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COVER PHOTO—Coral Pipe Speleothems in Old Man Cave, Nevada. Photo courtesy of Louise D. Hose *(see p. 12).*

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PALEOECOLOGICAL IMPLICATIONS of the MAMMALIAN FAUNA of LOWER SLOTH CAVE GUADALUPE MOUNTAINS, TEXAS

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SUMMARY

The vertebrate fauna of Lower Sloth Cave, Culberson County, Texas, spans the transition from late Wisconsinan to Recent time. Extinct species represent 4.8% of the mammalian fauna. Extant, but extralimital, mammalian species represent an additional 21.4% of the fauna; thus, 26.2% of the 37 taxa of mammals recorded from Lower Sloth Cave no longer occur in the Guadalupe Mountains. The majority of the extralimital mammals are found as near as the mountains of northern New Mexico, with only Cryptotis parva *suggesting an eastern influence on the fauna. Paleoclimatic reconstruction of the area indicates a slightly more mesic climate than at present. A late Pleistocene paleobotanical reconstruction of the area near Lower Sloth Cave suggests a spruce-fir forest interspersed with grassy glades or meadows. A single humerus of the Pleistocene Black Vulture (*Coragyps occidentalis*) was also recovered.*

FOR NEARLY HALF a century, the caves of the southern Guadalupe Mountains of New Mexico and Texas have provided a valuable source of information on vertebrate paleocommunities of the area. Rich bone deposits in Burnet Cave (Howard, 1932; Schultz and Howard, 1935), Dry Cave (Harris, 1970a), Pratt Cave (Gehlbach and Holman, 1974; Lundelius, 1979), Upper Sloth Cave (Logan, 1975; Logan and Black, 1979), and Williams Cave (Ayer, 1936) show dramatic changes in the vertebrate fauna of the southern Guadalupe Mountains over the past 15,000 years.

Remains of extinct vertebrates recovered from Lower Sloth Cave represent only three taxa: *Coragyps occidentalis* (Pleistocene Black Vulture), *Ovis canadensis catclawensis* (Pleistocene Bighorn Sheep), and *Nothrotherium shastense* (Shasta Ground Sloth). *Cryptotis parva* (Least Shrew), *Sorex cinereus* (Masked Shrew), *Sorex vagrans* (Wandering Shrew), *Marmota flaviventris* (Yellow-bellied Marmot), *Tamiasciurus hudsonicus* (Red Squirrel), *Sciurus* sp. (Tree Squirrel), *Cynomys gunnisoni* (Gunnison's Prairie Dog), *Neotoma cinerea* (Bushy-tailed Woodrat), and *Ovis canadensis* (Bighorn Sheep) are extant taxa represented in the vertebrate fauna of Lower Sloth Cave but have been extirpated from the area.

Excavations in Upper Sloth Cave, Lower Sloth Cave, Dust Cave, and Williams Cave, all within the boundaries of the Guadalupe Mountains National Park, have produced plant macrofossils and pollen profiles spanning the last 13,000 years (Van Devender, *et al.*, 1979a;b). These plant macrofossils and pollen, not commonly preserved in cave deposits, provide valuable information on paleohabitats and paleoclimates of the area.

Lower Sloth Cave (Fig. 1) is located in the extreme northwestern corner of Culberson County,

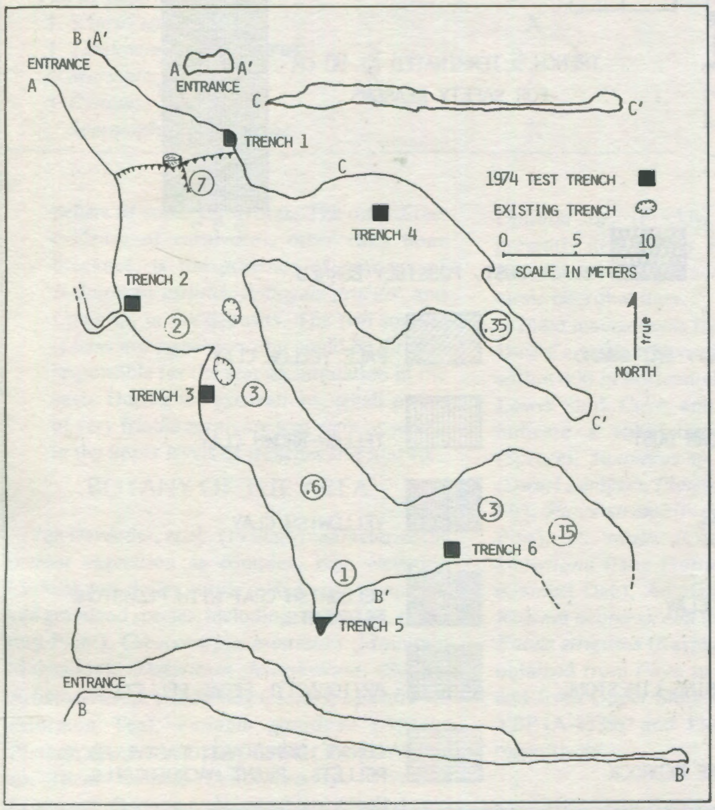


Figure 1. Lower Sloth Cave, Guadalupe Mountains National Park, Culberson County, Texas. CRG Grade 5 survey.

Figure 2. West face of the Guadalupe mountains, from Upper Sloth Cave. Arrow marks entrance of Lower Sloth Cave.

Texas, at an elevation of approximately 200 m. The entrance faces west-northwest and is located at the junction of a 35 m cliff of Permian limestone and a 60° talus slope (Fig. 2).

Lower Sloth Cave is a horizontal cave with a total vertical relief of less than 7 m. It is a very dry cave at present, with flour-like dust deposits up to 20 cm in depth. The cave is poorly ornamented and has only a few dead columns, stalactites, and minor draperies. There are a few solution pockets in the ceiling. These are utilized by bats of the genera *Plecotus*, *Myotis*, and *Eptesicus* as hibernation sites. Great Horned Owls occasionally utilize one ledge in the cave as a roost site.

METHODS

The locations for the six test trenches in Lower Sloth Cave (Fig. 1) were determined by surface prospecting for vertebrate remains throughout the cave, concentrating on areas of probable accumulation, *i.e.*, below owl roosts (presently utilized by Great Horned Owls) and at the bases of slopes. After an area was chosen, a one-meter square grid of nylon cord oriented north-south was placed above the surface of the deposit to define the limits of the excavation and to provide a reference point for determining the depth of the excavation.

Each trench was dug in 10 cm depth increments, taking care to keep separate the different stratigraphic units within each level. The matrix from each level was dry-screened through screens of 7 mm, 3 mm, and 0.75 mm mesh. Material that was too wet to dry screen immediately was sundried on vinyl sheeting and then screened. All levels deeper than 30 cm had to be dried prior to screening. Concentrate that was trapped by the 3 mm and 7 mm screens was examined in the field, and all organic material was saved. Concentrate trapped by the 0.75 mm screen was bagged and later examined under magnification in the laboratory. Vertebrate materials as small as isolated bat canines and incisors were recovered in this manner.

During the excavations, pollen samples were taken from each level and each stratigraphic unit. These samples were processed by Dr. Thomas Van Devender and Mr. Geof Spaulding of the University of Arizona. (Van Devender, *et al.*, 1979a;b). Some samples contained quantities of pollen; others had none.

After the excavation of each trench was completed, the trench was lined with polyvinyl sheeting and backfilled with the screened residue from the trench. This restored the cave to a more nearly normal condition as well as defined the limits of the excavation for future workers.

STRATIGRAPHY

The statigraphy of Lower Sloth Cave is so varied that correlations between trenches are extremely dubious in most cases. The only subsurface strata that can be correlated with any degree of certainty are the flowstone layer of trench one and the layer containing flowstone fragments in trench five. These strata certainly indicate a period of increased precipitation in the Guadalupe Mountains.

The depth within the deposit is obviously not useful in correlating sediments, considering the differences between trenches five and six. These trenches are within 12 m of each other, and, from surface indications, there should be little difference between them.

METHOD OF ACCUMULATION

The vertebrate material from Lower Sloth Cave apparently accumulated in the following manner:

1. **Natural deaths**—This mode of accumulation is apparently responsible for a very minor percentage of the total bone accumulation. Primarily, immature birds and bats seem to be involved. The bones of these animals, while relatively uncommon, have a tendency to show little breakage prior to deposition.
2. **Carnivore deposition**—The vast majority of vertebrate remains from Lower Sloth Cave are of vertebrates of jack rabbit (*Lepus* sp.) size or smaller. *Neotoma* sp. bones make up the bulk of the material. The breakage of these bones is nearly identical to the breakage of bone, described by Mellet (1974), observed in owl pellets and fecal

Figure 3. Simplified stratigraphy of trenches 1 to 6, Lower Sloth Cave, Culberson County, Texas. Excavations of July-August, 1974.

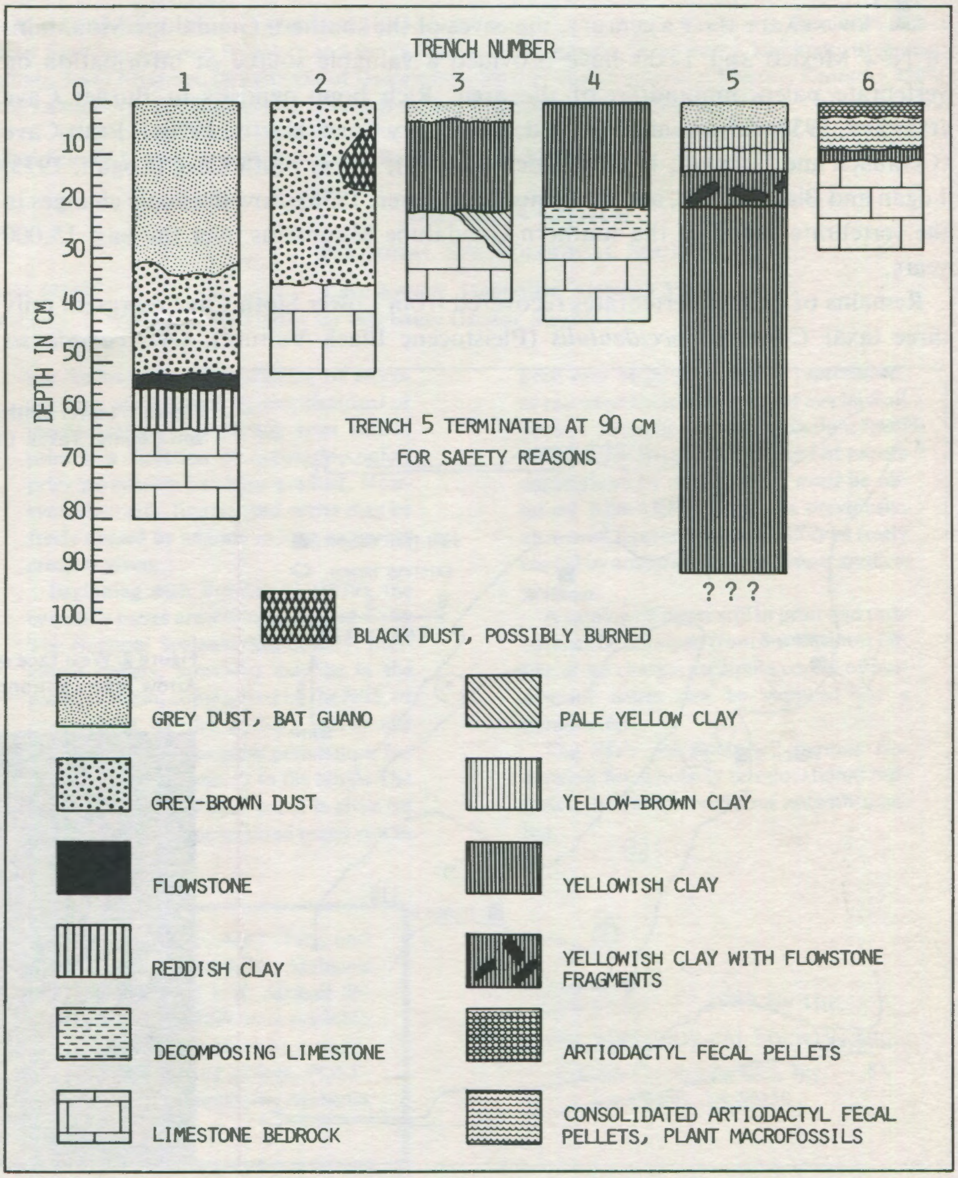


Table 1. Distribution of mammalian species of Lower Sloth Cave by collecting locality. Taxa marked with the symbol '*' are extinct; taxa marked with the symbol '†' are extant, but have been extirpated from the area.

Taxa	Trench 1	Trench 2	Trench 3	Trench 4	Trench 5	Trench 6	Surface or Existing Trench
Order Insectivora							
Family Soricidae							
†**Sorex cinereus*					X		
† *S. vagrans*					X	X	
† *Cryptotis parva*			X		X	X	
Notiosorex crawfordi	X	X			X	X	
Order Chiroptera							
Family Vespertilionidae							
Myotis sp.	X	X	X		X	X	
M. velifer	X	X			X	X	
M. thysanodes	X						
M. leibii	X						
Eptesicus fuscus	X				X	X	
Plecotus townsendii	X	X			X		
Antrozous pallidus	X				X		
Family Molossidae							
Tadarida sp.	X						
T. brasiliensis		X				X	
Order Edentata							
Family Megatheriidae							
**Nothrotherium shastense*							X
Order Lagomorpha							
Family Leporidae							
Sylvilagus sp.	X	X				X	
Order Rodentia							
Family Sciuridae							
† *Sciurus* sp.					X		
† *Tamiasciurus hudsonicus*	X					X	
† *Marmota flaviventris*	X				X		
† *Cynomys gunnisoni*	X						
Spermophilus spilosoma					X		
S. variegatus	X					X	
Eutamias sp.	X						
Family Geomyidae							
Thomomys umbrinus						X	
Family Muridae							
Peromyscus sp.					X	X	
Onychomys leucogastor						X	
O. torridus						X	
Neotoma sp.	X	X	X	X	X	X	X
N. micropus						X	
N. albigula					X	X	
N. mexicana					X	X	
† *N. cinerea*	X				X		
Microtus sp.	X	X	X		X		
M. mexicanus	X	X				X	
Family Erethizontidae							
Erethizon dorsatum					X	X	
Order Carnivora							
Family Canidae							
Canis sp.	X						
Family Procyonidae							
Bassariscus astutus	X					X	
Family Mustelidae							
Mustela frenata						X	
Spilogale gracilis						X	
Order Artiodactyla							
Family Cervidae							
Odocoileus sp.	X						
Family Bovidae							
† *Ovis canadensis*	X						X
**O. canadensis catclawensis*		X					

pellets of small carnivores. The only direct evidence of carnivores, other than bone breakage, is the presence of remains of *Bassariscus astutus, Spilogale gracilis,* and *Canis* sp. in the deposits. The two smaller species are carnivores that could be directly responsible for the scat accumulation in the cave. During the excavations, small pieces of very friable carnivore scat were observed in the upper levels of trenches five and six.

BOTANY OF THE AREA

Van Devender, *et al.*, (1979a;b) characterize the present vegetation as complex, high elevation Chihuahuan desert scrub mixed with chaparral and grassland species, including *Agave* spp. (Century Plant), *Cerococarpus montanus* (Mountain Mahagony), *Dasylirion leiophyllum* (Sotol), *Echinocerus* sp. (Hedgehog Cactus), *Ephedra* sp. (Mormon Tea), *Fallugia paradoxa* (Apache Plume), *Lesquerella* sp. (Bladder Pod), *Nolina* sp. (Bear Grass), *Oenothera* sp. (Evening Primrose), *Opuntia imbricata* (Cane Cholla), and *Opuntia* sp. (Prickly Pear). The only trees presently near Lower Sloth Cave are two relict *Pinus edulis* (Colorado Pinyon) in protected mesic microhabitats.

Plant macrofossils from Upper Sloth Cave and Dust Cave (Van Devender, *et al.*, 1979a;b), both within 400 m horizontally and 50 m vertically of Lower Sloth Cave, and from Lower Sloth Cave indicate a subalpine forest with *Picea* sp. (Spruce), *Juniperus* sp. (Juniper), *J. communis* (Dwarf Juniper), *Pseudostuga menziesii* (Douglas Fir), *Pinus strombiformis* (Southwestern White Pine), *P. edulis* (Colorado Pinyon), *Ostrya knowltonii* (Hop Hornbeam), *Quercus gambelii* (Gambel Oak), *Arctostaphylos* sp. (Manzanita), *Robinia neomexicana* (New Mexico Locust), and *Rubus strigosus* (Raspberry). Radiocarbon dates obtained from *Picea* sp. needles from Dust Cave and from Upper Sloth Cave were 13,000 ± 730 YBP (A-1539)* and 13,060 ± 280 YBP (A-1549) respectively.

* University of Arizona Laboratory.

Picea sp., *Juniperus communis* and *Rubus strigosus* are no longer components of the flora of Trans-Pecos Texas, but all three presently occur in New Mexico within 450 km of Lower Sloth Cave. The nearest population of *Juniperus communis* is in the southern end of the Rocky Mountains, in north-central New Mexico (Van Devender, *et al.*, 1979b).

During the late Pleistocene, the area around Lower Sloth Cave was probably a subalpine forest interspersed with grassy meadows (Van Devender, *et al.*, 1979a;b). The transition to the present high-elevation desert shrub community, which currently occurs near Lower Sloth Cave, was probably the result of the more arid conditions which prevail in the Guadalupe Mountains today.

MAMMALIAN FAUNA

The mammalian fauna of Lower Sloth Cave consists of at least 37 discernible taxa—(Table 1). The following list summarizes where specimens of these taxa were recovered during the excavations.

CLASS MAMMALIA
ORDER INSECTIVORA

Family Soricidae
Sorex cinereus (Kerr)—Masked Shrew
Material: Left mandible with I_1-M_2 (TTU-P-8485); left mandible with M_1(TTU-P-8486).
Discussion: The closest modern occurrence of *S. cinereus* is in the mountains of northern New Mexico, a distance of approximately 480 km (Hall and Kelson, 1959). Specimens from Lower Sloth Cave agree closely with a modern specimen (MALB-2684) from San Miguel County, New Mexico that is deposited in the collections of the Museum of Arid Lands Biology, the University of Texas at El Paso.

Sorex cinereus has previously been reported from late Wisconsinan sediments in Upper Sloth Cave, in the southern Guadalupe Mountains of Culberson County, Texas by Logan (1975) and by Logan and Black (1979), where it was the most abundant shrew in the deposits.

In New Mexico, masked shrews seem to be restricted to hydrosere communities, usually above 3,465 m (Findley; *et al.*, 1975). The elevation of Lower Sloth Cave is approximately 2000 m. This indicated former depression of life zones agrees with the interpretation by Van Devender, *et al.*, (1979a;b) based on plant macrofossils and pollen profiles taken from Upper Sloth Cave, Lower Sloth Cave, Dust Cave, and Williams Cave, all from the southern tip of the Guadalupe Mountains.

The presence of this species in the deposit is an indicator of more mesic conditions than presently occur in the southern Guadalupe Mountains.

Sorex vagrans (Baird)—Vagrant Shrew
Material: Left mandible with M_1 (TTU-P-8487); left mandible with M_{1-2} (TTU-P-8488); right mandible with U_2-M_1 (TTU-P-8489); right mandible with M_{1-2} (TTU-P-8490); left mandible with M_2 (TTU-P-8491).
Discussion: *S. vagrans* presently occurs within 160 km of Upper Sloth Cave, in the Sacramento Mountains of Lincoln and Otero counties, New Mexico (Findley; *et al.*, 1975).

The vagrant shrew is more common in hydrosere communities and less common within montane forests, with hydrosere communities of grasses and sedges seeming to be an important feature to this species (Findley, 1955).

The presence of *Sorex vagrans* in the fauna is an indicator of more mesic conditions than presently occur in the southern Guadalupe Mountains.

Cryptotis parva (Say)—Least Shrew
Material: Right mandible with U_1-M_1 (TTU-P-8492); right mandible with I_1-M_3 (TTU-P-8494).
Discussion: *Cryptotis parva* has previously been reported from Upper Sloth Cave, Culberson County, Texas, with an associated radiocarbon date of 11,760 ± 610 YBP (Logan, 1975; Logan and Black, 1979) and Dry Cave, Eddy County, New Mexico by Harris, *et al.*, (1973) and Harris (1970a; 1979), associated with a radiocarbon date of 10,730 ± 150 YBP.

The specimens of *C. parva* from Lower Sloth Cave are the second reported occurrence of this species from the Trans-Pecos of Texas. These records indicate a former range extension of over 320 km to the southwest of its present known range.

Graham (1976) characterizes *C. parva* as a 'deciduous' species to show its eastern affinities. However, it occurs primarily in grasslands, with occasional individuals being found beneath logs and in leaf litter in forested areas (Davis, 1974).

The presence of this species is an indicator of a more mesic climate than occurs in the area today.

Notiosorex crawfordi (Coues)—Desert Shrew
Material: Four left mandibles with I_1-M_3 (TTU-P-846-8464); two right mandibles with I_1-M_3 (TTU-P-8465, 8470); two right mandibles with I_1-M_1 (TTU-P-8473-8474); two right mandibles with M^{1-2} (TTU-P-8475-8476); left mandible with U_2-M_3 (TTU-P-8466); right mandible with U_2-M_3 (TTU-P-8467); left mandible with U_2-M_2 (TTU-P-8472); right maxilla with I-U^3 (TTU-P-8477); right maxilla with I^1-M^1 (TTU-P-8478); left maxilla with I^1-U^3 (TTU-P-8479); left maxilla with U^2-M^3 (TTU-P-8480); right maxilla with U^2-M^3 (TTU-P-848); right maxilla with U^2-M^3 (TTU-P-848); left maxilla with M^{2-3} (TTU-P-8483); right maxilla with M^2 (TTU-P-8484).
Discussion: The desert shrew is known from widely scattered localities in southwestern United States and western Mexico (Hall and Kelson, 1959). This strew does not seem to be restricted to any particular habitat (Davis, 1974). Although no desert shrews have been reported taken from Culberson County, Texas, specimens have been taken from Jeff Davis County, which adjoins it on the south (Davis, 1974) and from Eddy County, New Mexico, which adjoins it on the north (Findley, *et al.*, 1975).

Fossil specimens of *N. crawfordi* have previously been reported from the following localities in the southern Guadalupe Mountains: Dry Cave, Eddy County, New Mexico (Harris, 1970b); Pratt Cave, Culberson County, Texas (Lundelius, 1979); Upper Sloth Cave, Culberson County, Texas (Logan and Black, 1979); and Muskox Cave, Eddy County, New Mexico (Logan, 1981).

ORDER CHIROPTERA

Family Vespertilionidae
Myotis sp.—Mouse-eared Bat
Material: Numerous fragmentary and/or edentulous mandibles from throughout the cave.
Discussion: Several species of small *Myotis* are found in the immediate vicinity of Lower Sloth Cave today. These small, western *Myotis* are extremely difficult, if not impossible, to identify on the basis of fragmentary material. The worldwide distribution of the genus makes it useless as a paleoclimatic indicator.

Myotis velifer (J. A. Allen)—Cave Myotis
Material: Skull with right P^3-M^1 and left P^4-M^2 (TTU-P-8413); fragmentary skull with right P^2-M^3 and left P^{3-4} (TTU-P-8414); rostrum with right and left P^4M^2 (TTU-P-8415); left mandible with P_4-M_3 (TTU-P-8416); right mandible with C, P_4-M_2 (TTU-P-8417); right mandible with M_{2-3} (TTU-P-8418); left mandible with M_{2-3} (TTU-P-8419); left mandible with M_3 (TTU-P-8420); right mandible with M_{1-2} (TTU-P-8421); left mandible with M_2 (TTU-P-8422); right mandible with M_{2-3} (TTU-P-8423); right mandible with M_{2-3} (TTU-P-8424).
Discussion: *M. velifer*, the Cave Myotis, is a common inhabitant of caves throughout southwestern United States and has been collected from McKittrick Canyon in Guadalupe Mountains National Park (Davis, 1974). These specimens do not differ significantly from a series of *M. velifer* from west Texas and New Mexico. *Myotis velifer* occurs in a wide variety of habitats.

Myotis thysanodes (Miller)—Fringed Myotis
Material: Skull with right and left P^4 and M^1 (TTU-P-8411), skull with right P^2, P^4M^3 and left P^4M^3 (TTU-P-8412).
Discussion: *M. thysanodes* is a western bat that enters Texas in the Trans-Pecos and has been collected in McKittrick Canyon in the Guadalupe Mountains, Culberson County (Davis, 1974). This species is commonly recorded from caves (Findley, *et al.*, 1975).

Myotis leibii (Audubon and Bachman)—Small-footed Myotis
Material: Partial skull with right P^4-M^2 and left P^4-M^3 (TTU-P-8425).
Discussion: *M. leibii* is a small *Myotis* with a relatively flattened skull and is most easily confused with *M. californicus;* which has a more globuse skull (Bogan, 1974). Bogan states that 'Rostral breadth as measured at the junction of M^1-M^2; 96% of *californicus* not exceeding 5.0 mm, and 92% of *leibii* equalling or exceeding 5.2 mm.' Bogan (1975) lists a maximum rostral breadth of 5.2 mm for *M. californicus*. Specimen TTU-P-8425 has a rostral breadth of 5.65 mm and is referred to *M. leibii* on this basis.

Findley, *et al.*, (1975) suggests that *M. leibii* is primarily a rock crevice of cave inhabiting bat in western United States. Davis (1974) states that *M. leibii* is 'restricted in Texas to the Trans-Pecos region. Recorded from Brewster, Culberson, and Jeff Davis counties.' *M. leibii* is found throughout much of the United States (Hall and Kelson, 1959) and is therefore not useful as a climatic indicator.

Eptesicus fuscus (Beauvois)—Big Brown Bat
Material: Right mandible with M_3 (TTU-P-8433), left mandible with P_4-M_2 (TTU-P-8434), right mandible with M_{2-3}(TTU-P-8435), edentulous left mandible (TTU-P-8436), left maxilla M^{1-3} (TTU-P-8437), left maxilla P^4 (TTU-P-8438).
Discussion: Some of the specimens of *E. fuscus* from Lower Sloth Cave are eight to ten percent larger than modern specimens from Texas and New Mexico, while others are very close in size to these modern specimens. The larger specimens are the size of *E.f. grandis*, described by Brown (1908). Guilday (1967) and Engels (1936) both documented substantial sexual dimorphism and clinal variation with regard to size within this species. Guilday (1967) has shown that *E.f. grandis* (Brown, 1908) cannot be adequately separated from the modern subspecies *E.f. fuscus*.

Plecotus townsendii (Cooper)—Townsend's Big-eared Bat
Material: Left mandible with M_{2-3} (TTU-P-8444); edentulous left mandible (TTU-P-8445); edentulous right mandible (TTU-P-8446).
Discussion: The above mentioned specimens do not differ significantly from recent specimens from Culberson County, Texas. Upper Sloth Cave, located approximately 250 m from Lower Sloth Cave, was the site of a nursery colony of approximately 50 *P. townsendii* from 20 July 1974 to 17 August 1974. *P. townsendii* was observed hibernating in both Upper and Lower Sloth Caves in 1974 and 1975.

Family Molossidae
Tadarida brasiliensis (Saussure)—Brazilian Freetail Bat
Material: Right P^4-M^2 (TTU-P-8441); right P^4-M^2 (TTU-P-8442); edentulous right mandible (TTU-P-8443).
Discussion: *Tadarida brasiliensis* is a relatively common bat in the southern Guadalupe Mountains. The largest colony is at Carlsbad Caverns, approximately 40 km north of Lower Sloth Cave. The specimens from Lower Sloth Cave closely agree in both size and morphology with a series from Eddy County, New Mexico and Culberson County, Texas.

ORDER EDENTATA

Family Megatheriidae
Nothrotherium shastense Sinclair—Shasta Ground Sloth
Material: Fragments of dung balls (TTU-P-8428).
Discussion: No ground sloth dung was obtained from the 1974 excavations, although it was obtained from the working face of a previous excavation. This trench possibly was excavated by H. P. Mera in 1931; when he used Lower Sloth Cave for a campsite while excavating High Cave, now called Upper Sloth Cave (Mera, 1938). Samples of *N. shastense* dung from Lower Sloth Cave have been radiocarbon dated at 11,590 + 230 YBP (A-1519). This date agrees closely with radiocarbon dates from other North American sloth dung sites (Van Devender, *et al.*, 1979a;b). No bones of *N. shastense* have been found in Lower Sloth Cave, but the dung balls agree closely with specimens from Gypsum Cave, Nevada (Stock, 1931; Eames, 1930) and from Rampart Cave, Arizona (Wilson, 1942). *N. shastense* is one of two extinct mammals known from Lower Sloth Cave.

ORDER LAGOMORPHA

Family Leporidae
Sylvilagus sp.—Cottontail Rabbit
Material: Left mandible with P^3 (TTU-P-8439).
Discussion: *Sylvilagus auduboni* and *S. floridanus* both presently occur in the southern Guadalupe Mountains. In addition to these two species, *S. nuttallii* has been reported from Dry Cave, Eddy County, New Mexico (Harris, 1970b). No further identification of this specimen is possible on the basis of material present.

ORDER RODENTIA

Family Sciuridae
Sciurus sp.—Tree Squirrel
Material: Isolated left M^1 or M^2 (TTU-P-8512).
Discussion: Tree squirrels, which are commonly represented in many modern faunas, are relatively uncommon in the fossil record of the southwestern U.S. This is the first record of the genus *Sciurus* from the Guadalupe Mountains and the first fossil record of the genus from Trans-Pecos Texas. In neighboring New Mexico, tree squirrels have been reported from only three fossil localities: *Sciurus arizonensis* (cf) was reported from the Brown Sand Wedge Local Fauna, Roosevelt County, by Slaughter (1964); a squirrel 'the size of *Tamiasciurus hudsonicus*' from La Bajada Hill, Santa Fe County, was reported by Stearns (1942); and *Tamiasciurus hudsonicus* was reported from Muskox Cave, Eddy County by Logan (1981).

Modern populations of *S. niger* and *S. carolinensis* presently occur in eastern Texas (Davis, 1974); populations of *S. niger, S. arizonensis,* and *S. aberti* occur in New Mexico (Findley, *et al.*, 1975). This specimen most likely represents *S. aberti;* if we accept the paleobotanical reconstruction of the area proposed by Van Devender, *et al.*, (1977a;b). *Sciurus aberti* is an animal of coniferous or at least mixed coniferous forests; whereas the other species of *Sciurus* mentioned occur primarily in deciduous forests (Findley, *et al.*, 1975; Davis, 1974).

The presence of *Sciurus* sp. in the fauna is an indicator of more forested and more mesic conditions than occur in the Guadalupe Mountains today.

Tamiasciurus hudsonicus (Erxleben)—Red Squirrel
Material: Isolated left M^2 (TTU-P-8456); isolated left M^3 (TTU-P-8457); fragmentary left mandible with P_4-M_1 (TTU-P-8498).
Discussion: These specimens closely resemble a series of *Tamiasciurus hudsonicus* from northern New Mexico that are deposited in collections of the Division of Mammals, U.S. National Museum of Natural History.

T. hudsonicus presently occurs as near as the Sacramento Mountains of northern Otero County, New Mexico, but does not occur in the southern Guadalupe Mountains of Eddy County, New Mexico and Culberson County, Texas (Hall and Kelson, 1959). Findley, *et al.*, (1975) state that red squirrels are limited to mixed coniferous and spruce-fir forests. The presence of this species in the fauna gives considerable support to the proposed paleobotanical reconstruction of spruce-fir forest previously existing in the area (Van Devender, *et al.*, 1979a;b).

The presence of *T. hudsonicus* and spruce-fir forests in the area are both indicators of a more mesic and possibly cooler environment than occurs in the area today.

Marmota flaviventris (Audubon and Bachman)—Yellow-bellied Marmot
Material: Isolated right M^3 (TTU-P-8458); isolated left M_3 (TTU-P-8459); isolated left P^3 (TTU-P-8460).
Discussion: *Marmota flaviventris* is easily distinguished from *M. caligata* and *M. monax* by its smaller and less massive dentition (Howell, 1915). *M. monax*, which may have existed south and west of its present range during the late Pleistocene, is easily distinguished from *M. flaviventris* on gross dental morphology. The M_3 of *M. flaviventris* has a triangular outline when viewed from the occulusal surface; while the corresponding tooth in *M. monax* is much more quadranglar in outline. The M^3 of *M. monax* is nearly equal in length and width, while the M^3 of *M. flaviventris* is longer than wide (over 20% longer than wide in the Lower Sloth Cave specimen.)

The specimens from Lower Sloth Cave, referred to *M. flaviventris*, are indistinguishable from a series of late Pleistocene *M. flaviventris* from Rampart Cave, Arizona, housed in the collections of the Department of Paleobiology, National Museum of Natural History, Washington, D.C. A similar series of specimens, also from Rampart Cave, are referred to *M. flaviventris* cf. *engelhardti* by Wilson (1942).

M. flaviventris has previously been reported from the following localities in the southern Guadalupe Mountains: Upper Sloth Cave (Logan, 1975; and Logan and Black, 1979), Burnet Cave (Murray, 1957), Dry Cave (Harris, 1970a) and Muskox Cave (Logan, 1981). The present closest occurrence of *M. flaviventris* is in the mountains of northern New Mexico (Findley, *et al.*, 1975). Murray (1957) attributes the presence of *M. flaviventris* to the extension of the forests southward and to a lower elevation.

Harris and Findley (1964) point out that *M. flaviventris* occurs in other habitats, and its presence in conjunction with non-forest forms, as in Dry Cave (Harris, 1970a), may indicate an open habitat that now exists even farther to the north.

M. flaviventris is an indicator of more mesic conditions than presently occur in the southern Guadalupe Mountains. Harris (1970b) suggests that a minimum increase of two inches of winter precipitation would be necessary to provide enough green forage to carry this species through the spring dry season.

Cynomys cf. *gunnisoni* (Baird)—Gunnison's Prairie Dog
Material: Isolated right M^3 (TTU-P-8501).
Discussion: *Cynomys gunnisoni* may be differentiated from *C. ludovicianus* by its smaller and less specialized dentition (Pizzimenti, 1975). The specimen from Lower Sloth Cave agrees closely with a series of *C. gunnisoni* from New Mexico that are housed in the Recent mammal collections of the National Museum of Natural History.

Cynomys gunnisoni occurs in a variety of grassland situations in western and northern New Mexico, from low valleys to parks and meadows in montane forests up to at least 3050 m (Findley, *et al.*, 1975).

The presence of Gunnison's prairie dog, a primarily montane species, is an indicator of slightly more mesic conditions than presently occur in the southern Guadalupe Mountains.

Spermophilus spilosoma Bennet—Spotted Ground Squirrel
Material: Left maxilla with M^{1-2} (TTU-P-8440).
Discussion: This specimen is very close in size and morphology to recent material from Culberson and Jeff Davis counties. *S. spilosoma* was observed on the sandy flats west of Lower Sloth Cave during the period of excavation.

Spermophilus variegatus (Erxleben)—Rock Squirrel
Material: Isolated right P_4 (TTU-P-8430); isolated right M_3 (TTU-P-8431); left maxilla with P^4-M^3 (TTU-P-8432).
Discussion: The material referred to as this species does not differ significantly in size or morphology from modern specimens from Culberson County. *S. variegatus* has previously been reported from Williams Cave (Ayer, 1936), Pratt Cave (Lundelius, 1979), and Upper Sloth Cave (Logan and Black, 1979), all of which are located in Culberson County, Texas. Rock squirrels presently occur throughout Trans-Pecos Texas (Hall and Kelson, 1959; Davis, 1974).

Eutamias sp.—Chipmunk
Material: Right maxilla with P^4-M^1 (TTU-P-8426); isolated left P^4 (TTU-P-8429).
Discussion: Five species of *Eutamias* presently occur in New Mexico (Findley; *et al.*, 1975) but only *E. canipes* occurs in the Guadalupe Mountains of Texas (Davis, 1974: Genoways; *et al.*, 1979). On the basis of material preserved, these specimens cannot be referred to any specific species of *Eutamias* with certainty. *E. canipes* has been observed within 300 m of Lower Sloth Cave.

Family Geomyidae
cf. *Thomomys umbrinus* (Richardson)—Southern Pocket Gopher
Material: Maxilla with right M^1 (TTU-P-8508).
Discussion: *T. umbrinus* is the most abundant pocket gopher in the higher elevations of the Guadalupe Mountains (Davis, 1974). *Thomomys umbrinus* occupies valleys and mountain meadows of the southwestern United States, where it prefers a loamy soil, but it also occurs in sandy or rocky soil (Burt and Grossenheider, 1964). *T. umbrinus* is probably the pocket gopher that inhabits the small, grassy meadow directly above Lower Sloth Cave.

Family Muridae
Onychomys leucogastor (Wied)—Northern Grasshopper Mouse
Material: Right maxilla with M^2 (TTU-P-8450); right maxilla with M^{1-3} (TTU-P-8451).
Discussion: *O. leucogastor* is known from throughout Trans-Pecos Texas (Davis, 1974), where it is found primarily in areas of powdery or sandy soils. *O. leucogastor* also occurs in the sand and gravel flats southwest of Lower Sloth Cave.

Onychomys torridus (Coues)—Southern Grasshopper Mouse
Material: Right maxilla with M_{1-2} (TTU-P-8847); right maxilla with M_{2-3} (TTU-P-8448).
Discussion: *O. torridus* presently occurs in the sand and gravel flats southwest of Lower Sloth Cave. The distance to these flats, approximately 8 km, may explain the scarcity of this species in the fauna.

Neotoma sp.—Woodrat
Material: Numerous isolated teeth and fragmentary maxillae and mandibles from deposits throughout the cave.
Discussion: There is much variation in *Neotoma*, both at the individual and at the specific levels (Hall and Kelson, 1959), and certain individual specimens may be correctly placed systematically only with difficulty, even as to subgenus. This particular problem is substantially amplified when working with fragmentary dentitions, often making specific identifications sheer guesswork.

The vast majority of the fragmentary material is identified only to genus.

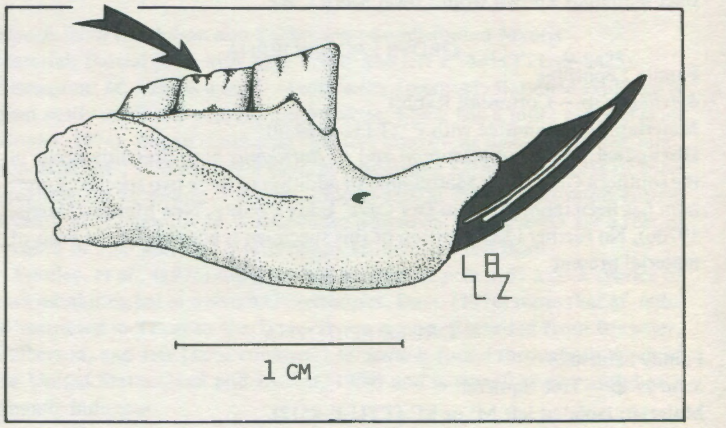
Neotoma mexicana (Baird)—Mexican Woodrat
Material: Three fragmentary right mandibles with M_1 (TTU-P-8520-8522), two fragmentary right mandibles with M_{1-2} (TTU-P-8523-8524), fragmentary left mandible with M_1 (TTU-P-8525), two fragmentary left mandibles with M_{1-2} (TTU-P-8526-8527).
Discussion: Three species of *Neotoma* presently occur sympatrically in the southern Guadalupe Mountains: *N. mexicana, N. albigula,* and *N. micropus* (Davis, 1974).

N. cinerea and *N. mexicana* were separated from *N. albigula* and *N. micropus* on the basis of dentine tracts on the antero-external side of the M_1 in the former two species. The dentine tracts on the M_1 extend from one-fourth to one-third the distance from the root to the crown of an unworn tooth, with the dentine tract on the M_2 being shorter.

N. cinerea was separated from *N. mexicana* on the presence of accessory cusps developed in the re-entrant angles on some *N. cinerea* teeth (Fig. 4). This condition was found on one or more teeth per specimen in five out of eight (62.5%) Recent specimens of *N. cinerea* examined. This condition was not observed in any of 33 Recent *N. mexicana* examined. A second condition found on worn teeth of *N. cinerea,* but not in *N. mexicana,* is the presence of enamel islands resulting from the isolation of the inner parts of the re-entrant folds due to wear (Lundelius, 1979).

Neotoma cinerea (Ord)—Bushy-tailed Woodrat
Material: Fragmentary right maxilla with M^{1-2} (TTU-P-8428), right mandible with I_1-M_3 (TTU-P-8429), isolated left M_1 (TTU-P-8430).

Figure 4. Labial view of the right mandible of *Neotoma cinerea,* showing the accessory cusp developed in the second re-entrant angle of the M_2.



SPELEOLIFEROUS LAVA FLOWS ASSOCIATED WITH THE BROTHERS AND SUBSIDIARY FAULT ZONES OF CENTRAL AND SOUTHEASTERN OREGON

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The Pacific Northwest, at the western edge of the North American Plate, is impacted by the interaction of three types of plate boundaries. As the Pacific plate slips northward toward subduction in the Gulf of Alaska, it is dragging Western Oregon northward. During the last 10 to 12 million years the terrain south of the Brothers Fault Zone has been extended an estimated 50 miles over a distance of 200 miles. The Brothers Fault Zone, along which magma has upwelled repeatedly, is the "pivot" between the older highly folded rocks of the Blue Mountain Province and the younger, highly faulted rocks of the Basin and Range Province. Caves have been discovered in most of the basaltic lava fields along the Brothers and subsidiary parallel fault zones whose basalts vary in age. A second group of cave flows are associated with stratovolcanoes which result from magma produced by the subduction of the Juan de Fuca plate.

THE CATLIN GABEL LAVA TUBES OF WEST PORTLAND: REMNANTS OF A PLIO-PLEISTOCENE CAVE SYSTEM

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During mapping of the Portland Hills, the author and his students found evidence of lava tubes. Their existance was first noted during a foundation study of the St. Vincent Hospital but their origin and extent was not apparent until our field investigation in 1974. They occur among a cluster of cinder cones and associated lava flows of Pliocene to late (?) Pleistocene age that occupy an area of approximately 25 square miles on the west side of the Portland Hills (probably they are the westernmost of this age in Oregon) and the fragmentary remains of their lava tubes present a very unusual opportunity to study the effects of the passage of time on such cave systems.

CAVES OF MOUNT ST. HELENS AND THE IMPACTS OF THE 1980 ERUPTIONS

William R. Halliday, Western Speleological Foundation

The Cave Basalt is the only known speleoliferous lava flow of Mt. St. Helens. It dates to about 1950 yr.B.P. Some of its caves underwent extensive aggradation about 450 years ago by two post-eruptive flash floods. These deposits underwent extensive subsequent erosion and reworking prior to the 1980 eruptions. Two and possibly more of the 1980 eruptions caused significant vertical airfall of tephra in the cave area. An unusual sequence of mudflows and flashflood landforms developed both above and below ground. Some caves and other subsurface spaces acted as conduits, others as sediment traps. Two caves and parts of others have been filled with 1980 and reworked pre-1980 deposits. In comparison with recent events elsewhere on Mount St. Helens, however, the impact of the 1980 eruptions and posteruption events has been spotty and comparatively minor. The greatest impact has been pre-1980 human activity.

VULCANOSPELEOLOGY OF THE LOWER SNAKE RIVER BASIN

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The Snake River Plain is a broad, arc-shaped downwarp trending across Idaho from west to east. This basin has been filled with plateau basalts interbedded with loess and river sediments. The plain can be divided into the lower, older section and the easterly younger or upper section. This paper looks at origins of the Snake River Plain and how vulcanospeleologic landforms have played a part in formation of today's structures.

OPEN VERTICAL VOLCANIC CONDUITS: THE STRUCTURE AND SPELEOGENESIS OF AN UNUSUAL VOLCANIC CAVE FORM WITH EXAMPLES FROM THE OREGON HIGH CASCADES.

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Open vertical conduits are a rather unusual and poorly described variety of lava cave found in several areas of Holocene to very late Pleistocene volcanic activity throughout the world. They are the open, conduit-shaped vertical vents that occasionally form in the later stages of certain types of volcanic activity and which remain unfilled by the ultimate eruptive activity.

These open conduits occur in aa and pahoehoe lavas. They are found at both primary and secondary (rootless) vents and are almost always associated, respectively, with spatter ridges and cones or hornitos. Their form is usually circular or somewhat elongate along the axis of the fissure they are built over. In profile, the conduits usually widen with increasing depth, forming a bell shape. Occasionally, they connect at depth with a lava tube, though this appears to be the case only when they exist at rootless vents fed by lava tubes from the main vent. The conduit diameter at the surface is usually less than 20 feet, though some that are associated with large spatter cones are known to exceed this. Aggregate depth of reported or observed individual conduits varies from only a few feet to over 260 feet. Some of the best examples of open vertical conduits are found in the McKenzie Pass region of Oregon. Preliminary studies of several vertical conduit systems in the basalts and basaltic andesites of this region and of the Northwest Rift Zone of Newberry Volcano have helped to shed some light on the structure, classification, and speleogenesis of open vertical conduits.

PROCESSES OF DEVELOPMENT OF LAVA TUBES AT MAUNA ULU, KILAUEA VOLCANO, HAWAII

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During the prolonged eruption of basaltic lava at Mauna Ulu from 1969 to 1974, many lava tubes developed. Conditions frequently allowed close and systematic observations, which greatly improved understanding of the processes involved. A basic requirement for a lava tube to form is a prolonged flow at a steady rate, during which the flow becomes confined to a discrete channel. Chilling of the upper surface of the flow results in the development of a thin, scum-like crust on the molten surface. Such crusts commonly adhere to the margins of the channel and during extended flow the crust grows outward from the margin across the flow surface. If the level of the surface remains constant, the crusts growing from opposite sides of the channel merge in the center. This initial roof is thin and weak, and either a rise or fall of the lava surface will cause it to break. But if the flow rate remains constant, continued cooling allows the crust to become thicker and stronger. Eventually it becomes strong enough to support itself. Partial collapse of roofs results in skylights which permit observation of the flowing lava in the tube, further verifying the process. The roof serves as a heat insulator allowing the lava beneath it to flow for long distances. The strong tendancy for tubes to develop is a significant cause of the gentle slopes of shield volcanoes.

THE UK SPELEOLOGICAL EXPEDITION TO THE HAWAIIAN VOLCANOES

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In 1979 a team of British cavers explored nearly 30 km of cave passage on Kilauea and Mauna Loa volcanoes, Hawaii. Detailed investigations of the lava flows produced during the 1969-1974 Mauna Ulu flank eruption of Kilauea proved the existance of some respectable caves, one of which was an outstanding stalactite cave. The speleological work added significantly to the knowledge of the Mauna Ulu tube system, the formation and operation of which was previously observed by scientists from the HVO. Exceedingly long lava tubes caves were discovered to be very adundant elsewhere on Kilauea, particularly on the northeast flank. Here, Kazumura Cave was mapped to a length of 11.713 km, while Ainahou Ranch Cave on the south side of Kilauea was mapped to a length of 7.11 km.

KALUAIKI AND THURSTON LAVA TUBE: AN UNRECOGNIZED JAMEO SYSTEM?

William R. Halliday, Western Speleological Foundation

Thurston Lava Tube is a famous but relatively featureless cave near the center of Kilauea Volcano, Hawaii. Its native name is Keanakakina. The cave extends downslope about 450 m from the downslope end of a sizable closed depression called Kaluaiki located close to the crater of Kilauea Iki. Traditionally, Kaluaiki has been considered to be a pit crater which was the source of a flow unit containing Thurston Lava Tube. Recent reconnaissance suggests a different interpretation, namely that Thurston Lava Tube is merely a small overflow or "squeeze-up" structure related to an unknown, larger lava tube cave extending down-slope from Kilauea Iki at greater depth. According to this interpretation, Kaluaiki is a jameo-type sink, probably originating entirely through stoping and collapse.

VULCANISM AND CAVES OF MT. ETNA: A BRIEF REPORT

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Mt. Etna is the most important volcano in Europe, both for its height (3,340 m asl) and for its persisting activity. It has been well known since the oldest times for its phenomona and caves. A systematic study of Mt. Etna's caves was started some 50 years ago by Dr. Francesco Miceli, who was a member of CAI-Etna (Alpine Club of Italy) and the founder of the Gruppo Grotte Catania. This study is continued today by the members of the GGC, some of whom are specialists in volcanospeleology. More than 200 caves have been located, explored, and recorded. The objective of this paper is to introduce a complete, thorough, synthetic picture of volcanospeleological research on Mt. Etna by drawing a geographical and geological outline of the volcano and its features and activity. Some historical notes are given on previous descriptions of Mt. Etna's caves and on the activity of the GGC and to 12,000 yr.B.P.; 26,000 to 38,000 yr.B.P.; 122,000 to 143,000 yr.B.P.; and 181,000 to 192,000 yr.B.P. These correlate well with the timing of interglacial and interstidial events in the British Late Pleistocene stratigraphic record as well as the marine O-isotope record. The four oldest ages of 122,000 (+12,000 -12,000) yr.B.P.; 143,000 (+16,000 -13,000) yr.B.P.; 181,000 (+24,000 -18,000) yr.B.P.; and 192,000 (+53,000 - 39,000) yr.B.P. for stalagmites and flowstone underlying a clastic (glacial?) fill in the caves are important because they are the first absolute age determination for the last penultimate interglacial periods in Scotland. In addition the 10 age determinations in excess of 25,000 yr.B.P. clearly demonstrate that the caves of Scottish karst cannot be post-glacial age, and are much older than had previously been supposed.

JORDAN CRATERS, OREGON

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The Jordan Craters Lava Flow is a seldom-visited, 73 square km basalt flow between 4,000 and 9,000 years old. The flow is 150 km from population centers in Malheur County, Oregon and can be reached only in dry weather by a 25 km dirt road. Geologists say a large lava tube system should exist because of evidence in several collapse pits. Several visits to the area have uncovered no tubes of note, but the search goes on. Fern Dome is a 10-meter pit inhabited by frogs and ferns. Coffee Pot Crater is an impressive cinder cone. These are the two most impressive features of the Jordan Craters Lava Flow. Presently it is a Research Natural Area administered by the BLM.

THE GAPING HOLES SYSTEM

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This is a review of the history of the discovery, exploration, and mapping of Gaping Holes using maps and slides. Gaping Holes is an extensive lava cave system located near Mount Shasta in the Medicine Lake Highlands of northern California. It extends south from Giant Crater approximately eighteen miles and consists of multi-mile portions of cave interspersed with sections of open trench. Discovery and exploration were carried on primarily by the San Francisco Bay Chapter of the NSS, beginning in April, 1976, and continuing to the present. Current new discoveries in the area will be described.

CAVE EXPLORATION IN THE KLAMATH MOUNTAINS

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In 1974, an alpine karst area was discovered in the Marble Mountains of California, a mountain range within the Klamath Mountains physiographic privince. Subsequent explorations by personnel of the Klamath Mountains Conservation Task Force led to the discovery of more than forty caves, many of which are of considerable significance. The Bigfoot Cave System, the largest of these caves, has been explored and mapped to a depth of 1,205 feet and a length of more than nine miles, making it the largest cave in the Far West.

MEGA-SCALLOPS IN THE CAVE OF THE WINDS, MANITOU SPRINGS, COLORADO

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Scallops - dish-shaped depressions formed by flowing water on cave walls, floors, and ceilings - are generally less than 1 foot (30 cm) in length and often much smaller. Large scallops up to 13 ft. (4 m) in length, here termed "mega-scallops", have not been previously identified and reported. Cave of the Winds is a commercial cave near Manitou Springs, Colorado with over 5000 feet (1500 m) of surveyed passage. It is the longest of the 35 known caves in a four mile (6.4 km) long band of Paleozoic age limestone along the axis of a southward plunging anticline. The cave is developed along four major levels over a vertical range of 290 ft. (87 m). Some of this relief has resulted from post-cavern tilting. Most of the cave developed in the phreatic zone with minor vadose development in the lowest portions.

2-Foot to 13-foot (0.6 to 4 m) long mega-scallops are abundant throughout the cave. They show the classic dish-shaped form with a steep and shallow side showing the direction of water flow. These scallops formed entirely within the phreatic zone. A map of the flow directions shows that the major water flows alternately followed passages trending parallel with the plunge of the fold and those which converged towards the axis of the fold. Typical calcuated flow velocities derived from the scallops are in the range of two feet (60 cm) per minute. These calcuated velocities are based on equations derived by Curl (1974) for smaller scallops using assumptions which may or may not hold for mega-scallops. The volumes of water flowing through each passage were calcuated using measured passage dimensions and the calcuated velocities. These flow volumes then established how much water flowed into each individual passage at junctions and gave a clearer picture of the cave's speleogenesis.

A MORPHOMETRIC ANALYSIS OF THE MONROE COUNTY KARST, WEST VIRGINIA WITH COMPARISONS TO KENTUCKY, TENNESSEE, AND INDIANA

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A morphometric analysis of five spring basins was performed on the Greenbrier Limestone Karst of Monroe County, West Virginia. Spring basin order was found to be directly proportional to the number of dolines, the number of swallets, the swallet / resurgence ratio (Rsr), and then the area of the basins. The number of dolines and the length of the surface streams was also found to be related to basin area, but the closed depression density was not related to basin order or to basin area. The percent area of dolines is related primarily to lithology and hydrologic setting. The Hillsdale and Taggard limestones are stratigraphically next to shales, thus allowing water to run off the impermeable shales and then enlarge the dolines by corrasion. The Patton limestone has the deepest and most asymetrical dolines, with the Sinks Grove limestone contains the most symmetrical dolines.

Using a modified version of the K-S test, factors controlling doline orentation were investigated. Although many dolines are oriented along joint and photo-lineament orientations, a statistical relationship (a=0.1) was not found. Finally, the average length of the long axis of dolines in West Virginia are often oriented along the strike, and, in general, are more asymmetrical than in the forementioned states. This suggests that where there is greater structural deformation, dolines will develop preferentially along the line of major structural weakness.

LITHOSTRATIGRAPHIC STRUCTURAL AND TOPOGRAPHIC IMPLICATIONS OF CAVE ORIGIN IN THE VICINITY OF BEND, SAN SABA COUNTY, TEXAS

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The Bend area, along the northeast margin of the Llano Uplift of central Texas, is underlain by an alternating sequence of limestone and dolostone of the Gorman and Honeycutt formations (Ordovician) that has been deeply dissected by the Colorado River and its tributaries. Although the carbonate units are dense and low in primary porosity, they are high in calcite content and thus are favorable for solutional excavation. Infiltrated water from upland areas has been guided vertically along systematic fractures to depths at which resistant dolostone is encountered. Mature conduits have evolved in limestone beds, where perched ground water has flowed down dip along open, tensionally-produced fractures toward base level at the Colorado River. Caves are conformable with strata, but locally exhibit modifications due to faults, zones of collapse, and flooding caused by constrictions in passages and rises in the Colorado River.

Fissure caves, consisting of large grikes, have developed on upland karst pavements, where closely spaced, open fractures have become solutionally enlarged. Denudation and unloading have allowed expansion of fractures and bedding-plane partings which, in turn, has permitted down-dip flow along bedding planes and enlargement of low horizontal shelves adjacent to the fissure. Bluff caves along the river have developed locally along former short ground-water flow paths or where back-flooding from the river occurred at a time when base level was higher than it is today. Travertine caves have formed by accretion of calcite at Gorman Falls, where dissolved CO_2 is expelled through agitation, as the water of Gorman Creek cascades over the canyon wall to the Colorado River.

SEASONAL FLUCTUATIONS IN THE CARBON DIOXIDE PARTIAL PRESSURE IN A CAVE ATMOSPHERE

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The concentration of CO_2 in a cavern atmosphere and its fluctuations through a full water year were measured in Tytoona Cave, Blair County, Pennsylvania. Tytoona is an active stream cave with a near-sump that isolates the back section of the cave from the front section. CO_2 concentrations were measured with a Dräger device at the entrance, at the near-sump, and at the terminal sump at roughly one-month intervals. Water temperatures and conductivities were also measured. The CO_2 concentration at the terminal sump varied from a minimum of 0.04 volume percent, essentially the atmospheric value, to a maximum of 0.35 volume percent. There is a well-defined maximum in the CO_2 concentration in the summer months. CO_2 concentration varies directly with water temperature but is not correlated with either the water hardness or with the discharge of the stream. The pattern observed in the seasonal variation of the cave atmospheric CO_2 was also observed in an earlier study of the CO_2 concentration in the cave water. These results support biological activity in the soil zone as the most important CO_2 source. Although large amounts or organic debris is washed into this active stream cave, the observed seasonal distribution of CO_2 concentration does not support the hypothesis that decay of inwashed organic matter is a major CO_2 source.

GEOLOGY OF BIGFOOT CAVE, MARBLE MOUNTAINS WILDERNESS AREA, CALIFORNIA

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Bigfoot is located in the Scotts Bar Quadrangle of northern California. It is currently the third deepest explored cave in the United States at -386 m. The cave developed in a warped "tectonic block" of almandine amphibolite marble. There are two beds of marble in the valley, separated by a high almandine amphibolite unit. The marble is capped by a greenschist metavolcanic unit and underlain by an upper greenschist metasedimentary unit. This area has experienced isoclinal folding, tight folding, and large scale warping. The block of marble is extremely jointed and linaments are abundant. A late high-angle faulting event is thought to be responsible for juxtaposing greenschist units against almandine amphibolite units.

The cave has experienced two periods of speleogenesis: an earlier phase where small, round sinuous passages were developed in the upper reaches of the marble bed, and a later phase of vadose development occuring at the base of the marble where it contacts impermeable mica schist. Numerous faults are located in the cave and are thought to be the dominant factor influencing passage orientation and growth. Bigfoot Cave has now reached a mature stage of development characterized by deposition of speleothems. Formations of calcite, gypsum, and aragonite are found. Calcite is the most common mineral in the cave with aragonite observed in only a few locations. Gypsum is found only in the southwest portion of the cave, which is mostly dry.

GEOLOGY AND HYDROLOGY OF THE BARRA HONDA AREA, COSTA RICA

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Cerro Barra Honda is located in the Guanacaste Region of Costa Rica. The area consists of a low plain (elev. 0 - 50 m) from which several hills abruptly rise to as high as 575 m. These hills are capped by the Barra Honda formation, a 250 m thick limestone of the Paleocene epoch. It is within the Barra Honda formation that the significant speleological resources of the region occur.

BEDDING PLANE KARST AND THE 1903 FRANK SLIDE, ALBERTA, CANADA

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At 4:10 am on the morning of April 29, 1903, approximately 30 million m^3 of limestone slid from the east face of Turtle Mountain, located in the Crowsnest Pass in the Front Ranges of the Canadian Rocky Mountains. The southern half of the town of Frank was buried by the rockslide.

The crest of the mountain is composed of limestone of the Mississipian Rundle Group folded in an anticline above the hanging wall of a major thrust fault. A splay of the fault forms the toe of the rupture surface of the slide on the east side of the mountain. Rupture also occured along bedding on the steeply dipping eastern limb of the anticline. A number of karst solution features have been observed on the crest. Soft bioclastic limestone beds are extensively weathered and softened by solution in outcrop. A small cave near the peak shows bedding plane development. A highly mineralized spring at the base of the east face is indicative of a large scale karst system in the area. Travertine found in a small surface collapse feature to the south of the slide displays massive dense crystals indicative of deposition by degassing of water in a cave environment. Bedding karst development on the east limb of Turtle Mountain anticline may have decreased the shear resistance of the rock and hence contributed to the Frank slide.

UV-VISIBLE SPECTRA AND IRON CONTENT OF THE SOLUTION OBTAINED FROM A DISSOLVED CALCITE SPELEOTHEM

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The color of brown calcite speleothems has been thought to be caused by iron compounds, though without evidence, for many years. Recently, several workers have shown that the color and the iron content of speleothems are not related in most cases. Gascoyne has proposed that organic stains, of which humic substances are the most likely, and not metals are responsible for these colors. Calcite samples obtained from an active limestone quarry were dissolved in acid and the iron content and the UV - visible spectrum of the resulting solution were measured. The iron concentration was found to be far too low to account for the color of the solution, but the spectrum was unlike a typical humic substance spectrum. The absorbance was radically reduced by the addition of a mild reducing agent. This is typical of iron III but not of humic substances. Based on these results, it is proposed that the color of this particular specimen is caused, not by iron or humic substance alone, but by a complex or chelate of the two.

A BIOLOGICAL SURVEY OF THE MARBLE VALLEY CAVES

Roy Sugget, Klamath Mountains Conservation Task Force, P.O. Box 1212, Lakeport, CA 95453

A biospeleological survey was conducted on the karst of Marble Valley, Siskiyou County, California from 1977 until the spring of 1982. Four caves were selected as representative of the different types of cave found in the area. They were Big Horn, Marble Gap, Planetary Dairy, and Upstairs-Downstairs Caves. Extensive searches for specimens were made in these caves in all seasons of the year. A variety of specimens were found in both the plant and animal kingdoms. For example, fungi, a new record for California; a new species of grylloblattid; and interesting fossil remains of species of mammals hitherto unknown in the area. The principal taxonomists involved in the research, along with their conclusions, will be mentioned.

THE MINEROLOGY OF BLACK MANGANESE DEPOSITS FROM CAVES

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Some 39 samples of black manganese oxide deposits from 18 caves were examined. Most of these minerals are amorphous to X-rays. Phase identification was by infrared spectroscopy. Morphological information and rough chemical composition were obtained by a scanning electron microscope with an energy dispersive X-ray detector. Infrared spectra of most specimens exhibited only a single broad band near 600 cm^{-1} suggesting a birnessite-like structure. The broad band and the absence of X-ray diffraction shows that the manganese minerals are highly disordered as well as having an extremely small grain size. Quartz and calcite occur as additional minerals in many of the coatings. One well-crystallized sample of romanchite was found. Zinc and copper occur commonly in the 100 to 1000 ppm range. Barium (1000 ppm) usually exceeds strontium (100 ppm). Iron is usually present in the 1 - 5 percent range. Magnesium appears in the 0.1 to 1 percent range.

MASTODON BONES IN AN ILLINOIS CAVE

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Fragmentary remains of at least three mastodons (Mammuthus americanus) have been found in a cave in Monroe County in southwestern Illinois. The molars of an adult, a jaw and pre-molors of a juvenile, and the lower jaw and teeth of an infant mastodon were located several thousand feet into the cave where a cave stream has undercut a filled fissure which evidentially was once open to the surface. Along the slope of the fill in this fissure and in the stream beneath were found several ribs approximately 1 m in length, a thoracic vertebra 20 cm in width, what appears to be the skull of a mastodon embedded in a clay fill, and a humerus of either a mastodon or a dwarf mammoth. Dating of the humerus gave a C^{14} age of 31,860 (+2,100 -2,100) yr.B.P. Bones of deer, turkey, and bison have also been found in the cave. Bones removed from the loose gravel have been identified at the Field Museum in Chicago but no excavation of clay or gravel fills has yet been attempted.

BIOGEOGRAPHY AND ECOLOGY OF THE CAVES OF THAILAND: PRELIMINARY OBSERVATIONS

Fred D. Stone, NSS 6015F, Dept. of Geography, University of Hawaii, Honolulu, HI 96822

Thailand has cavernous limestone deposits throughout its 1700 km length. Thailand lies between 6° and 20° N latitude. It is entirely within the tropics and is centrally located with respect to the biogeographic regions of mainland Asia, mainland Southeast Asia, and the Malay Archipelago. Until recently there have been few studies of Thai cave biology. Collections of Thai cave invertebrates were made by F.G. Howarth and F. Stone in 1967, and Stone conducted more detailed studies of the biogeography and ecology of cave organisms in 1972, 1973, and 1981 as the inception of an intended long term project.

Ecological observations relating cave organisms to habitat, food, and microclimate confirmed some expected distribution patterns, but showed some unexpected departures from predicted distributions. As expected, cave adapted organisms were highly correlated with saturated humidity and low to moderate energy input (vegetable debris, tree roots, and scattered bat or cricket guano rather than concentrated bat guano). Troglobites were expected to be commoner in deeper caves with few entrances and a more constant saturated atmosphere. Saturated microhabitats were more prevalent than expected, providing the required conditions for troglobites even in large caves with numerous entrances, in shallow caves near the water table, and in saturated bat guano. Cave adapted species were also found in saturated microhabitats in disturbed tourist caves with introduced vegetable debris, even when accidental and troglophilic scavengers and predators were present. It appears that microhabitats provide the necessary moist refugia for tropical troglobites, allowing them to escape the desicating effects prevalent in tropical caves.

NOTES ON THE STATUS OF AMBLYOPSIS ROSAE IN SOUTH-WESTERN MISSOURI AND WATER QUALITY DATA ON ITS HABITAT

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Don Rimbach, NSS 5469F, Rimbach and Associates, St. Louis, MO

The distribution of Amblyopsis rosae is reviewed with a discussion of historical and current sightings. Verification of sightings in Fantastic Caverns is presented, and the lone Typhlichthys subterraneus sighting for Green County is re-evaluated. Water quality data from the habitats of A. rosae are considered.

AMBER RAT, TEPHRA, AND FOSSIL POLLEN, OR HOW MT. ST. HELENS RELATES TO PACK RATS IN CAVES.

Ellen M. Benedict, Pacific University, Forest Grove, OR 97116

Amber rat is the strange, black and shiny, tar-like "rock" often seen in relatively dry caves. This rock "smells like a rat and tastes like urine" according to paleoecologist Dr. Peter Mehringer, Jr., a professor of anthropology and geology at Washington State University. As every caver knows, pack rats (Neotoma spp.) gather all sorts of materials--twigs, bones, rocks. They haul the material into the den (cave) where they stockpile it into large middens. As they defecate and urinate onto the midden, it becomes encrusted and compacted, hardening into amber rat. Thousands of years later a sample of amber rat can be examined for plant microfossils. The fossils are identified and C^{14} dated. The plants currently growing around the den are also identified. Now the vegetation of the past can be compared with that of the present, gradually building up a picture of the climatic history of the area. Other clues come from the analysis of fossil pollens and tephras from sediment cores from nearby lakes. A knowledge of climatic changes aids in the understanding of the evolutional history of invertebrate cavernicolous species in the relatively young lava tube caves of the Western United States.

SOME NOTES ON THE SPIDER SPECIES HYPOCHILUS BONNETI GERTSCH

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The spider species Hypochilus bonneti was described in December of 1964. At that time it was known from only two locations. Now the spider is known from a number of locations in both Colorado and northern New Mexico, ranging between 6,000 and 8,000 feet above sea level. All but one of these locations was a cave site. There is little reason that this species should not be found in a greater geographic area, altitude range, or outside of cave areas. Lack of careful, reported observations would seem to be the only major factor.

PRELIMINARY THEPERATURE AND HUMIDITY RESULTS FROM MEASUREMENTS TAKEN WITH THE SPELEO-THERM

Donald W. Denbo, NSS 19912, School of Oceanography, Oregon State University, Corvallis, OR 97331

Vertical profiles of temperature and humidity taken in Lake Shasta Caverns, California and Crystal Ice Cave, Lava Beds National Monument exhibit complex vertical structure and boundary layers at the ceiling and floor. These measurements were taken with the Speleo-Therm, a vertically profiling temperature and humidity instrument with an accuracy of 0.01°C and a resolution of 0.002°C. An experiment to determine the effect of an observer on the temperature in the cave environment was also conducted. The presence of two persons caused a measurable increase in the temperature within minutes of their entering the Red Ice Room, a small and well decorated room in Crystal Ice Cave. Crystal Ice Cave is a mulit-level lava tube with perennial ice and over 350 meters of surveyed passage.

BATS

Joe Fackler, NSS 18784, Gem State Grotto, 2404 Kootenai Street, Boise, ID 83705

Bats are members of an order which displays a remarkable variety of habitats, diets, body sizes, and shapes. Bats are capable of incredible feats of flight, can withstand amazing temperature ranges, and are able to navagate through complex cave passages in total darkness. Their consumption of insects has a major impact on the environment. Unfortunately, the bats' habitat is constantly threatened by man's activities. Construction projects which destroy bats' habitat and the widespread use of pesticides have reduced the bat population of the world considerably. Hopefully a better understanding of bats and their benefit to man will improve their odds of survival.

A COMPARISON OF TROGLOBITIC HARVESTMEN FROM LAVA TUBES AND LIMESTONE CAVES

Thomas S. Briggs, NSS 9304, Research, Dept. of Entomology, California Academy of Sciences, San Francisco, CA 94118

During the 1972 NSS Convention at White Salmon some very specialized cave harvestmen of the suborder Laniatores were collected. These have been described in the literature, but no follow-up studies have been reported. It would be unfortunate if these cavernicolous animals and their ecosystems did not inspire the attention that relatively less specialized limestone cave fauna has received in innumerable biological studies. Thus, I will try to support the suggestion that these harvestmen are indeed outstanding in their adaptation to the caves they inhabit by comparing them with the most highly modified harvestmen known from limestone caves.

The limestone cave species qualitatively comparable in specialization to the Pacific Northwest lava tube harvestmen Speleonychia sengeri, Speleomaster lexi, and Speleomaster pecki are those that completely lack eyes. Ideally, cave adaption should be measured by morphological changes that occurred in an ancestral surface population. It is necessary to screen out specialized structures that already exist in surface dwelling harvestmen and select cavernicolous modifications that are least likely to appear in epigean species. In addition to the loss of eyes, the most highly cave adapted harvestmen have a greater segment count on their tarsi, a higher ratio of the second leg length to the body length, a loss of the eye tubercle, a uniformly smooth scute (carapace), and a very light pigmentation. In assessing their specialization I will compare the troglobites with the most closely related epigean species as well as with each other, ranking species by subtracting the sum of the tarsal segment count and the ratio of the second leg length to the body length for the surface relative from the corresponding sum for the troglobite, and adding values assigned for a relatively modified eye tupercle, scute, and pigmentation in the troglobite. The results of this procedure applied worldwide give the highest cavernicolous ranking to three or four species of family Travuniidae isolated in European caves. Next in rank is a Venezuelan cavernicole, Phalangozea bordoni, followed by the lava tube travuniid Speleonychia sengeri. After these are a Mexican cavernicole, Hoplobunus inops, and one of the lava tube harvestmen, Speleomaster lexi, in family Erebomastridae. Low on the list are cavernicoles described from islands, Africa, Australia, and most of Asia.

BIOTA OF VOLCANIC CAVES: AN INTRODUCTION

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Basaltic lavas are among the most porous rocks known with overall permeabilities comparable to those of cavernous limestone. A comparable subterranean fauna is therefore to be expected, but recognition of this was slow in coming. Prior to the late 1960's, troglobitic animals in volcanic caves were almost unknown. Large subterranean faunas have now been found in a few volcanic cave areas such as Hawaii, Japan, the Galapagos, and the northwestern United States, including such diverse groups as fish (Japan, Galapagos), earwigs (Galapagos, Hawaii), harvestmen (nw U.S.), heteropterans (Hawaii), and millipedes (all areas studied). Even these areas are inadequately known.

The ecology of lava tube caves differs from that of solution caves in several respects, mainly arising from differences in physical structure. For example, lava tubes are generally very shallow, allowing tree roots and dissolved organic matter to penetrate readily to cave passages. Lava tubes are not associated with groundwater drainage other than incidentally, and relatively few contain streams; stream-transported debris is, accordingly, scarce. The shallow overburden and comparative shortness of the caves makes microclimate more variable than in deep solution caves. The collapse sink entrances contain large and often dry lava flow surfaces. There are also biological resemblances between volcanic and solution caves. The troglophilic and trogloxenic faunas are broadly similar. It is clear that the specialized subterranean fauna of basalt has not evolved primarily in the short-lived penetrable caves but exists throughout the premeable strata at the contacts of flow layers.

DIPLURA OF VOLCANIC CAVES

Lynn M. Furguson, NSS 6837, Dept. of Natural Sciences, Longwood College, Farmville, VA 23901

Campodeid diplurans inhabit volcanic caves of the western United States. They have been found in lava tubes in Idaho, Washington, Oregon, and California. The five species which have been identified thus far belong to the genus Haplocampa. Other species belonging to this genus have been found in limestone caves of Missouri and Illinois, in a gold mine in California, and as endogeans usually living on high mountains in California, Washington, Montana, and Alberta. Based on morphology, one can distingish three to four clusters of related species. Three species from Missouri and Illinois represent one such group. Three species from Utah and Arizona represent one or two groups. The five cavernicolous and six epigean species of northern California, Oregon, Washington, Idaho, Montana, and Alberta represent the last group. Among the cavernicoles of the northwestern group, the two species from Washington show a closer relationship to each other than to the other species of the group. Among the epigean species, Haplocampa drakei from Alberta is the most deviant. The majority of the Haplocampa species appear to be cold-loving forms, since they have been found at high elevations on Mt. Ranier, Mt. Baker, and Table Mountain in Washington and in the Rocky Mountains of Montana and Alberta. Several of the cavernicoles inhabit caves containing perpetual ice, as well as other cold volcanic caves of the Northwest. Both epigean and cavernicolous species of Haplocampa have been found in association with grylloblatids, Grylloblatta campodeiformis and other Grylloblatta spp., with which they can easily be confused.

ERUPTIVE IMPACTS OF MT. ST. HELENS ON LOCAL BAT POPULATIONS

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Pre-eruptive winter and summer records of eight bat species will be presented. Known eruptive effects on hibernacula, nursery roosts, male roosts, and known foraging and watering areas include denudation, extirpation, no change, and enhancement (?) of environment. Known cave hibernacula, three nursery roosts, and three foraging areas were relatively untouched. High impact was noted at two nursery roosts, one probable hibernaculum, and three foraging/watering sites.

THE CONSERVATION OF BIOLOGICAL RESOURCES IN CAVES

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The sometimes bizarre adaptions that restrict troglobites to a life in caves, coupled with their island-like habitat, have reinforced the assumption that cave ainmals are somehow fragile and therefore lead an endangered existence. Although many cave animals undoubtedly are endangered, the development of management recommendations for their conservation is hampered by the lack of good ecological data concerning the requirements of the species. For example, what factors limit cave animal distribution; what are the significant perturbations; and how do these cause rarity and endangerment? Experimental ecological studies in caves are difficult since in few other habitats is man so clearly an invader. Caves are a fragile window through which man can visit and study the fauna that lives in the unique environment. Many caves threatened by land use changes have never been surveyed, and their biological resources remain unknown. Indeed, it has only been within the last decade that biologists have recognized that highly specialized cave invertebrates live in lava tubes and in tropical caves. The following are some of the major threats to the cave ecosystem: 1) mining activities, 2) land use changes such as deforestation and urbanization, 3) alteration of groundwater flow patterns, 4) waste disposal and pollution, 5) local killing of trogloxenes (a food source), 6) the introduction of non-native species, and 7) direct human disturbance from visitation. Solutions to these perturbations include the development of workable management policies for both caves and surface, the protection of critical habitats, and the execution of a well-conceived and presented educational program.

THE FOUNDING OF THE CAVE CONSERVANCY OF THE VIRGINIAS

John M. Wilson, President, Cave Conservancy of the Virginias, P.O. Box 7017, Richmond, VA 23221

After discussing several alternatives, the members of the Virginia Cave Commission founded the Conservancy on April 13, 1980 at a meeting in Richmond, Virginia. The Conservancy plans to make the cave ownership and control approach one of its top priorities. There is clearly a need to face the fact that many past attempts to save the caves were inadequate, both in the effort and resources applied to the task. Most fund-raising efforts did not raise anywhere near enough money to significantly attack the problem of cave conservation. The Conservancy is an organized attempt to deal with these and many other problems. Some of the projects the Conservancy has undertaken to date are: 1) Establishment of a $500 reward fund for information leading to the conviction of cave vandals. 2) Establishment of plans with the Richmond Area Speleological Society for fund-raising through bingo. 3) Support of gating projects in cooperation with other groups. 4) Work with the Nature Conservancy in managing General Davis Cave. 5) Establishment of a management plan for Madison and Fountain Caves. 6) Efforts to obtain conservation easement legislation in Virginia. 7) Advised the Town of Grottoes on the hazards of constructing a water tower above Grand Caverns. 8) Work to obtain a stronger cave protection act in Virginia.

THE IMAGE OF THE NSS TO COMMERCIAL CAVE OPERATORS

George Huppert, Dept. of Geography, University of Wisconsin, LaCrosse, WI.

Betty Wheeler, University of Wisconsin, LaCrosse, WI.

Between December, 1981, and May, 1982, a survey was conducted of 25 state or federal cave operators and 75 commercial cave managers. The survey was set up to determine the image of the NSS as an organization and of individuals within the organization. In general the NSS has a fair to good image throughout the country. However the image varies greatly regionally. It seems the Society fares least well in the central states and in the border south. Significantly, these states are in the area of greatest concentration of commercial caves. This has great implications for cave conservation as commercial caves have the broadest appeal to the public of all caves and are an ideal medium to publicize cave conservation.

EDUCATION AND SECRECY IN CAVE CONSERVATION

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The techniques of conservation education need to be re-evaluated. We currently admonish would-be cavers by a series of don'ts — touch formations, litter, deface. This is basically similar to the approach used by civil authorities in our cities and parks, and we have only to look around us to see how well this campaign fares. Why should be expect similar techniques applied to the caving situation to produce different results? It is not a matter of more "education" that we need, but rather eduction aimed directly at changing the inner spirit of the listener. What must be instilled is a love and admiration for the land and its real value in a philosophical sense.

We must communicate our love of the land and caves in particular in our interactions with the public. This may succeed where current "education", laws, and public works have failed. Fear of caver proliferation must not stifle us. The message does not require aggressive publication or advertising; one-on-one contacts and messages in cave registers could be very useful. Secrecy of locations (but not attitudes) from the public will continue to be vital in the near future. However, a smug dependancy on secrecy is self-defeating and fosters false security. Our long term goal must be to reduce the need for and reliance upon secrecy.

CAVE CONSERVATION IN THE KLAMATH MOUNTAINS

Mike Sims, 505 Roosevelt, Oregon City OR 97045

The Klamath Mountains Conservation Task Force was organized in 1973 with the objective of "preventive conservation," that is, applying the concept of NSS Task Forces to promote cave concervation in a relatively unknown area before a crisis situation arises. Toward this objective, the KMCTF has carried out the location and assesement of little-known or previously unknown caves within the Klamath Mountains Physiographic Province and actively sought liaison with the government agencies managing these caves. This coincided with, and presumably reinforced, an emerging awareness by the governmental agencies of the need for management of cave resources. A result was the adoption of a cave management policy tailored to the existing cave situation in California by Region 5 of the U.S. Forest Service.

A METHOD OF PRODUCING FACSIMILES OF SPELEOTHEMS

Janet Queisser, Rt 3, Box 105, Salem, VA 24153

Kieth Smith, 2208 Drapers Meadow West, Blacksburg, VA 24060

By using naturally formed icicles and paraffin, a method is described to make realistic looking "speleothems". This method can provide a craft activity for young cavers while emphasizing the need to protect and preserve cave resources.

YOU WILL BE KNOWN BY THE GATES YOU BUILD

John M. Wilson, 7901 Dalmain Road, Richmond, VA 23228

One of the most important tools for the cave manager is the cave gate. To manage a cave for conservation or for almost any other purpose requires that human behavior be limited to a range of acceptable activities while in the cave. Experience has shown that in many cases this will require communication with and education of all people who enter the cave, active supervision of everyone in the cave, and/or limiting the traffic in some caves. A strong, effective gate will require anyone entering the cave to go through the established management procedures. A weak gate or a weak-link gate allows a higher percentage of persons who have not complied with cave management plans to enter the cave. Cave gates will be necessary until another method can be found to allow only responsible people into sensitive caves.

The economic advantages of strong cave gates are discussed as well as the disadvantages of weak links in gates. Specifications for allowing bats to enter and keeping people out are explained. Specific techniques for building strong gates are listed. The importance of the psychological impact on the would-be vandal is also analyzed.

EDUCATION: PANACEA OR PLACEBO?

Len Gaska, 1723 West 9th St., Pomona, CA 91766

Many cavers in the NSS believe that education is the only long term strategy for cave protection. Although much has been written on the subject of cave related education, little has been done to critically examine the effectiveness and "return on investment" of current efforts. Examination of other conservation education suggests that our efforts may not be effective. Effective conservation education is largely dependent on instilling values, not facts. Facts such as "bats are endangered and beneficial" are easy to teach whereas values such as "nature should be valued for aesthetic reasons" are not. Telling a cave vandal that caves are delicate and beautiful will, in all probability, not make one iota of difference. Teaching someone to appreciate caves will require more than a simple recitation of facts. Even if education is accepted as a viable cave protection tool, the return on investment must be examined. Education must necessarily involve publicity which generates new cavers and ultimately increased cave traffic. Any given level of educational effort must generate positive results or it is worse than useless. Lack of good data on our current educational efforts casts doubt on its effectiveness. The NSS must realize that education is effective only in the long run and may require many generations before other methods of cave protection are unnecessary. As a starting point, the NSS must insure that all of its members possess strong cave protection values. Only then will the membership have any chance of instilling those values in others.

THE PETTIBONE EXPERIENCE

Bob Addis, Route 4, Box 60, Parkersburg, WV 26101

Pettibone Falls Cave and the surrounding karst area near Chesire, Massachusetts has been threatened by timbering and development, and consequently it has been under study for acquisition by the NSS or a similar organization. Since 1978 plans of the Pettibone Project have progressed in steps from a simple conservation easement to protect the cave, to purchasing an 8 acre parcel, a 112 acre parcel, and finally to purchasing the entire 1550 acre property for approximately $1.125M. The Conservation Task Force (CTF) and then the ad hoc committee have incorporated a wide variety of talents in preparing the present proposal. CTF has concluded that the NSS could be the principal buyer for the entire property if the majority of the developable land and farmlands could be committed for sale at the time of purchase. It should be noted that the Pettibone Project is the only acquisition project before the NSS at this time that could possibly show a profit. If the profit is substantial, it could be used to endow the Pettibone Preserve and finance other cave conservation projects. The CTF is currently being joined in their efforts by the Massachusetts Farm and Conservation Lands Trust, a Conservancy. The MFCLT offers an exciting assist with this endeavor.

THE MICHIGAN INTERLAKES GROTTO BAT BOOTH

Rane L. Curl, Dept. of Chem. Engrg., University of Michigan, Ann Arbor, MI 48109

Since 1980, the MIG has presented an educational "bat booth" at the annual Michigan Outdoorama (outdoor sports show), sponsored by the Michigan United Conservation Clubs. The booth has included a habitat exhibit, photographs and educational posters, a continuous slide show, a recording of bat calls (slowed down to the audible range), a sample bat box and instructions for their construction, and free educational literature. Among the latter has been the NSS pamphlet "Bats Need Friends" and a brochure describing the bats found in Michigan. The booth has been staffed for up to 9 hours per day for 10 days by members and friends of the MIG. No way has yet been found to measure the educational impact of the booth except for anecdotal reports from repeat visitors of school projects about bats and the construction of bat boxes. However the exhibit continues to be invited back with free space provided by the MUCC.

THE ROLE OF THE AMERICAN CAVE CONSERVATION ASSOCIATION IN THE CAVE CONSERVATION MOVEMENT

John Wilson, President, Cave Conservancy of the Virginias, P.O. Box 7017, Richmond, VA 23221

In 1976 it became apparent to the author that there needed to be an organization that could bring together cave owners and cave managers. Such an organization would encourage responsible cave owners to buy other caves. It would also help cavers buy caves and find caves that were for sale. It would encourage present cave owners to become enlightened cave managers. In April, 1981, the American Cave Conservation Association (ACCA) was formed by several members of the Richmond Area Speleological Society. Some of the purposes of the ACCA are: 1) To promote the conservation of caves in North America. 2) To preserve caves as scientific, aesthetic, and recreational resources. 3) To acquire the management and access rights to significant caves. 4) To promote the science and technology of cave management. 5) To assist in gathering and disseminating data about caves available for sale.

As with any new organization, it is difficult, with limited resources, to achieve all of one's goals at the start. ACCA has limited its priorities to four items, rank ordered as follows: 1) Sponsorship of the National Cave Conservation and Management Symposium. 2) Establishment of a Caves for Sale and Cave Buyers Clearing House. 3) Establishment and enforcement of stronger cave protection laws. 4) Support for sound cave management and conservation practices and cooperation in and among cave-oriented organizations.

CAVE INVENTORIES AS A PRE-REQUISITE TO FORMULATION OF CAVE MANAGEMENT PLANS

J.B. Hummel, Bureau of Land Management, Roswell District, Roswell NM 88201

Cave inventories provide the information base from which sound, intelligent cave management plans can be built. Working from a data base reduces the risk of making poor decisions and value judgements. Inventory information enables the managers to weigh alternatives and effectively evaluate the cave resource to devise a plan which achieves their goals. Beginning data can also be used to monitor the effect of a cave management plan on the cave.

HOW TO SELL CAVE LEGISLATION TO STATE LEGISLATORS

John M. Wilson, Cave Conservancy of the Virginias, P.O. Box 7017, Richmond, VA 23221

This is a review of the legislative success with the Virginia General Assembly for cave conservation by cavers in Virginia. The methods used in getting the Virginia Cave Protection Law passed and the Virginia Cave Commission established is explained. The nature of politics as a decision making process involving public assets is discussed as well as some common misconceptions about the nature of the political process. The most effective methods of relating to legislators and taking maximum advantage of common values held by most Americans, such as abhorrence of vandalism and destruction of private property, are explained. The lack of organized opposition is usually an advantage available to the cave lobby. Choosing the patrons of legislation and avoiding undesirable friends is explained along with some suggestions of how to deal with the overzealous extremist supporters.

EQUIPMENT DISCUSSION: THE NEW FUJICA HD-S CAMERA AND TYPE 5247 FILM

Bob Addis, Route 4, Box 60, Parkersburg, WV 26101

The Fujica HD-S is an all-weather, waterproof 35mm auto-exposure camera with a built-in flash. Slightly more expensive than a 110 camera, far cheaper than a diving camera, easier to carry and use than a single lens reflex camera, yet possessing a high quality lens for good pictures, this almost ideal rangefinder camera nonetheless has its disadvantages and limitations.

Type 5247 35mm film, ASA 100, 200, 320 (or 400 with risk of graininess) yields color slides and a strip of negatives. Now many times have you gotten a less than satisfactory color print from a slide? Both slides and prints from Type 5247 film will be shown for examination.

VERTICAL HARNESS FOR COLD, WET DROPS

Gary Storrick, 400 Churchill Rd., Venetia, PA 15367

With minor modifications, the Pigmy System provides a versatile system well-suited to wet alpine drops. Alterations consist of constructing a quick-attach/release mechanism from the Gibbs to the shoulder strap, running an independant sling from the Gibbs to the seat sling, and adding a hold-open mechanism similar to one of the safety rappel cam designs. The resulting system is characterized by good efficiency, high versatility, the option of a built-in rappel safety, and the capability for very rapid transitions from rappel to ascent and back.

DOUBLE BUNGEE ROPEWALKER RIG

Peter Bosted, SLAC, Box 4349, Bin 57, Stanford, CA 94305

There is great advantage to using a single bungee cord in conjunction with two floating cams. The bungee cord is directly attached to each cam and passes through a pulley attached to the chest harness. The advantages are that it is simpler and more comfortable with no bungees pressing into the sholder and is more efficient.

THE DEVELOPMENT OF HARRISON'S CAVE, BARBADOS, W.I.

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Barbados, the easternmost of the Lesser Antilles, has a population of a quarter million people on 166 square miles of limestone. It is a classic karst region with the major streams underground. In 1972 Ole Sorenson, a young Danish speleologist, explored one of these underground streams, Harrison's Cave, visiting the area known for more than 150 years. He pushed on into a virgin portion of the cave to make a discovery that excited him and inspired him to make a proposal to the Barbados Government to open the cave as a tourist attraction. The project was approved by the Government and work was started in 1975. After two years effort the cave was made accessible to heavy construction equipment but it was not suitable for display as a show cave. In 1978, the work was suspended until a better plan could be devised. A team from the United States consisting of experienced cave developers donated their time to prepare a study for the completion of the work. This report, published by the National Speleological Foundation, provided a plan for restoration of the streamways, trails, lighting, transportation, ventilation, and flood control. In 1979, a contract was prepared between the Barbados Government and members of the study group in a joint venture to complete the project. In one year the work was completed providing a riding tour of the cave in 38-passenger electric vehicles, display of 40 waterfalls, 3600 feet of roadway, and a complete indirect lighting system. The cave was opened to the public in 1980 and now provides an entertaining and educational experience for the citizens of Barbados and visitors to the island.

1982 COSTA RICA EXPEDITION

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In February, 1982, 25 cavers flew to Costa Rica to study the caves and karst of the Barra Honda area, Guancaste. Working in close coperation with the Costa Rican government, the expedition engaged in a detailed study of the region and its many vertical caves. Studies included exploration, mapping, geology, hydrology, and paleontology. The result was a significant increase in the knowledge of the speleological resources of the area.

EXPLORATION OF CUEVA AYOCKAL, PUEBLA, MEXICO

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The Western Region expedition to Mexico in early January, 1982, was shown a resurgence which some of us could not resist exploring. We started mapping the cave a few days later, and spent the next eight days exploring 2.7 km of stream passages. The cave is basically horizontal, mostly formed along the strike of gently dipping limestone. The main stream, which averages about 1 cusecs of flow in the dry season is responsible for most of this part of the cave, entering the system at a cliff face 700 m NE of the resurgence. The trunk passage it formed averages 5 m wide by 20 m tall, with several fossil levels. In addition, several small tributaries enter from surface sinkholes with large domes underneath them. Close to the point where the main stream enters the cave, two tributary streams come into a large collapse area following the dip from the SE. The northern one has many chest deep pools and small waterfalls which pour over beautifully colored rock. One passes under several domes that are open to the surface. Finally the going gets too tight. The southernmost of the two tributaries is similar in character, also pinching out after several hundred meters. The entire cave can be explored without ropes, but wetsuits are recommended in some areas. A through trip is only possible in low water, as a near sump with only 10 cm of air space must be crawled through.

Discussion: The methods used to identify *Neotoma cinerea* have previously been discussed in the account of *N. mexicana*.

N. Cinerea occupies a wide variety of habitats in a wide range of climatic conditions in western North America, from the cold winters of the Northern Rocky Mountains to the hot semi-arid summers of northern Arizona (Finley, 1958). *N. cinerea* has been reported from the summit of Pikes Peak, Colorado, at an elevation of 4297 m, in the Artic-Alpine Life-zone (Warren, 1942). The absence of this species from the Lower Sonoran Life-zone is an indication that high summer temperatures in an arid or semi-arid environment may be a limiting factor for this species (Finley 1958).

Finley, (1958) states that the unifying factor throughout the range of *N. cinerea* is the presence of vertical clefts in cliffs or other high rocks; with caves nearly as preferred as clefts. These areas are vastly preferred for denning areas for the Bushy-tailed Woodrat.

N. cinerea is no longer found in the Guadalupe Mountains, occurring no closer than the mountains of northern New Mexico (Findley; *et al.*, 1975). In the Guadalupe Mountains, fossil *Neotoma cinerea* have been recovered from Burnet Cave (Harris, 1979), Pratt Cave (Lundelius, 1979), Upper Sloth Cave (Logan and Black, 1979), and Muskox Cave (Logan, 1981).

The presence of this species is an indicator of less extreme summer temperatures and of a more mesic environment than presently occurs in the southern Guadalupe Mountains.

Neotoma albigula (Hartly)—White-throated Woodrat
Material: Four fragmentary right mandibles with M_1 (TTU-P-8510, 8513-8515), two fragmentary right mandibles with M_{1-2} (TTU-P-8517 and 8509), one fragmentary right mandible with M_{1-3} (TTU-P-8511), fragmentary left mandible with M_{1-2} (TTU-P-8518).
Discussion: The specific identification of *Neotoma* mandibles and teeth is difficult at best, due to the variation in dental morphology that occurs within any given species.

Dalquest, *et al.*, (1969) separated *N. micropus* from *N. albigula* on the basis of the width of the second lophid of the M_1, which in *N. albigula* was always less than 1.93 mm but in *N. micropus* was always more than 1.94 mm. Lundelius (1979) checked this character in 32 specimens of *N. albigula* from the Texas high plains and in 30 specimens of *N. micropus* from south Texas. He found that five specimens (16.7%) of *N. micropus* had the second lophids of the M_1 less than 1.94 mm in width, and three specimens of *N. albigula* (10.7%) had second lophids of the M^1 greater than 1.94 mm in width. Thus, this character is not infallible, and the possibility exists that some specimens may be assigned to the wrong species.

Neotoma micropus (Baird)—Southern Plains Woodrat
Materials: Fragmentary left mandible with M_{1-3} (TTU-P-8519).
Discussion: The criterion used to differentiate this species, as well as ecological preferences and habitat preferences for this species, have been discussed in the previous account of *N. albigula*. *N. micropus* presently occurs in the lowland desert shrub community within 5 km of Lower Sloth Cave.

Microtus mexicanus (Saussure)—Mexican Vole
Material: Three isolated left mandibles with M_1 (TTU-P-8431-8433), two right isolated M_1 (TTU-P-8434-8435), one right mandible with M_2 (TTU-P-8436).
Discussion: *Microtus mexicanus* presently occurs in the higher elevations of the southern Guadalupe Mountains, where it is most common in the grassy meadows (Genoways, *et al.*, 1979; Wilhelm, 1979; and August, *et al.*,(1979). Specimens from Lower Sloth Cave agree closely with modern specimens from the Guadalupe Mountains of Texas and New Mexico in both size and morphology.

The relative rarity of this taxon in the fauna may be partially explained by the fact that the Mexican vole is more diurnal than are most small mammals (Davis, 1974). The bone accumulations in Lower Sloth Cave are apparently the result of scat accumulation from small mammalian predators and pellet accumulation below owl roosts. These predators are primarily nocturnal or crepuscular, thus, the chances for these rodents to fall prey to these predators may be somewhat less than with most other small rodents.

The presence of this species does not necessarily indicate any change from present climatic conditions in the southern Guadalupe Mountains, although *M. mexicanus* does require more mesic conditions than presently occur in the immediate vicinity of Lower Sloth Cave.

Family Erethizontidae
Erethizon dorsatum (Linnaeus)—Porcupine
Material: Quills (TTU-P-8408-8409).
Discussion: The quills from Lower Sloth Cave differ in no way from the quills of Recent porcupines from the southern Guadalupe Mountains. The majority of the quills are of the red-brown color phase that is common in porcupines from many areas of the southwest today.

Porcupines occur in a wide variety of habitats and have been observed within 1 km of Lower Sloth Cave.

ORDER CARNIVORA

Family Canidae—*Canis* sp.
Material: Fragment of right humerus (TTU-P-8495).
Discussion: *Canis latrans* (Harris, 1970b, Hornedo, 1971), *Canis lupus* (Hornedo, 1971), and *Canis dirus* (Ayer,1936; Hornedo, 1971; and Logan, 1981) have all been reported from late Pleistocene deposits in the southern Guadalupe Mountains.

C. latrans may be ruled out on the basis of size, because TTU-P-8495 clearly belongs to a larger animal. However, this specimen is within the size range of both *C. lupus* and *C. dirus*. TTU-P-8495 is nearly identical to *C. lupus*, the only difference being in a greater development of the rugosity in the area defined by the pectoral ridge and the deltoid ridge in the Lower Sloth Cave specimen. This particular character varies greatly from individual to individual, generally increasing with age. When compared to the two available *C. dirus* specimens from Rancho La Brea, TTU-P-8495 is slightly smaller, but the size of the humerus is apparently not a valid criterion for separating these two species.

Family Procyonidae
cf. *Bassariscus astutus* (Lichtenstein)—Ringtail
Material: Atlas (TTU-P-8406) and isolated left P_2 (TTU-P-8502).
Discussion: *Bassariscus astutus* is an inhabitant of the more rocky areas of the southern Guadalupe Mountains, where it feeds on a wide variety of small mammals, birds, insects, and plants. The small carnivore scat found in the upper levels of trenches five and six was of the right size and texture to have been deposited by this species.

Family Mustelidae
Mustela frenata (Lichtenstein)—Long-tailed Weasel
Material: Isolated right M_1 (TTU-P-8497).
Discussion: Although *M. frenata* has not been taken from Guadalupe Mountains National Park in recent times (Genoways, *et al.*, 1979), it occurs widely throughout much of the United States and Mexico. It has been recorded from Culberson County, Texas (Davis, 1974).

Fossil Long-tailed Weasels have previously been reported from Upper Sloth Cave (Logan and Black, 1979) and Pratt Cave (Lundelius, 1979) within the boundaries of the Guadalupe Mountains National Park.

Spilogale gracilis (Merriam)—Western Spotted Skunk
Material: Left maxilla with M^{2-3} (TTU-P-8407).
Discussion: This specimen is referred to *S. gracilis* instead of *S. putorius* on purely geographic grounds. Lower Sloth Cave is located over 480 km southwest of the present known range of *S. putorius*, while *S. gracilis* has been collected from Culberson County, Texas (Davis, 1974). Spotted skunks are inhabitants of rocky and bushy areas (Findley, *et al.*, 1975) and are found throughout Trans-Pecos Texas (Davis, 1974).

ORDER ARTIODACTYLA

Family Cervidae
Odocoileus sp.—Deer
Material: Partial left navicular (TTU-P-8500).
Discussion: Both *O. heminous* and *O. virginianus* have been reported as fossils from Williams Cave (Ayer, 1936). Lundelius (1979) has also reported *Odocoileus* sp. from Pratt Cave. Both species of *Odocoileus* presently occur in the Guadalupe Mountains (Davis, 1974), with *O. virginianus* occupying the foothills and *O. heminous* being more common in the higher and more rugged country.

Due to the fragmentary nature of this specimen, specific identification is not possible.

Family Bovidae
Ovis canadensis Shaw—Bighorn Sheep
Material: Left horn sheath (TTU-P-8404); fragmentary left astragalus (TTU-P-8405).
Discussion: *O. canadensis* formerly occurred throughout Trans-Pecos Texas in suitable habitat (Davis,1974), but this native sheep has been extirpated from Texas. Bighorn sheep inhabit rough, rocky, mountainous terrain (Davis, 1974), making the southern Guadalupe Mountains ideal habitat. The presence of *O. canadensis* in the fauna gives no indication of climatic change.

Ovis canadensis catclawensis Hibbard and Wright—Pleistocene Bighorn Sheep
Material: Fragmentary right mandible with dP_2-M_1 (TTU-P-8496).
Discussion: *O. c. catclawensis* was originally described as *O. catclawensis* from Catclaw Cave, Mojave County, Arizona (Hibbard and Wright, 1956). Harris and Mundel (1974) argued convincingly that *O. catclawensis* should be recognized as a Pleistocene temporal sub-species of *Ovis canadensis*, not as a separate species.

O. c. catclawensis, the late Pleistocene bighorn sheep of western North America, is characterized by a larger size than modern *O. canadensis* (Hibbard and Wright, 1956; Stokes and Condie, 1961), closer to the size of *Ovis ammon* (Marco Polo Sheep) from Eurasia.

The dental morphologies of TTU-P-8496 and of USNM 14010, a modern *O. c. canadensis* from Montana, are nearly identical, with the exception of the large size difference (Table 2).

CONCLUSIONS

The mammalian fauna of Lower Sloth Cave spans the transition from late Wisconsinan to Recent time. Remains of extinct mammals make up 4.8% of the mammalian fauna, and extant, but extralimital, species make up an additional 21.4% of the faunal remains; thus, 26.2% of the 37 mammalian taxa recorded from Lower Sloth Cave no longer occur in the southern Guadalupe Mountains. The majority of these extralimital mammals presently occur within 100 km to 450 km of Lower Sloth Cave in the mountains of western and northern New Mexico; *Cryptotis parva* represents the only eastern influence in the fauna.

All extralimital species are indicators of conditions more mesic than the present environment of the Guadalupe Mountains. This transition from more mesic to the present xeric conditions is reflected by the distribution of the extirpated species within the trenches. Both species diversity and absolute numbers of more mesic-adapted taxa increased with depth. This is in keeping with the distribution of more mesic taxa found in Upper Sloth Cave (Logan and Black, 1979). Harris (1970b) suggests that a minimum increase of two inches of winter precipitation in the southern Guadalupe Mountains would be necessary for *Marmota flaviventris* to survive the period immediately after hibernation and before the spring rains.

The paleobotanical reconstruction of the area by Van Devender, *et al.* (1979a;b) corresponds closely with the present habitat preferences of the majority of the extralimital species. In the light of the available evidence, the best paleobotanical reconstruction of the area is a spruce-fir forest interspersed with grassy glades or meadows. All the extralimital plants recorded from Lower Sloth Cave and nearby deposits are to be found in the more mesic mountains of northern New Mexico and southern Colorado (Van Devender, *et al.*, 1979a;b).

Based on available mammalian and botanical evidence, the climate in the southern Guadalupe mountains at the end of the Pleistocene was probably very similar to the climate today in the southern Rocky Mountains of New Mexico and Colorado. Winter temperatures may have been more equitable, as suggested by Graham (1976), allowing the more boreal species to co-exist with the more desert-adapted species.

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Table 2. Comparative measurements in millimeters of the deciduous premolars of *Ovis canadensis*, *O. ammon*, *O. aries*, and TTU-P-8496 (*O. canadensis catclawensis* Hibbard and Wright).

	O. canadensis	*O. ammon*	*O. aries*	TTU-P-8496
Length dP_{2-4}	27.0-36.7 (N = 6)	35.0-38.3 (N = 3)	31.1-34.4 (N = 3)	41.4 (N = 1
	31.3	*36.5*	*33.1*	
Length dP_2	4.8-6.2 (N = 6)	7.0-7.6 (N = 2)	5.3-6.8 (N = 3)	6.7 (N = 1)
	5.6	*7.3*	*6.07*	
Width dP_2	2.9-4.3 (N = 6)	4.7 (N = 1)	3.6-4.2 (N = 3)	3.9 (N = 1)
	3.5	*4.7*	*3.9*	
Length dP_3	7.8-10.3 (N = 6)	9.7-10.9 (N = 3)	8.2-10.1 (N = 3)	11.6 (N = 1)
	9.1	*10.4*	*9.2*	
Width dP_3	4.9-6.0 (N = 6)	5.0-5.4 (N = 3)	5.3-6.1 (N = 3)	6.2 (N = 1)
	5.4	*5.1*	*5.7*	
Length dP_4	15.0-21.3 (N = 6)	19.1-21.1 (N = 3)	17.8-19.4 (N = 3)	24.4 (N = 1)
	19.0	*20.1*	*18.9*	
Width dP_4	6.8-8.3 (N = 6)	8.4-8.5 (N = 3)	6.9-8.1 (N = 3)	8.6 (N = 1)
	7.5	*8.4*	*7.3*	

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The Origin of CORAL PIPES

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SUMMARY

Coral Pipe speleothems are rare, small, cylindrical deposits on walls in a few caves. Although their existence has been recognized in the literature, no method of deposition has been proposed previously. A newly recognized deposit in Silent River Cave, northern Arizona clearly shows that coral pipes are thin coatings of travertine deposited on silt pillars by dripping water. This mechanism of development is consistent with evidence from Old Man Cave, east-central Nevada.

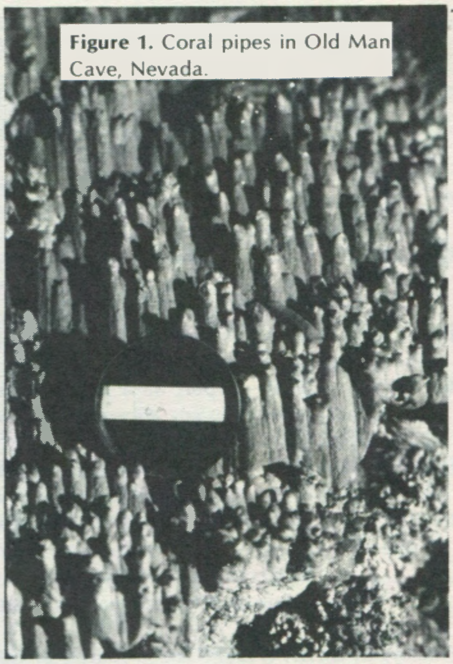

Figure 1. Coral pipes in Old Man Cave, Nevada.

CORAL PIPE speleothems (Fig. 1) are small, cylindrical deposits on steeply sloping walls in a few caves. They are about 0.8 cm in diameter and 1 to 7 cm in height, with a protuberance that extends approximately 0.4 cm perpendicular to the stalk and points down-slope. Coral pipes are always in clusters and are spaced about 1 to 5 cm apart.

There are 3 previously published discussions of these rare deposits. In the first, deSaussure, Lange, and Mowat (1953, p. 23) described coral pipes from Mitchell Caverns, a commercial cave in the Mojave Desert of California. Believing the speleothems to be similar to cave coral, they applied the name, 'coral pipes.' Later, Bridgemon (1964) identified a similar deposit in Old Man Cave, east-central Nevada. In both cases, the caves are dry, and the coral pipes are no longer actively developing. Hill mentioned the deposits in her book, *Cave Minerals* (1976, p. 13). No attempt was made by any of these authors to suggest a mechanism of growth.

The mystery of how coral pipes form was solved by the discovery of coral pipes in Mary's Hall in Silent River Cave, northern Arizona. This deposit is particularly interesting because the coral pipes are actively forming and are interspersed with silt (earth) pillars of the same dimensions. Some of the pillars have thin coatings of travertine. In this deposit, there is a range from uncalcified silt pillars to rigid coral pipes. It is evident that coral pipes are the result of thin travertine deposition over silt pillars.

Originally, silt pillars are developed where pebbles (in this case, of limestone) protect the mud underneath them from erosion by falling water (Nash, 1957). The surrounding unprotected mud is removed, after which small pillars remain under the stones, similar to 'hoodoos' formed above ground in some arid regions.

The second phase of development is the deposition of calcite over the silt pillar; deposition may occur simultaneously with erosion. Water-drops falling from a ceiling 5 to 30 m above the silt deposit have sufficient energy to erode silt pillars. The same water, splashing as secondary droplets, would have little energy left, but, because of agitation, could be supersaturated in calcite, allowing deposition on adjacent pillars. Both deposition and erosion appear to be occurring in Silent River Cave. For the coral pipes to be preserved, the flow of water must be cut off at a critical point, which may explain the rarity of this speleothem. If deposition of travertine were great, the coral pipes would be lost, embedded in a flowstone slope. No examples of this are known.

To test this hypothesis, permission was granted by Park Service and Forest Service officials for single coral pipes to be removed from Silent River and Old Man caves. Thin sections were made of each and were compared. The sample from Silent River, as hypothesized, clearly had a pebble within the top protuberance, a thin calcite shell engulfing it. The section revealed an unconsolidated, calcite-siltstone core.

There also appears to be a small pebble at the top of the sample from Old Man Cave (Fig. 2). The outer shell of the pipe is solid calcite; its core is nearly pure calcite, but is very porous, reminiscent of the texture of tufa. Apparently, much of the mud in the interior never became cemented and has been removed, possibly by careless sampling and laboratory techniques.

In general morphology, internal and external, the 2 coral pipes are the same. While no internal examination of the coral pipes in Mitchell Caverns has been made, it is clear that the features in all 3 caves are the result of deposition of thin calcite over silt pillars and are not similar to cave coral in origin.

Now that the processes that form coral pipes are understood, there are several issues to consider: First, is the term 'coral pipe' appropriate? Although pipes are not a form of cave coral, changing their name would surely lead to more confusion than would retaining the present term. Thus, the term, 'coral pipes,' should be continued. And, because they are depositional features, not erosional remnants (as are silt pillars), it is appropriate to distinguish pipes from pillars.

This leads to the question, at what point does a silt pillar become a coral pipe? In Silent River Cave, the full range between the 2 features is present. For simplicity in definition, it is suggested that, once deposition of travertine occurs on a silt pillar, it becomes a coral pipe. Lilburn Cave in the Sierra Nevada of California and Colorado Hall in Silent River Cave also have examples of such newly developing coral pipes.

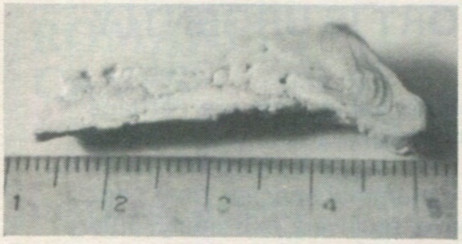

Figure 2. Cross section of a coral pipe from Old Man Cave, Nevada. Scale in millimeters.

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ANNOUNCEMENTS

METRICATION

The **Bulletin Advisory Board** has instructed the Editor to require all authors to use units of the 'Systeme Internationale' (metric) except in verbatim quotations where the original was not in SI units. Beginning with the January, 1983 issue, all measurements *must* be stated in metric (or other appropriate SI) units. Reference: ASTM E 380-70, 'Metric Practice Guide.'

When authors recompute figures into SI units from other systems of measurement, the original units must be placed in parentheses following the SI units.

The **Bulletin Advisory Board** consists of Rane Curl (Chairman), David Culver, Derek Ford, Russell Harmon, Jack Hess, Carol Hill, Arthur Palmer, and R. A. Watson. NSS President Rob Stitt requested Executive Vice-President Paul Stevens to form the board on 12 February 1982; Stevens then appointed Curl to be Chairman and directed him to select the members of the Board. The purpose of the Bulletin Advisory Board is to debate issues of general *NSS Bulletin* policy and to provide guidance thereon. Comments by readers should be addressed to Prof. Rane L. Curl, Department of Chemical Engineering, University of Michigan, Ann Arbor, Michigan 48109.

REFEREEING

Each manuscript submitted to *The NSS Bulletin* is first read by an associate editor. Those judged to meet the minimum standards of the journal are then sent to two referees: One referee is a speleologist knowledgeable in the subject discussed, the other referee is a person who may have some aquaintance with caves but whose training and experience have been in similar non-spelean areas. The purpose of using a non-caver referee is (a) to ensure that authors become aware of appropriate literature and concepts in related non-spelean areas and (b) to promote interdisciplinary exchanges between speleologists and other scientists. Too many speleologists write as though there were no world beyond the cave entrance, and too many other scientists are unaware of the world beneath their feet. The *Bulletin* staff intends to promote the integration of speleology with the general body of science. **JH**

ROMANIA'S CAVES

Dr. Thomas M. Iliffe

Site: The Apuseni Mountains and Transylvanian Alps, Romania

Disciplines: Speleology, geology, biology, conservation

Caves, underground rivers, and sinkholes evolve over thousands of years as water dissolves subterranean limestone deposits. Inside caves, the slow, steady drip of mineral-laden water builds occasionally massive, yet

Fragile stalagmites form over millenia at the rate of one cubic inch per century.

delicate, phantasmagoric columns and spires (speleothems) at the rate of about one cubic inch per century. Cave fauna and flora, descended from original cave colonizers of hundreds of thousands, perhaps millions, of years ago, have evolved unique adaptations to their dark, silent, isolated microcosms. Casual, seemingly minor human disturbances in this fragile environment can cause major ecological destruction.

Romania's Apuseni Mountains and Transylvanian Alps (the western Carpathians) north of the Danube Valley harbor some 2,000 known limestone caves, including the 12-mile-long Pestera Vintului (Wind Cave). Others await discovery. Romania, one of the world's leaders in cave research and conservation techniques, is the first country to establish a cave biology center, the Emile Racovitza Institute. Veteran speleologist Dr. Thomas Iliffe of the Bermuda Biological Station, who led EARTHWATCH teams in a study of Bermuda's limestone caves, has asked EARTHWATCH for two teams to assist in an international effort to promote the protection and understanding of Romania's caves by locating, mapping, and documenting their significant features.

Field Conditions: The caves maintain nearly constant temperatures from 30° to 50°F and generally are very damp. Each team will travel to three different cave areas and work in small groups with Romanian speleologists from the Racovitza Institute. Crews will explore and survey newly discovered or unmapped caves; collect and observe cave fauna; study cave geology, mineralogy, and chemistry; and document destruction caused by natural or human processes. Volunteers will camp or stay in primitive "chalets" without conventional plumbing. While occasionally dining in local restaurants, participants otherwise will share cooking of fresh produce and canned or smoked meats over wood fires. Romania's cave country is its most fertile land; the foothills are covered with small farms. The climate resembles that of the northern U.S. There will be free time for field trips and sightseeing. Romania is easy to negotiate in French, and excellent dining is inexpensive. Language and photographic skills and curiosity about caves are the best qualifications for this first of two EARTHWATCH expeditions to Eastern Bloc countries.

The foothills of Romania's rugged limestone cave country are its most fertile area.

Team I:	**Sep 21-Oct 5, 1983**
Team II:	**Oct 5-19**

Staging Area: Bucharest, Romania

Share of Costs: $1125

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