentary of Gambelia. *Lingual view of a modern left maxilla of* Gambelia *(NAUQSP-JIM 112; bottom right). Scale equals 10 mm.*

The frontal constricts medially and connects to the parietal posteriorly, forming the dorsomedial portion of the orbit, and contacts the prefrontals and nasals anteriorly. The frontal of *Crotaphytus* and the fossils is strongly convex which partly gives the skull of *Crotaphytus* its height. Supraorbital ridges are present. *Gambelia* differs from *Crotaphytus* by having a flat frontal and lacking supraorbital ridges (Figs. 42, 43). The frontal of the larger *Sceloporus* species is flat, more robust, and possesses no supratemporal ridges, but ridges are present on the posterior edge of the frontal. The frontal of Teiidae and Scincidae does not show such an exaggerated hourglass shape.

The parietal represents a major element of the skull roof and is trapezoidal in shape with short anterolateral processes and long posterolateral supratemporal processes. In *Crotaphytus*, the parietal constricts at the posterior border of the parietal shelf.

The supratemporal processes of *Crotaphytus* are robust, project dorsally, and have concave lateral faces (McGuire 1996). Parietals of *Crotaphytus* differ from *Gambelia* in the degree of constriction of the posterior border of the parietal shelf. The posterior edge of the parietal constricts more in *Crotaphytus*. The supratemporal processes of *Gambelia* are well developed anteriorly but quickly taper posteriorly, whereas in *Crotaphytus* no tapering occurs (McGuire 1996). The MHC parietals share the characteristics of *Crotaphytus* parietals (Figs. 42, 43). The parietals differ from other lizard families by size and shape. The size is comparable to the crotaphytids or large sceloporines. The posterior border of the parietal shows little constriction and the posterior ridges are less defined in the large species of *Sceloporus*. The supratemporal processes of *Sceloporus magister* or *S. poinsettii* are laterally produced, creating a much wider angle than the crotaphytids.

Figure 42. Dorsal view of a modern (NAUQSP-JIM 99; top left) and fossil (TP6 312; top right) frontal of Crotaphytus *sp. Dorsal view of modern (NAUQSP-JIM 99; bottom left) and fossil (TP6 297; bottom right) parietal of* Crotaphytus *sp. Scale equals 10 mm.*

Figure 43. Dorsal view of a fossil (TP6 311; top left) and modern (NAUQSP-JIM 111; top right) frontal of Gambelia. *Dorsal view of a modern* Gambelia *parietal (NAUQSP-JIM 112; bottom right). Scale equals 10 mm.*

The pterygoid, located on the ventral side of the skull, has a long posterior process connecting to the quadrate, transverse process reaching the ectopterygoid, and anteriorly meets the palatine. In *Crotaphytus*, the transverse process of the pterygoid shows a vertical crest where the pterygoid and ectopterygoid meet. This crest is absent or weak in *Gambelia*. The quadrate processes on the pterygoid are typically shorter in *Gambelia* (McGuire 1996). The MHC pterygoids strongly resemble *Crotaphytus* with the above characteristics (Figs. 44, 45). The transverse process in Teiidae and Scincidae is not as laterally produced. Only one (TP6-304) of the MHC pterygoids has two rows of teeth, the rest have one. *Crotaphytus* (as all Crotaphytidae) possesses the primitive character of pterygoid teeth, as do members in Teiidae and Scincidae. In contrast, *Sceloporus* and other phyrnosomatids do not possess pterygoid teeth.

The mandible is comprised of the dentary, coronoid, splenial, angular, surangular, articular, and prearticular. In Crotaphytidae, the surangular, articular, and prearticular contribute to the most posterior portion of the mandible. The surangular is dorsally located and bears a medial process just anterior to the articular and large lateral process anterolateral from the articular. A ridge occurs on the dorsolateral face of the surangular and extends anteriorly to the coronoid. The articular (roughly oval in shape) articulates with the quadrate. The prearticular possesses two large, posteriorly positioned processes. The angular process, ventral to the articular, is medially directed while the retroarticular process projects posteriorly. The tympanic crest associated with the retroarticular process is roughly triangular in lateral view and expanded posteriorly. The tympanic crest is almost as broad as the retroarticular process and is angled, producing a twisted form (McGuire 1996). A thin piece of bone connects the retroarticular process to the angular process in *Gambelia*, not seen in *Crotaphytus*. McGuire (1996) emphasizes the importance of a dorsal lateral ridge in distinguishing between the two species. The dorsolateral ridge of the surangular that extends anteriorly to the coronoid is present in *Crotaphytus* but absent or weakly developed in *Gambelia*. The surangular, articular, and prearticular are articulated in TP3-541 and the surangular and articular are articulated in TP6-305. TP6-305 and TP3-541 resemble *Crotaphytus*, displaying the above characters (Figs. 44, 45). The surangular, articular, and prearticular differ in the large species of *Sceloporus* in that no lateral process of the surangular exists. The retroarticular process of the prearticular is less robust than the crotaphytines. The tympanic crest in *Sceloporus* is not expanded posteriorly and the articular appears more rounded than oval.

HABITAT. McGuire (1996) recognizes nine species of *Crotaphytus, C. antiquus, C. bicinctores* (Mojave black collared), *C. collaris* (eastern collared), *C. dickersonae* (Dickerson's collared), *C. grismeri* (Grismer's collared), *C. insularis* (black collared), *C. nebrius* (Sonoran collared), *C. reticulatus* (reticulate collared), and *C. vestigium* (Baja black collared). *Crotaphytus bicinctores* lives near MHC today and *C. collaris* and *C. grismeri* are distributed the next closest, occurring in Arizona, some 600 km away.

Crotaphytus bicinctores inhabits rocky terrain in canyons where the vegetation is sparse. This species ranges from southeastern Oregon and adjacent Idaho, through Nevada and western Utah to western Arizona, and into southeastern California (McGuire 1996).

Figure 44. Medial view of fossil (TP3 541; top left) and modern (NAUQSP-JIM 100; top right) surangular, articular, and prearticular of Crotaphytus *sp. Ventral view of fossil (TP3 542; bottom left) and modern (NAUQSP-JIM 99; bottom right) pterygoid of* Crotaphytus *sp. Scale equals 10 mm.*

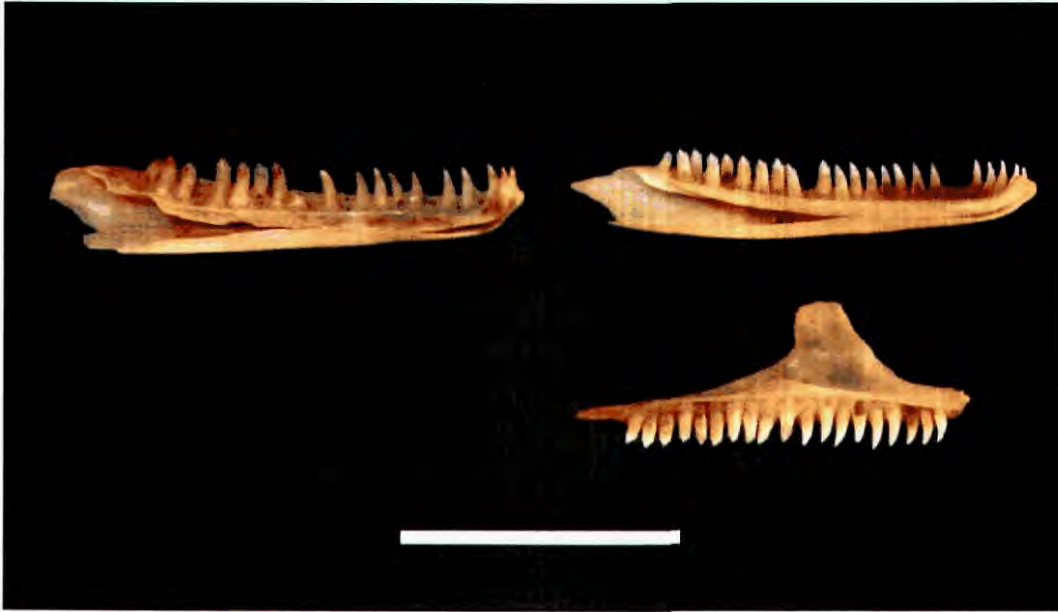*Figure 45. Medial view of a modern* Gambelia *surangular, articular, and prearticular (NAUQSP-JIM 112; top right). Ventral view of MHC fossil (TP6 307) and modern (NAUQSP-JIM 112)* Gambelia *pterygoid. Scale equals 10 mm.*

cf. *Crotaphytus*

MATERIAL RECOVERED. NAUQSP 14205 [L partial dentary (TP6-154), R juvenile dentary (TP3-549), R maxilla (TP3-471, 532; TP6-144, 263), L maxilla (TP3-454, 475, 528, 534; TP6-177), R juvenile maxilla (TP3-552)].

DISCUSSION. TP3-532 and TP6-263 consists only of the anterior portion of the right maxilla. The area where the nares and the maxilla make contact forms a right angle like *Crotaphytus*. TP3-534 has no teeth and the dorsal projection was broken but the nares-maxilla contact resembles *Crotaphytus*. In the other incomplete fossil specimens, the dentition resembled *Crotaphytus*. The fragmentation of these fossils did not allow a positive *Crotaphytus* identification, because it is the combination of characters that allows positive generic identification.

TP3-549 and TP3-552 share *Crotaphytus* characters; however, the dentary and maxilla could not be compared to a juvenile *Gambelia*; therefore, a positive generic identification was not possible.

Gambelia sp.
Leopard lizard

MATERIAL RECOVERED. NAUQSP 14206 [L dentary (TP3-461, 521, 524; TP6-164), R dentary (TP3-485, 525; TP6-134-35, 150, 165, 171), frontal (TP6-311, 336), L maxilla (TP6-152), pterygoid (TP6-307(2))].

DISCUSSION. Characters of the dentaries, maxilla, pterygoids, and frontals of *Gambelia* were described above in comparison to *Crotaphytus* (Figs. 40-45). Diagnostic characteristics of the three *Gambelia* species were not found, partly due to the lack of comparative material from southern California, where two of the three species are distributed.

HABITAT. McGuire (1996) recognizes three living species of *Gambelia*: *G. copei* (Cope's leopard lizard), *G. silus* (blunt-nosed leopard lizard), and *G. wislizenii* (long-nosed leopard lizard). *Gambelia copei* and *G. silus* live in southern California. *Gambelia wislizenii* lives near MHC today and throughout the Southwest, California, and the Great Basin, living in semiarid regions where the soil is sandy or gravelly and the vegetation is sparse (McGuire 1996).

cf. *Gambelia*

MATERIAL RECOVERED. NAUQSP 14207 [L maxilla (TP6-178), premaxillae (TP3-544, 696; TP4-78)].

DISCUSSION. TP6-178 displays thin, recurved teeth; however, the posterior portion and the dorsal projection of the maxilla are broken. The fragmentation of this fossil does not allow for a positive identification.

The dental platform of the premaxilla of *Gambelia* is typically rectangular in shape. The teeth are unicuspid and taper to a point. The projecting nasal process is long and slender. A strong vertical ridge occurs at the anteromedial portion of the alveolar shelf where the premaxilla and vomers meet (McGuire 1996). The MHC premaxillae display a rectangular base, which is typically found in *Gambelia*; however, variation in *Crotaphytus* creates uncertainty in the identification. *Crotaphytus* typically displays a trapezoid premaxillary base (McGuire 1996). The nasal process of the premaxilla is present on TP4-78 but broken on TP3-544. McGuire (1996) states that the nasal process is broad in most species of *Crotaphytus*. Examination of modern comparative material shows much variation between the two genera. *Sceloporus* bears pillar-like teeth in the premaxilla; the MHC specimens have tapered, unicuspid teeth.

Crotaphytidae gen. et sp. indet.

MATERIAL RECOVERED. NAUQSP 14208 [R dentary (TP3-462, 558, 560, 561, 567; TP6-317), R juvenile dentary (TP3-565, 587; TP6-316), L dentary (TP3-450, 557), L juvenile dentary (TP3-553), L partial dentary (TP3-496), ectopterygoid (TP3-543; TP4-77(2); TP6-309(2)), R femur (TP6-170), L femur (TP3-499; TP6-299), R humerus (TP6-302(2)), jugal (TP3-540(2); TP4-74; TP6-303(2)), R maxilla (TP3-453, 468, 563, 566; TP6-239), L maxilla (TP3-526, 531, 559, 562, 564; TP6-145, 179, 318), R partial maxilla (TP3-573-574, 591, 593), R juvenile maxilla (TP3-550-51, 556, 583; TP6-315), L juvenile maxilla (TP3-554), partial maxilla (TP6-329), parietal (TP6-149(2)), postorbital (TP6-310(2)), pterygoid (TP4-76), quadrate (TP3-523, 533), surangular, articular, and prearticular (TP6-335)].

DISCUSSION. The incomplete juvenile and adult maxillae and dentaries show no defining characters for differentiating *Gambelia* and *Crotaphytus*. They do represent Crotaphytidae because they present wide teeth with slight recurvature in some specimens. Although the cusps are worn on some specimens, no other North American lizard group displays such wide, blunt to recurved teeth.

The ectopterygoids connect the pterygoid to the jugal and maxilla. The dorsal portion of the ectopterygoid has a transverse ridge extending to the end of the medially projecting process. The ridge has a posterior projection in *Crotaphytus* that overlaps the vertical crest of the transverse process of the pterygoid. *Gambelia* does not show the posterior projection (McGuire 1996). I did not find this character consistent among comparative specimens, and therefore, could not further the identification. The ectopterygoids of crotaphytines and the fossils differ from *S. magister* or *S. poinsettii* by having an additional process connecting to the maxilla and jugal.

The femur of Crotaphytidae and the fossils shows a strong curvature in the shaft. The size of the femur is comparable to the larger *Sceloporus* species; however, this shaft curvature is not seen in the larger sceloporines.

TP6-302 strongly resembles the humerus of a crotaphytid because of the large size and the presence of a foramen on the posterior end. *Sceloporus* does not have this foramen. Teiidae does have this foramen, but it is much deeper.

The jugal forms the ventral portion of the orbit and is connected anteriorly to the lacrimal and prefrontal, anteroventrally with the maxilla, medially to the ectopterygoid, and posterodorsally to the postorbital and squamosal. McGuire (1996) notes that a lateral ridge on the jugal occurs more strongly in *Crotaphytus* than *Gambelia*. This character appeared to be inconsistent among the comparative specimens, inhibiting further identification. The jugal of crotaphytines and the fossils differs from other sceloporines by possessing an enlarged tubercle posterior to the maxillary toothrow. The shape of the jugal differs as well. The portion of the jugal from the tubercle to the postorbital shows more curvature in Crotaphytidae than *Sceloporus*.

The MHC parietals and surangular, articular, and prearticular shared some of the above characteristics (see previous section on *Crotaphytus* sp.) but were too incomplete for generic designation.

Postorbitals of crotaphytines and the fossils are triangular with a tubercle on the anterolateral surface. The postorbital contacts the jugal anterolaterally, frontal and parietal medially, and squamosal posteriorly. McGuire (1996) only notes this tubercle in *Gambelia*, but I observed this tubercle in both species. The larger species of *Sceloporus* do not have this tubercle.

The incomplete pterygoid could not be identified to one genus but does represent Crotaphytidae. See the *Crotaphytus* species section for differentiating Crotaphytidae from other lizard families.

Crotaphytine and the fossil quadrates have a straight-edged tympanic crest, giving an overall square appearance. Weiner and Smith (1965) state that *Gambelia* has a narrower lateral conch and the ridge separating the lateral and medial conch is positioned more vertically. I found this character to be inconsistent among comparative specimens, and therefore, no attempt was made to differentiate between the two species. *Phrynosoma* shows a straight edged crest as well; however, the crest is narrower than that on the crotaphytines. Other sceloporines have curved tympanic crests (Mead et al. 1999a). The tympanic crest of a Teiidae is C-shaped while in Scincidae it forms a deep depression (Fig. 46).

Figure 46. Posterior view of a quadrate from MHC (TP3 523; left), Crotaphytus *(NAUQSP-JIM 108),* Sceloporus *(NAUQSP-JIM 186), Teiidae (NAUQSP-JIM 273; right), Scincidae (NAUQSP-JIM 334), and* Phrynosoma *(NAUQSP-JIM 1035). Scale equals 10 mm.*

Family Phrynosomatidae

Phrynosoma platyrhinos
Desert horned lizard

MATERIAL RECOVERED. NAUQSP 14209 [L dentary (TP3-456; TP6-257, 258, 259), R dentary (TP6-175, 256), R maxilla (TP3-470; TP6-313-14), L maxilla (TP3-518), parietal (TP6-141, 143), squamosal (TP6-298(4))].

DISCUSSION. Presch (1969) and Montanucci (1987) provide detailed descriptions of the osteology of *Phrynosoma*. Dentaries (the most common element), maxillae, squamosals, a surangular, and scapulocoracoids of *Phrynosoma* were recovered from MHC. I cautiously follow Zamudio et al. (1997) in separating the *P. douglasi* (spelling follows Hammerson and Smith (1991)) group into two species, *P. hernandezi* (mountain short horned lizard) and *P. douglasi* (pigmy short horned lizard), a distinction that is based on molecular systematics. I am unable to differentiate the skeletons of *P. douglasi* and *P. hernandezi* based on skeletal morphology.

Phrynosoma dentaries are deep, ventrally flattened, and show a strong anterior-posterior curvature. The strongly angled ventrolateral surface may appear smooth or rugose/undulating. The peg-like teeth expand at the base. The unfused Meckel's canal is medially positioned and constricts medially

in some species. The ventrolateral surface of the dentary is rounded and smooth in *P. coronatum* (coast horned lizard) and *P. hernandezi/douglasi*. This surface is more angled with protuberances in *P. cornutum* (Texas horned lizard), *P. mcallii* (flat-tailed horned lizard), *P. modestum* (round-tailed horned lizard), *P. platyrhinos* (desert horned lizard), and *P. solare* (regal horned lizard) (Presch 1969; Montanucci 1987). The dentaries from MHC resemble the latter group in displaying an angled surface with protuberances and show no medial constriction of the Meckel's canal, resembling *P. platyrhinos*, *P. mcallii*, and *P. cornutum*. The dentary of *P. platyrhinos* differs from *P. mcallii* and *P. cornutum* by exhibiting a stronger curvature, especially anteriorly, with less pronounced protuberances. The fossils exhibit the above characteristics for *P. platyrhinos*. The above characters differentiate dentaries of *Phrynosoma* and the fossils from those of other sceloporines (Fig. 47).

The maxilla of *Phrynosoma* has a dorsal projection, which follows the nares anteriorly and reaches the prefrontal or nasal bone dorsally. The dorsal projection comes to a point in *Phrynosoma*. Medially, the maxilla bears a flange, which articulates with the palatine. This medial flange curves upward to varying degrees. The peg-like teeth expand at the base (Fig. 47). The differences of the maxilla within *Phrynosoma* partly occur because of the shape of the nares and whether or not the nasal process of the maxilla touches the nasal bones. In *P. coronatum* and

P. *hernandezi/douglasi*, the nasal process reaches the maxilla. The prefrontal separates the two bones in *P. cornutum, P. mcallii, P. modestum, P. platyrhinos,* and *P. solare* (Fig. 48; Montanucci 1987). The connection of these two elements forms a 90° angle at the anterior portion of the maxilla adjacent to the nares in *P. coronatum* and *P. hernandezi/douglasi* while the separation of the two elements produces a greater than 90° angle in *P. cornutum, P. mcallii, P. modestum, P. platyrhinos,* and *P. solare.* The medial flange of the maxilla that adjoins to the palatine curves dorsally in *P. platyrhinos, P. hernandezi/douglasi,* and *P. coronatum.* The other North American *Phrynosoma* species show a less curved to flattened flange. Robinson and Van Devender (1973) and Bell (1993) provide maxillary tooth space counts and mention the presence/absence of a maxillary labial ridge for some *Phrynosoma* species. The tooth space counts show overlap

between species, and therefore, are not useful for species identification. Bell (1993) noted the presence of a weak to strong labial ridge in the following *Phrynosoma* species: *P. cornutum* (absent-weak), *P. coronatum* (weak-moderate), *P. hernandezi/douglasi* (absent), *P. platyrhinos* (moderate-strong), and *P. solare* (weak-strong). *Phrynosoma platyrhinos* and the MHC fossils show the following characteristics: (1) the anterior portion of the maxilla adjacent to the nares forms a greater than 90° angle; (2) the medial flange, abutting the palatine, curves upward; and (3) moderate to strong labial ridge. TP3-470 has 14 tooth spaces and a strong labial ridge while TP3-518 has 12 tooth spaces and a moderate labial ridge. Typically, sceloporines have a squarish dorsal projection, a flat medial flange, and pillar-like unicuspid to tricuspid teeth.

Figure 47. Lingual and dorsal view of a fossil (TP6 256; top left) and modern (NAUQSP-JIM 1035; top right) Phrynosoma platyrhinos *dentary. Lingual view of fossil (TP6 314; bottom left) and modern (NAUQSP-JIM 1035; bottom right)* P. platyrhinos maxilla. *Scale equals 10 mm.*
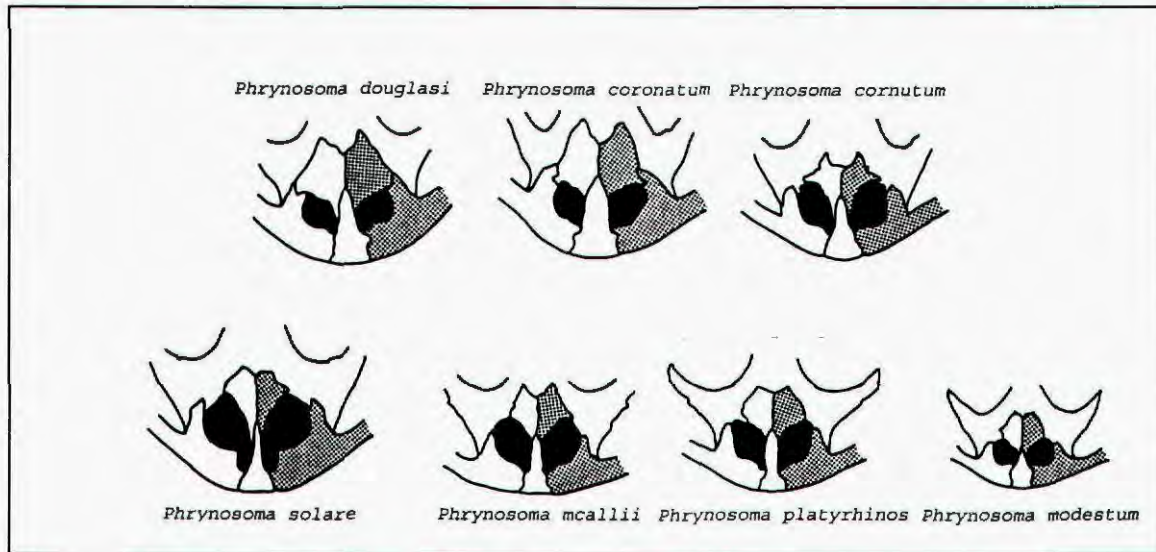
Figure 48. Variation in the arrangement of the nasal, maxilla (both stippled), and prefrontal among Phrynosoma *sp. Modified from Montannucci (1987).*

Ornamentation, in the form of tubercles, enlarged scales, and lateral horns, is present on the parietal surface in all North American species of *Phrynosoma,* but not in the other members of Phrynosomatidae, Crotaphytidae, Teiidae, and Scincidae. The parietal surface has two or more tubercles in *P. hernandezi/douglasi,* are longer and spine-like in some *P. coronatum, P. cornutum,* and *P. solare,* and low and rugose in *P. mcallii, P. modestum, P. platyrhinos,* and the fossils (Fig. 49; Montanucci 1987).

Most species of *Phrynosoma* have enlarged scales at the dorsolateral base of the lateral horns on the parietal; one of which is enlarged in *P. modestum, P. mcallii,* and *P. platyrhinos,* especially in the latter two species (Montanucci 1987; Norell 1989). In *P. platyrhinos* and the fossils, the parietal surface consistently bears seven major tubercles, a medial tubercle between the two lateral horns, a tubercle on the dorsolateral base of the lateral horns, a smaller tubercle on each dorsolateral side of the parietal anterior to the basal tubercle of each lateral horn, and two enlarged tubercles near the center of the parietal (Jenkins and Tanner 1968).

Figure 49. Dorsal view of a modern (NAUQSP-JIM 1035; left) and MHC fossil (TP6 143; right) parietal of Phrynosoma platyrhinos. *Scale equals 10 mm.*

In all species of *Phrynosoma*, the posterior parietal edge bears lateral horns. Except in *P. hernandezi/douglasi*, the lateral horns in *Phrynosoma* are well developed and vary in size and length, projecting posteriorly at varying angles (Presch 1969). Geographic variation in horn length occurs in species with significant latitudinal distributions, especially *P. hernandezi/douglasi* and *P. coronatum* (Montanucci 1987). Four horns may occur in *P. solare, P. modestum,* and *P. hernandezi/douglasi*, but only *P. solare* possesses an additional well-developed pair. A small median horn occurring between the two lateral horns is present in some species but is especially large in *P. coronatum* and *P. cornutum*. This median horn may appear as a small, oblique horn in some *P. mcallii, P. platyrhinos,* and is apparent on the fossils (Norell 1989). *Phrynosoma platyrhinos* and *P. mcallii* possess many similar parietal attributes. They differ in lateral horn length; *P. platyrhinos* and the fossils bear shorter horns (as described by Montanucci, 1987) and the horns are directed slightly more posteriorly and laterally forming more of a U-shape (vs. V-shape). TP6-141 and 143 strongly resemble modern *P. platyrhinos* parietals portraying the above characters.

Unique to *Phrynosoma*, squamosal horns differ in the relative size and number within

Phrynosoma. Two or three horns are found in *P. hernandezi/douglasi* and *P. coronatum* while *P. modestum* and *P. solare* possess four horns. The remaining species show three sagitally aligned horns with a smaller anterior horn. In *P. mcallii* and *P. cornutum*, the two large posterior horns are the same size. The horns are equidistant in *P. platyrhinos* and *P. mcallii* and decrease in size anteriorly in *P. platyrhinos*. In *P. cornutum* and *P. hernandezi/douglasi*, the anterior two horns join at the base. *Phrynosoma coronatum, P. mcallii,* and *P. cornutum* display dorsal accessory horns (Norell 1989). TP6-298 strongly resembles modern *P. platyrhinos* squamosal by exhibiting the following characteristics: three squamosal horns, which equidistantly decrease in size anteriorly and are not joined at the base.

HABITAT. The North American species consist of *P. platyrhinos, P. hernandezi, P. douglasi, P. solare, P. cornutum, P. coronatum, P. mcallii,* and *P. modestum. Phrynosoma platyrhinos* is the only species that lives near MHC today. *Phrynosoma platyrhinos* occurs in the desert valleys and foothills throughout much of the Great Basin and into southeastern Oregon, western Arizona, northwestern Sonora, southeastern California, and northeastern

Baja California. *Phrynosoma platyrhinos* is found within diverse plant communities (*Artemisia, Atriplex, Sarcobatus,* and *Larrea*) and inhabits sandy, gravelly soil in arid areas where rocks and scrub are present, feeding mostly on ants (Tanner and Krogh 1973; Behler and King 1998).

Phrynosoma platyrhinos/modestum
Desert /Round tailed horned lizard

MATERIAL RECOVERED. NAUQSP 14212 [Articulated surangular, articular, and prearticular (TP6-261)].

DISCUSSION. The surangular, articular, and prearticular contribute to the posterior portion of the mandible. The prearticular, fused to the articular, forms the postero-medial part of the mandible and projects a robust, rectangular process posteriorly. The articular articulates with the quadrate. The surangular, forming the lateral wall of the mandible, is the more diagnostic bone. The lateral portion of the surangular may be convex or angular and smooth or rugose. Lateral horns may occur, creating a continuous row with those of the dentary (Precsh 1969). The lateral surface of the surangular is smooth and convex in *P. coronatum* and *P. hernandezi/douglasi.* Two to four laterally directed horns on the outer surface of the surangular occurs in *P. cornutum, P. mcallii, P. modestum, P. platyrhinos,* and *P. solare* (Montanucci 1987). *Phrynosoma modestum* and *P. platyrhinos* possess two horns, although *P. modestum* can have three horns. TP6-261, referred to as *P. platyrhinos/modestum,* displays two horns.

HABITAT. *Phrynosoma modestum* lives in southeastern Arizona, southern New Mexico, and west Texas, inhabiting sandy washes and scrub areas (Behler and King 1998). This lizard does not live near MHC today. See the *P. platyrhinos* discussion for habitat.

Phrynosoma cf. *platyrhinos*

MATERIAL RECOVERED. NAUQSP 14210 [Incomplete parietal horns (TP6-157(3))].

DISCUSSION. TP6-157 was identified using the criteria mentioned above on the parietal horns and tuberosities of *P. platyrhinos*; however, due to the incomplete nature of the parietal, absolute specific determination was impossible.

Phrynosoma hernandezi/douglasi
Mountain/Pigmy short-horned lizard

MATERIAL RECOVERED. NAUQSP 14213 [L maxilla (TP3-546)].

DISCUSSION. TP3-546 shows the following characteristics: (1) the anterior portion of the maxilla adjacent to the nares forms a 90° angle; (2) the medial flange, abutting the palatine, curves upward; and (3) a weak labial ridge. The fossil has 18 tooth spaces (Fig. 50). See the *Phrynosoma platyrhinos* section for the description of the maxilla for the North American *Phrynosoma.*

HABITAT. *Phrynosoma douglasi* inhabits eastern Washington and Oregon to Idaho, northern California and Nevada. *Phrynosoma hernandezi* ranges from Montana to northern Mexico and from eastern Nevada to west Texas. These two species typically inhabit mesic, forested/woodland areas up to 2700 m (Fig. 51; Zambudio et al. 1997; Behler and King 1998). Although most distribution maps show *P. douglasi* occurring not as far south as MHC (Reeve 1952; Behler and King 1998), Lindsdale (1938) notes the presence of *P. douglasi* in Elko County. Neither species lives near the cave today.

Figure 50. Lingual view of a fossil (TP3 546; top) and modern (NAUQSP 6723; bottom) Phrynosoma hernandezi/douglasi left maxilla. Scale equals 10 mm.
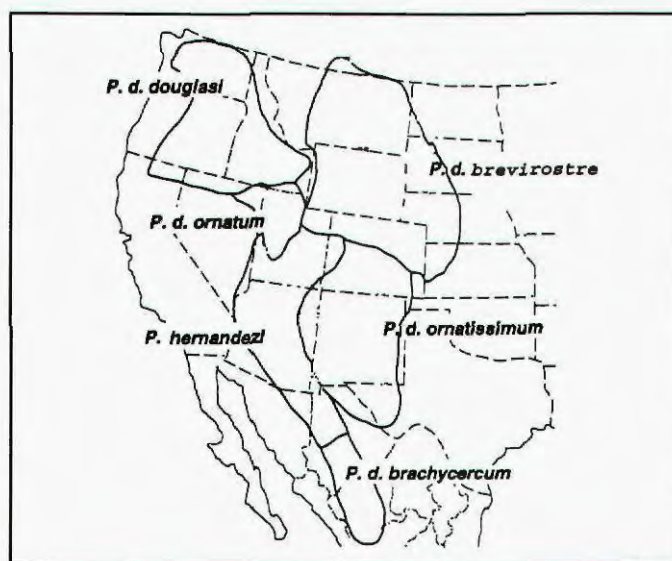
Figure 51. Distribution map of Phrynosoma hernandezi and the subspecies Phrynosoma douglasi. Modified from Zamudio et al. (1997).

Phrynosoma sp.

MATERIAL RECOVERED. NAUQSP 14211 [L dentary fragment (TP3-519), L maxilla fragment (TP3-520, 547), broken horns of parietal (TP3-535; TP4-73), scapulocoracoid (TP6-296(2))].

DISCUSSION. TP3-519-20, 535, 547 and TP4-73 were too fragmentary for identification to species.

The scapulocoracoid is a composite bone consisting of the scapula and coracoid and is a robust bone in *Phrynosoma*. *Phyrnosoma* possesses a large scapulocoracoid fenestra between the scapular ray, which is short or entirely absent, and primary coracoid ray. A primary coracoid fenestra is present between the primary and secondary coracoid rays. The scapular and secondary coracoid fenestrae are absent in *Phrynosoma*. Other sceloporines, such as *Uta* and *Urosaurus*, will show this pattern as well, but with thin, bony fills (Etheridge, 1964). *Phrynosoma* and TP6-296 differ in having a very robust, heavy scapulocoracoid with the above characteristics. Identification to species was not possible.

"Sceloporine" taxa
Sceloporine Type A

MATERIAL RECOVERED. NAUQSP 14216 [R dentary (TP3-680, 686; TP6-176), L dentary (TP3-681, 687-688), R maxilla (TP3-682, 685), L maxilla

(TP3-679), L partial maxilla (TP3-625, 683-684), quadrate (TP3-689(3))].

DISCUSSION. Living sceloporines form a monophyletic group consisting of ten genera and 105 species, 80 of which live in North America (Sites et al. 1992; Wiens and Reeder 1997). Four generic groups exist within the extant sceloporines: (1) the *Petrosaurus* (rock lizards) group; (2) the *Sator* (sators)-*Sceloporus* (spiny lizards)-*Urosaurus* (tree lizards)-*Uta* (side-blotched lizard) group (the "*Sceloporus* group"); (3) the sand lizard group including *Callisaurus* (zebra-tailed lizard), *Cophosaurus* (earless lizards), *Holbrookia* (earless lizards), and *Uma* (fringe-toed lizards); and (4) the *Phrynosoma* group (Fig. 52; Etheridge and de Queiroz 1988). Difficulties arise when identifying the sceloporines using isolated skeletal elements because no adequate, consistent osteological characters permit generic differentiation within the sceloporines except for *Phrynosoma* (Larsen and Tanner 1974; Wellstead 1982; Norell 1989; Mead et al. 1999b). Therefore, the fossils could only be referred to as Type A, B, and C, and differentiation between them is based on size and morphology. The snout-vent length of Type A is approximately 35-55 mm, Type B is 60-70 mm, and Type C measures about 95 mm.
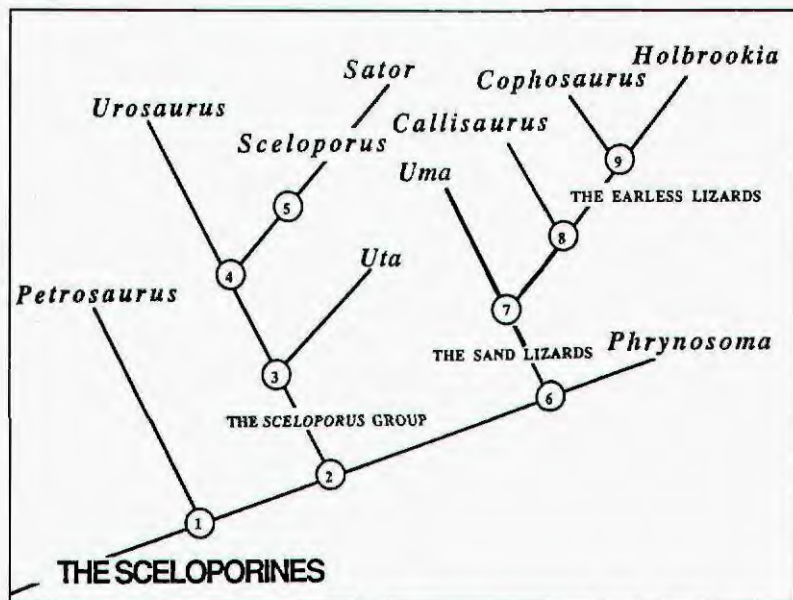
Figure 52. Relationships of the sceloporine iguanid lizards. Taken from Etheridge and de Queiroz (1988).

Robinson and Van Devender (1973), Norell (1989), and Mead et al. (1999b) provide dental morphological descriptions for the different genera of sceloporines. *Uta, Urosaurus, Holbrookia*, and some small *Sceloporus* species can be indistinguishable. Typically, the small *Uta* has high crowned, weakly tricuspid teeth that widen at the bases and taper distally. *Urosaurus* can show recurved, conical anterior teeth to straight to slightly recurved, tricuspid posterior teeth. *Holbrookia* bears cone-shaped, weakly tricuspid teeth with expanded bases. Small *Sceloporus* species generally have straight pillar-like teeth that are tricuspid posteriorly. The dentary of *Urosaurus* and *Holbrookia* curves more from posterior to anterior in comparison to *Uta* or *Sceloporus*.

Small, delicate dentaries and maxillae with high crowned teeth were assigned to Sceloporine Type A. In most of the MHC specimens, the pillar-like teeth are posteriorly tricuspid. The small lateral cusps abut the relatively large, pointed median cusp. The dentaries are straight and thin. The unfused Meckel's canal constricts medially. The anterior portion of the dentary ends bluntly. These traits most closely resemble *Uta stansburiana* or a small *Sceloporus*. Three specimens (TP3-686-688) differ from the other Type A fossils by possessing cone shaped, unicuspid teeth. Furthermore, the dentary tapers anteriorly to a point. These traits also compare well with *Uta stansburiana*. Similar patterns of variation are seen in modern specimens of *Uta stansburiana* (Fig. 53). The maxillae are too fragmented for descriptions beyond these dental observations.

The Type A fossils most closely resemble *Uta* or *Sceloporus* (*S. graciosus* was used for comparison; it lives near MHC today). The teeth of the fossils show no recurvature as in *Urosaurus* and no posterior-anterior curvature as seen in *Urosaurus* and *Holbrookia*. More than one genus might be represented in Type A. Since no consistent osteological characters occur, reference of Type A to a lower taxon level could not be justified.

The quadrates resemble a small sceloporine. The fossil quadrates have a curved tympanic crest and represent a lizard with a snout-vent length of approximately 50 mm. See the Crotaphytidae section for quadrate description of different taxa.

HABITAT. *Uta stansburiana* and *Sceloporus graciosus* live near MHC today. *Uta stansburiana* ranges throughout the Great Basin, the southern half of California, western Arizona, southern New Mexico, and west Texas. This lizard lives in arid to semiarid areas with gravelly soil and low vegetation. *Sceloporus graciosus* can be found in the Great Basin, into northern California, Oregon, southern Washington, western Wyoming and Colorado, living in sagebrush country with gravelly soils or sand dunes. The closest *Urosaurus* (*U. graciosus*) can be found in southern Nevada while the nearest *Holbrookia* (*H. maculata*) occurs in northwestern Arizona (Behler and King 1998).

Figure 53. Right dentaries of MHC fossil Sceloporine Type A (TP6 680; top left and TP6 686; middle left), Uta stansburiana *(NAUQSP-JIM 117; bottom left),* Sceloporus graciosus *(NAUQSP-JIM 1080; top right),* Holbrookia maculata *(NAUQSP-JIM 112; middle right), and* Urosaurus ornatus *(NAUQSP-JIM 145; bottom right). Scale equals 10 mm.*

Sceloporine Type B

MATERIAL RECOVERED. NAUQSP 14217 [R dentary (TP3-481, 631, 642-644, 648, 652, 655, 659, 666, 670, 672; TP6-168-169, 172, 241-242, 324), L dentary (TP3-483, 489, 633-638, 641, 649, 651, 654, 656, 658, 662, 665, 667; TP6-146, 162-163, 238, 320, 322-323, 464), partial R dentary (TP3-474, 645-646, 653, 660, 690; TP6-147), partial left dentary (TP3-601, 605-606, 608, 610, 616, 620, 626, 639-640, 661, 668, 673, 691; TP6-319, 326-328), R maxilla (TP3-657, 664, 667, 671; TP6-166, 325), L maxilla (TP3-632, 650, 669, 675-676; TP6-240), partial R maxilla (TP3-472, 480, 575, 578, 595, 607, 609, 630, 663, 678; TP6-173, 321), partial L maxilla (TP3-598-599, 647, 674), maxilla fragment (TP3-611), R scapulocoracoid (TP3-699), articulated surangular, articular, and prearticular (TP3-697(3); TP6-338(3))].

DISCUSSION. The fossil dentaries and maxillae of Type B represent medium-sized sceloporine lizards.

The teeth are pillar-like and weakly tricuspid posteriorly. The Meckel's canal constricts medially, opening ventrally at the anterior tip of the dentary. Overall, the dentaries are relatively straight. The nasal area of the maxillae forms a large platform. The dorsal projection of the maxilla is rounded where the nasal and prefrontal bones meet.

Callisaurus, Cophosaurus, and *Holbrookia* have fewer teeth than *Sceloporus. Callisaurus* has pointed, unicuspid teeth. *Cophosaurus* and *Holbrookia* have high crowned, cone-shaped, tricuspid teeth. The heavy, conical teeth of *Uma* are recurved anteriorly and strongly tricuspid posteriorly. *Sceloporus* typically has lower crowned, columnar, tricuspid teeth. *Phrynosoma* differs in having peg-like teeth with expanded bases (Norell 1989; Mead et al. 1999b).

The fossils compare best with *Sceloporus,* with an approximated snout-vent length of 60-70 mm. They are too large to represent *Uta, Holbrookia, Urosaurus,* or other small sceloporines, and are not as delicate as *Cophosaurus* or *Callisaurus.* The slender,

pillar-like, weakly tricuspid teeth are unlike *Uma*. Small specimens (SVL=60-70 mm) of large *Sceloporus* (*S. magister*) species differ in having wider teeth than a medium-sized *Sceloporus* of equal size (Figs. 54, 55).

Figure 54. Right dentary of MHC fossil Sceloporine Type B (TP6 242; top), Sceloporus occidentalis *(NAUQSP-JIM 171),* Cophosaurus texanus *(NAUQSP-JIM 52),* Callisaurus draconoides *(NAUQSP-JIM 73), and* Uma notata *(NAUQSP-JIM 62; bottom). Scale equals 10 mm.*

Figure 55. Right maxilla of MHC fossil Sceloporine Type B (TP6 166; top), Sceloporus occidentalis *(NAUQSP-JIM 171)*, Cophosaurus texanus *(NAUQSP-JIM 52)*, Callisaurus draconoides *(NAUQSP-JIM 72)*, *and* Uma notata *(NAUQSP-JIM 62; bottom). Scale equals 10 mm.*

The scapulocoracoid has 3 rays: a dorsal scapular ray, a primary coracoid ray, and a secondary coracoid ray. The scapular shaft is connected to the scapular ray by a thin bony fill in *Uta, Urosaurus, Petrosaurus, Sator*, and two species of *Sceloporus*. In most species of *Sceloporus, Callisaurus, Holbrookia*, and *Uma*, a scapular fenestra exists. All sceloporines have a large scapulocoracoid fenestra and a large primary coracoid fenestra. A thin bony fill connects the coracoid plate and secondary coracoid ray in all sceloporines (Etheridge 1964). TP3-699 resembles *Sceloporus, Callisaurus, Holbrookia*, or *Uma* (Fig. 34).

The posterior portion of the surangular, articular, and prearticular from the retroarticular process to the angular process and to the articular facet has a triangular, flattened appearance. A thin sheet of bone connects the retroarticular process to the angular process. The size of these bones is consistent to a lizard with a snout-vent length of 60-70 mm. These fossils compare best with a medium-sized *Sceloporus*. *Cophosaurus, Callisaurus*, and *Uma* have a more rounded, truncated retroarticular process (Fig. 56).

HABITAT. *Sceloporus occidentalis* and *Callisaurus draconoides* are medium-sized lizards living near MHC today. *Sceloporus occidentalis* ranges throughout the Great Basin, California, Oregon, and into central Washington. This lizard enjoys rocky and mixed forest habitats from sea level to 2700 m. *Callisaurus draconoides* ranges from north-central Nevada to southern California and Arizona, living in areas with hard packed soil with little vegetation. Today the vegetation near the cave is abundant, and thus unlikely to currently support populations of *C. draconoides*.

Figure 56. Medial view of surangular, articular, and prearticular of MHC fossil Sceloporine Type B (TP6 338; left), Sceloporus occidentalis *(NAUQSP-JIM 171),* Cophosaurus texanus *(NAUQSP-JIM 52),* Callisaurus draconoides *(NAUQSP-JIM 73), and* Uma notata *(NAUQSP-JIM 62; right). Scale equals 10 mm.*

Sceloporine Type C

MATERIAL RECOVERED. NAUQSP 14218 [Partial L dentary (TP3-473), quadrate (TP6-337)].

DISCUSSION. Only the posterior half of TP3-473 remains. TP3-473 is a relatively heavy bone with wide, blunt, weakly tricuspid teeth. The estimated snout-vent length is 95 mm. The dentary compares best with a large *Sceloporus*, such as *S. orcutti, S. poinsetii, S. magister*, and *S. clarkii* (Fig. 57). The teeth are too slender to belong to Crotaphytidae.

The fossil quadrate has a curved tympanic crest and represents a lizard with a snout-vent length of 95 mm. See Crotaphytidae section for description of quadrates of different taxa. TP6-337 closely resembles a large sceloporine (Fig. 58).

HABITAT. No large sceloporine lives near MHC; however, *Sceloporus magister* is found just south of the cave today. *Sceloporus magister* lives in southern Nevada, California, and New Mexico plus west Texas and much of Arizona, inhabiting arid to semiarid regions at low altitudes.
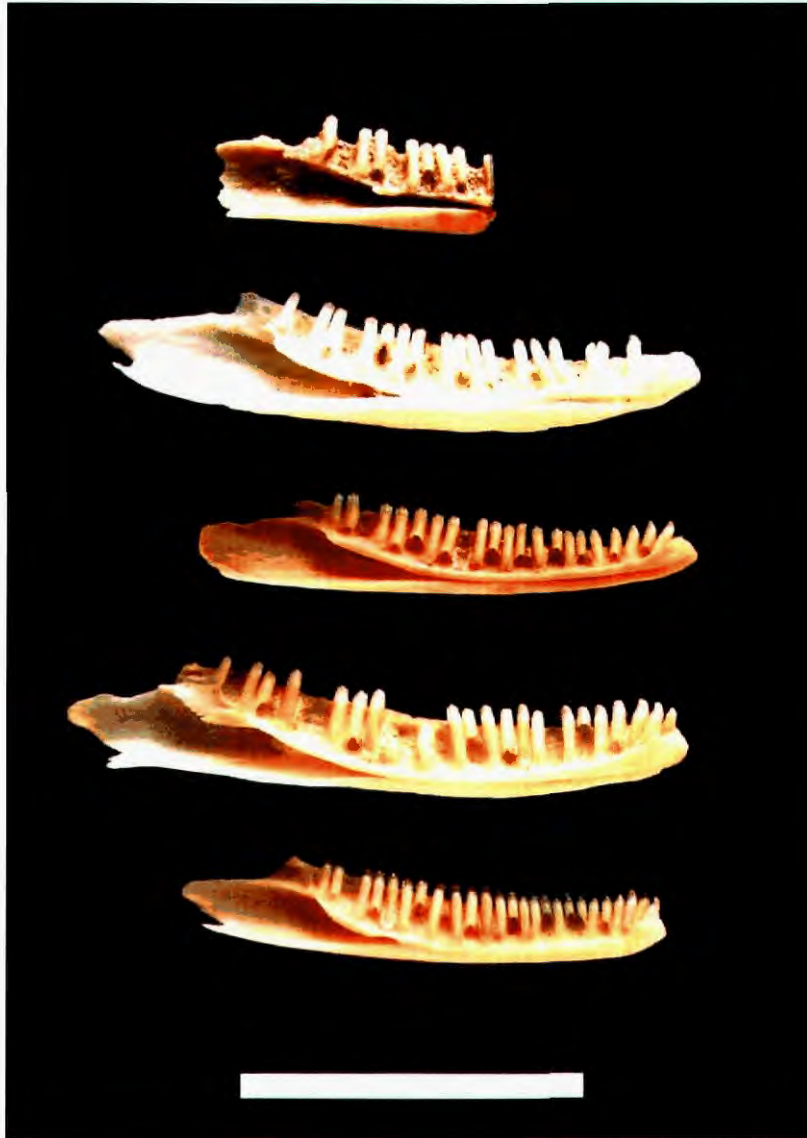
Figure 57. Lingual view of left dentaries from MHC fossil Sceloporine Type C (TP3 473; top), Sceloporus magister *(NAUQSP 6718),* S. clarkii *(NAUQSP-JIM 162),* S. poinsettii *(NAUQSP-JIM 201), and* S. orcutti *(NAUQSP-JIM 206; bottom). Scale equals 10 mm.*

Figure 58. Posterior view of quadrates of the MHC fossil Sceloporine Type C (TP3-337; left), Sceloporus occidentalis (NAUQSP-JIM 171), S. magister (NAUQSP 6718), S. clarkii (NAUQSP-JIM 162), S. poinsettii (NAUQSP-JIM 201), and S. orcutti (NAUQSP-JIM 206; right). Scale equals 10 mm.

Family Phrynosomatidae gen. et sp. indet.

MATERIAL RECOVERED. NAUQSP 14233 [R partial dentary (TP3-618), L partial dentary (TP3-589), frontals (TP3-700(3);TP6-314(7)), R partial maxilla (TP3-580, 582, 585, 588, 590, 594), L partial maxilla (TP3-579, 602), partial maxilla (TP3-604; TP6-330), premaxillae (TP3-701(3); TP6-340), tooth-bearing fragment (TP3-581)].

DISCUSSION. The dentaries, maxillae, premaxillae were too fragmentary for further identification but did bear sceloporine teeth. The frontals were mostly incomplete, but did bear sceloporine characteristics such as a flattened, hourglass shape.

Family Teiidae

Cnemidophorus sp.
Whiptail

MATERIAL RECOVERED. NAUQSP 14214 [R dentary (TP3-469, 537, 548), L dentary (TP3-455), R partial maxilla (TP3-539), L partial maxilla (TP3-536, 538)].

DISCUSSION. Fisher and Tanner (1970) describe the osteology of *Cnemidophorus tigris* (western whiptail). The asymmetrical bicuspid teeth of *Cnemidophorus* and the fossils have the smaller cusp positioned anteriorly, differentiating *Cnemidophorus* from Phrynosomatidae, Scincidae, and Crotaphytidae. Teiids can display triconodont teeth, seen in *Ameiva* and some species of *Cnemidophorus*. Some species of *Cnemidophorus* show no or only one triconodont tooth posterior in the dentary or maxilla such as *C. tigris, C. sexlineatus* (six-lined whiptail), and *C. hyperythrus* (orange throated whiptail) (Presch 1974). The teeth of *C. tigris* are more robust and larger than most species, including *C. inornatus* (little striped whiptail), *C. exanguis* (Chihuahuan spotted whiptail), *C. flagellicaudus* (Gila spotted whiptail), *C. sonorae* (Sonoran spotted whiptail), *C. uniparens* (desert grassland whiptail), or *C. velox* (plateau striped whiptail), but similar in size to *C. burti* (canyon spotted whiptail) (Van Devender et al. 1977). The dentary of *Cnemidophorus* and the fossils show virtually no posterior-anterior curvature. The Meckel's canal of the dentary opens widely posteriorly and remains open along the ventral portion of the dentary (Fig. 59; Fisher and Tanner 1970; Bell 1993). TP3-537, the only complete dentary, has 18 teeth, 7 of which are bicuspid. The toothrow measures 9.4 mm. The dentaries share the characteristics above for *Cnemidophorus*. The teeth are comparable in size to *C. tigris* and *C. burti*. No consistent characters of the dentary were found which would allow identification to species. The three maxillae have rather large, bicuspid teeth but are too incomplete for further identification.

HABITAT. Of the 16 species of *Cnemidophorus* living in North America, only *C. tigris* lives near MHC today, inhabiting the Great Basin, California, most of Arizona, southern New Mexico, and west

Texas. This diurnal predator lives in the desert to open woodland areas (Behler and King 1998).
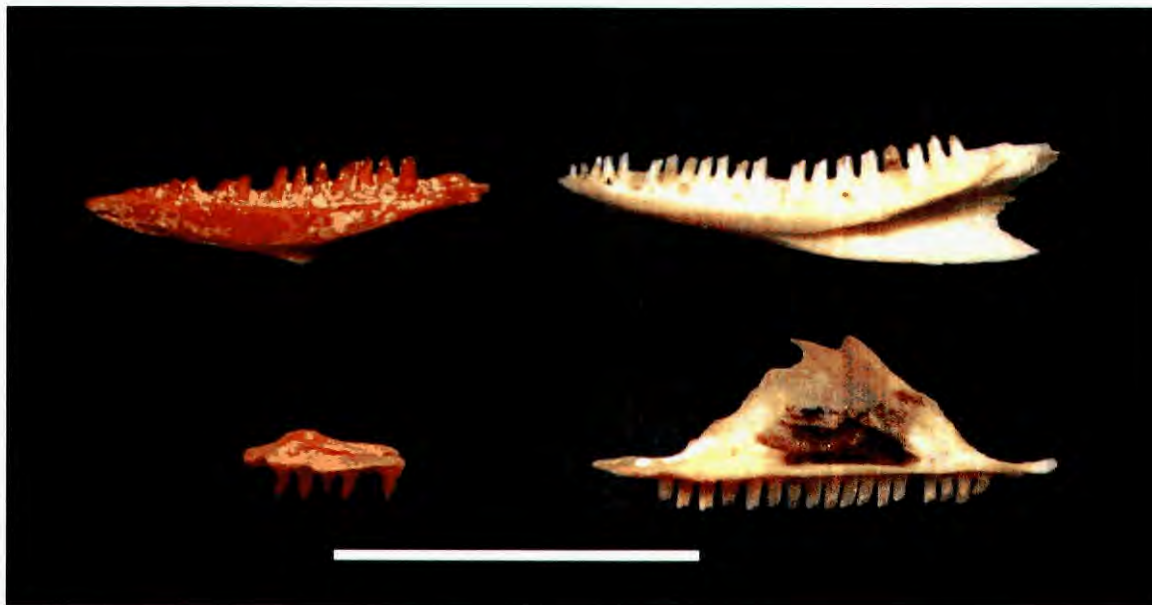
Figure 59. Lingual view of a fossil (TP3 537; top left) and modern (NAUQSP-JIM 275; top right) right dentary of Cnemidophorus *sp. Lingual view of fossil (TP3 538; bottom left) and modern (NAUQSP-JIM 275; bottom right) left maxilla of* Cnemidophorus *sp. Scale equals 10 mm.*

Family Scincidae

Eumeces sp.
Skink

MATERIAL RECOVERED. NAUQSP 14215 [L dentary (TP3-555)].

DISCUSSION. Kingman (1932) and Nash and Tanner (1970) describe the osteology of *Eumeces*. The western North American skinks are *E. gilberti* (Gilbert skink), *E. multivirgatus* (many-lined skink), *E. obsoletus* (Great Plains skink), *E. skiltonianus* (western skink), and *E. tetragrammus* (four-lined skink), *E. gilberti* and *E. obsoletus* being the largest skinks (Behler and King 1998). No characters exist that will allow identification of *Eumeces* to species using a single element (Nash and Tanner 1970; Norell

1989). The dentary of *Eumeces* and the fossil has a wide Meckel's canal that opens lingually then narrows anteriorly to become ventrally positioned. The unicuspid, slightly bulbous teeth have low, blunt, striated, lingually concave crowns and are uniformly positioned and sized (Fig. 60; Norell 1989; Bell 1993). The referral of TP3-555 to *Eumeces* is based on tooth morphology and interdental tooth spacing. The toothrow measures 5.5 mm and contains 23 teeth. The fossil is an adult because of the presence of a dental gutter and equivalent in size to a skink with a snout-vent length of 65 mm. *Eumeces* and the fossil differ from other lizard families by the unique set of characters listed above. See the above sections on Phrynosomatidae, Crotaphytidae, and Teiidae for details on how these groups differ.

Figure 60. Lingual view of MHC fossil (TP3 555; top) and modern (NAUQSP-JIM 1658; bottom) left dentaries of Eumeces *sp. Scale equals 10 mm.*

HABITAT. Of the six western North American species, only *E. skiltonianus* lives near MHC today. *Eumeces skiltonianus* ranges from southern British Columbia, south to the tip of Baja, and east to Utah. In the Great Basin, this skink shows a discontinuous distribution in the basin and range of Nevada and western Utah and is limited to a mixed pine and hardwood forest and riparian areas. It lives at sea level in California to 2500 m elevation in southern Utah, southern Nevada, and northern Arizona (Tanner 1988). *Eumeces skiltonianus* has been found in five mountain ranges in Nevada: the Cortez, Toyabe, Snake, Toquima, and Charleston Mountains (Linsdale 1938). MHC is surrounded by pinyon-juniper woodland habitat, which is not the preferred habitat for *E. skiltonianus*. The nearest most suitable habitat would most likely be the Ruby Mountains about 35 km to the east.

"Lizards"

MATERIAL RECOVERED. NAUQSP 14229 [basisphenoid (TP6-265), coronoid (TP3-698; TP6-306), R juvenile dentary (TP3-628), R partial dentary (TP3-576, 600, 623; TP6-174), L edentulous dentary (TP3-693), L juvenile dentary (TP3-627, 629), L partial dentary (TP3-568, 592, 597, 619, 624, 695), R

femur (TP6-300), partial frontal (TP3-702(3); TP6-266), R humerus (TP3-703(2)), L humerus (TP3-704(3)), R partial maxilla (TP3-577, 584, 615, 617, 622, 694), L partial maxilla (TP3-603, 613-614, 621), partial maxilla (TP3-569-571, 586, 612; TP6-332, 596), R pelvis (TP3-479; TP6-333), L pelvis (TP6-334), R scapulocoracoid (TP6-264), L partial scapulocoracoid (TP3-705(2)), partial surangular, articular, and prearticular (TP3-706; TP4-75; TP6-339), tooth-bearing fragment (TP3-572), partial quadrate (TP3-463(4)), R ulna (TP6-301), vertebrae (TP3-692(361); TP4-79(16); TP6-331(159))].

DISCUSSION. These fossils were too fragmented or exhibited no defining characters that would permit further identification.

Suborder Serpentes

Snake vertebrae are the most common reptilian element recovered from MHC, most likely due to the large number of vertebrae per individual. Difficulties arise when identifying isolated snake vertebrae because of variation in the vertebral morphology between taxa and within taxa. In addition, individuals vary geographically,

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ontogenetically, and along the vertebral column; as one progresses anteriorly to posteriorly on the snake, the morphology changes. These changes are subtle, occurring gradually the length of the snake. Furthermore, similar morphological characters can appear in different taxa. Oftentimes, in the past, scientists based their identifications on extant species within the geographic area of the site. In order to improve upon this method of identification, extensive comparative collections with broad geographic and ontogenetic variation must be examined. This will enable scientists to recognize the patterns of vertebral morphology and variation.

Auffenberg (1963) and LaDuke (1991) provide the most commonly used terminology for features found on snake vertebrae (Figs. 37, 38). Auffenberg (1963), Meylan (1982), and LaDuke (1991) offer the most detailed descriptions of snake vertebrae of different taxa. Initially, authors provided only qualitative descriptions, although more recently such authors as Auffenberg (1963), Meylan (1982), Van Devender and Mead (1978), and Mead et al. (1984) offer quantitative as well as qualitative descriptions.

LaDuke's (1991) divisions of the vertebral regions were used here. He follows Hoffstetter and Gasc (1969) but also recognizes subregions within the trunk area. The vertebral regions are as follows: (1) atlas and axis; (2) trunk vertebrae (divided into ATV, MTV, and PTV) which lack the processes found in the other regions; (3) cloacal vertebrae, which typically have fused lymphapophyses; and (4) postcloacal vertebrae, in which pleurapophyses and hemapophyses are present.

Family Erycidae

Charina bottae
Rubber boa

MATERIAL RECOVERED. NAUQSP 14226 [2 articulated MTV (TP3-509)].

DISCUSSION. Holman (1979), Rage (1984), and Bell and Mead (1996) describe *Charina* vertebrae. The small, short MTV of *Charina bottae* and the fossils possess flattened neural arches and low, thick, short neural spines that are flattened dorsally. The vertebrae (modern and MHC fossils) show reduced prezygapophyseal processes and pre- and postzygapophyses are laterally produced. No hemal keel or hypopophysis occurs (Fig. 61). The neural spine of *C. bottae* extends longer than in *C. trivirgata* (rosy boa) (Holman 1970). Parmley and Holman (1995) used the following characters to distinguish *C. bottae* from *C. trivirgata*: (1) zygosphene not strongly U-shaped when viewed dorsally in *C. bottae*; (2) zygosphene not strongly concave when viewed anteriorly in *C. bottae*; (3) neural arch is not as wide or depressed in *C. bottae*; and (4) posterior border of the neural arch are not deeply incised in *C. bottae*. TP3-509 is consistent with the characters listed above for *C. bottae*.

HABITAT. *Charina bottae*, a nocturnal species, lives from British Columbia to southern California and eastward to Montana, Wyoming, and Utah, and inhabits damp woodland and coniferous forest, large grassy areas, meadows, and moist sandy areas along rocky streams from sea level to 2800 m (Behler and King 1998). *Charina* is found near the cave today.
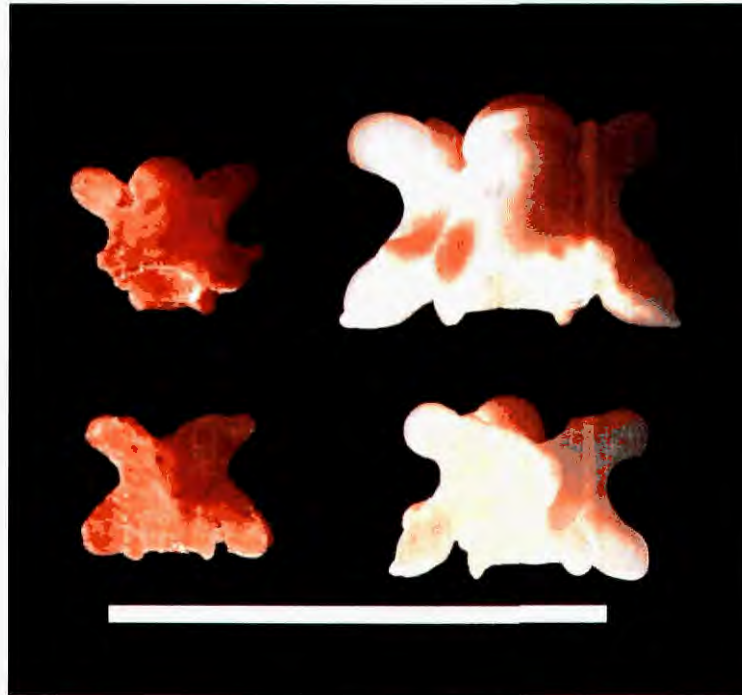
Figure 61. Ventral (top) and dorsal view (bottom) of fossil (TP3 509; left) and modern (NAUQSP 8341; right) MTV of Charina bottae. *Scale equals 10 mm.*

Family Colubridae

Coluber constrictor
Racer

MATERIAL RECOVERED. NAUQSP 14221 [12 MTV (TP3-503), 1 MTV (TP4-64), 1 MTV (TP6-244)].

DISCUSSION. Auffenberg (1963), Meylan (1982), and LaDuke (1991) describe *Coluber contrictor* vertebrae. The elongate MTV of *Coluber* are square across the zygapophyses. Well-developed epizygapophsyeal spines exist. The elongate, low to medium in height neural spine overhangs anteriorly and posteriorly. The long, narrow accessory processes are directed anterolaterally. Strong subcentral rigdes occur and the well-developed hemal keel is spatulate. The MHC fossils share the above *Coluber* characters (Fig. 62).

    Coluber constrictor strongly resembles *Masticophis* (whipsnake) and *Salvadora* (patch nosed). *Coluber* and *Masticophis* differ from *Salvadora* by having longer vertebral centra, less robust accessory processes, epizygapophyseal spines, higher neural spines, and smaller condyles (Auffenberg 1963; Holman 1962, 1970, 1976). Auffenberg (1963), Van Devender and Mead (1978), Meylan (1982), and Mead et al. (1984) provide measurements, which aid in distinguishing between *Masticophis* and *Coluber*. These measurements include the cl, naw, pr-pr, and pr-po, but the ratios of cl/naw and pr-pr/pr-po were used for identification. However, these measurements are not always definitive because overlap does occur (Fig. 63). Table 47 presents measurements from published data and those taken from the fossil and modern specimens of *Coluber*.

HABITAT. *Coluber* ranges widely across the United States, inhabiting fields, mountain meadows, grasslands, woodlands, and pine forests from sea level to 2150 m in elevation (Behler and King, 1998). *Coluber constrictor* lives near Mineral Hill Cave today.

Figure 62. Ventral (top) and dorsal (bottom) view of fossil (TP3 503; left) and modern (NAUQSP 8190; right) MTV of Coluber constrictor. *Scale equals 10 mm.*
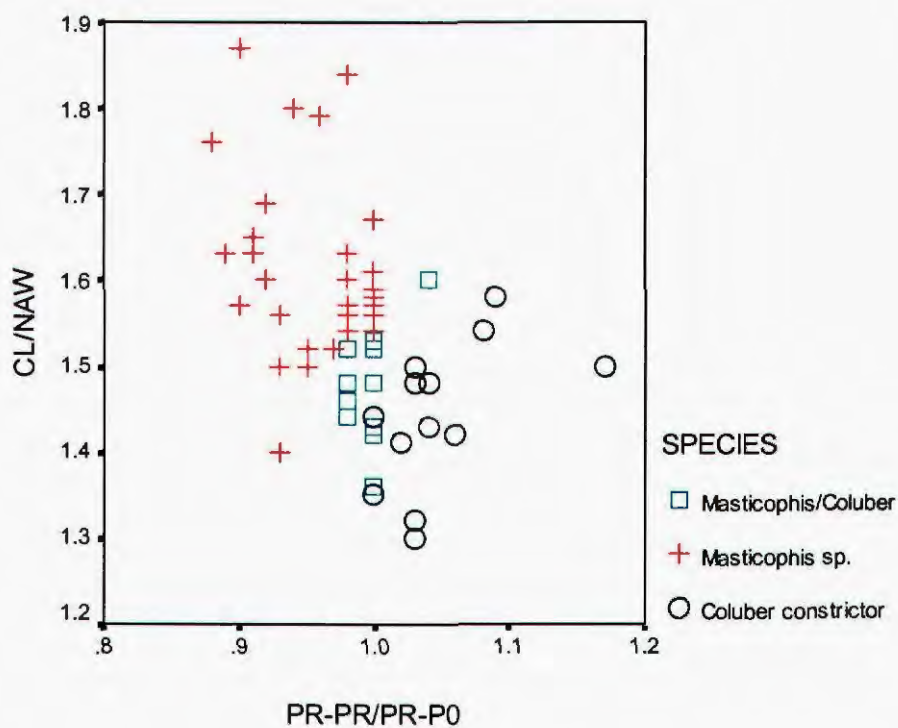
Figure 63. Scatter plot of CL/NAW and PR-PR/PR-PO of fossil Masticophis *sp.*, Coluber constrictor, *and* Masticophis/Coluber *vertebrae.*

Table 47. Measurements (in mm) of Coluber constrictor *from fossil and modern specimens and published data.* * *indicates measurements from fossil specimens.*

Coluber	CL/NAW	PR-PR/P0-PR
Fossils (MHC) (n=14)	1.30-1.58*	1.00-1.17*
Auffenberg (1963)	1.23-1.53 1.32-1.48*	0.98-1.25 1.03-1.07*
Meylan (1982)	1.2-1.5 NA	1.00-1.08 0.94-1.04*

Masticophis sp.
Whipsnake or Coachwhip

MATERIAL RECOVERED. NAUQSP 14222 [21 MTV (TP3-504), 1 MTV (TP4-65), 14 MTV (TP6-245)].

DISCUSSION. Auffenberg (1963), Meylan (1982), and LaDuke (1991) describe *Masticophis* vertebrae.

The vertebrae of *Masticophis* and the fossils fit the description of *Coluber constrictor* above, except they are narrower across the zygapophyses and centrum (Figs. 63, 64; Table 48). See the section on *Coluber* for details on differentiating *Salvadora*.

Figure 64. Ventral (top) and dorsal (bottom) view of MHC fossil (TP6 245; left) and modern (NAUQSP 7671; right) MTV of Masticophis. *Scale equals 10 mm.*

Identification within the genus *Masticophis* is difficult. La Duke (1991) provides characters, such as the size of epizygapophyseal spines, size of the neural canal, and thickness of the neural arch laminae for differentiating between species within *Masticophis*. However, when examining modern comparative specimens, I found these characters were not preserved on the fossils or overlapped between species. Therefore, the fossil vertebrae could not be identified to the species level.

HABITAT. Of the four species that inhabit North America today, only *M. taeniatus* (striped whipsnake) lives near the cave. In the United States, *M. taeniatus* ranges from Washington, Great Basin, New Mexico, and Texas. This snake lives in grassland, arid, brushy flat land, and pinyon-juniper woodlands, from sea level to 2850 m in elevation (Behler and King 1998).

Table 48. Measurements (in mm) of Masticophis *from modern and fossil specimens and published data.* * *indicates fossil specimens. Auffenberg (1963) and Meylan (1982) measured M. flagellum.*

Masticophis	CL/NAW	PR-PR/P0-PR
Fossils (MHC) (n=34)	1.40-1.87*	0.89-1.00*
Van Devender and Mead (1978); Mead et al. (1984)	1.48-1.75	0.87-1.00
Auffenberg (1963)	1.34-1.64 1.42-1.53*	0.87-1.00 0.92-.98*
Meylan (1982)	1.38-1.79 NA	0.93-1.03 0.92-1.02*

Coluber/Masticophis
Racer or Whipsnake/Coachwhip

MATERIAL RECOVERED. NAUQSP 14223 [27 MTV (TP3-505), 5 MTV (TP4-66), 3 MTV (TP6-246)].

DISCUSSION. Differentiating between *Coluber* and *Masticophis* was impossible due to fragmented vertebrae or an overlap of measurements (Fig. 63).

Pituophis melanoleucus
Pine-Gopher snake

MATERIAL RECOVERED. NAUQSP 14219 [38 MTV (TP3-502), 5 MTV (TP4-63), 126 MTV (TP6-243)].

DISCUSSION. Auffenberg (1963), Van Devender and Mead (1978), Meylan (1982), Mead et al. (1984), and LaDuke (1991) provide descriptions of *Pituophis* vertebrae and comparisons with other genera. The moderately short MTV of *Pituophis* have high neural spines that slightly overhang posteriorly and a high neural arch. The low, narrow hemal keel is gladiate to spatulate in shape with moderate to weak subcentral ridges adjacent to the keel. The zygosphene is moderately convex from the anterior and flat to concave dorsally. The acute, short accessory processes are directed oblique to anterior from dorsal view and lateral to dorsal from anterior view. The cotyle is large and round to slightly oblique. The MHC fossils share the above *Pituophis* characters (Fig. 65). The quantitative size (cl) and shape (cl/naw) of the vertebrae, using measurements from the fossil and modern vertebrae, and from published data, are presented in Table 49.

Among western colubrids, *Pituophis* can be confused with *Arizona* (glossy snake), *Lampropeltis* (milk/kingsnake), and *Elaphe* (rat snake). *Pituophis* displays higher neural spines in comparison to the other large lampropeltine snakes, although overlap can occur with *Elaphe*. More elongate vertebrae differentiate *Pituophis* from *Arizona*. The weaker subcentral ridges will distinguish *Pituophis* from *Elaphe*. *Pituophis* shows higher vaulted neural arches, weaker subcentral ridges, and thinner, more acute accessory processes than *Lampropeltis* (Holman 1965; LaDuke 1991). Although *L. pyromelana* more closely resembles *Pituophis* than the other species within *Lampropeltis*, the same diagnostic characters apply.
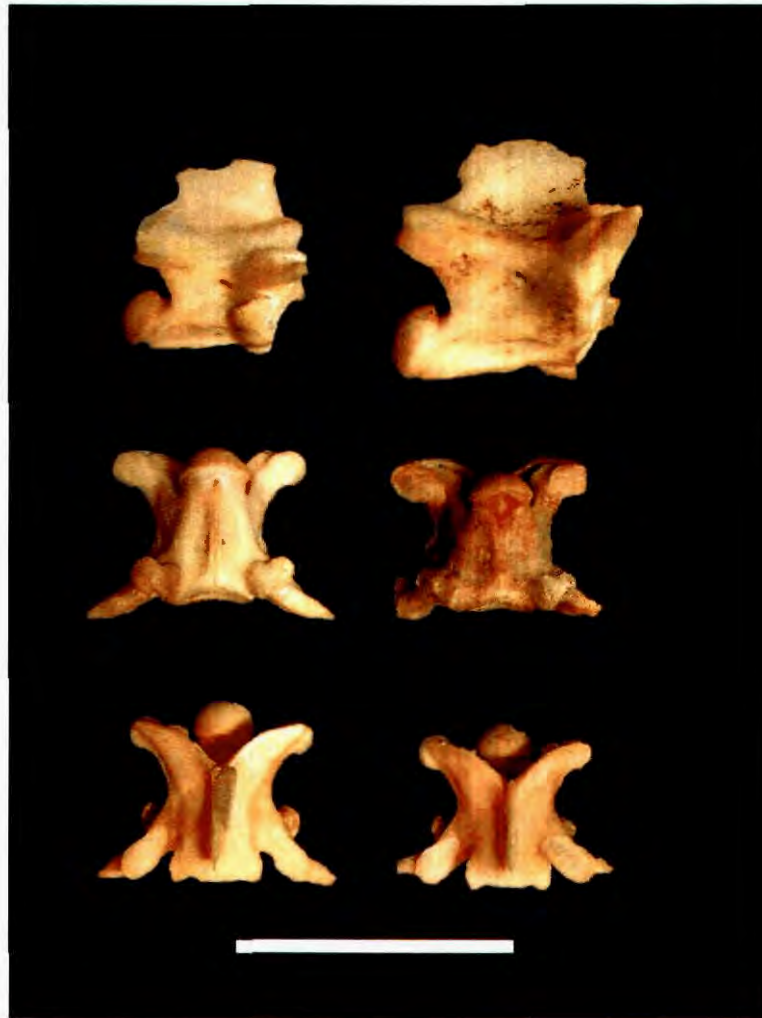
Figure 65. Lateral (top), ventral (middle), and dorsal (bottom) views of modern (NAUQSP 8242; left) and MHC fossil (TP6 243; right) Pituophis melanoleucus. *Scale equals 10 mm.*

HABITAT. *Pituophis* ranges throughout North America, inhabiting dry oak woodlands and pine forests, fields, prairies, open brushland, rocky desert, and chaparral and ranges in elevation from sea level to 2750 m (Behler and King 1998). *Pituophis melanoleucus* lives near MHC today.

Table 49. Measurements (in mm) for Pituophis melanoleucus *from fossil and modern specimens and published data.*

Pituophis	CL	CL/NAW	Average
Fossils (MHC) (n=158)	up to 6.4	.92-1.29	1.10
NAUQSP (n=27)	up to 7.7	1.07-1.29	1.17
Van Devender and Mead (1978); Mead et al. (1984)	up to 7.5	1.07-1.17	1.12

cf. *Pituophis*
Pine-Gopher snake

MATERIAL RECOVERED. NAUQSP 14220 [54 vertebrae (TP3-511), 2 vertebrae (TP4-68), 92 vertebrae (TP6-250), L dentary (TP6-158)].

DISCUSSION. These vertebrae probably represent *Pituophis* but are either transitional vertebrae between ATV and MTV and/or too fragmented to make a positive identification.

Snake dentaries are uncommon in the fossil record, and therefore, few published reports provide characters to distinguish snake dentaries. The dentary tooth row of TP6-158 measures 12.0 mm (Fig. 66). Twenty aveoli exist and the thin teeth are recurved near the base. The Meckel's groove closes around the 10th aveolus. The dentary could only be referred to as cf. *Pituophis* because the variation of dentary characters within and between taxa is not understood. The characters provided below were observed on a small sample size of each taxon (n=3-5). *Lampropeltis* differs from *Pituophis* and the fossil in having fifteen aveoli, the Meckel's groove closes at the seventh alveolus, and the teeth are thicker. *Masticophis* displays a medial curvature at the anterior portion of the dentary whereas the dentary of *Pituophis* and the fossil is straight. The teeth of *Pituophis* and the fossil are thinner and more recurved than *Coluber* teeth. LaDuke (1991) reports that *Thamnophis* generally has tooth counts approaching 27-30, greater than that found on *Pituophis* and the Meckel's canal of *Thamnophis* closes around the sixth alveolus. *Crotalus* can be

distinguished from all colubrids by the ventral-dorsal dentary depth and open Meckel's canal to the anterior tip (LaDuke 1991).
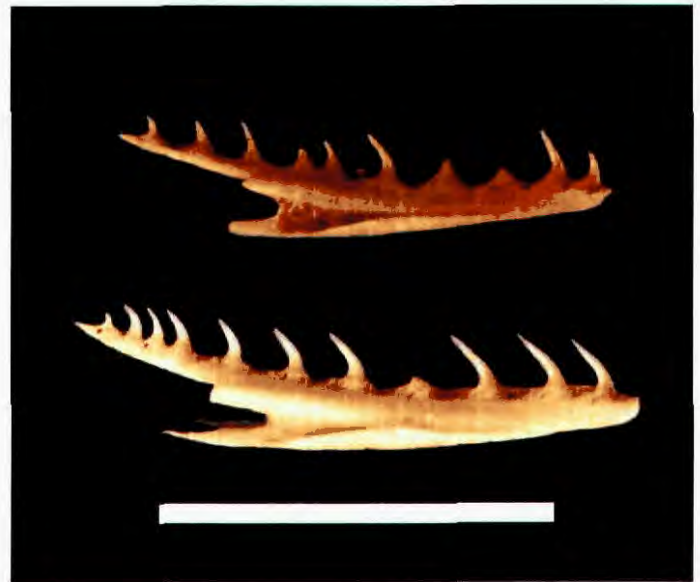
Figure 66. Lingual view of fossil (TP6 158; top) and modern (NAUQSP 7384; bottom) left dentary of Pituophis melanoleucus. *Scale equals 10 mm.*

Rhinocheilus lecontei
Long-nosed snake

MATERIAL RECOVERED. NAUQSP 14224 [4 MTV (TP3-506)].

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DISCUSSION. Hill (1971), Mead et al. (1984), Van Devender and Mead (1978), and LaDuke (1991) describe the vertebrae of *Rhinocheilus lecontei*. The moderately short MTV of *Rhinocheilus* and the fossils possess a thick, dorsally flattened neural spine of medium height, which overhangs anteriorly and posteriorly. The long, thick accessory processes are distally blunt and lateral from dorsal view. The strong, spatulate hemal keel has defined lateral edges.

The subcentral ridges are well developed but less so than in *Lampropeltis getulus* (common kingsnake). The zygosphene is flat from the anterior. The round cotyle is narrower than the zygosphene (Fig. 67). Table 50 provides measurements of published data and the fossil *Rhinocheilus*. The above characters differentiate *Rhinocheilus* from *Lampropeltis getulus*.
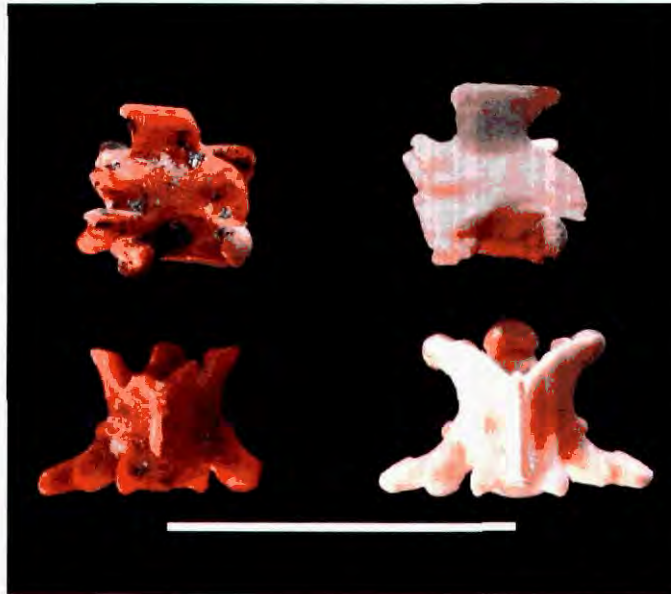
Figure 67. Lateral (top) and dorsal (bottom) view of Rhinocheilus lecontei *MTV from MHC (TP 506; left) and a modern specimen (NAUQSP 8319). Scale equals 10 mm.*

Table 50. Measurements (in mm) for Rhinocheilus lecontei *from fossil specimens and published data.*

Rhinocheilus	CL	CL/NAW	Average
Fossils (MHC) (n=4)	up to 3.6	.94-1.16	1.07
Van Devender and Mead (1978); Mead et al. (1984)	up to 3.0	1.07-1.21	1.11

HABITAT. *Rhinocheilus* lives near the cave today and inhabits the southwestern portion of the United States, living in dry open prairies and desert brush land from sea level to 1600 m elevation (Behler and King 1998).

Thamnophis sp.
Garter snake

MATERIAL RECOVERED. NAUQSP 14225 [24 MTV (TP3-508), 1 MTV (TP4-67), 9 MTV (TP6-247)].

DISCUSSION. The following authors describe *Thamnophis* vertebrae: Auffenberg (1963), Brattstrom (1967), Holman (1962, 1977), Meylan (1982), and La Duke (1991). The moderately elongate MTV of *Thamnophis* and the fossils show parapophyseal processes projected below and anterior to the lower lip of the cotyle. The neural spine is typically longer than it is high and overhangs posteriorly. Well-developed epizygapophysial spines and subcentral ridges exist. The strongly developed hypapophyses are sigmoid shaped when viewed laterally. The accessory processes are well developed, long, and acute (Fig. 68).

According to Auffenberg (1963), two subgroups exist within the Natricinae subfamily. Group 1, including the genera *Haldea* (earth snake), *Tropidoclonion* (lined snake), *Seminatrix* (swamp snake), and *Storeia* (red-bellied snake), exhibits elongate vertebrae and a long, low neural spine. Group 2 displays a moderate to long centrum and a higher neural spine compared to Group 1, and includes *Thamnophis, Nerodia* (water snake), and other related genera. *Nerodia* differs from *Thamnophis* by having larger vertebrae; short, wide centra; short, broad hypapophyses; and the neural spine equally overhangs posteriorly and anteriorly.

The projected parapophyseal processes and sigmoid hypapophysis distinguish MTV of *Thamnophis* and the fossils from other colubrids; however, the ATV of non-natricine colubrids can resemble natricine MTV. The short, sigmoid shaped hypapophysis of *Thamnophis* and the fossils differs from *Crotalus* (rattlesnake), which is long, thick laterally, posteroventrally directed, and sharply pointed. The parapophyseal processes differ as well. In *Thamnophis* and the fossils the flattened portion of the process is more medially directed, whereas in *Crotalus* the facets face ventrally.

Distinguishing between species within this genus is difficult. Several authors (Auffenberg 1963; Meylan 1982; Rogers 1987; La Duke 1991) provide characters that differentiate between certain species within *Thamnophis*. Some qualitative characters used for distinguishing between species are height of the neural spine and the degree of posterior and/or anterior overhang of the neural spine. When examining the modern comparative specimens; however, I found overlap of these characters. Therefore, the fossil vertebrae could not be identified to the species level.

HABITAT. Eight species of *Thamnophis* occur in the western portion of the United States, *T. couchi* (western aquatic), *T. cyrtopsis* (black-necked), *T. elegans* (western terrestrial), *T. eques* (Mexican), *T. marcianus* (checkered), *T. rufipunctatus* (narrow-headed), *T. sirtalis* (common), and *T. ordinoides* (northwestern). Only *T. elegans* lives near MHC today. This species inhabits much of the west except for Texas and the Mojave Desert. *Thamnophis elegans* lives in moist environments near water, damp meadows, and open grasslands to forests, occurring in elevations from sea level to 3200 m (Behler and King 1998).

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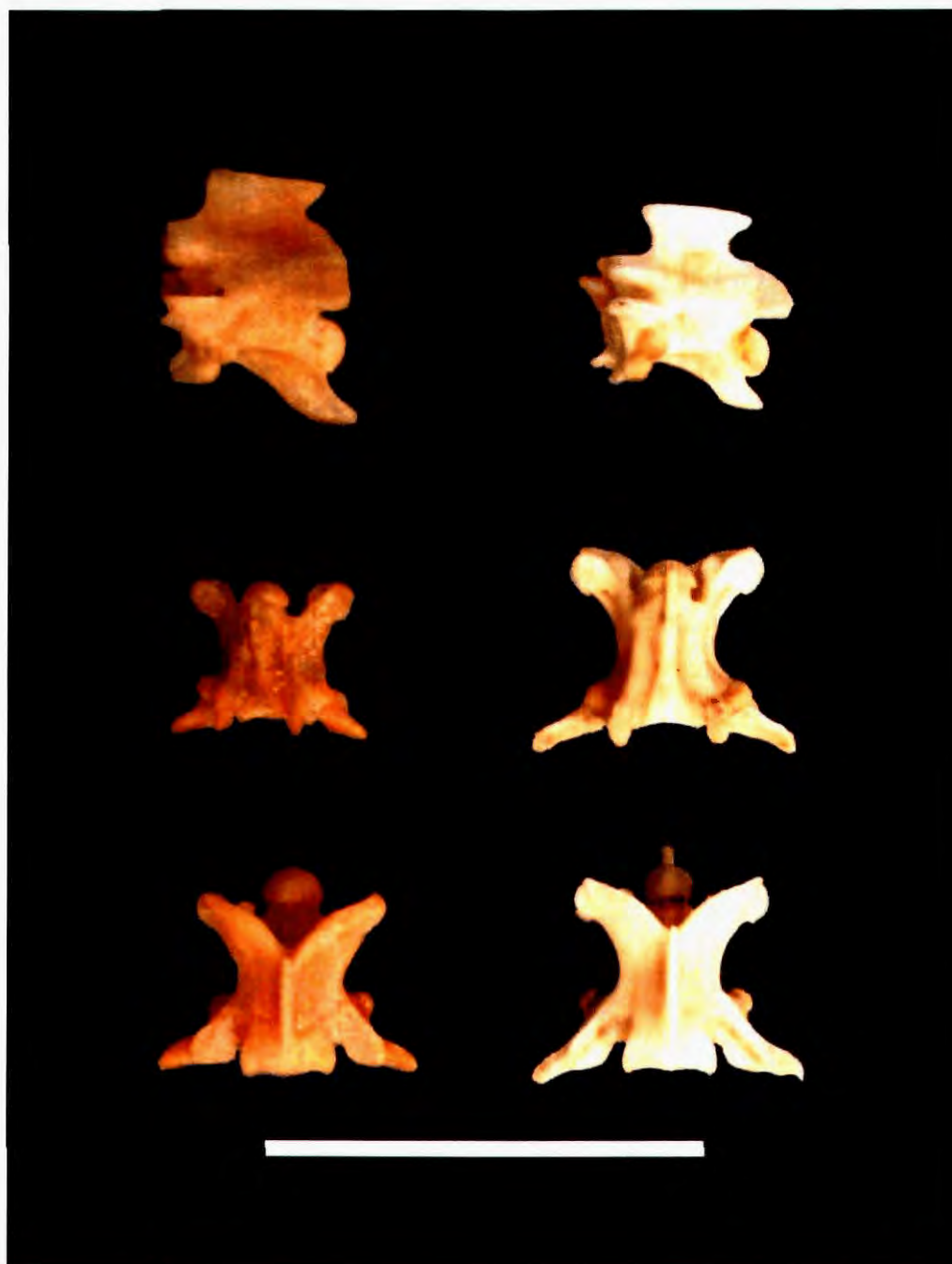
Figure 68. Lateral (top), ventral (middle), and dorsal (bottom) views of MHC Thamnophis *sp. MTV (TP3 508; left) and modern* Thamnophis elegans *MTV (NAUQSP 8247; right). Scale equals 10 mm.*

Hypsiglena torquata
Night snake

MATERIAL RECOVERED. NAUQSP 14231 [7 MTV and 1 ATV (TP3-507)].

DISCUSSION. Van Devender and Mead (1978), Mead et al. (1984), Van Devender et al. (1985), and La Duke (1991) describe *Hypsiglana torquata* vertebrae. The wide, short MTV of *Hypsiglena* and the fossils have a broad neural canal and the neural arch is depressed from the anterior. The laterally produced zygapophyses show large, round facets. The low neural spine thickens dorsally with the anterior portion bifurcate. Strong anterior and weak posterior overhangs exist. The strong hemal keel is moderately narrow and ventrally rounded or flattened. The elongate accessory processes have blunt distal ends, lateral from the anterior with a slight hook

anteriorly (Fig. 69). Table 51 provides measurements from published data and the fossil *Hypsiglena*.

Shorter vertebrae; higher, dorsally thickened, anteriorly bifurcate neural spines; and a wider, less flat hemal keel distinguishes *Hypsiglena* and the fossils from *Diadophis* (ringneck snake), *Chionactis* (shovel-nosed snake), and *Sonora* (ground snake). *Rhinocheilus* and *Phyllorhynchus* (leaf-nosed snake) show a less depressed neural arch and wider NAW (La Duke 1991).

HABITAT. *Hypsiglena torquata* lives in the southwestern part of the United States as well as Kansas, Washington, Oregon, and California. This snake is found near the cave today and inhabits semiarid to arid sandy or rocky areas in the plains, desert flats, and brush chaparral, living from sea level to 2100 m in elevation (Behler and King 1998).
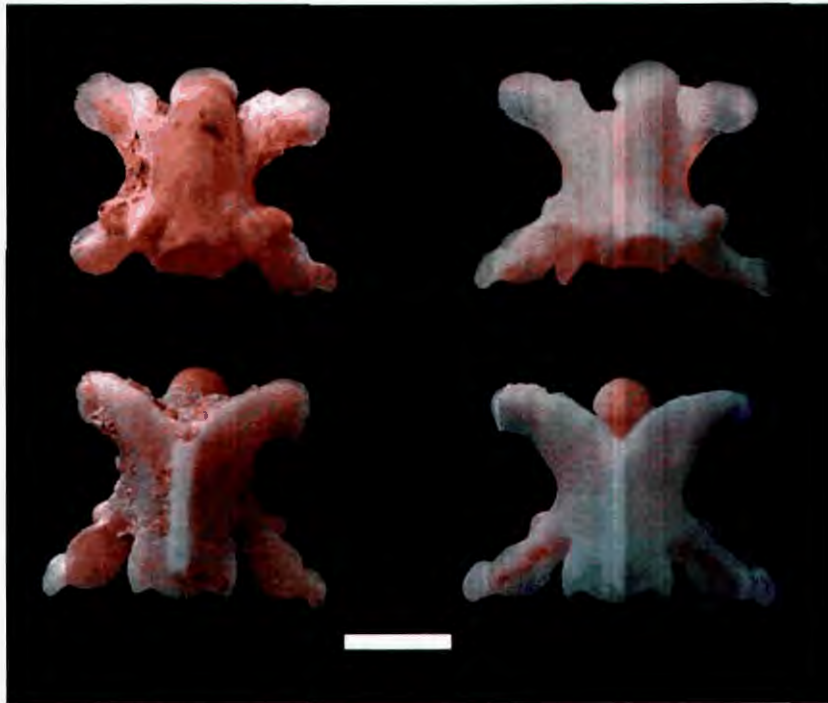
Figure 69. Ventral (top) and dorsal (bottom) view of fossil (TP3 507; left) and modern (NAUQSP 8264; right) MTV of Hysiglena torquata. *Scale equals 1 mm.*

Table 51. Measurements (in mm) for Hypsiglena torquata *from fossil specimens and published data.*

Hypsiglena	CL	CL/NAW	Average
Fossils (MHC) (n=8)	1.9-2.0	1.33-1.82	1.46
Van Devender and Mead (1978); Mead et al. (1984)	1.65-2.75	1.18-1.31	1.26

Family Crotalidae

Crotalus sp.
Rattlesnake

MATERIAL RECOVERED. NAUQSP 14227 [19 MTV (TP3-510), 22 MTV (TP6-248)].

DISCUSSION. Auffenberg (1963), Brattstrom (1964), Holman (1965), and LaDuke (1991) describe *Crotalus* vertebrae. The short and broad MTV of *Crotalus* and the fossils have divergent zygapophyses. Prezygapophyses may become elongate and oval with the long axis laterally directed. The long, straight hypapophysis is laterally thick, pointed at the distal end, and posteroventrally directed. The short accessory processes can be distally acute or blunt (Fig. 70).

 Agkistrodon (copperhead or cottonmouth) shows larger, deeper fossae with a single large foramen adjacent to the cotyle than does *Crotalus*. In *Crotalus* and the fossils, the smaller foramina may be multiple. A small spine exists on the zygosphene anterior to the neural spine in *Sistrurus*, which has longer centra in comparison to *Crotalus* and the fossils (Holman 1963, 1965).

Distinguishing between species of *Crotalus* is difficult. Some qualitative characters used for distinguishing between species are the height of the neural spine and the length of the centrum (Table 52; Van Devender and Mead 1978; Meylan 1982; La Duke 1991). However, when examining the modern specimens, overlap occurred between the species. Therefore, the fossil vertebrae could not be identified to the species level.

HABITAT. Eleven species of *Crotalus* live in the western United States, *C. atrox* (western diamondback), *C. cerastes* (sidewinder), *C. lepidus* (rock rattlesnake), *C. mitchelli* (speckled rattlesnake), *C. molossus* (black-tailed rattlesnake), *C. pricei* (twin-spotted rattlesnake), *C. ruber* (red diamond rattlesnake), *C. scutulatus* (Mojave rattlesnake), *C. tigris* (tiger rattlesnake), *C. viridis* (western rattlesnake), and *C. willardi* (ridge-nosed rattlesnake). *Crotalus viridis* lives near MHC today and inhabits the western portion of the United States, living in grasslands, coniferous forests, rocky outcrops, talus slopes, and canyons from sea level to 3350 m in elevation (Behler and King 1998).

Table 52. Measurements (in mm) of Crotalus *from modern and fossil specimens and published data.*

Crotalus	CL/NAW	PR-PR/P0-PR
Fossils (MHC)		
Crotalus sp. (n=30)	0.95-1.42	1.12-1.85
Meylan (1982)		
Crotalus atrox (n=31)	1.15-1.39	1.24-1.48
Crotalus horridus (n=17)	1.20-1.68	1.14-1.42
Crotalus adamanteus (n=31)	1.07-1.41	1.29-1.57

Figure 70. Lateral (top), ventral (middle), and dorsal (bottom) view of fossil (TP6 248, lateral view; TP3 510, ventral and dorsal view; left) and modern (NAUQSP 7392; right) MTV of Crotalus *sp. Scale equals 10 mm.*

cf. *Crotalus*

MATERIAL RECOVERED. NAUQSP 14228 [4 MTV (1 juvenile) (TP6-249)].

DISCUSSION. The above MTV are too fragmentary (lacking the hypapophysis) or too young for a positive identification.

Family Colubridae gen. et sp. indet.

MATERIAL RECOVERED. NAUQSP 14232 [R dentary fragment (TP3-517, 707; TP6-255), 2 tooth bearing fragments (TP3-516), ATV or fragmented vertebrae (TP3-513(45); TP4-70(3); TP6-251 (63)), juvenile vertebrae (TP3-512(132); TP4-69(8); TP6-254(19))].

DISCUSSION. These vertebrae were fragmented, juvenile, or ATV, and therefore, could not be identified beyond family. The dentaries and tooth bearing fragments were too fragmented for a positive identification.

"Snakes"

MATERIAL RECOVERED. NAUQSP 14230 [Broken vertebrae (TP3-515(110); TP4-71(13); TP6-253(35)), caudal vertebrae (TP3-514(96); TP4-72(5); TP6-252(32))].

DISCUSSION. Since these vertebrae were too fragmented or caudal vertebrae, they could only be identified to the suborder Serpentes.

Overview of Great Basin Reptile Fossil Localities

Although many archaeological and paleontological sites occur within the Great Basin (Grayson 1993), few have produced reptilian remains. The reason for this often lies with the motivation for the excavations. Many of the cave sites were excavated for archaeological and/or mammalian remains. Usually, the screen size was too large to capture many reptile fossils (or even small mammal fossils). Only during the last two decades have scientists intentionally recovered and studied reptilian remains found in Great Basin caves.

Fossil reptiles have been found in a number of different settings, from packrat middens to natural trap and walk-in caves. All localities date from either the late Pleistocene or the Holocene. Fossil localities are clustered in the northwestern and eastern portions of the Great Basin. The rest of the Great Basin undoubtedly has fossil localities that remain unstudied. Site surveys in the past have focused on archaeological questions. Sites in the Great Basin have never been surveyed solely for fossil herpetofaunas. This is unfortunate, because many gaps exist in our understanding of late Quaternary reptile distributions in the Great Basin and elsewhere. However, eleven sites within the Great Basin have produced fossil reptiles and are listed as follows: CHC, CBC, DC, GRS, HRS, HC, LC, LSC, MHC, SCC, and SCBC (Fig. 71; Table 53 [pp.122-123]).

The Holocene sites are more numerous (CHC, DC, GRS, HC, HRS, and LSC) than the late Pleistocene sites (CBC, LC, and SCC), although the reptilian faunas are similar (Table 54 [pp. 124-125]). The Holocene sites are scattered around the Great Basin, while the late Pleistocene sites are clustered along the eastern portion of the Great Basin. Two important sites, SCBC and MHC, have reptilian remains spanning the late Pleistocene into the Holocene. Unfortunately, only SCBC has well-dated, stratified sediments. The sediments from MHC suffered extensive bioturbation; therefore, 65 dates on charcoal, plant macrofossils, and bones ranging from 50-2 ka were required to provide chronological context. Although SCC has well-dated, stratified sediments spanning the Pleistocene-Holocene transition, only the reptilian remains from the Pleistocene strata have been identified; the Holocene reptilian fossils remain unstudied.
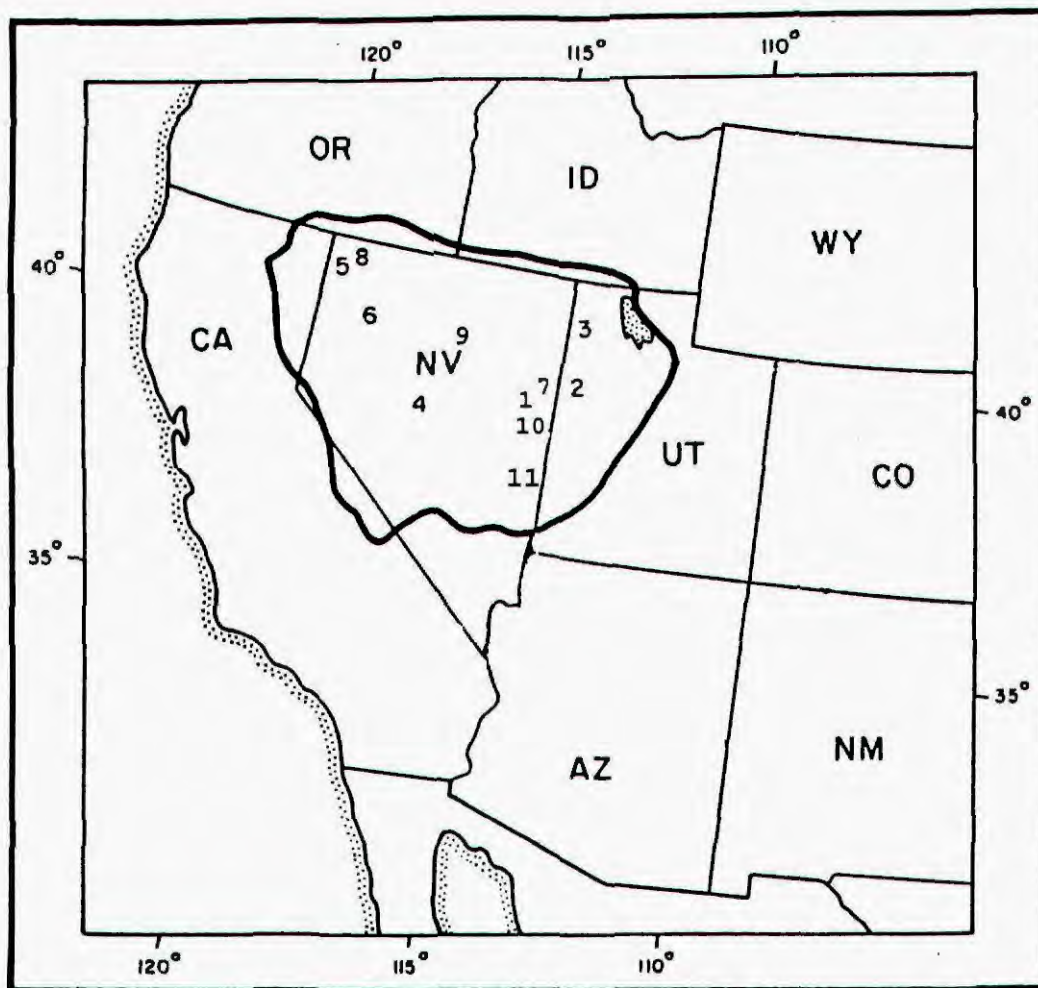
Figure 71. Map showing the eleven reptile producing localities in the Great Basin. (1) CHC, Council Hall Cave; (2) CBC, Crystal Ball Cave; (3) DC, Danger Cave; (4) GRS, Gatecliff Rock Shelter; (5) HRS, Hanging Rock Shelter; (6) HC, Hidden Cave; (7) LC, Ladder Cave; (8) LSC, Last Supper Cave; (9) MHC, Mineral Hill Cave; (10) SCC, Smith Creek Cave; and (11) SCBC, Snake Creek Burial Cave. Modified from Mead and Bell (1994).

CBC, situated at 1760 m elevation on the northeast side of Gandy Mountain in the northeastern portion of the Snake Range, is 4.8 km west of Gandy, Millard County, Utah and 0.9 km east of the Utah-Nevada border. The cave lies in pinyon-juniper woodland. Packrats and storm runoff are responsible for the cave deposits that date to at least 23,000 yr B.P. The sediments, which produced a rich mammalian and avian fauna, were shallow and unstratified; only four radiocarbon dates were obtained (Heaton 1985; Mead et al. 1989). One hundred sixty-two lizard (5 genera) and two snake (2 genera) remains were identified from CBC. *Phrynosoma hernandezi/douglasi* was the most common species (38%) and represents an extralocal distribution (Mead et al. 1989).

CHC, LC, and SCC are within Smith Creek Canyon, which is an east-facing canyon in the Snake Range in White Pine County, eastern Nevada. CHC (2040 m) is located on a north-facing slope near the canyon floor in pinyon-juniper woodland, with nearby montane and subalpine conifers. LC (2060 m) and SCC (1950 m) are situated on a south-facing slope at the entrance of the canyon in pinyon-juniper woodland. Midden 1b from CHC dated to 4220±60 yr B.P. and produced one species of snake, *Hypsiglena torquata* (Mead et al. 1982). Three middens (modern, 3, and 2a) produced reptilian remains from LC, dating to the present, 13,230±110, and 27,280±970 yr B.P. respectively. Three lizard genera and one snake genus were identified and extralocal *Phrynosoma hernandezi/douglasi* were represented. Sediment (12,600-28,650 yr B.P.) and one midden (11,660±245 yr B.P.) from SCC also produced reptilian remains. Fifteen species (7 snake and 8 lizard species) were identified from SCC. The following extralocal species were recovered from SCC: *Sceloporus magister, Phrynosoma hernandezi/douglasi, Lampropeltis triangulum,* and *Masticophis flagellum* (Mead et al. 1982).

DC is located at 1314 m elevation on the southern edge of the Silver Island Mountains, about 2 km east of Wendover, Utah. The vegetation surrounding the site is composed of *Sarcobatus vermiculatus* (black greasewood), *Atriplex confertifolia* (shadscale), *Tetradymia* sp. (horsebrush), *Ephedra* sp. (Mormon tea), *Suaeda fruticosa* (alkali seepweed), and grasses. One *Pituophis melanoleucus* vertebra was recovered from Stratum 5, dating between 1930-4900 yr B.P. (Jennings 1957; Grayson 1988; Mead and

Bell 1994). Large screen size was responsible for the poor recovery of reptilian fossils (Mead 1988).

GRS is located at 2319 m elevation within the pinyon-juniper woodland in Moniter Valley on the north side of Mill Canyon, Nye County, Nevada (Thomas 1983). Three hundred thirty-three reptilian remains were recovered from Strata 1-56 dating between 0-7100 yr B.P. One hundred sixty-nine lizard (5 genera) and 164 snake elements (9 genera) were recovered. The fossils exhibited evidence of raptor digestion, indicating that raptors created the deposit. *Coluber constrictor* appears to be the only extralocal taxon represented (Mead et al. 1983).

Hanging Rock Canyon is positioned northwest of the Calico Mountains, 40 km southeast of Vya, Washoe County, Nevada. The shelter (30 km southwest of LSC) is located on the north side of the canyon at 1725 m elevation. The vegetation consists of *Artemisia tridentata* and *Chrysothamnus* sp. as well as riparian plants, *Populus* sp. (cottonwoods) and *Ribes* sp. (currants) (Grayson and Parmalee 1988). Strata 2, 4, and 5 contained 26 identifiable reptile elements (3 *Sceloporus* species and 5 snake genera) and dated to the Holocene; however, the chronology was poorly controlled. *Sceloporus magister* represents an extralocal taxon (Mead 1988; Mead and Bell 1994).

HC, at 1251 m elevation, is located on the north side of Eetza Mountain within the Lahontan Mountains. The cave is 15 km southwest of Fallon, Nevada (Thomas and Peter 1985). The vegetation consists of *Sarcobatus baileyi* (little greasewood), *Atriplex canescens* (four-winged saltbush), and *Artemisia spinescens* (budsage) (Kelly and Hattori 1985). Mead (1985) identified 189 lizards (5 genera) and 709 snakes (9 genera) from cave deposits. Most of the remains date to less than 8000 yr B.P. although a few remains (*Pituophis melanoleucus, Lampropeltis* cf. *zonata*, Sauria, and Colubridae) date to between 15,000-21,000 yr B.P. *Sceloporus magister, Lampropeltis getulus, Lampropeltis* cf. *pyromelana,* and *Lampropeltis* cf. *zonata* are extralocal taxa. *Phrynosoma hernandezi/douglasi* was found in mixed proveniences, and therefore, data for the fossil distribution of this species was disregarded. *Phrynosoma hernandezi/douglasi* lives in higher elevations in the mountains near the cave today. The most important mode of bone accumulation appears to be raptor roosting (Mead 1985).

LSC is located just north and 20 km above Hell Creek in Humbolt County, Nevada and sits at 1646 m elevation. Nearby vegetation consists of *Atriplex* cf. *canescens*, *Chrysothamnus* sp., and *Artemisia tridentata* (Grayson 1988). LSC produced 64 identifiable reptilian specimens, 56 of which were from packrat middens. Strata 3 and 4, in which the remaining nine specimens were recovered, date to between 6000-9000 yr B.P., but unfortunately, the stratigraphy was poorly controlled yielding an uncertain chronology (Mead 1988). Seven snake genera and one lizard genus were identified. *Lampropeltis getulus* does not occur near the cave today (Mead 1988; Mead and Bell 1994).

As noted above, MHC is located in north-central Nevada at 2134 m elevation in pinyon-juniper woodland. MHC produced 918 lizard and 1063 snake remains, representing eight lizard and eight snake genera. Two *Crotaphytus* sp. dentaries date to 6320$\pm$40 yr B.P. (Cal BP 7330 to 7230; Beta-145833) and 29,240$\pm$350 yr B.P. (not calibrated; Beta-145834). Most dates (on mammal bones) cluster around 30,000-45,000 yr B.P., but range from >50,000-2000 yr B.P. Water transport and predators deposited the bone (Hockett 2001; also see chapters 1-2 above). *Phrynosoma hernandezi/douglasi* and Sceloporine Type C (most likely representing *S. magister*) are extralocal taxa recovered from the deposit. The presence of *Eumeces* sp. marks the first fossil occurrence of this taxon in the Great Basin.

SCBC is a natural trap cave, located in a bajada of the southern Snake Range at 1731 m elevation, 8 km south of Baker, White Pine County, Nevada. This cave is unique in that it is a natural trap cave and the assemblage represents a valley-bottom community (Mead and Mead 1989). Shadscale and saltbush dominate the valley bottom floral community (Grayson 1993). The cave deposits produced three lizard (2 genera) and 31 (3 genera) snake remains. Two of the reptile-producing layers date to 7860$\pm$160 and 15,100$\pm$700 yr B.P. As excellent climbers, lizards are unlikely to become natural trap victims. Flash floods are probably responsible for the lizard remains within the deposit. No evidence suggests that raptors created the accumulation of fossils. *Phrynosoma hernandezi/douglasi* represents the only extralocal species from this locality (Mead et al. 1989).

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Table 53. Great Basin sites with reptilian remains.

Site	Elevation (m)	Radiocarbon Age (yr B.P.)	Reference
1. Council Hill Cave (CHC)			
1b midden	2040	4220+60	Thompson 1979; Mead et al. 1982
2. Crystal Ball Cave (CBC)	1760	<23,000	Heaton 1985; Mead et al. 1989
3. Danger Cave (DC)			
Stratum V	1310	1930-4900	Jennings 1957; Grayson 1988; Mead 1988
4. Gatecliff Rock Shelter (GRS)			
Strata 1-56	2319	0-7100	Thomas 1983; Mead et al. 1983
5. Hanging Rock Shelter (HRS)			
Strata 2, 4, 5	1725	Holocene	Grayson 1988; Mead 1988
6. Hidden Cave (HC)	1251	<8000	Thomas 1983; Mead 1988
7. Ladder Cave (LC)			
Modern midden	2060	modern	Thompson 1979;
3 midden		13,230+110	Mead et al. 1982
2a midden		27,280+970	

Table 53. (continued)

8. Last Supper Cave (LSC)			
Strata 3, 4	1646	6000-9000	Grayson 1988; Mead 1988
9. Mineral Hill Cave (MHC)	2060	2000-50,000	
10. Smith Creek Cave (SCC)			
Sediment	1950	12,600-28,650	Brattstrom 1976; Thompson 1979
1 midden		11,660+245	Mead et al. 1982
No provenience		late Quaternary	
11. Snake Creek Burial Cave (SCBC)			
2 layers	1720	7860+160	Mead, Heaton, Mead 1989;
		15,100+700	Mead, Mead 1989

Table 54. Modern and fossil lizards and snakes from the Great Basin. • indicates species not currently present in the Great Basin.

	Council Hall 1b	Crystal	Danger	Gatecliff	Hanging	Hidden	Ladder 2a	Ladder 3	Last Supper	Mineral Hill	Snake Creek	Smith Creek Sed.
LIZARDS												
Callisaurus draconoides	--	--	--	--	--	--	--	--	--	--	--	--
Cnemidophorus sp.	--	--	--	--	--	--	--	--	--	X	--	--
C. tigris	--	X	--	--	--	X	--	--	--	--	--	X
Crotophytus sp.	--	X	--	--	--	X	--	--	--	X	--	X
Crotaphytus collaris	--	X	--	X	--	X	--	--	--	--	--	X
Eumeces skiltonianus	--	--	--	--	--	--	--	--	--	--	--	--
Eumeces sp.	--	--	--	--	--	--	--	--	--	X	--	--
Gambelia sp.	--	--	--	--	--	--	--	--	--	X	--	--
Gambelia wislizenii	--	X	--	X	--	--	--	--	--	--	--	X
Phrynosoma sp.	--	--	--	X	--	--	--	--	--	X	--	--
P. hernandezi/douglasi	--	X	--	--	--	--	X	X	--	X	X	X
P. platyrhinos	--	X	--	X	--	X	--	--	--	X	--	X
Sceloporus sp.	--	X	--	X	X	X	--	--	--	--	--	X
S. graciosus	--	X	--	X	X	--	--	--	--	--	X	X
S. magister	--	--	--	X	X	X	--	--	--	--	X	X
S. occidentalis	--	--	--	X	X	--	--	--	X	--	--	--
S. undulatus	--	--	--	--	--	--	--	--	--	--	--	--
S. undulatus/occidentalis	--	X	--	X	--	--	X	--	--	--	X	X
Type A-small sceloporine	--	--	--	--	--	--	--	--	--	X	--	--
Type B-medium "	--	--	--	--	--	--	--	--	--	X	--	--
Type C-large "	--	--	--	--	--	--	--	--	--	X	--	--
Uta stansburiana	--	X	--	X	--	X	X	--	--	--	X	--

Table 54. (continued)

SNAKES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Charina bottae	--	--	--	--	X	--	--	--	--	--	X	--	--	--
Chionactis occipitalis	--	--	--	--	--	--	--	--	--	--	—	--	--	--
Crotalus sp.	--	--	--	X	--	--	--	--	--	--	X	--	--	--
C. viridis	--	--	--	X	X	X	--	--	--	X	—	X	X	X
Coluber constrictor	--	--	--	X	--	X	--	--	--	--	X	--	X	--
Diadophis punctatus	--	--	--	--	--	--	--	--	--	--	—	--	--	--
Hypsiglena torquata	X	--	--	--	--	--	--	--	--	X	X	--	X	X
Masticophis sp.	--	--	--	X	X	X	--	--	--	X	X	--	--	--
Masticophis/Coluber	--	--	--	--	--	X	--	--	--	--	X	--	--	--
M. flagellum	--	--	--	--	--	--	--	--	--	--	—	--	X	--
M. taeniatus	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lampropeltis sp.	--	X	--	--	--	X	--	--	--	X	—	X	--	--
L. getulus	--	--	--	X	--	X	--	--	--	X	—	--	X	--
L. pyromelana	--	--	--	--	--	X	--	--	--	--	—	--	--	X
L. triangulum*	--	--	--	--	--	--	--	--	--	--	—	--	--	X
L. zonata*	--	--	--	--	--	X	--	--	--	--	—	--	--	--
Pituophis melanoleucus	--	--	X	X	X	X	--	--	--	X	X	X	X	X
Rhinocheilus lecontei	--	--	--	--	--	X	X	--	--	--	X	--	--	X
Salvadora hexalepis	--	--	--	X	--	X	--	--	--	--	—	--	--	--
Sonora semiannulata	--	--	--	--	--	X	--	--	--	--	—	--	--	--
Thamnophis sp.	--	X	--	X	X	X	--	--	--	X	X	--	--	X
T. couchii	--	--	--	--	--	--	--	--	--	--	--	--	--	--
T. elegans	--	--	--	--	--	--	--	--	--	--	—	--	--	--

Discussion. Mineral Hill Cave gives insight into reptilian biogeography in north-central Great Basin by providing 918 lizard and 1063 snake fossil remains. The lizards include *Phrynosoma platyrhinos* and *P. hernandzi/douglasi*, *Crotaphytus* sp., *Gambelia* sp., Sceloporine Type A, B, and C, *Cnemidophorus* sp., and *Eumeces* sp. *Phrynosoma hernandezi/douglasi* and Sceloporine Type C are extralocal taxa and *Eumeces* sp. marks the first fossil occurrence of this genus in the Great Basin. The snake remains represent eight genera, including *Charina bottae*, *Coluber constrictor*, *Masticophis* sp., *Pituophis melanoleucus*, *Thamnophis* sp., *Hypsiglena torquata*, *Rhinocheilus lecontei*, and *Crotalus* sp. The fossil reptilian fauna from MHC strongly represents the modern herpetofauna of the MHC area. Of the seven lizard genera inhabiting the MHC area, a minimum of six of these genera were recovered and of the eight snake genera occurring near MHC, eight of these genera were identified. Two radiocarbon dates on two *Crotaphytus* sp. dentaries dated to 6350±40 (Cal BP 7330-7230; Beta-145833) and 29,240±350 yr B.P. (not calibrated; Beta-145834; Table 55).

Faunal Interpretation. Although modern distributions of lizards and snakes in the Great Basin are understood, knowledge of late Pleistocene and Holocene distribution is poor. Prior to any studies of Great Basin fossil herpetofaunas, Tanner (1978) examined modern distributions of Great Basin amphibians and reptiles and suggested that they were formed after the close of the Pleistocene. However, the discussion of late Pleistocene sites demonstrates that most modern day distributions were established by at least the end of the Pleistocene if not earlier. Clearly, more well dated sites that include reptilian fossil assemblages from a variety of taphonomic settings (packrat middens to cave deposits) and from a number of different ecological settings (valley bottoms into higher elevations) need to be studied to better resolve Quaternary herpetofaunal distribution patterns.

The known late Pleistocene reptilian community appears quite similar to the modern community. However, two lizards (*Phrynosoma hernandezi/douglasi* and *Sceloporus magister*) and four snakes (*Lampropeltis triangulum, L. zonata, L. getulus,* and *L. pyromelana*) enjoyed extended ranges in the late Pleistocene and early Holocene. *Phrynosoma hernandezi/douglasi* was found as far south as SCBC between 8-15,000 yr B.P. and also occured in MHC, SCC, LC, and CBC. Thus, the distribution of *P. hernandezi/douglasi* apparently extended further south in the late Pleistocene (Fig. 51). *Sceloporus magister* was found as far north as MHC, SCC, and on the eastern side of Nevada in HRS and HC. *Sceloporus magister's* northern range extension occurred at least by the late Pleistocene; however, in the northeastern portion of Nevada, it was still present in the mid-late Holocene (Fig. 72).

The presence of most of the snakes reported from the Great Basin fossil record was expected based on their modern distributions. Exceptions include certain species of *Lampropeltis*, such as *L. zonata, L. getulus, L. triangulum,* and *L. pyromelana* (Fig. 73-76). *Lampropeltis zonata, L. getulus, and L. pyromelana* were all identified from Hidden Cave. *Lampropeltis zonata* presently lives west of the cave in California inhabiting moist forests and *L. getulus* is distributed in the southern half of Nevada living in a variety of habitats. *Lampropeltis pyromelana,* a mountain dweller, survives as a disjunct population in the Snake Range. *Lampropeltis pyromelana* and *L. triangulum* were recovered from SCC. *Lampropeltis triangulum* occurs just outside the Great Basin in Utah inhabiting a variety of habitats. Both species had a more northern and western distributional extension into the Great Basin in the late Pleistocene (Mead and Bell 1994). *Masticophis flagellum* was recovered from SCBC but lives just south of the cave today. *Coluber constrictor* was recovered from GRS but lives just north of the cave today. The presence of these taxa may indicate either raptor transport or a slightly expanded range in the past.

Table 55. Lizards and snakes reocovered from MHC. The abundance of each taxon are given for testpits 3, 4, and 6.

	TP3	TP4	TP6
LIZARDS			
Crotaphytidae	34	3	20
Crotophytus sp.	20	0	50
cf. *Crotaphytus*	8	0	6
Gambelia sp.	3	0	10
cf. *Gambelia*	2	1	1
Phrynosomatidae	14	0	9
Phrynosoma sp.	4	1	2
P. hernandezi/douglasi	1	0	0
P. platyrhinos	3	0	13
P. cf. *platyrhinos*	0	0	3
P. platyrhinos/modestum	0	0	1
Type A-small sceloporine	14	0	1
Type B-medium "	78	0	23
Type C-large "	1	0	1
Eumeces sp.	1	0	0
Cnemidophorus sp.	7	0	0
Sauria	408	17	170
TOTAL	609	22	310
SNAKES			
Charina bottae	2	0	0
Coluber constrictor	12	1	1
Hypsiglena torquata	7	0	0
Masticophis sp.	0	1	14
Masticophis/Coluber	27	5	3
Pituophis melanoleucus	38	5	126
cf. *Pituophis*	54	2	92
Rhinocheilus lecontei	4	0	0
Thamnophis sp.	24	1	9
Colubridae	180	11	83
Crotalus sp.	19	0	22
cf. *Crotalus*	0	0	4
Serpentes	206	18	67
TOTAL	573	44	421
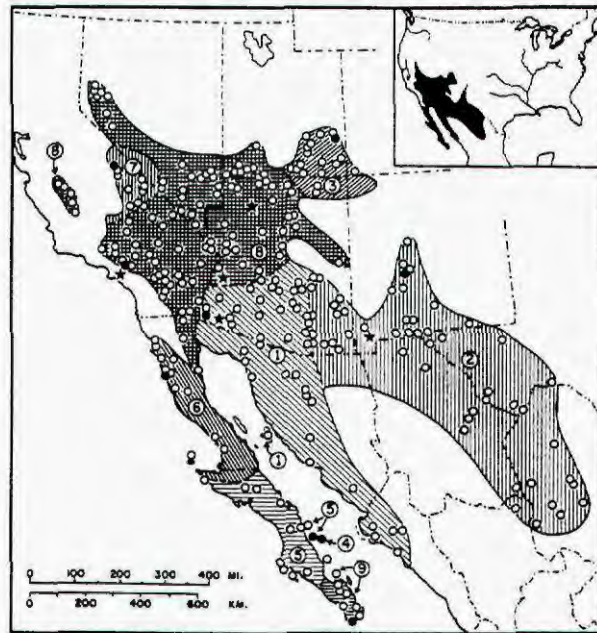
Figure 72. Distribution map of Sceloporus magister. *Solid circles mark type localities and open circles indicate other records. Stars signify late Pleistocene fossil localities within its modern distribution. Modified from Parker (1982).*
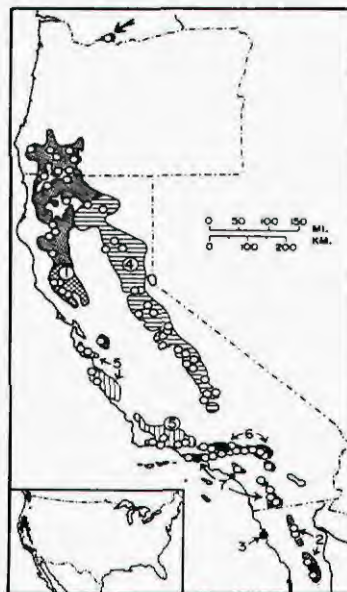
Figure 73. Distribution map of Lampropeltis zonata. *Solid circles mark type localities and open circles indicate other localities. Taken from Zweifel (1974).*
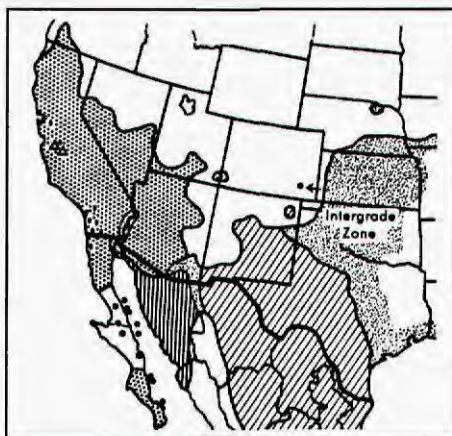
Figure 74. Distribution map of Lampropeltis getulus. *Modified from Stebbins (1985).*
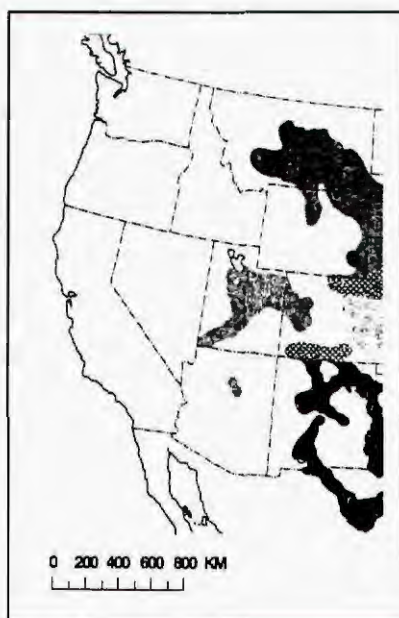
Figure 75. Distribution map of the western subspecies of Lampropeltis triangulum. *Modified from Williams (1994).*
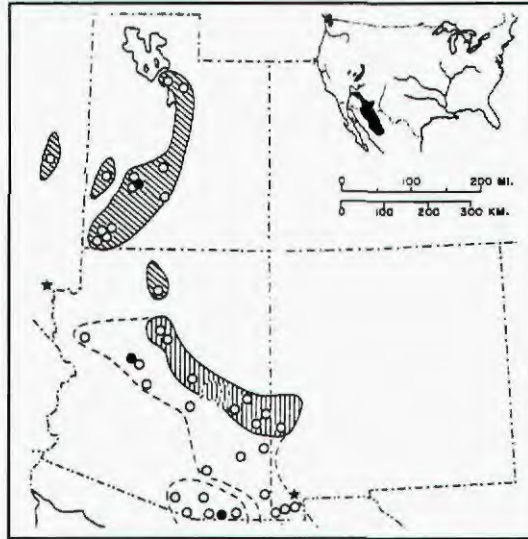
Figure 76. Distribution map of Lampropeltis pyromelana *within the four corners. Solid circles indicate type localites and the open circles mark other localities. The stars represent late Quaternary fossil sites. Modified from Tanner (1983).*

Paleoecology. Climatic inferences should not be based solely on reptiles, but should include analyses of the entire floral and faunal assemblage. Assuming their habitat preferences have not changed, the presence of extralocal taxa indicates a different climatic regime. For example, at HRS, *Sceloporus magister* and *Ochotona princeps*, both extralocal species, are found within the same unit. The co-occurrence of these species would suggest a more equable climate. Survival of *Sceloporus magister* requires winters no colder than today, while *O. princeps* needs cooler summers to survive (Mead and Bell 1994). Disharmonius reptilian and mammalian communities are possibly present at MHC. Unfortunately the mixed sediments at MHC preclude assumptions that *S. magister, Phrynosoma hernandezi/douglasi, P. platyrhinos,* and *O. princeps* lived contemporaneously in the local community. If these fossil assemblages reflect actual community composition, the late Pleistocene/early Holocene climate could be inferred to be more equable than today. More aridity with colder winters and increased seasonality during the mid-Holocene could drive these communities to disintegrate, leading to their modern distributions (Mead 1988; Mead and Bell 1994).

Eleven of the 12 lizard and 11 of the 18 snake species live in the floristic Great Basin today. Several taxa that inhabit the Great Basin today are either absent or poorly represented in the fossil record. *Callisaurus draconoides, Eumeces, Charina bottae, Diadophis punctatus, Sonora semiannulata,* and *Salvadora* are rare in the Great Basin fossil record. *Callisaurus draconoides,* which lives today in the south and southwestern portion of Nevada, has never been reported as a Great Basin fossil (Fig. 77). However, the only fossil locality within its range (GRS) does not include the scantily vegetated open desert wash or hardpan habitats that *C. draconoides* currently prefers (Stebbins 1985). Furthermore, the preferred habitat of low elevation, sandy or gravelly desert washes was most likely covered during much of the Pleistocene by pluvial lakes, which would have prevented colonization of *Callisaurus draconoides* until the lakes disappeared sometime during the middle Holocene (Mead pers. comm.). Mead et al. (1984) found *C. draconoides* from Deadman Cave in southern Arizona, which comprises its only known late Pleistocene-Holocene occurrence. It is possible that the morphological similarity of medium-sized sceloporine skeletal material has hampered researchers recognizing fossil *C. draconoides*. More low elevation, late Pleistocene-Holocene sites in the south and southwestern portions of the Great Basin need to be surveyed in order to determine when *C. draconoides* established its modern distribution.

Figure 77. Distribution map of
Callisaurus draconoides. *Modified
from Stebbins (1985).*
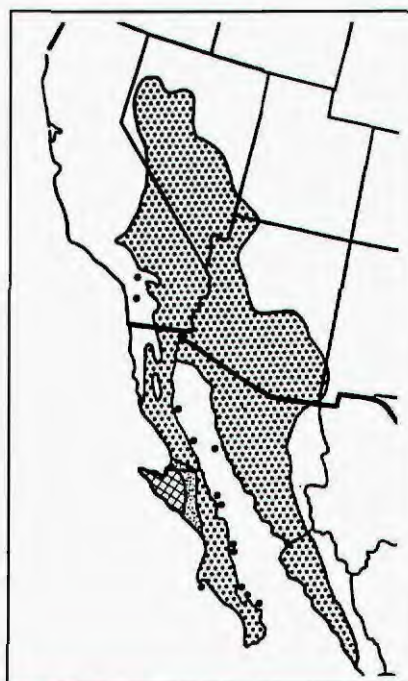
Eumeces sp. has only been recovered from
MHC. Although *Eumeces skiltonianus* occurs today
throughout most of the Great Basin, its occurrence is
spotty (Fig. 78). It can be encountered on rocky
slopes bearing *Artemisia tridentata* or *Juniperus
utahensis* from 1378-2134 m elevation; however, it is
most abundant in the cooler, higher elevations of
some mountain ranges. *Eumeces skiltonianus* has a
discontinuous distribution in the Great Basin as a
consequence of the basin and range geomorphic
setting (Tanner 1957, 1988). The habitat most likely
to support a *Eumeces* population has not been
prospected for fossils, with most known fossil sites
occurring in pinyon-juniper woodland or valley
bottoms. However, the data indicate that the late
Pleistocene-early Holocene climate was more
equable, which would seem to favor the preferred
habitat of *Eumeces* at lower elevations. One
possibility for their scarcity lies with their secretive
nature. Skinks are diurnal but rarely seen (Stebbins
1985); therefore, they are possibly not a common
prey item, and thus would not be found in
accumulations made by predators.

*Diadophis punctatus, Sonora semiannulata,
Salvadora,* and *Charina bottae* are also rare as fossils
in the Great Basin. This might be a collectiong bias
resulting from the use of screens that are too large to
recover some of the smaller snake species at some
fossil localities (i.e., DC). *Diadophis punctatus* has a
limited distribution in the Great Basin along the
Nevada-Utah border (Fig. 79) as does *Lampropeltis
pyromelana.* In the West, this seldom seen snake is
restricted to mountains unless water courses are
available, which then enables the snake to descend to
730 m elevation into desert areas (Stebbins 1985).
Diadophis punctatus, a crepuscular snake, is often
found under rocks or logs (Hammerson 1999). The
modern distribution appears to support the
interpretation of Brown (1971, 1978), who argued
that the distribution of small mammals on the Great
Basin mountain ranges resulted in extinction rather
than immigration. He claimed that these mountains
had experienced greater colonization during the late
Pleistocene when habitat bridges connected the Sierra
Nevada and Rocky Mountains. Holocene extinctions
followed when boreal habitats became restricted to
mountaintops, creating the distributional patterns seen
in small mammals today in the Great Basin. Grayson
(1987) and Thompson and Mead (1982) further this
discussion by providing specific examples of small

mammal biogeography. Based on Brown (1971, 1978), *D. punctatus* should have enjoyed an extended range during the late Pleistocene, and then retreated to higher elevations with the increasing aridity and seasonality of the middle Holocene. However, no

fossil evidence of *D. punctatus* exists to support this hypothesis. Like *Eumeces*, the secretive nature of *Diadophis* may limit its occurrence as a fossil.
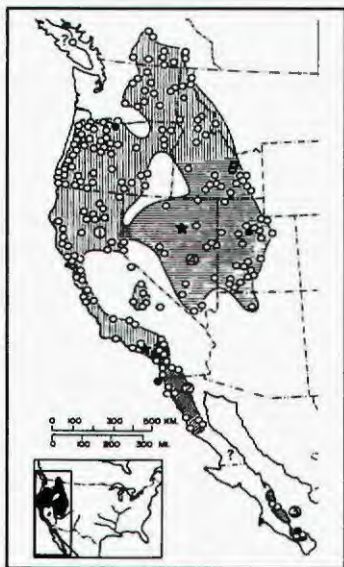
Figure 78. Distribution map of Eumeces skiltonianus. *The stars mark fossil localities. Modified from Tanner (1988).*
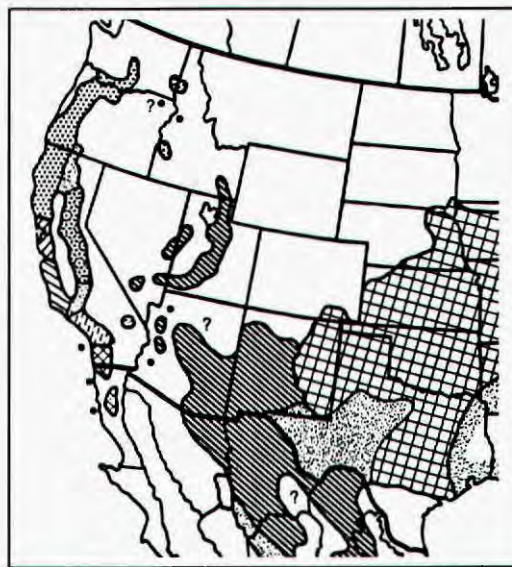
Figure 79. Distribution map of western subspecies of Diadophis punctatus. *Modified from Stebbins (1985).*

Salvadora hexalepis have similar distributions in Nevada, living in the southern and western part of the state (Figs. 80, 81). *Sonora semmiannulata* is a secretive, nocturnal snake living in arid to semiarid regions, ranging from prairies to thornscrub, pinyon-juniper woodland, and oak-pine zones. *Salvadora hexalepis* is a diurnal snake living in pinyon-juniper woodland, desertscrub, sagebrush plains, and grasslands (Stebbins 1985). These taxa were only found at the studied Holocene sites, HC for the former and GRS and HC for the latter species. The secretive, nocturnal nature of *S. semiannulata*

may explain its rare occurrence in the fossil record. These snakes could be recent invaders into the Great Basin, as has been suggested for *Callisaurus*. The ranges for these three species are quite similar (Figs. 77, 80, 81). However, *Salvadora* and *Sonora* are less restrictive in their habitat preference than *Callisaurus*. More Pleistocene sites should be excavated within the modern ranges of these two snakes in order to understand their fossil history more fully.
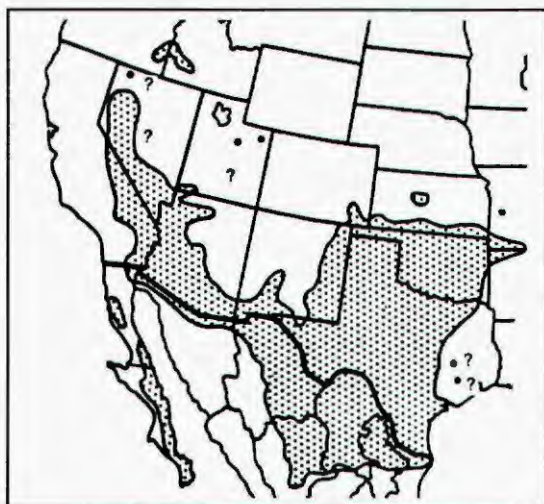
Figure 80. Distribution map of Sonora semiannulata. *Modified from Stebbins (1985).*
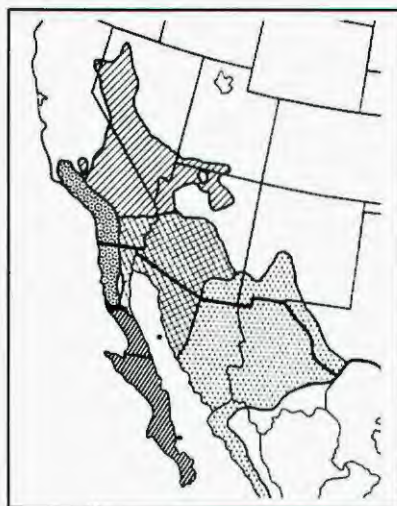
Figure 81. Distribution map of the subspecies of Salvadora hexalepis. *Modified from Stebbins (1985).*

Charina bottae, a nocturnal snake, lives in the northern portion of Nevada in montane riparian habitats from sea level to 3050 m elevation and is typically found under rocks or logs (Fig. 82; Behler and King 1998). Presumably, the preferred habitat of

C. bottae (like Eumeces and Diadophis) expanded during the late Pleistocene and thus the range of Charina would have extended into lower elevations, but fossil remains of C. bottae have only been reported MHC and HRS.
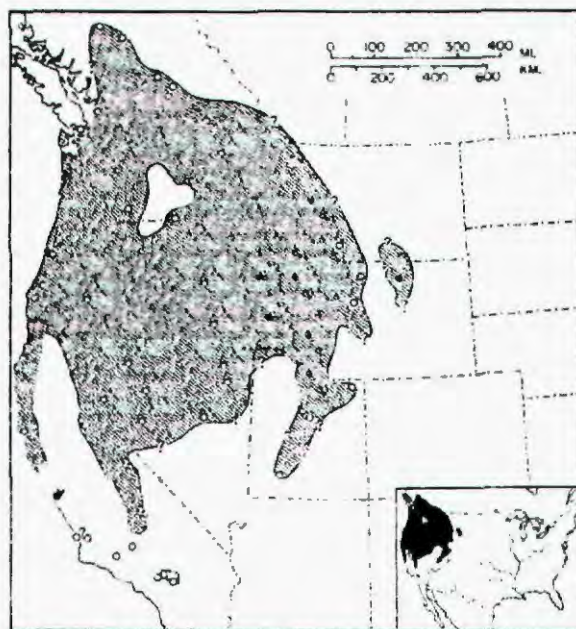
Figure 82. Distribution map of Charina bottae. *Modified from Stewart (1977).*

Typically, *Charina, Diadophis,* and *Eumeces* inhabit montane riparian areas. Since these taxa are consistently rare in raptor roosts, packrat middens, and cavefill of the large walk in caves, other settings need to be surveyed. Sandy Swift and Jim Mead (pers. comm. 2002) found *Bassariscus astutus* (ringtail cat) dung from Weeping Cliffs in the Grand Canyon. Within the carnivoran dung, Sandy Swift (pers. comm. 2002) identified *Leptotypholps* (blind snake), *Scaphiopus* (spadefoot toad), and *Dipsosaurus* (desert iguana), all of which mark the first fossil occurrence in the Grand Canyon. Unfortunately, carnivores tend to heavily break and etch bone during digestion, and therefore, the preservation quality can be poor (Andrews 1990). Small carnivores have the ability to find and eat particular taxa that are rare in the diets of larger

predators because of their small size and maneuverability. In order to find these rare taxa in the fossil record, small carnivore dens might prove to be an informative tool.

Negative evidence does not necessarily mean that the animal did not inhabit the area in the past. However, if particular taxa are consistently absent in fossil deposits then either sampling protocols need to be improved or the taxa are indeed late invaders into the Great Basin. Sampling protocols could be improved by using the appropriate screen size, ensuring recovery of all reptile remains. Furthermore, prospecting localities to answer specific reptilian research questions will provide the needed understanding of fossil herpetofaunas and their biogeography in the Great Basin.

Conclusion. Mineral Hill Cave is unique in the location and age of the deposits. Mineral Hill Cave is the only cave in north-central Nevada that has been studied for its paleontological significance that dates to the Pleistocene and into the Holocene. The rich reptilian fauna provides evidence of the past occurrence of two extralocal species (Phrynosoma hernandezi/douglasi and Sceloporine Type C) and the first fossil occurrence of Eumeces sp. from the Great Basin. The presence of extralocal taxa and possibly disharmonious assemblages suggests a different climatic regime, one apparently more equable than today. Evidence implicates predation and water as the taphonomic agents that formed the MHC deposit.

The identification to species from disarticulated skull elements is difficult in any lizard group, but the sceloporines are especially problematic. Little is known of the geographic and ontogenetic skeletal variation within this group. More quantitative and qualitative analyses should be performed on single skull elements so identification to species may be possible. This effort in turn may allow researchers to further the study of fossil herpetofaunas.

Eleven reptile-producing sites exist in the Great Basin, all but two are located on the eastern or western portion of the Great Basin. The central corridor through the Great Basin has been largely ignored. An overview of the other reptile producing sites in the Great Basin indicates that very little is known of their biogeography of reptiles over the past millenia. The fauna from MHC begins to fill in the gap of our knowledge for the north-central Great Basin at the Pleistocene-Holocene transition. In order to understand when modern distributions were established, a variety of localities should be sought out (i.e., lacustrine, packrat middens, natural traps, valley bottoms to the higher elevations) that will hopefully date to different ages and may provide more insight into fossil herpetofaunas and the biogeographic history of modern reptiles.

CHAPTER 7

Mineral Hill Cave Avifauna

Steven R. James

The Mineral Hill Cave avifaunal assemblage is very significant for our understanding of the distribution of some Late Pleistocene and Holocene birds in the Great Basin and elsewhere in western North America for at least three reasons. First, most specimens are very well-preserved for a wet cave, especially those recovered from the rear of the cave in Chamber 5. Second, very early AMS radiocarbon dates were obtained on individual bone specimens for several of the identified species. Third, the radiocarbon dates may be the first and earliest direct dates for five avian species recovered from a late Pleistocene paleontological locality in North America.

In total, 68 avifaunal specimens representing 6 orders, 8 families, and at least 14 species were identified from the Mineral Hill Cave deposits (Table 56). This chapter presents the descriptive results of the avifaunal analysis. These data should be considered preliminary at this time, as further research on the avifaunal assemblage is in progress. In addition, data on the distribution of the late Pleistocene avifauna from other sites in western North America that is presented below should be considered preliminary in light of more recent paleontological and archaeological literature.

Taxonomic identifications are based on comparisons of the Mineral Hill Cave avifaunal material with modern and/or extinct comparative specimens at the Museum of Vertebrate Zoology, University of California at Berkeley; Museum of Northern Arizona in Flagstaff (particularly the Hargrave Collection); and the George C. Page Museum at Rancho La Brea in Los Angeles, which is part of the Natural History Museum of Los Angeles County. Determinations are to the species level whenever possible; approximate identifications are indicated by cf. (i.e., compares favorably with) followed by the genus and/or species name. Additional abbreviations used in this chapter are as follows: * = extinct species; AMS = accelerator mass spectrometer (for C-14 dates); C-14 = radiocarbon date; Spec. No. = Specimen Number; SR = Stafford Research Lab, Inc. (C-14 dates); BP = years before

present (uncalibrated C-14 date).

Table 56. Avifauna identified from Mineral Hill Cave.

Common and Scientific Name	NISP
Tundra Swan (*Cygnus columbianus*)	1
Indeterminate Large Accipitridae	1
Golden Eagle (*Aquila chrysaetos*)	1
Red-tailed Hawk (*Buteo jamaicensis*)	3
Fragile Eagle (*Buteogallus fragilis*)*	1
Prairie Falcon (*Falco mexicanus*)	4
American Kestrel (*Falco sparverius*)	2
Indeterminate Phasianidae	9
cf. Blue Grouse (cf. *Dendragapus obscurus*)	7
Sage Grouse (*Centrocercus urophasianus*)	27
Mourning Dove (*Zenaida macroura*)	6
Short-eared Owl (*Asio flammeus*)	1
Pinyon Jay (*Gymnorhinus cyanocephala*)	2
Common Raven (*Corvus corax*)	1
Black-billed Magpie (*Pica pica*)	1
American Robin (*Turdus migratorius*)	1
Total	**68**

NISP = Number of Identified Specimens (i.e., bone counts)

*based on comparison with specimens at Page Museum

Class Aves

Order Anseriformes

Family Anatidae

Cygnus columbianus
Tundra Swan

MATERIAL RECOVERED. One scapula

C-14 AGE. TP2-11-2 [29,180 ± 190 BP (SR-5409)]

DISCUSSION. Tundra swan (*Cygnus columbianus*) is represented by a single scapula that was recovered from TP2. The specimen is mineral-stained a gray color. The AMS radiocarbon date of 29,180 ± 190 BP (uncalibrated) on the scapula element may be the first and earliest direct date for *Cygnus columbianus* from a late Pleistocene paleontological locality in North America.

Although relatively rare in late Pleistocene contexts in western North America, a few specimens assigned to this species were identified from the Rancho La Brea and McKittrick tar pits in southern California (Miller and DeMay 1942:82). However, no *Cygnus* specimens were reported from Smith Creek Cave in eastern Nevada (Howard 1952). Further research of more recent literature is needed to better determine the late Pleistocene distribution of tundra swan in western North America.

Order Accipitriformes

Family Accipitridae

Indeterminate Large Accipitridae

MATERIAL RECOVERED. One carpometacarpus

C-14 AGE. unknown

REMARKS AND DISCUSSION. A small fragment of a left proximal carpometacarpus shaft resembles golden eagle (cf. *Aquila chrysaetos*), but could not be assigned with certainty. The element could be from another large accipiter such as bald eagle or perhaps an extinct late Pleistocene species. The specimen (TP3-212) was recovered from TP3.

Aquila chrysaetos
Golden Eagle

MATERIAL RECOVERED. One tarsometatarsus.

C-14 AGE. TP3-187 [38,650 ± 530 BP (SR-5410)].

DISCUSSION. The MHC avifaunal assemblage contains a single, nearly complete tarsometatarsus from a golden eagle (*Aquila chrysaetos*). The specimen (TP3-187), which was recovered from TP3, is relatively fresh in appearance, but slightly mineral stained in a few places. Measurements of the specimen are as follows: Total Length: 92.9+ mm (lacks proximal articulating surface); Proximal Width: 19.2+ mm (lacks proximal articulating surface); Distal Width: 23.8 mm. The AMS radiocarbon date of 38,650 ± 530 BP (SR-5410) may be the first and earliest direct date for golden eagle in North America.

In late Pleistocene contexts in western North America, remains of golden eagle are extremely common in the southern California tar pits at Rancho La Brea, McKittrick, and Carpinteria (Miller and DeMay 1942:101-102). In fact, Stock and Harris (1992:60) remarked: "This species occurs more abundantly at Rancho La Brea than any other bird, a census indicating in excess of 1,000 individuals in the Page Museum collection." Oddly enough, golden eagle was not reported from the late Pleistocene Sierra Nevada caves of Hawver, Potter Creek, and Samwel (cf. Miller and DeMay 1942:62-63), but the species was identified in Smith Creek Cave in eastern Nevada (Howard 1952).

Buteo jamaicensis
Red-tailed Hawk

MATERIAL RECOVERED. One tibiotarsus, one proximal tarsometatarsus, one distal tarsometatarsus (the latter two specimens from separate test pits refit on an old break)

C-14 AGE. unknown

DISCUSSION. The three specimens assigned to red-tailed hawk (*Buteo jamaicensis*) were recovered

in three separate test pits within MHC—TP1a, TP3, and TP4. However, two of the specimens (TP4-5 and TP3-425) are the proximal and distal portions, respectively, of the same tarsometatarsus from two adjacent test pits in Chamber 5 that refit along what appears to be an old break. This is important from a taphonomic standpoint, indicating that the two specimens were displaced in the cave deposits at sometime in the past. For this reason and given their vertical and horizontal spatial separation, the elements are counted here as two specimens. All three red-tailed hawk elements are well preserved.

Red-tailed hawk is relatively common in late Pleistocene contexts in western North America. For example, the species was reported from the three southern California tar pit localities (Rancho La Brea, McKittrick, and Carpinteria) and Potter Creek Cave in northern California (Miller and DeMay 1942:97), as well as Smith Creek Cave in eastern Nevada (Howard 1952).

Buteogallus fragilis
Fragile Eagle

MATERIAL RECOVERED. One coracoid.

C-14 AGE. unknown

DISCUSSION. A well-preserved, nearly complete coracoid specimen (TP3-187) is identified as an extinct species of late Pleistocene hawk known as fragile eagle (*Buteogallus fragilis*). Identification of the MHC specimen is based on comparisons with late Pleistocene specimens recovered from the Rancho La Brea tar pits, which are stored at the George C. Page Museum in Los Angeles.

As with many of the avifaunal bones in the MHC assemblage, this coracoid is unfossilized and remarkably "fresh" in appearance. The specimen was recovered from TP3. With regard to taphonomic processes, portions of the proximal and distal ends of the coracoid exhibit edge damage that suggests the specimen was broken into by the beak of another raptor during consumption of the upper wing and breast meat. I have observed similar marks on the elements of black-tailed jackrabbits (*Lepus californicus*) in northern Nevada that have been eaten by raptors and owls (see also Hockett 1989, 1991 for a discussion of similar marks).

Fragile eagle is the only extinct avifaunal species identified, thus far, in the MHC assemblage.

The distribution of this late Pleistocene species is mainly known from localities in western and southwestern North America. This species was first identified as *Geranoaëtus fragilis* by Miller (1911) from the late Pleistocene Rancho La Brea tar pit deposits in Los Angeles County, California. The species was later identified in other California tar pit deposits at Carpinteria in Santa Barbara County (Miller 1928) and McKittrick in Kern County (Miller 1935). A detailed list of the literature on fragile eagle specimens recovered between 1911 and 1940 from these three southern California localities has been published (Miller and DeMay 1942:99). Other synonyms in this literature include *Urubitinga fragilis* and *Hypomorphus fragilis*, and the species was assigned to the genus *Buteo* in 1933 (Wetmore 1933). Fragile eagle has also been identified in late Pleistocene cave deposits at Shelter Cave in the Organ Mountains of Donna Ana County, New Mexico (Howard and Miller 1933). Fragile eagle has been described as "slender-limbed" and is related to a modern species in the southern United States (Stock and Harris 1992:60), that of *Buteo melanoleucus* (cf. Miller 1925, cited in Miller and DeMay 1942:99).

With regard to the distribution of fragile eagle from other late Pleistocene localities, the MHC specimen appears to be the first recorded account in the central and eastern Great Basin. Although another species of extinct eagle, that of Willett's eagle (*Spizaëtus willetti* Howard 1935), was identified in the avifaunal assemblage recovered during the early 1930s from Smith Creek Cave in White Pine County, eastern Nevada, there is no mention of fragile eagle (Howard 1935, 1952). Similarly, fragile eagle was not identified in the late Pleistocene avifaunal assemblages reported from Hawver, Potter Creek, and Samwel Caves in the western Sierra Nevada, although Miller's eagle (*Hypomorphus milleri*), an extinct species, was reported from Hawver Cave (Miller and DeMay 1940:63). Further, in the early 1960s, Brodkorb (1964:269) only mentioned the three southern California tar pit localities and Shelter Cave in New Mexico in the distribution of fragile eagle. Examination of more recent literature may identify other late Pleistocene specimens of fragile eagle in western North America (e.g., see discussion in Grayson 1993:168-169, 188-189 about an extinct species of black hawk, *Buteogallus* [formerly *Hypomorphus*], from Fossil Lake in Oregon).

Family Falconidae

Falco mexicanus
Prairie Falcon

MATERIAL RECOVERED. Two ulnae, one femur, one tibiotarsus

C-14 AGE. TP3-192 [>45,200 BP (SR-5411)]

DISCUSSION. Four elements are assigned to prairie falcon (*Falco mexicanus*) in the MHC avian assemblage. One complete ulna (TP3-192) recovered from TP3 at the rear of the cave was submitted for C-14 dating. This specimen is very "fresh" in appearance, but slightly mineral stained in a few places. Measurements of the ulna are as follows: Total Length: 82.0 mm; Proximal Width: 10.9 mm; Distal Width: 7.9 mm. These measurements are similar to three *Falco mexicanus* specimens that I measured at the Museum of Northern Arizona in Flagstaff. The AMS radiocarbon date of >45,200 BP (SR-5411) indicates that the specimen is older than the range of C-14 dating. As with other avian specimens in the MHC assemblage, this may be the first and earliest direct date for prairie falcon in North America.

Skeletal remains of prairie falcon are common in late Pleistocene and Holocene sites in western North America. For example, at Smith Creek Cave in White Pine County, eastern Nevada near the Utah state line, prairie falcon was one of the most common remains with 117 specimens identified (Howard 1952). Similarly, of the large falcons recovered from Rancho La Brea and McKittrick in southern California, prairie falcon was the most numerous (Miller and DeMay 1942:104).

Falco sparverius
American Kestrel

MATERIAL RECOVERED. One coracoid, one humerus

C-14 AGE. unknown

DISCUSSION. American kestrel (*Falco sparverius*) is represented in the MHC avifaunal assemblage by two elements. One specimen (TP1b-07-8) was collected in TP1 near the entrance to the cave; it is a well-preserved left coracoid. The other

specimen (TP6-16) is a left humerus recovered from TP6, which was also excavated in Chamber 1 but at the rear of this chamber in an alcove. This specimen is not as well-preserved as the other *Falco sparverius* element. From a taphonomic standpoint, this humerus is white in color and appears to have been eroded slightly by either the stomach acids of a carnivore and was passed as scat or through consumption by an owl, followed by digestion and regurgitation as an owl pellet.

As with prairie falcon, American kestrel is relatively common in late Pleistocene and Holocene sites in the western North America. The species was reported from Smith Creek Cave in eastern Nevada (Howard 1952), as well as from many late Pleistocene localities in California (e.g., Potter Creek Cave, Samwel Cave, Rancho La Brea, McKittrick, and Carpinteria [Miller and DeMay 1942:104-105]).

Order Galliformes

Family Phasianidae

Indeterminate Phasianidae

MATERIAL RECOVERED. One coracoid, three humeri, one carpometacarpus, four femora

C-14 AGE. unknown

DISCUSSION. Most of these elements are similar to sage grouse and could tentatively be assigned to this species. However, blue grouse (*Dendragapus obscurus*) and/or sharp-tailed grouse (*Tympanuchus phasianellus*) might be represented in some of these specimens. In addition, two of the femora (TP4-4 and TP2-SL-9) are quite large, suggesting either that the specimens are from a large male sage grouse or that the species was more robust during the late Pleistocene. Alternatively, the specimens could be from an extinct late Pleistocene species of grouse. Further comparative research is needed on these and the other grouse specimens in the MHC avifaunal assemblage.

The distribution of sage grouse and blue grouse is discussed below. With regard to sharp-tailed grouse, historically the species may have inhabited the extreme northern edge of Nevada, but their modern distribution does not include this state (Johnsgard 1973:Figure 32). Sharp-tailed grouse inhabit "open expanses of short grass prairie"

(Parmalee 1992:312). Parmalee (1992:312), citing Wetmore (1959:180), indicates that it is difficult to separate sharp-tailed grouse and greater prairie chicken (*Tympanuchus cupido*), except for the pelvis.

As with sage grouse (*Centrocercus urophasianus*) (see below), sharp-tailed grouse is absent from late Pleistocene avifaunal assemblages from the major caves and tar pits localities in California (cf. Miller and DeMay 1942:105-106). However, a few elements were tentatively assigned to this species (listed as *Pedioecetes phasianellus*?) in the Smith Creek Cave assemblage (Howard 1952:54).

cf. *Dendragapus obscurus*
Blue Grouse

MATERIAL RECOVERED. Six humeri, one carpometacarpus

C-14 AGE. unknown

DISCUSSION. Blue grouse (*Dendragapus obscurus*) is tentatively represented in the MHC avifaunal assemblage by seven elements. Six of these specimens were recovered from TP3, and one specimen came from TP6. The identification of these specimens as blue grouse compares favorably with modern comparative material in the Museum of Northern Arizona. However, further comparative research needs to be conducted on the blue grouse and sage grouse specimens from MHC in order to better discern characteristics for separating the two species.

In their modern distribution, blue grouse inhabit the higher elevations of northeastern Nevada (Johnsgard 1973:Figure 24). In late Pleistocene localities in California, blue grouse was identified at Samwel and Potter Creek Caves in the Sierra Nevada, but it was not represented in the southern California tar pit sites (Miller and DeMay 1942:105). Oddly enough, blue grouse was not identified from Smith Creek Cave (Howard 1952:54), and I would expect the species to have been present at that locality in the late Pleistocene.

Centrocercus urophasianus
Sage Grouse

MATERIAL RECOVERED. Four coracoids, six scapulae, one humerus, four ulnae, three carpometacarpi, three femora, two tibiotarsi, four tarsometatarsi

C-14 AGE. TP6-4 [4,660 ● 40 YBP (SR-5414)].

DISCUSSION. A total of 27 grouse elements in the MHC assemblage is assigned to sage grouse (*Centrocercus urophasianus*). The majority (21 elements, 77.8%) were recovered in TP3 in Chamber 5 at the rear of the cave. Distribution of the other sage grouse specimens is as follows: TP1a (3), TP2 (1), and TP6 (2). Based on these results, sage grouse is the most common bird species represented in the MHC avifaunal assemblage, which similarly compares with other late Pleistocene localities in the Great Basin, especially Smith Creek Cave as discussed below.

The sage grouse element that was submitted for AMS dating is a single coracoid (TP6-4) that was recovered from TP6 in the first chamber within MHC. The specimen is slightly mineral stained but otherwise well preserved. Measurements for the coracoid are as follows: Total Length: 68.6 mm; Proximal Width: 14.0 mm; Distal Width: 15.7+ mm. Since the specimen is slightly larger than the other sage grouse coracoids in the Museum of Northern Arizona comparative collection, this suggests that it might be from a male. Although this specimen looked older than some of the other avifaunal remains in the MHC assemblage due to its mineral stained appearance, a late Pleistocene C-14 date was expected. However, a mid-Holocene AMS date of 4,660 ± 40 YBP (SR-5414) was obtained on the specimen.

The modern distribution of sage grouse includes eastern Nevada (Johnsgard 1973:Figure 22). Its distribution in western North American generally coincides with the presence of sagebrush (e.g., *Artemisia tridentata*) (Johnsgard 1973:157). In late Pleistocene localities, sage grouse was identified from Smith Creek Cave in eastern Nevada, where it was one of the most common avifaunal remains in the assemblage with 122 specimens (Howard 1952). In contrast, sage grouse is absent from the major late Pleistocene caves and tar pits in California (cf. Miller and Day 1942:105-106).

Order Columbiformes

Family Columbidae

Zenaida macroura
Mourning Dove

MATERIAL RECOVERED. Two humeri, one ulna, one carpometacarpus, one pelvis, one femur

C-14 AGE. unknown

DISCUSSION. Mourning dove (*Zenaida macroura*) is represented by six elements in the MHC avifaunal assemblage. All but one specimen came from TP3. The other specimen, a left humerus (TP1b-04-1), was recovered from TP1b in the first chamber.

Mourning dove has been recovered in late Pleistocene and Holocene sites in western North America. At Smith Creek Cave in eastern Nevada, the species was represented by only one specimen (Howard 1952). The reason for this may be due to the lack of screening during excavations of the cave in the 1930s. At late Pleistocene localities in California, small numbers of mourning dove elements were recovered from Rancho La Brea and McKittrick (Miller and DeMay 1942:104-105).

Order Strigiformes

Family Strigidae

Asio flammeus
Short-eared Owl

MATERIAL RECOVERED. One femur

C-14 AGE. TP3-193 [>44,900 YBP (SR-5412)]

DISCUSSION. Short-eared owl (*Asio flammeus*) is represented in the MHC assemblage by a single, nearly complete femur, which was recovered from TP3. Measurements for the femur (TP3-193) are as follows: Total Length: 56.4 mm; Proximal Width: 9.7 mm; Distal Width: 9.8 mm. Since the specimen is relatively fresh in appearance with slight mineral staining, the antiquity of the element was not expected. The AMS radiocarbon date of >44,900 BP (SR-5412) indicates that this short-eared owl

specimen is older than the range of C-14 dating. Once again, as with most other avian specimens in the MHC assemblage that were C-14 dated, this may be the first and earliest direct date for short-eared owl in North America.

In late Pleistocene localities in western North America, short-eared owl has been reported from Rancho La Brea, but was not recovered in the well-known Sierran caves or other tar pit locations (e.g., McKittrick and Carpinteria) discussed by Miller and DeMay (1942:119). In eastern Nevada, *Asio flammeus* was identified from a few elements recovered from the early 1930s excavations at Smith Creek Cave (Howard 1952:54). In southeastern New Mexico near Carlsbad, a single element was tentatively identified as short-eared owl in the assemblage from Dark Canyon Cave (Howard 1971:Table 1).

Order Passeriformes

Family Tyrannidae

Gymnorhinus cyanocephala
Pinyon Jay

MATERIAL RECOVERED. Two carpometacarpi

C-14 AGE. unknown

DISCUSSION. The two carpometacarpi elements (TP1b-013-1 and TP6-13) assigned to pinyon jay (*Gymnorhinus cyanocephala*) were recovered from two separate test pits, that of TP1b and TP6, which are both located in Chamber 1. Both specimens are well-preserved and represent right and left elements.

Pinyon jay has not been reported from many late Pleistocene localities in western North America. A single element of an unspecified jay was identified from the early 1930s excavations at Smith Creek Cave in eastern Nevada (Howard 1952:54). In early Holocene contexts, only one element of pinyon jay was reported from Stratum 1 at Hogup Cave in northwestern Utah (Parmalee 1970:Table 1).

Corvus corax
Common Raven

MATERIAL RECOVERED. One carpometacarpus

C-14 AGE. TP3-424 [45,800 ± 1,300 YBP (SR-5413)]

DISCUSSION. Common raven (*Corvus corax*) in the MHC avifaunal assemblage is represented by a single complete carpometacarpus, which was recovered from TP3. Although fairly well-preserved, the specimen has mottled dark spots from mineral staining. Measurements for the carpometacarpus are as follows: Total Length: 71.3 mm; Proximal Width: 14.6 mm; Distal Width: 14.5 mm. The AMS radiocarbon date of 45,800 ± 1,300 BP (SR-5413) may be the first and earliest direct date for common raven in North America.

With regard to other late Pleistocene sites in western North America, *Corvus corax* is commonly represented at a number of localities, such as Rancho La Brea, McKittrick, Carpinteria, and Del Rey Hills in southern California, and Hawver Cave in northern California (Miller and DeMay 1942:124). Other late Pleistocene localities with common raven include Smith Creek Cave in eastern Nevada (a few elements, Howard 1952:54) and Dark Canyon Cave in southeastern New Mexico (10 elements, Howard 1971:Table 1) to list just a few. Early Holocene sites in the Great Basin where common raven have been reported include Hogup Cave (Stratum 1, one element, Parmalee 1970:Table 1).

Pica pica
Black-billed Magpie

MATERIAL RECOVERED. One carpometacarpus

C-14 AGE. unknown

DISCUSSION. Black-billed magpie (*Pica pica*) is represented in MHC by a single, very well-preserved complete left carpometacarpus. The specimen (TP3-227) was recovered from TP3.

In late Pleistocene contexts in western North America, remains of black-billed magpie have been identified from a few sites, which include Smith Creek Cave in eastern Nevada (1 unspecified

element, Howard 1952:54). However, only yellow-billed magpie (*Pica nuttalli*) has been identified from Rancho La Brea and Carpinteria in southern California (Miller and DeMay 1942:123; Stock and Harris 1992:88). In the eastern Great Basin, early Holocene sites that have recovered black-billed magpie include Hogup Cave (five elements, Parmalee 1970:Table 1).

Family Muscicapidae

Turdus migratorius
American Robin

MATERIAL RECOVERED. One humerus

C-14 AGE. unknown

DISCUSSION. The MHC avian assemblage contains a single, complete right humerus from American Robin (*Turdus migratorius*). This well-preserved specimen (TP3-228), which was recovered from TP3, exhibits a light gray mineral stain.

Only a few remains of American robin have been reported from late Pleistocene localities in western North America. These localities include Smith Creek Cave in eastern Nevada (1 unspecified element, Howard 1952:54) and Carpinteria near Santa Barbara in southern California (a few unspecified elements, Miller and DeMay 1942:127). As of the early 1940s, American robin had not been reported from Rancho La Brea (Miller and DeMay 1942:127), but it has been identified since that time (Stock and Harris 1992:88).

CHAPTER 8

A Late Pleistocene Record of Humboldt Cutthroat Trout (*Oncorhynchus clarki* subsp.) from Mineral Hill Cave, Northeastern Nevada

Jack Broughton

Only two fish specimens were recovered from the Mineral Hill Cave deposits: two mostly complete centra from the caudal vertebrae of a large salmonine. Although a species-level identification can not be made for these specimens on osteological criteria, the established ranges for Great Basin salmonines, including fossil histories, suggest those materials represent Humboldt cutthroat trout (*Oncorhynchus clarki* subsp.). The agent of deposition of these remains is unknown, but the fish most likely originated from Pine Creek, a tributary of the Humboldt River, now located approximately six miles (10 kilometers) from the cave. The deep-brown staining of the vertebrae along with the multiple radiocarbon determinations from other materials (Chapter 1), strongly suggest a mid-Wisconsinan age for the specimens. (One of the two vertebrae was burned for a radiocarbon date, but it did not contain enough organic material to yield one). These Mineral Hill specimens represent one of only a few Pleistocene records of cutthroat trout in the Great Basin and the first Pleistocene record for Humboldt cutthroat trout.

Great Basin Salmonines

Cutthroat trout is the only native salmonine of the Lahontan Basin with records in the region extending back to Pliocene times (Smith et al. 2002:220). The native range of rainbow trout (*Oncorhynchus mykiss*) is within the Columbia River drainage to the north, and west of the Sierra Nevada-Cascade Range. Trout populations of the northwestern Great Basin (e.g., redband trout of the Oregon Lakes Basin [*O. m. gairdneri*] and Eagle Lake rainbow trout [*O. m. aquilarum*] of Eagle Lake) exhibit a mix of cutthroat and rainbow trout characters (Behnke 1992; Smith et al. 2002). Bull trout (*Salvelinus confluentus*) may have occurred in the Bonneville Basin during the late Pleistocene, and perhaps up into early historic times, but records are limited to a single fossil premaxilla from Homestead Cave and an 1834 Bear River report (but no specimen vouchers) by reputable zoologists (Broughton 2000a; 2000b; Broughton et al. 2000; Smith et al. 2002). A native Nevada population of bull trout also existed in the Jarbidge River, a tributary to the Snake River drainage, just over the northern edge of the Great Basin (Smith et al. 2002:218). *Salvelinus* also occurred in central Nevada during the Miocene, about 14 million years ago (Smith et al. 2002:218), yet no Quaternary or Recent records exist for this taxon in the Lahontan Basin. These spatial-temporal distributions suggest the Mineral Hill materials represent cutthroat trout.

Pleistocene Records of Cutthroat Trout in the Great Basin

Only seven published Pleistocene records of cutthroat trout exist for the Great Basin (Smith et al. 2002:180-181). Of these records, four are Wisconsinan in age and each of the latter are derived from the Bonneville Basin. These include three localities in the northern Bonneville Basin (Black Rock [Smith et al. 1968], Homestead Cave [Broughton 2000a, 2000b], Old River Bed [Oviatt 1984]), and one locality in the southwestern Bonneville Basin (Snake Creek Canyon [Mead et al. 1982]). The Mineral Hill cave specimens thus represent the first Wisconsinan records of cuttthroat trout in the Lahontan system.

Humboldt Cutthroat Trout

The Humboldt River system is inhabited by a distinctive, but as yet unnamed, subspecies of cutthroat trout and the Mineral Hill Cave specimens almost surely represent this fish. The Humboldt cutthroat trout (*O. c.* subsp.) has larger scales, fewer gill rakers, and distinctive mtDNA compared to the Lahontan cutthroat trout (*O. c. henshawi*) (Smith et al. 2002). The 0.1% mtDNA sequence divergence between these subspecies suggest a divergence of ~200,000 years, well prior to the deposition of the Mineral Hill trout materials. The Mineral Hill

specimens thus appear to represent the first
Pleistocene records of Humboldt cutthroat trout.

CHAPTER 9

Paleoecology of Mineral Hill Cave: Interpretations Based on Stable Isotope Data

Peggy H. Ostrom and Thomas W. Stafford, Jr.

Approximately 35 years ago DeNiro and Epstein (1978, 1981) demonstrated that stable carbon and nitrogen isotope values ($\delta^{13}C$ and $\delta^{13}C$, respectively) of a modern organism and its diet are similar. Several other subsequent studies confirm that the isotope values of the muscle or whole-body of consumers differ from their diets by 1 ‰ in $\delta^{13}C$ and 3-4 ‰ in $\delta^{15}N$. Paleobiologists have exploited these relationships to address questions regarding trophic structure and ecological relationships among extinct organisms (Schoeninger and DeNiro 1984; Koch et al. 1994; Bocherens et al. 1996; McNulty et al. 2003). This approach requires the isolation and subsequent analysis of proteins that are preserved in ancient bones or teeth. We also must be careful to ensure that diagenetic loss of organic matter and introduction of contaminants do not alter the original isotope values of collagen (Ostrom et al. 1993; McNulty et al. 2003).

In this chapter we present $\delta^{13}C$, $\delta^{15}N$ and C/N values of collagenous protein (herein termed collagen) for a suite of radiocarbon dated samples from Mineral Hill Cave. We discuss the chemical and physical preservation state of the collagen isolated from these fossils and reconstruct paleoecological relationships of species based on their isotope data.

Methods

Isolation of Collagenous Proteins for Stable Isotope and Radiocarbon Analysis

Approximately 200 to 900 mg of dense, cortical bone were used for isolating collagen. The smallest sample was a single mandible of a bat (*Myotis* sp.). Bones were broken into coarse fragments 10 to 15 mm long by 3 to 5 mm thick to enable observation of the collagen's physical properties, including the degree of its pseudomorph in acid and base solutions. Decalcification was in 4°C 0.2N HCl for several days. After neutralization in di water, collagen fragments were treated with 4°C 0.1M KOH for two days, the collagen neutralized and made acidic with pH2 water and finally freeze dried. Solution colors, and collagen physical conditions were recorded and a percent yield of base-extracted decalcified collagen was calculated. Fifty milligrams or less of KOH-extracted decalcified collagen were heated at 90°C in sealed, nitrogen-purged tubes containing 0.02N HCl until the collagen dissolved (gelatinized). Dissolution required less than 5 minutes to 30 minutes. The gelatin solution was filtered through 0.45 μm Millipore Millex filters and the solution was freeze dried. Approximately 20 to 30 mg of freeze-dried collagen were used for the final purification step with XAD resin. The gelatin was hydrolyzed at 110°C for 24 hours in sealed, nitrogen-purged tubes containing distilled, 6N HCl. The collagen hydrolyzate was passed through a 5mm diameter X 10 mm high bed of 100-200 μm XAD-2 resin in a 5 ml syringe mounted atop a 0.45μm Millipore Millex filter. The XAD-purified hydrolyzate was collected in a glass tube and dried to viscous syrup over N_2 at 110°C.

Approximately 5 mg of purified gelatin was used for stable isotope analyses. From 1 to 8 mg of XAD-purified collagen hydrolyzate was combusted at 850°C for 3 hours and the CO_2 was used for AMS ^{14}C dating. Combustions were performed in sealed quartz tubes containing CuO and Ag powder. Graphite for AMS ^{14}C dating was made catalytically converting CO_2 into graphitic carbon by using the Zn-Fe method. AMS ^{14}C measurements were made at the Center for Mass Spectrometry, Lawrence Livermore National Lab, Livermore, California.

Stable isotope analysis

Isotope values and elemental (C/N) ratios of collagen (ca. 1 mg) were analyzed by a Eurovector elemental analyzer interfaced to an Isoprime mass spectrometer (GV Instruments) (Wong et al. 1992). The carbon and nitrogen isotopic values are expressed as:

$$\delta X\ ‰ = \{(R_{sample} / R_{standard}) - 1\} \times 1000 \quad (1)$$

where X represents ^{13}C or ^{15}N, and R represents $^{13}C/^{12}C$ or $^{15}N/^{14}N$, respectively. The standard for carbon is V-PDB and for nitrogen is atmospheric N_2. Precision was #0.2‰.

Discussion

The preliminary sample set consisted of 20 individuals representing 17 mammal and bird species whose radiocarbon ages ranged from ca. 4,500 to 50,000 BP (Table 57). Accurate paleoecological interpretations of isotope data from fossils requires some assurances that collagen has not suffered severe alteration. DeNiro (1985) suggested that C:N values of well-preserved collagen should fall within a range of 2.9-3.6. C/N appears to be an acceptable indicator of trophic structure even when collagen yield is as low as 2% (McNulty et al. 2003). The C/N of collagen isolated from samples from MHC exhibit exceptional consistency and have values between 3.2 and 3.3. These data are consistent with a well-preserved protein and little contamination.

Inferences on food web structure rely strongly on nitrogen isotope data. Here we anticipate that increasingly higher $\delta^{15}N$ values identify an increase in trophic position. Carbon isotope values do not respond as strongly to trophic level but can be an indicator of source carbon. Because the majority of the samples analyzed are from a terrestrial environment whose food web base may have been similar over the last 50,000 years, it is difficult to draw strong conclusions from $\delta^{13}C$ data.

Despite the wide range of radiocarbon ages, small sample size and large number of species, significant food web relationships appear in the data (Figure 83). The elevated nitrogen isotope value of the extinct North American cheetah, *Miracinonyx trumani*, clearly identifies its high trophic status. This contrasts to the low $\delta^{15}N$ value of the white-tailed jackrabbit (*Lepus townsendii*) and is consistent with its position at the base of the food web. The $\delta^{15}N$ value of the cheetah is ca. 5 ‰ higher than that of the bobcat, *Lynx rufus,* suggesting that resource partitioning existed between these two taxa and that the bobcat relied on food resources from a lower trophic level than the cheetah. Resource partitioning among large carnivores was also suggested by nitrogen isotope data at Natural Trap Cave (McNulty et al. 2003). The relatively high nitrogen isotope value of the cf. brown bear (9.5 ‰) is consistent with carnivory, and similar to that reported for the short-faced bear *Arctodus* (Matheues 1995). The possibility that the MHC bear phalange is an early Holocene-aged *Arctodus* rather than *Ursus* cannot be entirely discounted (see discussion in Chapter 3 of this report); subsequent DNA analysis may resolve this issue.

The average $\delta^{13}C$ and $\delta^{15}N$ values of large herbivores (pronghorn, bison, camel, horse, deer and sheep) are $-18.0\forall$ 0.5 and 7.6$\forall$ 1.8 ‰, respectively. The upper range in $\delta^{15}N$ is 11.2 ‰ for one of the two camels and the lower range is 4.8 ‰ for the deer. Removing these data points does not change the average but reduces the standard deviation to 1.1 ‰, suggesting that these two individuals had much more distinct diets or metabolisms than the group of large herbivores as a whole. The nitrogen isotope value for the camel is higher than all other organisms except the golden eagle and the cheetah. Thus, because camels are not carnivores it is likely that something other that diet is influencing this datum point. Starvation and urea excretion and protein deprivation associated with water deprivation can elevate the nitrogen isotope values of organisms (Livingston et al. 1962; Sealy et al. 1987; Ambrose 1991; Cormie and Schwarcz 1994; Hobson et al. 1993). The low nitrogen isotope value of the deer may genuinely reflect resource partitioning but additional samples would be required to verify this possibility. The pronghorn and mountain sheep are isotopically similar to their taxonomic counterparts from Natural Trap Cave, Wyoming (McNulty et al. 2003).

The MHC data set includes four avian species (Table 54). Among these the tundra swan has a unique carbon isotope value (-14.8‰) that likely reflects an aquatic food web base. This being the case, we are unable to discuss the swan in context of the other members of the MHC data set. The golden eagle, short-eared owl and raven all have relatively high nitrogen isotope values (10.0 to 11.8‰) that are consistent with their predatory (carnivorous) habits. The prairie falcon has a nitrogen isotope value (8.6 ‰) that is notably lower than the other terrestrial birds. Whether this individual or prairie falcons as a group prey on lower trophic level organisms such as terrestrial birds than do golden eagles, short eared owls or ravens will be an interesting question to address with further analyses.

Because a large number of physiological, environmental, taxonomic and diagenetic factors can influence the isotopic composition of organisms (McNulty et al 2003 and references therein) interpretations that we set forth may change as additional data from MHC come forth. We will be interested to know if apparent resource partitioning is a robust feature of the MHC assemblage, if the isotope value of the camels reflects metabolic or dietary tendencies and if resource partitioning

between the cheetah and the bobcat is a common occurrence. Clearly, isotope data provide a unique tool for expanding our perspectives on the ecology of fossil assemblages.

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Table 57. *Carbon & nitrogen isotope, C/N and radiocarbon data for mammal and bird fossils from Mineral Hill Cave. Asterix indicates extinct taxon. ND indicates "No Data".*

| Taxon and Specimen No.	Common Name	^{14}C AGE, RC yr.	δ^{13}C‰	δ^{15}N ‰	C/N
*Acinonyx trumani TP4-1	American Cheetah	> 52,200 (CAMS-61144)	-17.0	13.3	3.2
Antilocapra americana TP3-96	Pronghorn	>50,300 (CAMS-58195)	-17.4	7.9	3.2
Antilocapra americana TP3-96	Pronghorn	>50,300 (CAMS-58195)	-18.6	6.6	3.2
Aquila chrysaetos TP3-187	Golden Eagle	38,650±530 (CAMS-61891	-18.3	11.8	ND
cf. Ursus arctos TP5-01-1	Brown Bear	9960±50 (CAMS-58435)	-18.6	9.5	3.2
Asio flammeus TP3-193	Short-eared owl	>44,900 (CAMS-61893)	-18.4	10.5	ND
*Bison antiquus TP3-88	Pleistocene Bison	43,080±730 (CAMS-54732)	-18.5	8.5	3.2
*Camelops hesternus TP3-41	Yesterday's Camel	48,900±3100 (CAMS-58196))	-17.9	11.2	3.2
*Camelops hesternus TP2-SL-1	Yesterday's Camel	44,600±3000 (CAMS-58197)	-17.5	8.9	3.2
Corvus corax TP3-424	Common Raven	45,800±1300 (CAMS-61894)	-18.4	10.0	ND
Cygnus columbianus TP2-11-2	Tundra Swan	29,180±190 (CAMS-61890)	-14.8	6.3	ND
*Equus conversidens TP3-133	Mexican Ass	>46,400 (CAMS-58193)	-18.7	6.0	3.2
*Equus occidentalis TP3-87	Western Horse	45,700±1000 (CAMS-58194)	-17.3	7.7	3.2
Falco mexicanus TP3-192	Prairie Falcon	>45,200 (CAMS-61892)	-19.9	8.6	ND
Lynx rufus TP3-151	Bobcat	30,310±170 (CAMS-58202	-18.8	8.2	3.2
*Hemiauchenia macrocephala TP3-89	Large-Headed Llama	ND	-17.8	8.4	3.2
Lepus townsendii TP3-346	White-tailed jackrabbit	7980±60 (CAMS-58440)	-20.0	4.1	3.2
*Navahoceros fricki TP3-3	Mountain Deer	49,800±1700 (CAMS-58191)	-18.3	4.8	3.2
Ovis canadensis TP3-1	Mountain Sheep	4540±50 (CAMS-58192)	-18.2	6.4	3.2
Taxidea taxus TP3-283	Badger	11,290±50 (CAMS-58434)	-18.6	7.9	3.2
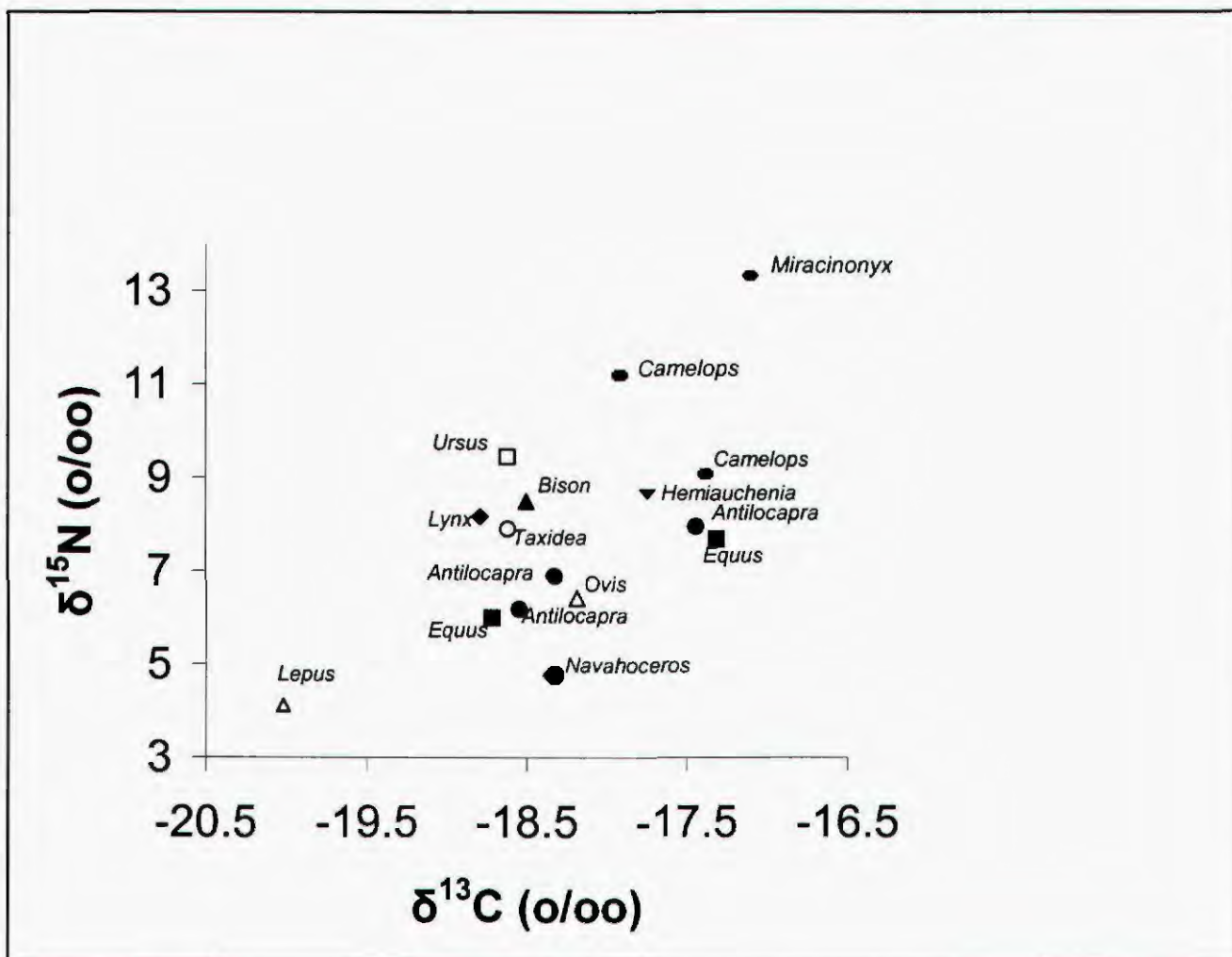
Figure 83. Stable isotope plots of various mammalian taxa from Mineral Hill Cave.

CHAPTER 10

Mineral Hill Cave: Concluding Remarks and Summary

Bryan Hockett and Eric Dillingham

Mineral Hill Cave is an ancient carnivore den that contains one of the most diverse assemblages of Late Pleistocene faunal specimens recovered to date from the Great Basin. The taphonomic character of the assemblage, namely the predominance of lower leg and foot bones of large herbivores, as well as the presence of puncture marks on the bones of both large and small animals, suggests that carnivores deposited many of the bones inside the cave. Additionally, the presence of several cones of terrestrially-derived debris stemming from chimneys that are now sealed suggests that bone deposition occurred through a complex of biotic and geologic changes.

Importantly, many of the bone specimens date between ca. 30,000 and 50,000 BP. This is the first Middle Wisconsinan assemblage backed by multiple C-14 dates reported from the central Great Basin. Many Pleistocene faunal specimens from the Great Basin remain undated (Grayson 1993). Those that have been dated often return dates between 10,000 and 20,000 BP, many millennia after the first occurrence of many species in the region.

The AMS dating of a relatively large sample of bones from Mineral Hill Cave has produced a rather impressive record of late Rancholabrean-aged extinct and extant species in the region. Among these are the following: *Miracinonyx trumani* occupied the central Great Basin before 50,000 BP; *Lynx rufus* by 30,000 BP; *Ursus arctos* by 9,800 BP; *Vulpes vulpes* before 50,000 BP, and present until at least 38,000; *Antilocapra americana* before 50,000 BP; *Ovis canadensis* by 39,000; *Bison bison* before 50,0000; *Ochotona princeps* before 50,000 BP; *Marmota flaviventris* by 42,000; *Asio flammeus* by 45,000 BP; *Aquila chrysaetos* by 39,000 BP; *Falco mexicanus* by 45,000 BP; *Corvus corax* by 46,000 BP; *Crotaphytus collaris* by 29,000 BP; and, most probably, Humboldt cutthroat trout by 50,000 BP.

The large number of bones of different species submitted for AMS dating, together with the U-Th dating of speleothems, offers a somewhat detailed chronological history of bone deposition in the cave. As a result, interesting patterns of species contemporaneity emerge.

Mineral Hill Cave began forming speleothems before 350,000 BP. A gallery with the potential for animal habitation has therefore existed for a very long time. Some of the bones that returned AMS dates in excess of 50,000 BP may in fact be quite ancient, but because no species were identified that are diagnostic of the Irvingtonian Land Mammal Age, none of the bones likely predate 400,000 BP. All we can say at this time is that bones began to be deposited in Mineral Hill Cave after 400,000 BP but before 50,000 BP. Bone deposition continued as recently as 3,000 BP. Bones continue to be deposited near the mouth of the cave, and bats currently inhabit all the chambers. However, during the Pleistocene there seems to have been pulses of bone deposition between ca. 30,000 and 50,000 BP, and between ca. 10,000 and 18,000 BP. Another pulse of bone deposition seems to have occurred after ca. 8,000 BP.

The issue of species contemporaneity at Pleistocene caves is an important topic. The data recovered from Mineral Hill Cave suggest that caution is in order with respect to this issue at some locales. It has been tempting in the past to report an entire assemblage as Late Pleistocene in age based on two or three C-14 dates on extinct species. This often places many extinct and extant species contemporaneous with one another during the Pleistocene. While these conclusions are justified at some locales, others may have an extensively time-averaged assemblage of bones similar to Mineral Hill Cave. The mustelids from Mineral Hill Cave illustrate this issue. While the *Brachyprotoma* mandible remains undated, every mammal bone dated at Mineral Hill Cave that displayed the same condition as this specimen pre-dated 30,000 BP. If no other information on the age of the mustelids was available, it might be argued that during the Pleistocene an impressive array of skunks, weasels, and the badger co-existed in the central Great Basin

for tens of millennia. However, four AMS dates on three other species of mustelid place *Spilogale putorius* near the cave during the Middle and Late Holocene, *Mustela frenata* during the Late Holocene, and *Taxidea taxus* during the latest Pleistocene. None of these dates suggest that these mustelids were contemporary with the extinct short-faced skunk. On the other hand, specimens of each of these animals, as well as other species of mustelid, remain undated. The point is that current dating procedures failed to show contemporaneity between the extinct and extant species of mustelids, and the possibility that some of the extant species moved into the region after the extinction of *Brachyprotoma* must remain a viable interpretation until more AMS dates are obtained.

In addition, many of the extant species do not show contemporaneity with a number of the extinct large herbivores. The youngest date obtained on the two extinct species of camelid was ca. 36,000 BP; the youngest date on *Navahoceros* was ca. 38,000 BP; and the youngest date on *Bison* was ca. 32,000 BP. Currently, contemporaneity with these large herbivores has only been established for the North American cheetah, bobcat, red fox, mountain sheep, pronghorn, pika, hare, pygmy rabbit, and marmot.

It may be significant that none of the large extinct herbivores returned an AMS date post-dating ca. 31,000 BP, yet the extant mountain sheep and pronghorn returned dates both before 30,000 BP and after the Late Glacial Maximum. One pronghorn bone dated to greater than 50,000 BP, while two dated to ca. 17,000 and 13,000 BP. Two mountain sheep bones dated to greater than 32,000 BP, while three dated ca. 8,100 BP, 6,900 BP, and 4,500 BP. While intra-species counts are low, taken as a whole, the continual 50,000 BP – 8,000 BP presence of these extant mid-sized herbivores serves as an excellent control, while the record of other herbivores disappear from the 6,800 foot-high elevation cave by the "second pulse" of bone deposition 10-18,000 BP.

Could this mean that populations of large herbivores such as horses, camels, llamas, mountain deer, and bison were stressed and severely reduced in numbers before the onset of Late Glacial Maximum conditions in the central Great Basin? If these animals were as common during the latest Pleistocene as they apparently were before ca. 30,000 BP, there seems to be no logical explanation for their non-occurrence after this time. Climatic-induced negative impacts on populations of large herbivores may have begun well before the arrival of humans in the Great Basin. This,

in turn, may have fostered the spread of medium-sized herbivores such as mountain sheep in the Great Basin and Southwestern United States after ca. 40,000 BP.

Before the onset of the cold conditions of the Late Glacial Maximum (ca. 24,000 – 17,000 BP), southern Pine Valley was alive with an impressive array of large herbivores: camels, llamas, bison, large horses, small horses, large mountain deer, mountain sheep, and pronghorn. This suggests the presence of very productive vegetative communities sometime during the Middle Wisconsinan. Pursuing these animals was the North American cheetah; unfortunately, MHC is silent on other large predators that undoubtedly pursued these "first-pulse" animals as well. But the small carnivores, among them the red fox, bobcat, and short-faced skunk, were active as well. Some of these smaller predators probably deposited many of the abundant marmot and rabbit specimens recovered from the cave.

During the "second pulse", a very large bear (cf. *Ursus arctos*) roamed Pine Valley for game. Both large and small predators, mammalian and avian, continued to have the opportunity to transport bones of all types to the cave. Though major valleys in northwestern Nevada continued to have mammoth, bison, camel, cheetah and horses 20,000 to 13,000 years ago, it may be that in Pine Valley, diminished populations of these large mammals highlights a loss of productivity in the northern sagebrush belt that continued past the Pleistocene-Holocene boundary. Like Heaton (1985) observed at Crystal Ball Cave, Utah, we see some new species arrive at MHC during the Holocene but relatively few compared to the species reductions and ultimately extinctions or range reductions at the end of the Pleistocene.

Because of terrain, precipitation and latitude, mountains just north of the Snake River serves as a defacto border between the boreal forest and the modern sagebrush belt. MHC may be very close to or at the northern limits of Pleistocene mountain deer (*Navahoceros)* and possibly other sagebrush animals such as Miracinonyx trumani, various species of Antilocaprids, sagebrush vole, pygmy rabbit and yellow-bellied marmot (*Marmota flaviventris*). Meanwhile, reindeer continue to roam the northern Idahoan forests as they have since the Pleistocene (Anderson and White 1975). Despite the Late Glacial Maximum and previous climatic changes, the southern Idahoan ecotone appears to have considerable time depth.

Our species designations in Chapter 3 place

us as "lumpers" rather than "splitters". Part of this is based on our conversations with Elaine Anderson; part is based on the recent DNA work of researchers such as Allen Cooper and colleagues, who suggest that caution is in order when designating Pleistocene species, especially when the size of teeth or bones are the only differences between the Pleistocene and Holocene forms. Mountain sheep are a good example. A comparison between the size of Pleistocene and modern mountain sheep bones suggests that the Pleistocene individuals were overall bigger than their modern counterparts. Yet the largest mountain sheep alive today overlap with many of their Pleistocene counterparts, and nearly match the largest known individuals from the past. Does a larger overall mean size justify species designation? Subspecies designation? Or are they simply ecomorphs of the same species? Place modern mountain sheep lambs in Pleistocene ecosystems and they probably would grow to the larger overall mean size that we see in individuals at this time.

One herbivore that bucked this trend was the pronghorn. There is little difference between the size of Pleistocene and modern pronghorn. Perhaps this is related to their adaptation to attain fast running speeds; perhaps the forage they preferred during the Pleistocene has not changed appreciably during the Holocene. The variety of antilocaprids found elsewhere in the American West does not appear to be present at MHC. *Capromeryx* appears in southern California, southern Nevada and possibly in the Bonneville Basin. *Tetrameryx* is so far notable for its absence at MHC.

We were forced by circumstance to rely on bones such as phalanges that are often ignored in other Pleistocene assemblages. In the scavenged assemblage, we did not possess high numbers of intact and identifiable upper limb bones, the axial skeletal bones or crania, except for small mammals and reptiles. The data shown in chapter 3 represent an effort to compare as many published results of mammalian phalanx measurements to the MHC specimens, and in some cases, this was insufficient. Chapter 3 is important because it presents new metric data for phalanges in addition to the MHC collection, including Rancho La Brea and San Josecito Cave, especially for the equids. However, metric data alone were not enough for some specimens: considerable comparative (morphological) analyses of felid metatarsals, for example, led to the identification of *Miracinonyx*.

MHC is generally listed as an 'outlier' locale

for the presence of shrub ox in Pleistocene North America. However, we have reidentified the bovid phalange originally identified as shrub ox as a proximal hind phalanx of Pleistocene bison. In addition, although gray fox was originally identified from the cave, we found all fox specimens to match those of the red fox.

The lagomorphs at Mineral Hill Cave were similar to other Great Basin Pleistocene locales. Pika (*Ochotona princeps*) is extralocal, depressed down from higher altitudes during the Pleistocene. Pika survives nearby at higher altitudes in the Ruby Mountains. Not surprisingly, local Holocene leporids such as the jackrabbit and pygmy rabbit that are found in other Pleistocene deposits in the Great Basin returned dates of more than 30,000 years. No date was obtained for cottontail rabbits.

Given the mixed nature of the deposits at MHC, the smaller animals presented some problems. Radiocarbon dating of chemically extracted amino acids allowed us to extend more precise records of Pleistocene mammals about 15,000 to 20,000 years beyond our previous records. The limitation of this method is that several grams of bone are consumed, so we did not date some small, rare bones (*Brachyprotoma*) and occasionally failed to obtain radiocarbon results on the small specimens. Because of this, chapters 5-8 provide relatively less detailed chronology than chapters 3 and 4.

There is an excellent chronological record of yellow-bellied marmot over the past 50,000 years at MHC with no hoary marmot present. Although hoary and yellow-bellied marmots are sympatric in Montana, the Mineral Hill Cave data supports Mead's (1989) conclusion that hoary marmot would not be present in the Great Basin, even during the Pleistocene. The extensive woodrat collection from MHC is almost entirely composed of N. cinerea. None of the MHC rodent species found are extralocal today.

The extensive MHC herpetological collection, like the remainder of the assemblage, is mixed Rancholabrean and Recent. Collared lizard has Holocene and Pleistocene radiocarbon dates at MHC. One possibly extralimital genus is present (skink; *Eumeces* sp.), though the Ruby Mountains would provide good regional habitat. Brattstrom (1953; in Stock and Harris 1992:67) identifies western skink at Rancho la Brea, which was much warmer than the region surrounding Mineral Hill Cave at that time. M. Hollingshead identified mountain or pygmy short-horned lizard (*Phyrnosoma hernandez* or *P.*

douglasi) at MHC. These two species live in mesic, forested woodland to 2,700 m. Heaton (1985) had similar findings at Crystal Ball Cave, Utah for *P. hernandez / douglasi*.

S. James provides some of the earliest direct dates on a number of birds. Almost all of these dates range between ca. 40,000 and 45,000 BP. Birds dated to this time include the short-eared owl, golden eagle, prairie falcon, and common raven. Tundra swan may also fall into this category of 'earliest direct date', although slightly younger than the others mentioned at ca. 30,000 BP. MHC also provides the first occurrence of the extinct fragile eagle in the state of Nevada.

J. Broughton provides the first published result of Wisconsinan-age Lahontan Cutthroat Trout actually in the Lahontan system, though apparently ancestral cutthroat trout have lived within the Lahontan Basin since the Pliocene (Smith et al 2002:220).

The stable isotope data attests to the superb preservation of the MHC bones considering their age. Among the more interesting findings was the high trophic status of *Miracinonyx* compared to the bobcat. This may lend support to the idea that the North American cheetah pursued fast-running game such as pronghorn and horse. P. Ostrom and T. Stafford note that the high nitrogen values of *Camelops* could reflect starvation conditions, which in turn could support the interpretation that populations of large herbivores were stressed during MIS 3.

Much of the deposits within MHC remain intact. In places, chamber 5 is essentially filled to the ceiling with silts, clays, and eboulis. It is possible that other chambers exist but are sealed off by deep sediment and debris. Also, in the back chamber of the cave laminated clay deposits contain relatively few bones but aditional labor and analysis might achieve dateable horizons with time-associated species. Continued radiocarbon dating of MHC and other, previously collected northern Nevada Pleistocene locations would provide additional information about time depth of species in the central and northern Great Basin. DNA analysis may be possible on many specimens, and would be useful for more secure identifications of some specimens (e.g., the 10,000 year-old cf. *Ursus arctos* phalanx and the cf. *Miracinonyx trumani* metatarsal), as well as provide for examination of evolutionary relationships of cervids, American cheetah, mountain sheep, camels, llamas, horses and other mammals represented in the cave. The final chapter of the paleontological significance of Mineral Hill Cave will be written far into the future.

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APPENDIX I

Table 58. AMS radiocarbon dates of bones, charcoal, and plant material from Mineral Hill Cave.

Catalog #	Description	C-14 Date	Laboratory Numbers
TP3-1	*Ovis canadensis* mandible	4,540 ± 50	SR-5283 CAMS-58192
TP3-3	*Navahoceros fricki* central phalanx	49,800 ± 1,700	SR-5287 CAMS-58191
TP3-4	*Bison bison* terminal phalanx	43,080 ± 730	SR-5125 CAMS-54732
TP3-8	*Marmota flaviventris* mandible	42,350 ± 1,140	NSRL-3883 CAMS-42366
TP3-15	*Marmota flaviventris* mandible	5,640 ± 40	Beta-134244
TP3-37	*Hemiauchenia macrocephala* humerus	39,230 ± 1,330	Beta-145662
TP3-41	*Camelops hesternus* pisiform	48,900 ± 3,100	SR-5280 CAMS-58196
TP3-50	*Hemiauchenia macrocephala* navicular	36,320 ± 320	Beta-134248
TP3-81	*Ovis canadensis* proximal phalanx	38,830 ± 430	Beta-134245
TP3-87	*Equus* cf. *occidentalis* central phalanx	45,700 ± 1,000	SR-5279 CAMS-58194
TP3-88	*Bison bison* central phalanx	55,500 ± 4,300	SR-5297 CAMS-58437
TP3-92	*Equus* sp. carpal	31,130 ± 200	Beta-134250
TP3-96	*Antilocapra americana* proximal phalanx	>50,300	SR-5284 CAMS-58195
TP3-128	*Equus* cf. *occidentalis* premaxilla	42,420 ± 820	NSRL-3885 CAMS-42368
TP3-133	*Equus* cf. *conversidens* central phalanx	>46,400	SR-5278 CAMS-58193
TP3-140	*Bison bison* sesamoid	31,880 ± 570	Beta-145663
TP3-146	*Erethizon dorsatum* mandible	3,890 ± 110	SR-5285 CAMS-58200
TP3-147	*Vulpes vulpes* mandible	50,800 ± 1,900	SR-5295 CAMS-58199
TP3-148	*Ochotona princeps* mandible	>49,900	SR-5286 CAMS-58190
TP3-151	*Lynx rufus* mandible	30,310 ± 170	SR-5292 CAMS-58202
TP3-170	*Lynx rufus* mandible	9,640 ± 40	Beta-134243

TP3-187	*Aquila chrysaetos* tarsometatarsus	38,650 ± 530	SR-5410 CAMS-61891
TP3-192	*Falco mexicanus* ulna	>45,200	SR-5411 CAMS-61892
TP3-193	*Asio flammeus* femur	>44,900	SR-5412 CAMS-61893
TP3-247	*Ochotona princeps* mandible	34,050 ± 260	Beta-134242
TP3-264	*Lepus* cf. *townsendii* mandible	35,270 ± 300	Beta-143264
TP3-283	*Taxidea taxus* mandible	11,290 ± 50	SR-5291 CAMS-58434
TP3-340	*Spilogale gracilis* mandible	3,020 ± 50	SR-5289 CAMS-58201
TP3-341	*Mustela frenata* mandible	3,950 ± 50	SR-5288 CAMS-58433
TP3-344	*Neotoma cinerea* mandible	3,030 ± 50	SR-5298 CAMS-58438
TP3-345	*Myotis* sp. mandible	2,010 ± 60	SR-5299 CAMS-58439
TP3-346	*Lepus* cf. *townsendii* mandible	7,980 ± 60	SR-5300 CAMS-58440
TP3-388	*Neotoma cinerea* mandible	5,970 ± 40	Beta-145664
TP3-424	*Corvus corax* carpometacarpus	45,800 ± 1,300	SR-5413 CAMS-61894
TP3-477	*Brachylagus idahoensis* tibia	31,530 ± 240	Beta-145666
TP3-500	*Crotaphytus* sp. dentary	6,320 ± 40	Beta-145833
TP3-501	*Crotaphytus* sp. dentary	29,240 ± 350	Beta-145834
TP3-561	*Thomomys talpoides* skull fragment	8,110 ± 50	Beta-145665
TP1a-08-8	*Vulpes vulpes* mandible	39,200 ± 1,200	SR-5296 CAMS-58436
TP1a-012-2	*Marmota flaviventris* mandible	18,290 ± 60	NSRL-3882 CAMS-42365
TP1b-06-1	*Hemiauchenia macrocephala* proximal phalanx	50,190 ± 1,940	NSRL-3886 CAMS-42369
TP1b-09-3	*Antilocapra americana* proximal phalanx	13,150 ± 50	Beta-134249
TP1b-012-3	*Spilogale gracilis* mandible	6,600 ± 40	SR-5290 CAMS-61141
TP2-11-2	cf. *Cygnus columbianus* scapula	29,180 ± 190	SR-5409 CAMS-61890
TP2-4-1	*Equus* cf. *conversidens* proximal phalanx	35,080 ± 280	Beta-134247

TP2-SL-1	*Camelops hesternus* proximal phalanx	44,600 ± 3,000	SR-5281 CAMS-58197
TP2-SL-8	*Antilocapra americana* calcaneus	16,810 ± 50	NSRL-3884 CAMS-42367
TP2-2	*Ovis canadensis* humerus	32,970 ± 680	Beta-145661
TP4-1	cf. *Miracinonyx trumani* metatarsal	>52,200	SR-5294 CAMS-61144
TP4-3	*Ovis canadensis* mandible	8,110 ± 50	Beta-145666
TP4-10	*Navahoceros fricki* proximal phalanx	37,750 ± 440	Beta-134241
TP5-01-1	cf. *Ursus arctos* first phalanx	9,960 ± 50 9,710 ± 40	SR-5293/CAMS-58435 Beta-134246
TP6-4	*Centrocerus urophasianus* coracoid	4,660 ± 40	SR-5414 CAMS-61895
TP6-36	*Ovis canadensis* mandible	6,810 ± 50	Beta-145667
TP8-1	*Camelops hesternus* proximal phalanx	46,550 ± 1,100	Beta-134251
TP2-A	Stratum 3, Level 1 charcoal	1,263 ± 74 1,289 ± 113	DRI-3421 DRI-3423
TP2-B	Stratum 3, Level 2 charcoal	645 ± 82 620 ± 60	DRI-3422 ETH-18337
TP2-C	Stratum 4 charcoal	600 ± 50 620 ± 50	NSRL-4002/CAMS-42818 NSRL-4002/CAMS-43072
TP3-C-1	charcoal	2,300 ± 70 2,400 ± 40	NSRL-4003/CAMS-43073 NSRL-4003/CAMS-42820
TP3-A	bark	50 ± 70 modern	Beta-130508
TP3-B	wood	modern	Beta-130509
TP3-C	plant material	modern	Beta-130510
TP9-A	seeds	40 ± 50 modern	Beta-130511