

# LATE QUATERNARY FAUNAS FROM CAVES IN THE BLACK HILLS, SOUTH DAKOTA

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## ABSTRACT

The dolomitic limestone Pahasapa Formation exposed in the Black Hills of South Dakota is well known to contain a multitude of caves and other karst features. In order to raise greater awareness of the Black Hills caves and karst fissures as a source of paleontologic data, we summarize the major Quaternary and Pliocene cave and karst localities which contain fossils. The Richmond Hill quarry provides at least eight fissure deposits which contain a diverse range of vertebrate and invertebrate fossils of the Pliocene. Nine caves (Don's Gooseberry Pit, Graveyard Cave, Jewel Cave, Parker's Pit, Persistence Cave, Rushmore Cave, Salamander Cave, Stagebarn Cave, and Wind Cave) contain late Quaternary age fossils. Many of these faunas are part of on-going study. A record of climate and environmental change is emerging from these caves which illustrates that the Black Hills have been part of the dynamic changes throughout the Quaternary.

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## INTRODUCTION

The Black Hills of southwestern South Dakota and northeastern Wyoming are a haven for cave and karst features as a result of extreme uplift and exposure of the Pahasapa Formation (=Madison, Redwall formations; Mississippian age). This massive dolomitic limestone is well known to contain a multitude of aquifers, springs, karst sinkholes, karst fissures, and caves with a range of extensive to short passageways (Palmer and Palmer, 1989; Palmer, 2016; Palmer et al., 2016). Collectively these caves, fissures, and sinkholes preserve a warehouse of information that record changing climatic and biotic communities throughout the Quaternary (Pleistocene [Ice Age] and Holocene; the most recent 2.58 million years of Earth history) in the Black Hills.

The unglaciated Black Hills represent a doubly plunging anticline (essentially a dome shape) formed by the Laramide Orogeny during the Late Cretaceous and Early Cenozoic (Karner, 1989; Lisenbee, 2010). The Black Hills encompass nearly 15,500 km<sup>2</sup> (6,000 mi<sup>2</sup>) and rise more than 1,220 m (4,000 ft; [highest peak 2,207 m; 7,242 ft elevation]) above the surrounding northern Great Plains, essentially a forest-covered, mountainous island surrounded by a 'sea' of sagebrush and grasslands (Froiland, 1999; Larson and Johnson, 2007). The Belle Fourche and Cheyenne rivers bracket the Black Hills north and south, respectively (Fig. 1). They provide down-river riparian access to the Black Hills from the sagebrush steppe and shortgrass prairies from the north and west in Wyoming and Montana, and up-river riparian approach from the extensive mixed-grass and tall-grass prairies to the east (see related discussion in Buskirk, 2001). The geographic position of the Black Hills allows the isolated mountain mass to act as an island ecotone scenario for surrounding biomes (i.e., the grassland prairie habitats of the east and the shrublands and forests of the inter-mountain West. As fluctuations between glacial and interglacial climatic regimes occurred, the Black Hills were inhabited by plant and animal species with centers of distribution often much farther east, west, and north (Graham et al., 1987; Fulton et al., 2013; Jass et al., 2020). Because of their geographic position and the abundance of fossils in the caves, the Black Hills provide a unique opportunity to develop and test various biogeographic and ecological models. These fossil records also produce a 'natural' accumulation of flora and fauna not biased by the procurement by human cultures.

Caves in the Pahasapa Limestone exposed in the Black Hills often have multi-level passageways with a number of now-closed entrances characterized by old debris cones indicating the ancient nature of the enclosed sedimentary deposits (Palmer and Palmer, 1989). Many of the sedimentary deposits, some encased by flowstone, contain abundant vertebrate and invertebrate remains. In order to raise greater awareness of the Black Hills caves as an important source of paleontologic data, we summarize the major Quaternary and Pliocene cave and karst localities which contain fossils. Our summary is derived from existing publications, museum collections at the Mammoth Site of Hot Springs, SD and the South Dakota School of Mines and Technology, and previously unpublished field notes and laboratory data from the authors. The general locations of all sites are presented in Figure 1.

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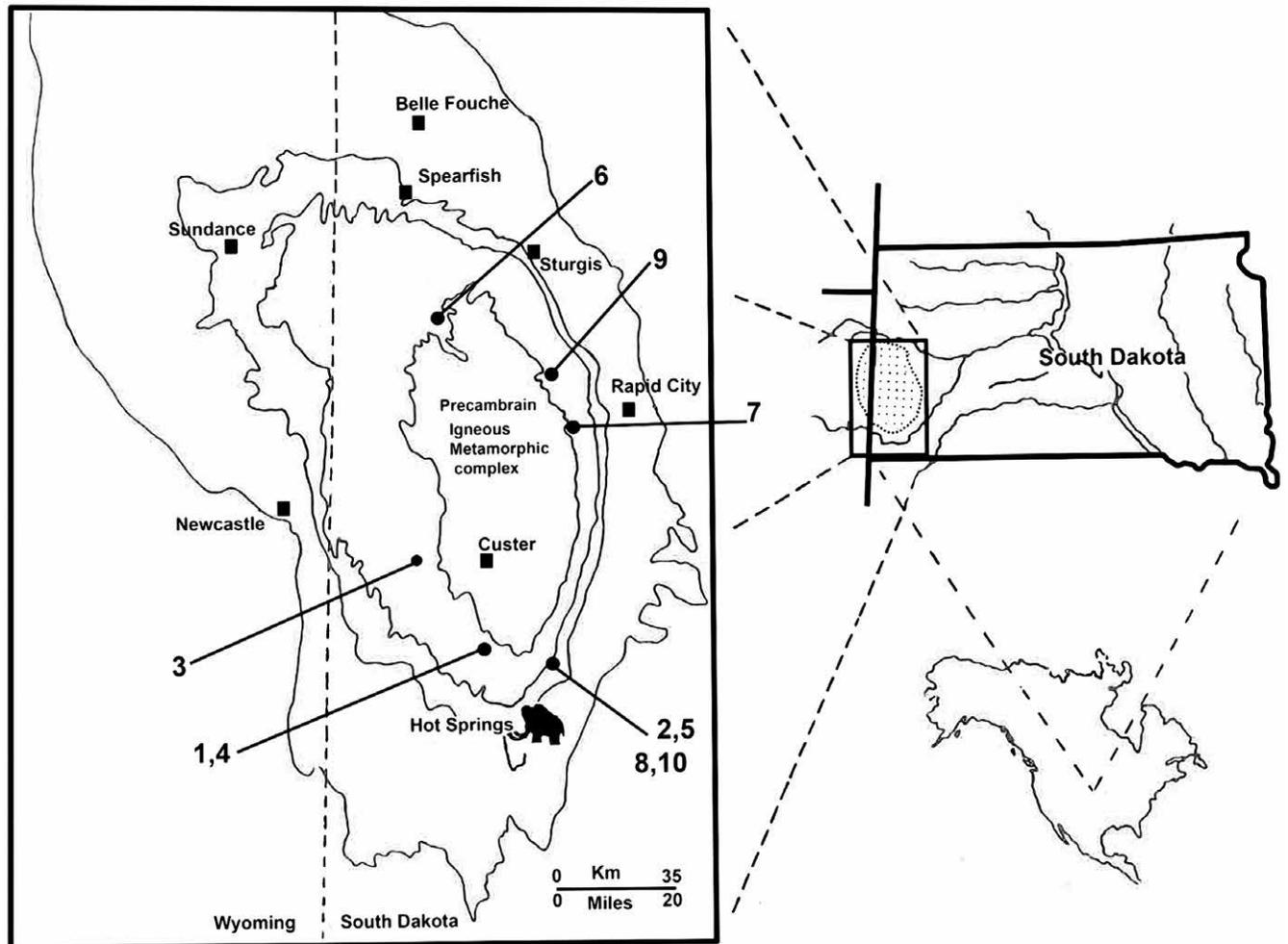


Figure 1. Map of the Black Hills illustrating general locations of cave sites with fossils discussed in text. 1, Don's Gooseberry Pit; 2, Graveyard Cave; 3, Jewel Cave; 4, Parker's Pit; 5, Persistence Cave; 6, Richmond Hill fissures; 7, Rushmore Cave; 8, Salamander Cave; 9, Stagebarn Cave; 10, Wind Cave.

## ICE AGE CAVE LOCALITIES OF THE BLACK HILLS

The most studied cave/karst deposit with a paleontological record in the Black Hills is the Mammoth Site, a surface exposed filled karst sinkhole locality containing a large assemblage of mammoth (*Mammuthus*; ~60 individuals) remains in the town of Hot Springs (Fig. 1). Prior to the discovery and assessment of this locality, little was understood about the Late Pleistocene faunas of the Black Hills. The study of its fossils, stratigraphy, and chronology was initiated in 1974 (Agenbrood and Mead, 1994) and remains an active research center for Pleistocene deposits of the Black Hills and western North America. Initially the Mammoth Site deposits were thought to be about 26,000 years old based on radiocarbon dating using bone apatite. Errors were presumed based on the use of bone apatite, and thus more analyses were needed. More recently quartz and feldspar grains from high and low stratigraphic levels in the sinkhole deposit were assessed using optically stimulated luminescence (OSL). Luminescence ages (n=6) indicate that the fossil-bearing sediments span all of Marine Isotope Stage (MIS) 7 and MIS 6 and ended with complete infilling at the start of the interglacial age of MIS 5; approximately 255,00 to 130,000 years old (Shannon Mahan, in litt., March 2024). Details of the recovered fauna, flora, and geology can be found in the chapters within Agenbrood and Mead (1994).

Younger, Holocene faunas are known in archaeological contexts in rock shelters of the region (e.g., Beaver Creek Shelter: Abbott, 1989; Benton, 1990; Martin et al., 1993). Although those sites contain significant Quaternary records, our focus here is to highlight cave localities that are (or were) encountered as part of recreational and exploratory caving, and to emphasize the continued potential for recovery of significant paleontological data/sites within Black Hills cave systems likely to be explored by the recreational or professional caving community.

The number of caves known for the Black Hills is voluminous (Palmer et al., 2016) but research on fossil resources from these caves was intermittent prior to 2010 (e.g., Manganaro, 1994; Mead et al., 1996; Jass et al., 2002). Since that time,

the evaluation of paleontological resources from Black Hills caves has evolved into a more concentrated effort to understand the Pleistocene record preserved in caves of the region (Pardi, 2010; Pardi and Graham, 2018; Jass et al., 2020; Mead et al., 2021). Presently, nine caves in the Black Hills are known to preserve late Quaternary paleontological records along with a series of karst fissures of Pliocene age. Some of these sites (e.g., Parker's Pit and Persistence Cave) form the basis of active, on-going field research, whereas others (e.g., Richmond Hill fissure fills) are partially described or are in exploratory stages in terms of paleontological research. Below, we summarize the present state of knowledge of each fossil locality. The chronological context for most localities is established using radiocarbon dating, typically on select, taxonomically important species. All radiocarbon dates presented here are calibrated typically using OxCal 4.4 program (either in the original publication or provided here) which produces an age presented as 'cal yr BP' (calibrated years before present). For specific details of individual radiocarbon dates, we provide the original reference(s) for those data.

### Don's Gooseberry Pit

Don's Gooseberry Pit is a small natural trap cave positioned near the point of a flat ridge (approximately 1,665 m, 5,463 ft elevation) overlooking steep canyons to the north and east, within the Black Hills National Forest (Fig. 1). The cave is a vertical tube cave with a rectangular, modern entrance approximately 25 cm by 50 cm (Pardi and Graham, 2018:supplemental data). Today the cave is surrounded by an open ponderosa pine forest (Pardi and Graham, 2018).

Assessment of the cave was supervised by staff from the Illinois State Museum and the Pennsylvania State University. Excavation of the cave fill was initiated in 2003 and continued with short field seasons over many years until 2014. Preliminary analysis of rodents from the excavation was produced as a thesis by Pardi (2010). A thunderstorm in 2015 illustrated that much of the sediment in the cave is the result of surface sheet wash, mainly on the northeastern edge (field notes Don Brandborg; Pardi and Graham, 2018). The area within this tube-cave is not large enough to permit significant stratigraphic dip to deposited clastic layers; however, some cut-and-fill deposits were observed. Sedimentary matrix was wet screen washed through window mesh sieves (see details in Pardi and Graham, 2018).

Overall, the cave contains a diverse assemblage of mollusks, amphibians, reptiles, and mammals, including some that do not co-occur together today (non-analog). Detailed radiocarbon dating of non-analog species demonstrated severe mixing of the deposits. Thus, the presumed contemporaneity of a non-analog assemblage was refuted (Pardi and Graham, 2018). A list of the identified mammals was provided in Pardi and Graham (2018). Directly radiocarbon dated rodent specimens provide an age range for the deposit of 18,235 – 6,287 cal yr BP. Because of the mixed nature of the deposit, dating of the fauna requires directly radiocarbon dating each taxon in question (e.g., see details in Pardi and Graham, 2018).

Of paleoecological and biogeographical importance are specimens of Richardson's collared lemming (*Dicrostonyx richardsoni*), a lemming that today is tightly linked to the temperate shrub tundra environment near Hudson Bay, Canada (Kowalski, 1995; Pardi and Graham, 2018). Fossils of *Dicrostonyx* were radiocarbon dated directly yielding ages over 18,000 cal yr BP and were also sampled for aDNA analysis (Fulton et al., 2013; Pardi and Graham, 2018). Those records imply that during the Last Glacial Maximum at least the higher elevations of the Black Hills may have had a similar climate and vegetation community to the shrub tundra communities found much farther to the north today. Further study of the diverse fauna starting with the amphibians and reptiles is in progress.

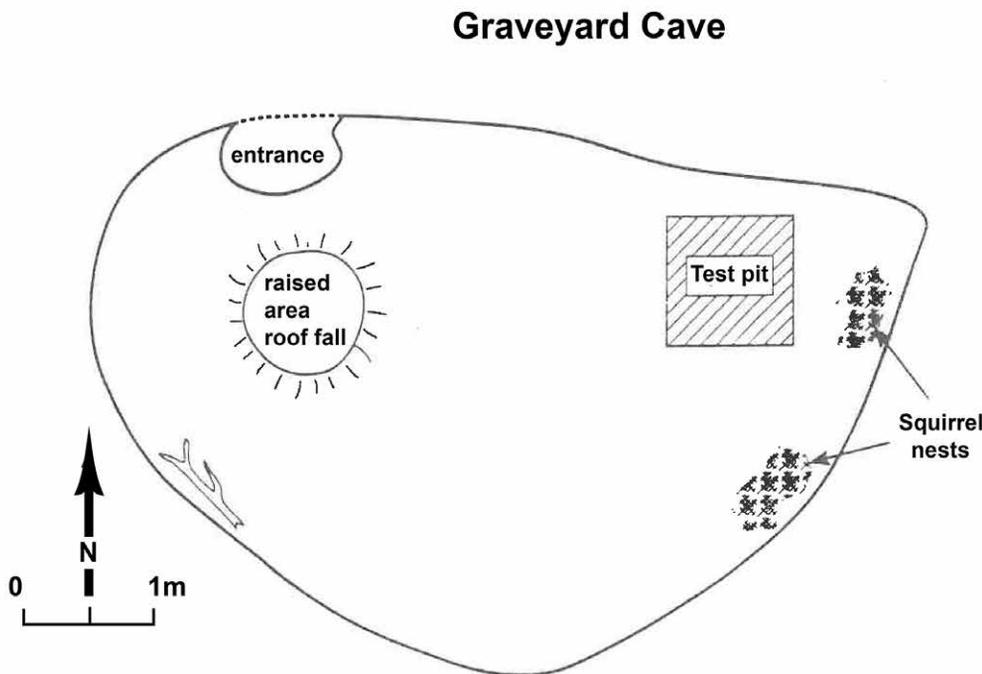
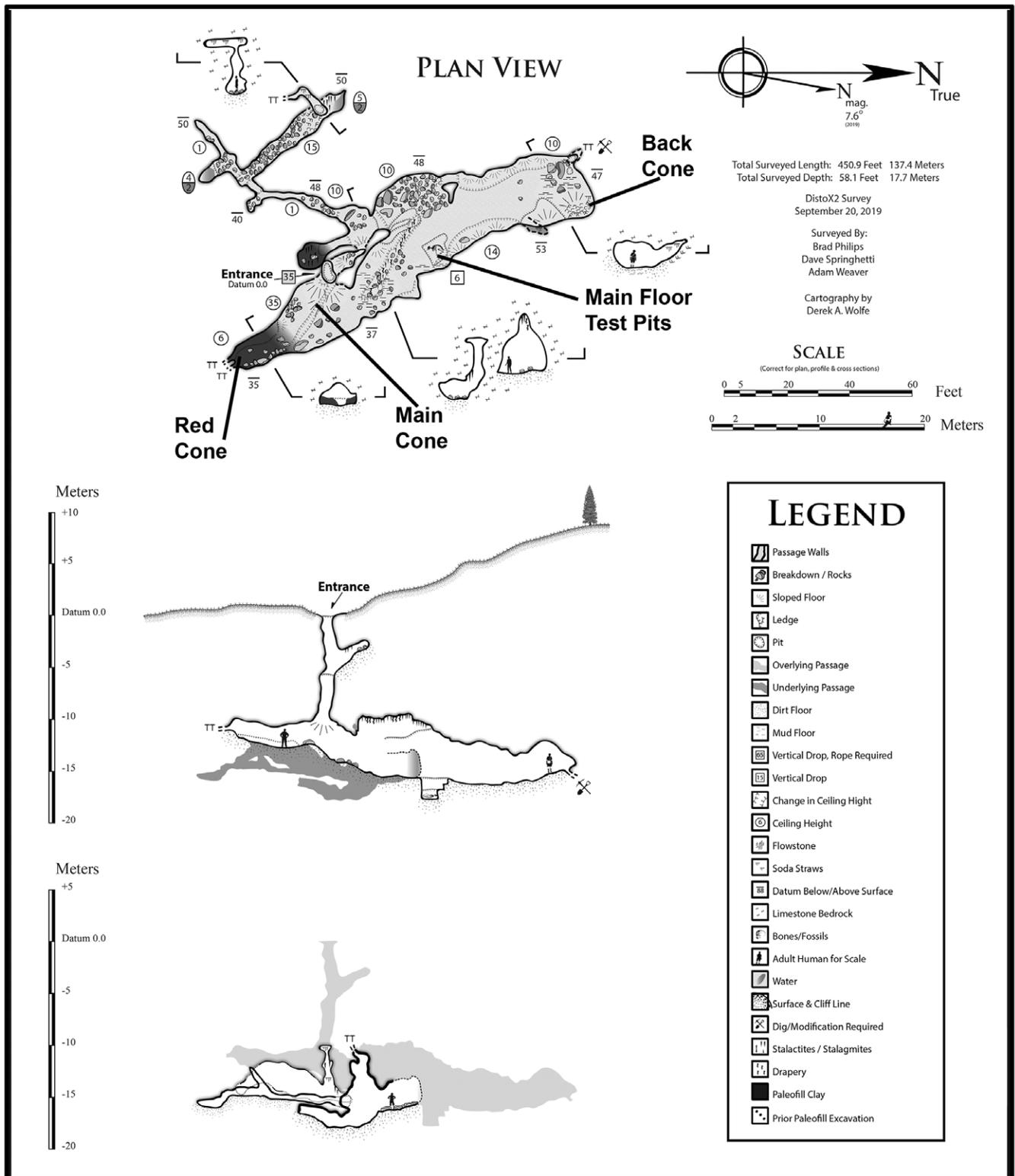


Figure 2. Map of Graveyard Cave (from Manganaro, 1994).



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Figure 3. Map of Parker's Pit locating the Red Cone, Main Cone, and the Main Floor test pits discussed in the text. Illustration for this article modified from official map provided by Adam Weaver.

### Graveyard Cave

Graveyard Cave is a small, bowl-shaped cave situated at 1,355 m (4,457 m) elevation in Wind Cave National Park (Figs. 1). Vertebrates and mollusks dating to the late Holocene (2,547 – 2,037 cal yr BP) were recovered in a preliminary test pit excavation (Fig. 2) in the early 1990s for part of a master's thesis (Manganaro, 1994). Terrestrial snails from the

# Persistence Cave

## WIND CAVE NATIONAL PARK

### Black Hills, South Dakota



Total Surveyed Length: 359.8 Feet 109.7 Meters **0.07 Miles**  
 Total Surveyed Depth: 21.8 Feet 6.7 Meters

DistoX2 Survey  
 August 2016 - July 2019

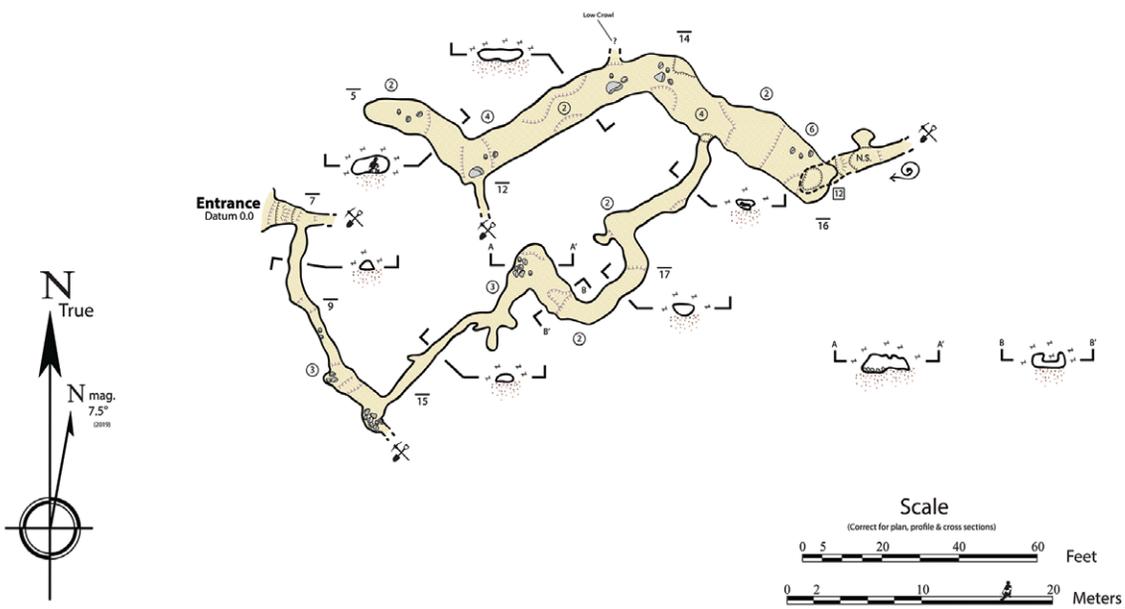
Surveyed By:  
 Derek Bristol  
 David Lambert  
 Matthew Luckwitz

Cartography by  
 Derek A. Wolfe  
 August 2019

### Legend

- |                   |                           |
|-------------------|---------------------------|
| Passage Walls     | Ceiling Height            |
| Breakdown / Rocks | Datum Below/Above Surface |
| Sloped Floor      | Limestone Bedrock         |
| Ledge             | Adult Human for Scale     |
| Pit               | Surface & Cliff Line      |
| Dig               | Change in Ceiling Height  |

### Plan View



### Profile View

Some detail and side passages omitted for clarity

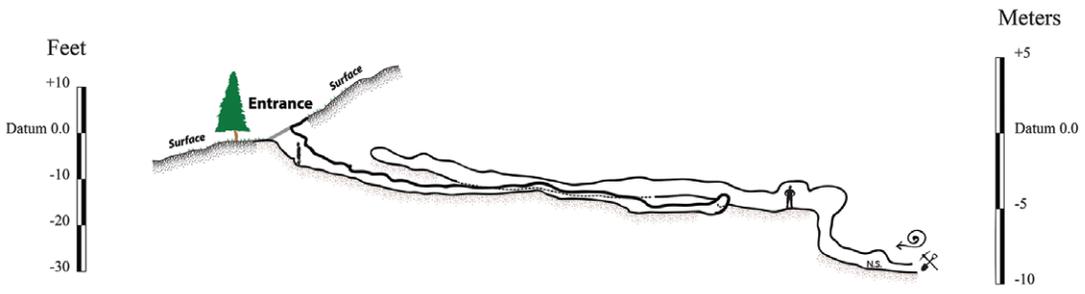


Figure 4. Map of Persistence Cave. Fossils are found in all the sediments that fill the cave system. Map provided by Marc Ohm, Wind Cave National Park.

locality were reported as part of a larger project that summarized Quaternary mollusk records from the southern Black Hills (Jass et al., 2002).

### **Jewel Cave**

Jewel Cave (JECA) is located on the southwestern side of the Black Hills at 1,655 m (5,430 ft) elevation and is part of a national monument (Jewel Cave National Monument; Fig. 1). As with Wind Cave (see below), JECA contains limited amounts of clastic sediments likely to contain Quaternary fossils, except for a few constrained accumulations near the current entrance (Palmer, 2016). The cave has received extensive attention to its mineralogy, geology, passageway exploration, air flow, and hydrology (Conn, 1966; Conn and Conn, 1981; Wiles et al., 2009; Wiles, 2013, 2019). Staff from JECA requested an initial analysis of seemingly unfossiliferous cave sediments only to find out that there were fossils present (Agenbroad, field notes). An assemblage of vertebrate remains is known from an unpublished report, but the entire fauna is currently being reassessed by researchers at the Mammoth Site. The preliminary age range of the fauna is 3,819 – 185 cal yr BP and further radiocarbon dating will likely occur in conjunction with on-going fossil identifications.

### **Parker's Pit**

Parker's Pit is a small limestone cave located near and at approximately the same elevation as Don's Gooseberry Pit in the Black Hills National Forest (Fig. 1). Excavations were overseen by Eric Grimm, Russ Graham, and other staff from the Illinois State Museum and the Pennsylvania State University. The current cave entrance is situated just below the crest of the ridge, and, as with Don's Gooseberry Pit, has a small surface catchment area which restricts how much plant debris and surface animal remains can be washed into the cave during rain storms. The entrance is a small opening with an approximately 14 m (45 ft) vertical drop to the top of a sloping debris cone below and serves as a natural trap today and likely did so during the Late Pleistocene. There is evidence of additional, entrances with older debris cones and associated faunas. These openings had different catchment areas and entrance scenarios versus the existing entrance. Paleontologically, the cave has two major debris cones from now-closed entrances (Red Cone, Main Cone; Fig. 3) that have been preliminarily assessed, and both contain a record of vertebrate and invertebrate remains (Graham et al., this volume). Graham et al. (this volume) have produced a preliminary overview about the fossil rodents from these two cones. The excavation of these two debris cones ceased in the early 2010s.

Since that time, work at Parker's Pit has focused on an extensive, seemingly continuous fossiliferous, clastic deposit on the Main Floor of the cave north of the Main Cone (Fig. 3). The extensive deposit at the center of the Main Floor is flat, and likely accumulated as runoff from the Main Cone debris. Excavations were initiated by Eric Grimm in 2013 in this area of the cave and continued to 2015, followed by a subsequent pause. Excavation resumed in 2017 under the coordination of researchers from the Mammoth Site and the Royal Alberta Museum. Excavations have proven fruitful for the recovery of a diverse fauna and an intact stratigraphic sequence acutely linked to both a detailed radiocarbon chronology (11,999 – 4,334 cal yr BP) and paleoenvironmental record enhanced with an analysis of isotopes (Rolfe Mandel, pers. com., 2024). Research on the Main Floor excavations is on-going.

### **Persistence Cave**

Persistence Cave (PC) is a small cave in the Pahasapa Limestone, within Wind Cave National Park, in the southern Black Hills (Fig. 1). Initial work in PC by the National Park Service (NPS) was to further explore for new passageways. The cave is a sinuous, small tubular system mostly choked with sediments that entered via numerous short-lived small sinkhole openings along a ridgeline (Fig. 4). The initial request by the NPS in the early 2010s was to determine if cave sediments collected at the current entrance contained any fossils. Analysis by paleontologists originally at East Tennessee State University and now at the Mammoth Site (Mead, Swift) indicated that wet screen washing the cave deposit through 0.5 mm mesh sieves produced thousands of small mammal, amphibian, and reptile bones; fossils unobservable in the field when covered with a sediment coating. From the current and only known entrance, the cave immediately diverges into two narrow passages at the bottom of a short 2.6 m (8.5 ft) drop-in opening which acts as a natural trap for small species of animals.

One field season of excavation by a crew from the Mammoth Site occurred in the northern-most passageway and produced thousands of fossil remains. The main passageway, which emits strong wind in association with changes in barometric pressure, is being explored by park service personnel. Removal of sediments by the NPS from this lengthy passageway is primarily associated with exploration and has minimal or no stratigraphic control. As a result, all fossils determined to be of paleontological interest are directly radiocarbon dated. Because sediment removal continues from the cave, work is on-going in terms of identification and analysis. All sediments removed are wet screen washed through 500-600 $\mu$ m (0.5-0.6 mm) mesh sieves, dried, and sorted for plants, mollusks, and skeletal remains using a 10X microscope.

Nineteen radiocarbon dates directly on various taxa produced ages from greater than 44,000 cal yr BP to about 11,000 cal yr BP, with some indication that there may be a depositional hiatus. Five additional dates represent the

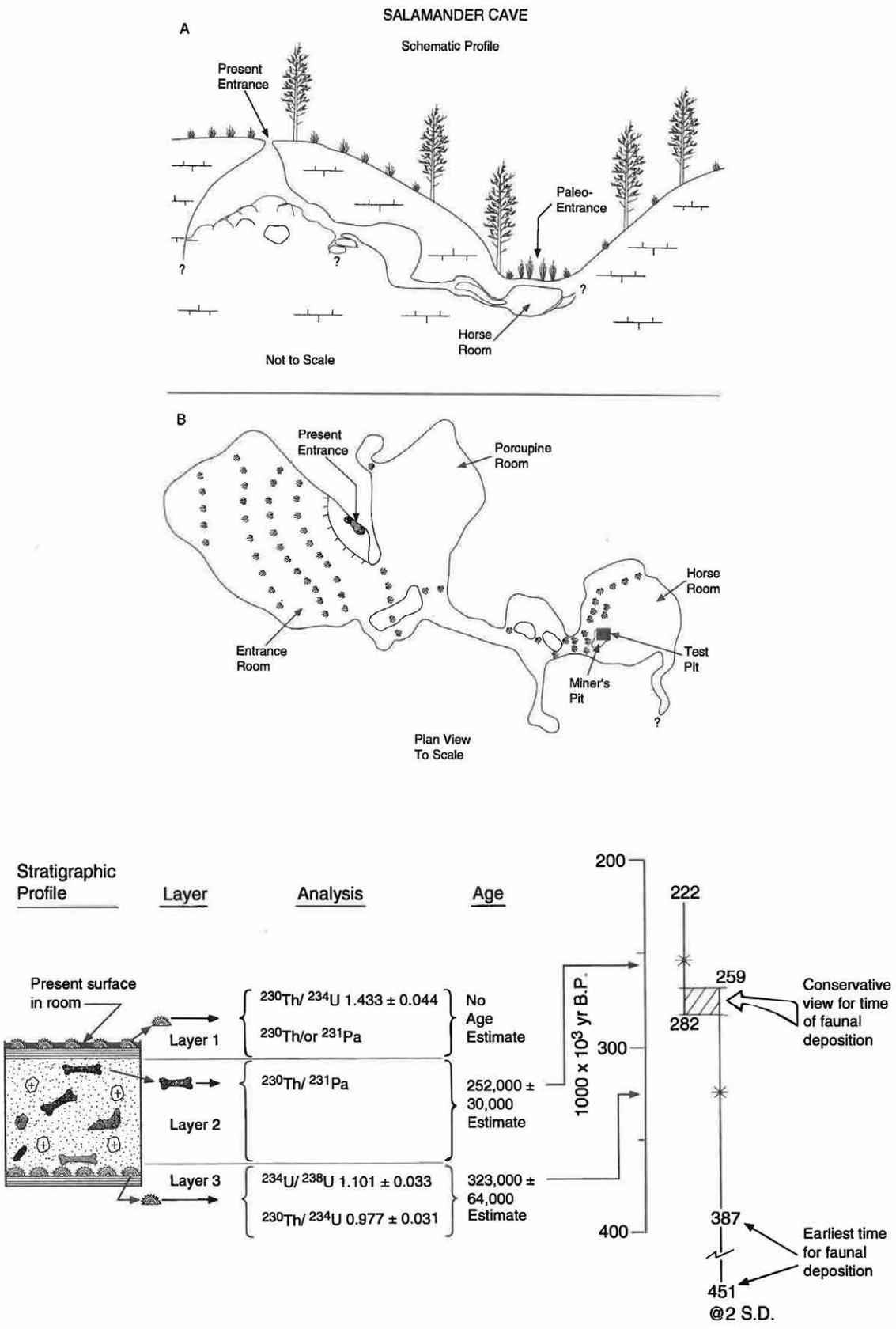


Figure 5. Schematic map of Salamander Cave in Wind Cave National Park showing the profile view, A, and the plan view B (from Mead et al., 1996). The chronological analysis of the deposits in the Horse Room is outlined in the graph showing the conservative estimate of 282 to 259 thousand years old based on U-series dates; older estimates are possible (Mead et al., 1996).

modern through the Holocene. Vole species recovered include heather vole (*Phenacomys* sp.), muskrat (*Ondatra* sp.), southern bog lemming (*Synaptomys cooperi*), red-backed vole (*Clethrionomys* sp. [=Myodes]; we follow Kryštufek et al., 2020), sagebrush vole (*Lemmiscus curtatus*), prairie vole (*Microtus ochrogaster*), and another unidentified meadow vole (*Microtus* sp.). The record supports an interpretation of a faunal turnover in the Late Pleistocene to early Holocene (Jass et al., 2020). Most of the faunal remains from the cave have yet to be completely studied but include a large, extinct form of bison, lizards, snakes, frogs, salamanders, fish, birds, mollusks, camel (*Camelops*), horse (*Equus*), bats, shrews, bear (*Ursus*), and other smaller carnivores. A few skeletal elements of the genus *Martes* (pine marten) were identified (Mead et al., 2021; see Wind Cave discussion below; see also Stagebarn Cave discussion). Considering the specimen from Wind Cave with the Persistence Cave specimen, most specimens are of the size of the extant pine martens (*Martes americana/caurina*), which are not known historically from the Black Hills. An additional jaw with teeth from PC is distinctly larger and within the size variation of the extinct noble marten (*M. nobilis*; Mead et al., 2021 and references within). The abundance of snake bones, especially of the rattlesnake (*Crotalus*) indicates that the cave was used as a hibernaculum for a long time. Descriptions of the amphibian and reptile fossils are in progress.

### Richmond Hill

The quarry operation at the Richmond Hill Gold Mine in the northern Black Hills (8 km north of Lead, SD; Fig. 1) breached a number of small cave and fissure deposits containing Pliocene to early Pleistocene age fossils. Only two of the fissure deposits have been preliminarily assessed but approximately eight fossil sites have been removed and are now stored at the Museum of Geology, South Dakota School of Mines and Technology (SDSM&T). P. Bjork (SDSM&T) produced the initial excavations of two fissures but subsequent removal of the remaining fissures was conducted by James Martin (SDSM&T). The methodology used in recovering the fissure fill sediments is not currently available in publications. Carnivore species from the Unwily Coyote Site and the East-West Fissure Site indicate a Blancan North American Land Mammal Age for at least two of the sites (Bjork, 1997). Preliminary evaluations by CNJ and JIM on the arvicoline rodents, prairie dog (*Cynomys* sp.), pika (*Ochotona*), reptiles, and amphibians from these two fissure deposits have been conducted. These fissure fills provide the first and earliest record of pika in the Black Hills in addition to being the oldest known cave faunas for the region.

### Rushmore Cave

Rushmore Cave is a privately-owned commercial walk-in cave at about 1,176 m (3,860 ft) elevation (Fig. 1). A 'grab-bag' of sediment samples from a few locations within the cave were assessed by researchers at the Mammoth Site and indicate that a Holocene age deposit of bats is preserved at the cave. Additional work is needed to evaluate the presence or absence of older, Pleistocene faunas. Presently, little is understood about the paleontological potential of this cave but the processed sediments hold great promise for a more expansive and focused study.

### Salamander Cave

Salamander Cave is a small cave located in Wind Cave National Park (Fig. 1). Currently the cave has a 1.6 by 0.75 m entrance with a 6 m natural trap drop ending on an active debris cone. Live salamanders (*Ambystoma*) along with skeletal remains of rabbits, rodents, other small mammals, anurans (frogs and toads), and reptiles (snakes and lizards) were observed across the cone (J. Mead, pers. observation). A preliminary test of the cone produced thousands of skeletal remains that require further analysis; the chronology of the cone needs assessment but certainly contains records of the modern biota and likely contains at least a late Holocene record.

The cave also contains several larger rooms of which only two are being infilled via the current entrance (Fig. 5). The Porcupine Room is actively being infilled on one side via the current entrance but the opposite side of the room there is an older, fairly consolidated talus cone yet to be evaluated. A small corridor leading away from this room leads down into a back chamber called the Horse Room. Deposition into the Horse Room likely occurred from a previous entrance into the cave. A miner's test pit through the flowstone floor of the Horse Room exposed a mud, cobble, and bone unit, which was sampled in 1991 (Mead et al., 1996).

Details about the chronology and simple stratigraphy of the bone unit in the Horse Room indicate that the bone layer is no older than approximately 323,000 year old and no younger than 252,000 years old (Fig. 5; details in Mead et al., 1996). Multiple taxa are recorded from the bone unit including the extinct voles *Mictomys* cf. *M. meltoni*, *Microtus paroperarius*, and *Microtus* [*Terricola*] *meadensis*, a wolf (*Canis* cf. *C. dirus*; =*Aenocyon dirus*), a horse (*Equus*), and camel (*Camelops*). Additional taxa recovered include prairie dog (*Cynomys* sp.), pronghorn (*Antilocapridae*), and possibly snowshoe hare (*Lepus* cf. *L. americanus*), among other species of mammals. Presently, all are being reinvestigated. Fauna from the other rooms deserve further evaluation both in the lab and field.



brae from the skeleton were radiocarbon dated and are modern, (UCIAMS 256729: 1.1776 modern fraction, dermestid egg casts; UCIAMS 260204: purified collagen content on bone:  $\delta^{13}\text{C}$  -21.0, 1.1814 modern fraction; D14C 181.4). The mandibles have most of the cheek teeth (p2 – m1) in place, with only the m2 alveolus being edentulous.

The weasel tooth and mandible measurements were taken with digital calipers and follow the methodology of Anderson (1968). The length of the m1 is 5.1 mm and its width 2.2 mm. These measurements fit within the range for the long-tailed weasel (*Mustela frenata*) of both modern specimens (length = 4.5 – 5.6 mm; width = 1.4 – 2.0 mm) and fossils (length = 3.9 – 5.8 mm; width = 1.6 – 2.9 mm) recovered from Little Box Elder Cave, Wyoming (Anderson, 1968:table 9). The alveolar tooth row length, c – m2, is 15.3 mm for the Stagebarn Cave specimen which also fits within the range of modern populations (13.8 – 18.2 mm) and fossils from Little Box Elder Cave (13.1 – 17.0 mm) for *M. frenata* (Anderson, 1968). Although well within the size parameters of *M. frenata*, the size of the tooth and the tooth row from Stagebarn Cave is also congruent with the size of larger living males of the ermine (*M. erminea*) from Alaska; however, our measurements are not compatible with the fossil specimens of the typically smaller *M. erminea* or the minute least weasel (*M. nivalis/rixosa*) (Anderson, 1977). Both *M. frenata* and *M. erminea* live in various habitats of the Black Hills today (Turner, 1974). Based on the size of the specimen, and the consistency with modern and fossil data, we hypothesize that the Stagebarn Cave specimen is *M. frenata*.

Another complete carcass was mapped in situ, but only the left mandible and the left femur were removed, leaving most of the skeleton in situ in the cave. The bones of the skeleton are fragile, but all the teeth were preserved in the mandible (Fig. 7). The canine was removed for radiocarbon dating, producing a median age of 28,777 cal yr BP (range: 29,095 – 28,545 cal yr BP; 24,510±110 radiocarbon years old; UCIAMS 256736:  $\delta^{13}\text{C}$  -19.6, D14C -952.7). Measurements taken from the mandible follow the methodology of Anderson (1970) as used in Mead et al. (2021) for fossil specimens of *Martes* from the Black Hills. The length of the m1 from Stagebarn Cave is 9.79 mm (reported as Lgm1 in Mead et al., 2021:table 1). This tooth in extant *Martes caurina* ranges from 8.1 – 10.9 mm, in *M. americana* ranges from 8.5 – 10.2 mm, and in the extinct *M. nobilis* ranges from 9.8 – 11.8 mm, including specimens from Little Box Elder Cave (WY) and Chimney Rock Animal Trap (CO) (see discussions in Anderson, 1968; Hager, 1972; Mead et al., 2021). These measurements imply that the Stagebarn Cave specimen could represent either of the two living North American species of pine martens. Neither species is indigenous to the Black Hills today, but it was introduced historically (Buskirk, 2001). However, the depth of the mandible (dorsoventral height below the posterior end of the m1) of the Stagebarn Cave specimen is 9.81 mm, indicating a stout jaw. Extant North American martens have a thinner mandible with both species having less than 8.7 mm for the depth of the mandible. The extinct *M. nobilis* is a more robust marten with a mandible depth of 7.9 – 11.0 mm (see discussion in Anderson, 1970; Mead et al., 2021 and references within). We hypothesize that the Stagebarn Cave marten specimen represents the extinct *M. nobilis*, which is also known locally from Persistence Cave (Mead et al., 2021; see discussion of Wind Cave). The implication is that this extinct, larger-than-present form of marten may have lived over most of the Black Hills during the Late Pleistocene. This hypothesis can be further tested by locating, measuring, and directly dating additional remains found in caves throughout the Black Hills.

### Wind Cave

Wind Cave (Wind Cave National Park; Fig. 1) is a large cave system consisting of over 240 km (150 mi) of crisscrossing passageways with many corridors still to be explored, especially to the north. Exploration in new sections of the cave in 2019 produced the discovery of a complete skeletal carcass of a pine marten. The relatively dry passageway permitted the preservation of some hide, muscle tissue, and dermestid beetle debris. Direct radiocarbon dating of the carcass indicated that the animal died in that remote section of the cave system 11,182 – 10,779 cal yr BP years ago (for details, see Mead et al., 2021; and see discussion above: Persistence Cave). Other carcasses are known from the same and other distant passageways but have yet to be assessed. Isolated bones occur throughout the cave but have received little attention. A bison (*Bison bison*) leg bone with adjacent charcoal in the sediments produced a late-middle Holocene age (4658 – 4528 cal yr BP on charcoal). Given the extensive passageways in the cave system, with new corridors to be located, it is likely that there are deposits with significant faunal remains yet to be assessed.

## DISCUSSION AND CONCLUSIONS

Caves are significant for the preservation of Quaternary faunas across North America (Jass and George, 2010). Fossil resources have been known from caves and karst deposits from the Black Hills for at least 50 years, yet compared to other geographic regions the number of known Quaternary fossil localities seems small compared to the extensive nature of the known cave systems. We suggest that this is largely an artifact of less focused attention to the presence of fossil resources, and the fact that Quaternary resources are often diagenetically unaltered (i.e., they may look like something that was trapped in a cave last year, versus thousands of years ago, and be dismissed as such).

A preliminary examination of the faunas from these caves have produced data that illustrates that the Black Hills have long been an ecotonal island influenced by distinct regional biomes to the east, west, and north. Pikas that live no closer

than the higher elevations in the Big Horn Mountains approximately 80 km (150 mi) west in Wyoming today had no record of their fossil history in the Black Hills until the Richmond Hills discovery (Mead, 1987; Bjork, 1997). The record of voles and lemmings from a number of the caves illustrates that the Black Hills island has had considerable biotic turnover, as different taxa from north, west, east appear and disappear from the record through latter portions of the Quaternary (Pardi and Graham, 2018; Jass et al., 2020). The record of the pine marten from a number of caves, possibly representing two species, also points to this mountain island as a location where certain species once existed during previous glacial phases but have since become locally extirpated (until a historic re-introduction) (Mead et al., 2021, and above discussion). This may reflect a pattern of insular mountain mass occupation similar to other topographically high areas of western North America where the transition of glacial phases to interglacial phases resulted in some species becoming isolated at elevations, and ultimately leading to extirpation. Such a pattern was noted elsewhere at part of a complex theory about insular biogeography that has been a critical part of research on past climates and biotic community changes of the Intermountain West (Great Basin) (chapters in Harper and Reveal, 1978; Grayson, 1993; among others). Whether the Pleistocene record of the Black Hills mirrors biogeographic models observed elsewhere or represents a unique pattern of biological change requires further analysis. Much more work is needed on the existing faunas, and much remains to be discovered in cave systems of the Black Hills.

The records of cave localities and fossils summarized here illustrate that there is a wealth of Quaternary faunal remains preserved in Black Hills caverns, deposits which have much to contribute to our broader understanding of the natural history, environment, climate, and biogeography of the northern Great Plains region. Our hope is that by raising more awareness of the potential significance of those records, we continue to create collaborative endeavors with the larger caving community (be them private cavers or state and federal land managers) that explores Black Hills caves as well as caves of other surrounding regions. Bones situated on cave floors may be significantly older than they look and random bags of seemingly uninteresting looking, clastic cave sediments can often produce a wealth of fossil data. More of those finds will continue to help us understand the complex natural history of the Black Hills.

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