

## A FOSSIL SLOTH SKELETON FROM A CAVE IN QUERETARO, MEXICO

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### ABSTRACT

Over thousands of years, a pit within Cueva del Tesoro in Queretaro, Mexico, has functioned as a death trap for mammals. This has resulted in the accumulation of mammalian fossils. At the bottom of this pit there is an almost complete and articulated skeleton of a ground sloth (*Xenarthra*, Folivora, Nothrotheriidae), *Nothrotheriops shastensis*. Remains of other animals include partial remains of at least a second ground sloth, a bovid, and bats. Given the extreme fragility and brittle nature of the remains, no attempt was made to extract or excavate them. Here we report our results mainly through photographic documentation in situ, with particular emphasis on dentary elements.

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### INTRODUCTION

Caves are important environments for the preservation of fossils (Schubert et al., 2003). Some animals seek out caves as preferred habitats, and caves can also act as traps, resulting in the accumulation of fossils over thousands of years. The stable temperature and humidity of some caves can help to preserve fossils. Fossils can occur in many contexts, but among them, the remains of Pleistocene/Holocene animals that either entered, lived, or fell inadvertently into caves during their lives are of particular interest. Polaco and Butrón (1997) initially reported 14 caves in México where fossil vertebrate remains have been found. Six years later, Arroyo-Cabrales and Polaco (2003) recorded 18 different cave sites and described their fossil fauna, which represented more than half of the known Pleistocene fossil mammals of Mexico. More recently, Ferrusquía-Villafranca et al. (2017) and Bonilla (2018) mentioned 27 different cave sites with Pleistocene age materials. This number has increased in recent years by at least one cave and two cenotes (McDonald et al., 2017; McDonald et al., 2020; Stinnesbeck et al., 2021). Collaborations between cavers and paleontologists are bound to further increase this list (McDonald et al., 2020).

Mexico is key to understanding many aspects of the paleoecology and biogeography of ground sloths (*Xenarthra*, Folivora) in North America after their dispersal from South America during the Great American Biotic Interchange (McDonald, 2002). While most of the clade's evolutionary history is restricted to South America, during the late Miocene, some xenarthrans dispersed across the water barrier separating North and South America and became integrated into the North American fauna. Others entered North America following the formation of the Panamanian land bridge (McDonald, 2002). The geographic position of Mexico represents the southern portions of the temperate zone and northern portions of the tropics and is thus critical to a complete understanding of xenarthran zoogeography, paleoecology, and evolution, given that Mexico is the passageway for faunas dispersing between the Neotropics and the Nearctic.

The fossil record of xenarthrans in Mexico extends from the Hemphillian to Rancholabrean i.e., from the late Miocene to late Pleistocene (McDonald, 2002). Currently, ten genera of ground sloths have been reported from Mexico (Fig. 1A): *Pliometanastes*, *Zacatzontli*, *Megalonyx*, *Nohochichak*, *Nothrotheriops*, *Eremotherium*, *Glossotherium*, *Paramylodon*, *Xibalbaonyx*, and *Meizonyx* (McDonald, 2002; McDonald et al., 2020; Stinnesbeck et al., 2021).

A pit within a cave was explored by members of the Sociedad Mexicana de Exploraciones Subterráneas (SMES) in Queretaro, Mexico. At its bottom, a skeleton of a ground sloth was discovered, as well as bones from other vertebrates. A second expedition was then organized to photographically document the remains and assess their state of conservation. The purpose of this article is to report on its findings.

### MATERIALS AND METHODS

Exploration and study of Cueva del Tesoro (20°58'23" N, 99° 40'21" W 1,303 masl), in the canyon of Barranco de Orduña, near the town of Rancho Quemado, Queretaro, Mexico is difficult to explore and requires technical caving expertise. The entrance of the cave is perched on the side of the canyon, 110 m above stream level and 200 m below the rim of the canyon, and single-rope-techniques must be employed to reach it. Once inside the cave, the first 170 m of terrain is mostly flat and very easy to traverse until, abruptly, a pit is encountered, the Sima de los Huesos (Fig. 1B-C). This pit is close to 50 m in depth. The pit has three sections: a 26 m vertical portion, a first landing step with a steep 12.6 m ramp, and a final 10 m vertical section to the bottom of the pit (Fig. 1C). Fossils were found on the landing step and ramp, as well as at the bottom of the pit.

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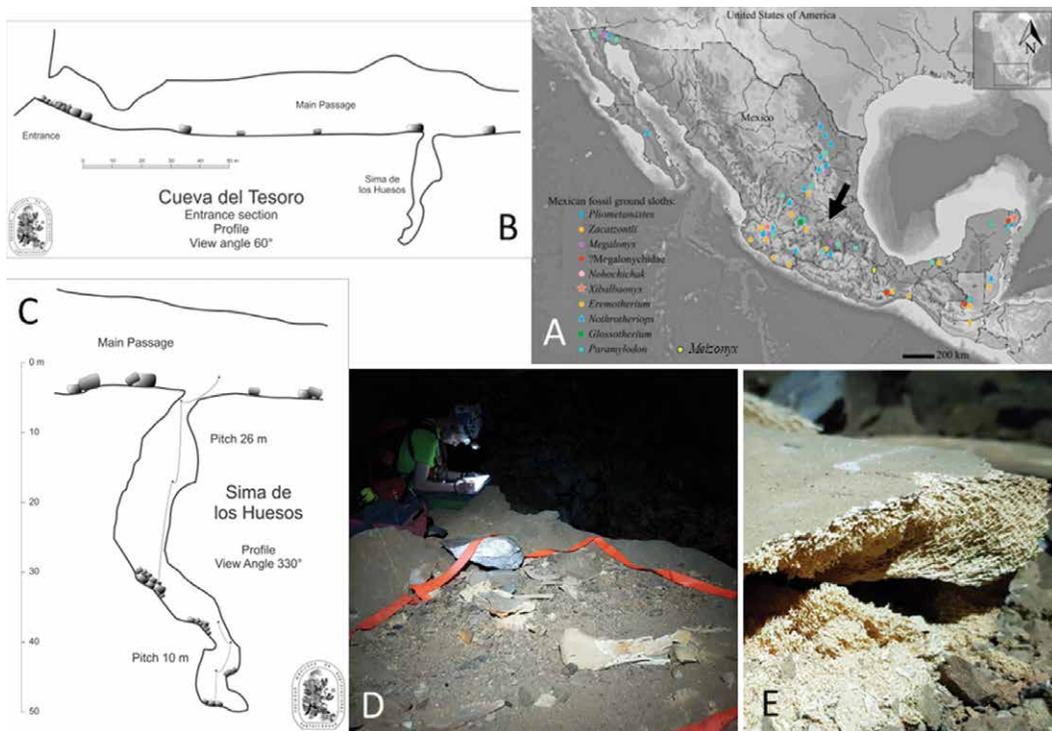


Figure 1. A; Map showing localities of ground sloths fossils in Mexico. Arrow points to the new locality of Cueva del Tesoro. Modified from Stinnesbeck (2020). B; Profile map of the area where the fossils were found in Cueva del Tesoro. Notice that a pit is encountered after flat, easily traversed galleries. C; Profile of the pit. Notice that a first landing step followed by a steep slope divides the pit. Fossils were found both in this step and at the bottom of the pit. D-E; Bones are extremely fragile and brittle. When disturbed, they break and pulverize.

The cave was mapped using the methods described in Ellis (1976), Dasher (1994), and Day (2002) by setting permanent stations along the cave passage, between which the distance was measured to the nearest millimeter with a Disto A5 laser rangefinder. Azimuth was measured to the nearest 0.5° using a Suunto KB-14 Compass, and inclination was measured to the nearest 0.5° using a Suunto PM-5 Inclinator. At each survey station, distances to the left and right wall, ceiling and floor were also measured with the Disto A5 laser rangefinder. While recording these data, a scaled and properly oriented sketch of the cave passage was made in a hand-held notebook, in which passage shape

detail, sedimentary fills, flowstone and calcite decorations, and any other data of interest were plotted. Survey data were processed using the Compass and CaveXO software to generate plan and profile views of the cave. Particularly detailed sketches were made of the areas of the cave where fossils were found (Fig. 1B-C).

The bottom of this pit had been explored previously by miners and/or cavers, as indicated by footprints. Regrettably, some of the fossils had been stepped on and destroyed (Fig. 1D). To prevent further accidental damage, areas with visible fossils on the surface were marked with orange flagging (Fig. 1D). Using a Samsung S21FE camera and an iPhone 12 Mini, iOS version 15.5, fossils were imaged in situ together with a 1 cm scale ruler or with a 1-inch-wide orange flagging tape for scale.

Visual inspection of the bones indicated that they were not permineralized or hardened in any way. Thus, they are extremely fragile and brittle. When fossils are disturbed, they turn easily into powdery dust (Fig. 1 E). Therefore, we decided to leave all bones in situ and no excavation was performed. Any future efforts to rescue the fossils will need to be done carefully, and the fossils will require considerable stabilization before



Figure 2. A; Barranco de Orduño canyon, where the cave is located. The entrance of the cave is behind the left cliff. B; Entrance chamber. C; Sima de los Huesos pit. D; Assemblage of bones at the base of the pit. Circled in white is the skull of the ground sloth.

they can safely be removed from the cave. The single exception was a claw of a ground sloth (Registered to the Instituto Nacional de Arqueología e Historia, Dirección de Registro Público de Monumentos y Zonas Arqueológicas e Históricas, Tramite INAH-03-001, No. de Oficio 401.3S.4-2023/1390), which was removed because it was on the ramp in the middle of the pit in a precarious position where it could easily be accidentally dislodged and destroyed. Also, it was not as fragile or brittle as most bones. This specimen was given the collection number CT-1 and is currently in the custody of the Sociedad Mexicana de Exploraciones Subterráneas A.C. (SMES).

Species identification from photographic material was done by H.G. McDonald, leading expert on fossil xenarthrans, and in particular, of fossil sloths from Mexican caves.

## RESULTS

### Cave description

The Barranco de Orduña is very steep with many vertical walls (Fig. 2A). The entrance of Cueva del Tesoro is perched a hundred meters above the floor of this canyon and 200 below the top of the cliff. It is difficult to access due to the steepness of the terrain. The main galleries of the cave have been extensively trampled by miners looking for the mineral cinnabar, to extract mercury. The cave has been mapped to 4,207 m and it has a single entrance. The 10 m wide entrance gives access to a large entrance chamber (Fig. 2B). Cave galleries follow. The first 170 m of passage is mostly flat and without obstacles. Ground sloths in the past and modern goats, whose skeletal remains are amply scattered throughout the cave, would have easily traversed its galleries. The exception is the Sima de los Huesos pit. After the initial flat 170 m of gallery, 105 m of which are in complete darkness, a pit adjoining one of the walls is abruptly encountered (Fig. 1B-C and 2C). Any animal traversing the cave could have stumbled into this unseen pit, making it a death trap. A mummified modern goat on the first step of the pit illustrates that this continues in the present. It is likely that the wide range of bones found in this pit are derived from a diverse array of mammals, ranging in age from the late Pleistocene to the Recent. Therefore, is an attritional, highly time-averaged sample.

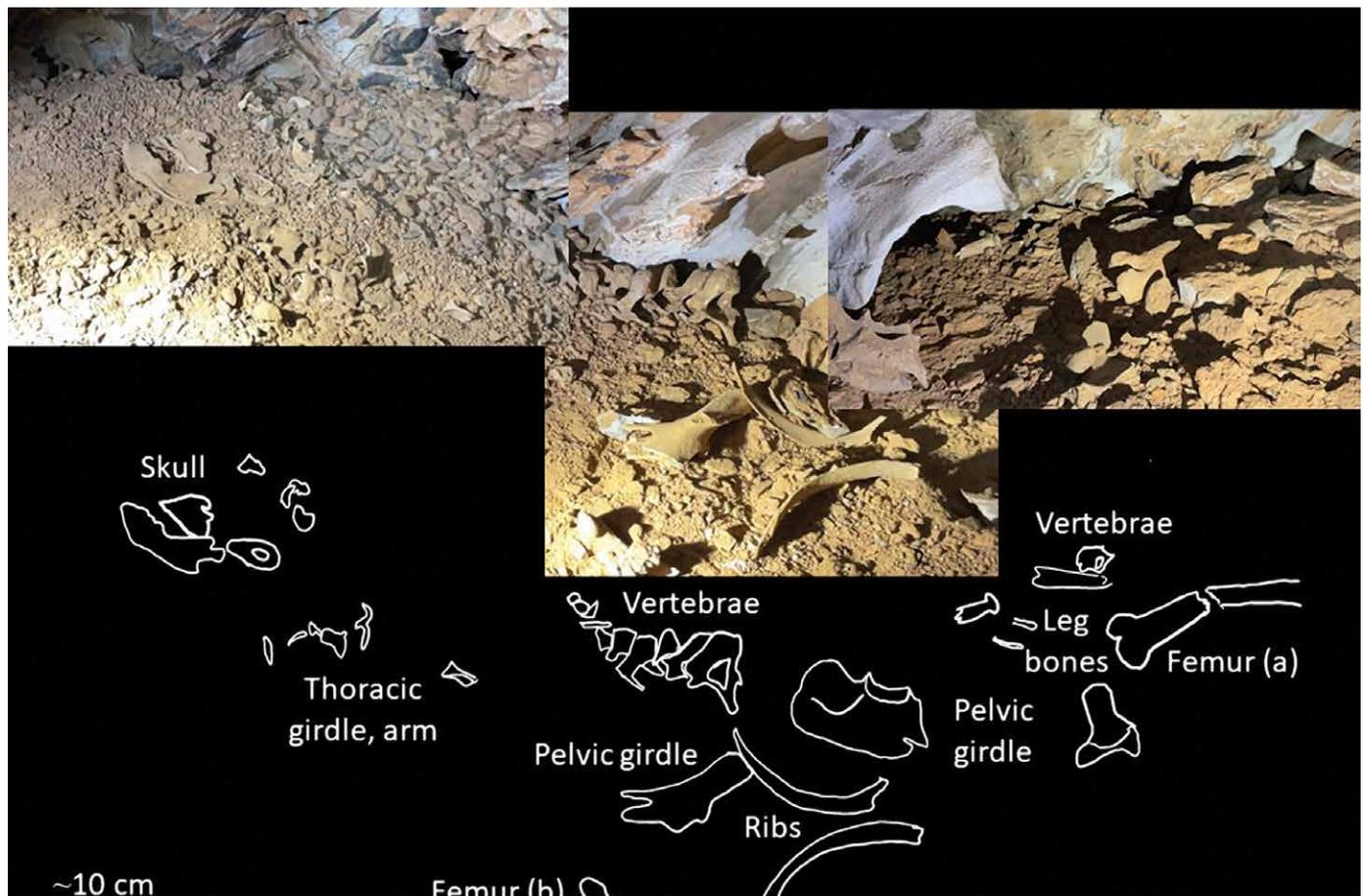


Figure 3. An almost complete skeleton of a ground sloth (*Xenarthra*) discovered at the bottom of the pit of Sima de los Huesos. Bones are mostly in the position in which the animal laid when it died, when its skeleton was still articulated. In color (top) is a collage of photos showing bones in situ. In black and white (below) is a schematic representation of the above photo showing only the bones.

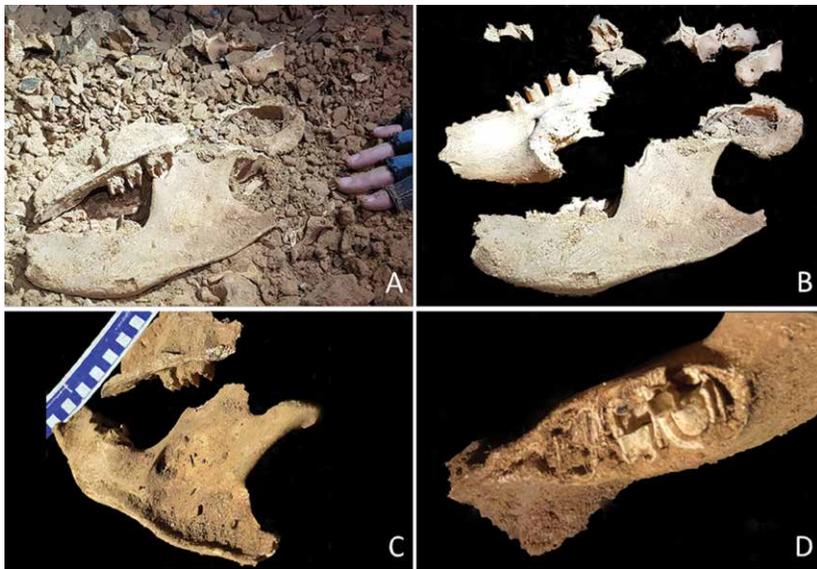


Figure 4. Cranium and mandible of ground sloth. A; Bones as preserved in situ. Left mandible, right internal side of maxilla, and fragments of skull are exposed. B; Bone fragments are isolated through photoshop for clarity. Maxilla and mandible shown in lateral view, with the former having been physically inverted, so that the dentition faces the top of the image and maxilla shows its external side. C; Left Mandible and right maxilla photographed from a different angle. Scale in centimeters. D. Occlusal view of left mandible showing fragments of the three molariform teeth.

The preserved remains of this individual includes the skull and mandible (Figs. 4-5), pectoral girdle and forelimb bones (Fig. 3), many vertebrae arranged as they were when articulated (Fig. 6A-B), pelvic girdle and ribs (Fig. 6C-D), and hindlimb bones (Fig. 7A-C). Some of the bones at the bottom of the pit belong to a different species of mammal. For example, there are two femurs (“a” and “b” in Fig. 3) of very different sizes, a small one (Fig. 6E) and a large one (Fig. 7C). The large one appears to belong to the nearly complete ground sloth skeleton.

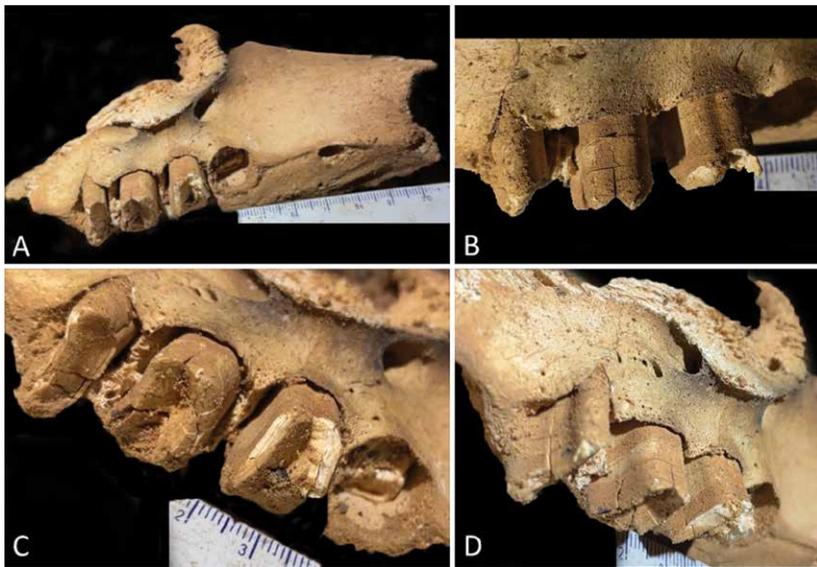


Figure 5. A; Right maxilla of ground sloth. B-D; Molariform maxillary teeth. in lateral (B), ventrolateral (C), and posteroventrolateral (D) views. Scales in centimeters and millimeters.

Other bones could be found on the landing step and slope in the middle of the pit. Many of them are likely derived from modern goats. But there were other bones from larger animals. Regrettably, this landing step is where rocks and debris thrown in by miners landed when thrown into the pit. Rocks cover, and probably destroyed, most fossils. In this section of the cave, the 10 cm long claw of a ground sloth was also found (Fig. 7E). We assume it belongs to a second ground sloth whose remains are under the rocks and debris, with just a few fragments of the long bones showing between rocks.

It is likely that ground sloths would have gained access to the cave when the base of the canyon was not so deeply eroded. Vegetation growing in the canyon or on its walls at the time might also have allowed for easier access. A topographic map of the cave suggests it is extremely unlikely that in the past there was another entrance with a passage that gave easier access to the pit, because the cave transects perpendicular to the canyon walls, away from the cliff, and the top of the mountain plateau is 200 vertical meters above the entrance.

#### Field description of the deposits

At the bottom of the pit (Fig. 2C), a large assemblage of bones is present (Fig. 2D) and partially covered by gravel. Regrettably, some have been broken by falling rocks thrown into the pit by miners or by cavers descending into the pit. The main component of this bone assemblage is an almost complete skeleton of a ground sloth. Bones are mostly in the position in which the animal laid when it died, and its skeleton was still partially articulated (Fig. 3).

The skeleton was easily identified as belonging to a ground sloth because of its dental formula of 5/4 and its bilophodont molariform teeth (McDonald and De Iuliis, 2008; Gaudin and McDonald, 2008). The right maxilla has four molariform teeth and a socket for the caniniform tooth (Figs. 4B and 5). In the left mandible, the sockets for, and fragments of three molariform teeth, can be seen (Fig. 4D). Based on the photographic documentation and dental morphology in general, the sloth was identified as *Nothrotheriops shastensis* (McDonald and De Iuliis, 2008; Gaudin, 2004;). The presence of an alveolus for a caniniform is interesting but is atavistic and has been reported in *Nothrotheriops* before (McDonald, 1995), so it does not preclude the specimen from being assigned to *Nothrotheriops*.

On this landing step there is also at least the back of the skull and horns (Fig. 7D) of a *Bison* sp. (*Bison latifrons* or *Bison antiquus*?). From tip to tip, the horns measure about 40 cm. The skull is protected under a hollow at the side of the landing step, covered only by small pebbles, and luckily protected from the main destructive impact of rocks. We did not attempt to excavate it as it would still require considerable stabilization for its conservation.

The pit also preserves the remains of small vertebrates. Skulls and bones presumably from bats are included. They were not extracted for reasons mentioned before and no attempt at identification was made. Exoskeletons of beetles are also present. It remains to be determined if they are modern beetles, like those that can presently be found in the cave, or if they are the remains of insects that contributed to the decomposition of the ancient fauna.



Figure 6. A-D; Ground sloth. E; Femur of a smaller mammal. A-B; Approximately nine vertebrae partially articulated and preserved in order. In B, several of the vertebrae have been isolated in Photoshop for clarity's sake in B, whereas in A they are photographed in situ. Also, in B three thoracic vertebrae are shown in posteroventrolateral view, with the spinous processes facing the bottom of the image C; Pelvic girdle fragments. D; Pelvic girdle fragment and two ribs. E; Right femur of small mammal shown in posterior view.

North America at least 10,000 ybp at the end of the Pleistocene (McDonald, 2022). As noted above, any large mammal traversing the darkness of the cave could stumble into this unexpected death trap. It appears that at least two ground sloths, a large bovid, and many goats succumbed in this manner.

Remains of *Nothrotheriops* have been recovered from some 70 localities in the United States and Mexico (De Iuliis, 2015). They range in age from early Irvingtonian (ca. 1.7 Ma) to latest Rancholabrean (ca. 11Ma), with most records from the late Pleistocene (McDonald and Jefferson, 2008). The genus has two species; *N. texanus* and *N. shastensis*. Whereas both species have been described in the United States, the former is known from a single locality in Sonora, Northeast Mexico. On the contrary, *N. shastensis*' range extends throughout Mexico and as far south as Belize (De Iuliis et al., 2015). *Nothrotheriops shastensis* is commonly preserved in caves (McDonald, 2002; McDonald and Jefferson, 2008; McDonald et al., 2013). In Mexico, this species has been found in multiple caves including Bustamante Cave, Cerro de la Silla Cave, and San Josecito Cave in Nuevo Leon, Northeast Mexico, and La Presita Cave, in San Luis Potosi, Central Mexico (McDonald and Jefferson, 2008). San Luis Potosi is the neighboring state to Queretaro. To our knowledge, La Presita Cave, 200 km away, is the closest cave locality to Cueva del Tesoro with described remains of *N. shastensis*.

The small caniniform and the general dental morphology suggests that the Cueva del Tesoro articulated skeleton is a nothrotheriid sloth. Given the aforementioned biogeographic considerations, it supports the identification of the specimen as *N. shastensis*. Though *N. shastensis* has lost its caniniform, the tooth has been recorded in an early Pleistocene juvenile specimen of *N. texanus* (McDonald, 1995). Future studies may confirm that the specimen belongs to *N. shastensis* or may instead indicate that it pertains to some other nothrotheriid that retains the caniniform.

Recent revisions of the phylogenetic relationships of sloths based on DNA (Delsucet et al., 2019) and palaeoproteomics (Presslee et al., 2019) have elucidated the broader relationships among sloths. Although these studies are important, sloth phylogeny is hardly a settled matter. The limited number of fossil specimens that preserve DNA or proteins means that resolution of the relationships for most sloth taxa will still have to be based primarily on morphology to determine the phylogenetic

## DISCUSSION

Sloth remains from North American caves and associated karst features suggests they utilized caves in general (McDonald, 2003). The hypothesis that some ground sloths in Mexico passed part of their life in caves is supported by the findings of complete and articulated skeletons inside the cave systems of Quintana Roo (Stinnesbeck et al., 2021; McDonald et al., 2017). These articulated ground sloth skeletons discovered in deep parts of the caves, hundreds of meters from the nearest cenote entrance, suggest that these individuals died in situ and there was no secondary transport into the cave. The nearly complete and partially articulated skeleton found in Cueva del Tesoro further supports this notion. The location where the remains were found is 170 m from the entrance, well within the perpetual dark zone.

The topography of this cave likely enabled the accumulation of fossils over thousands of years, an inference confirmed by the presence of a sloth species that went extinct in



Figure 7. A-C; Bones of ground sloth at the bottom of the pit. D-E; Remains found on the first step and ramp in the middle of the pit. A; Arrows point at sloth remains predominantly from hind limbs. Black arrows point at a cervical vertebra (B) and large femur (C). D; Skull and horns of a bovid. E; Claw of a ground sloth shown in lateral view. CT-1 Sociedad Mexicana de Exploraciones Subterráneas (SMES).

relationships of members of the clade in South, North, and Central America, as well as the Antillean taxa (McDonald et al., 2020). The relevance of the new discovery at Cueva del Tesoro lies in the completeness of the skeleton. Many studies rely on fragmentary material, such as fragmentary skulls with little to no associated other skeletal parts. The opportunity provided by having most of the skeleton of a single individual preserved will be of great value for comparative morphological and taxonomic studies.

Many interesting studies remain to be performed at this locality. Unfortunately, while the stable temperature and dry conditions have enabled the preservation of these bones over thousands of years, the bones have also become extremely fragile and brittle. Any future efforts to recover the fossils will require considerable stabilization of the bones prior to their removal. In their eagerness to extract interesting new bones, future scientists will have to be cautious not to destroy these valuable fossils. Conservation should be the priority.

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