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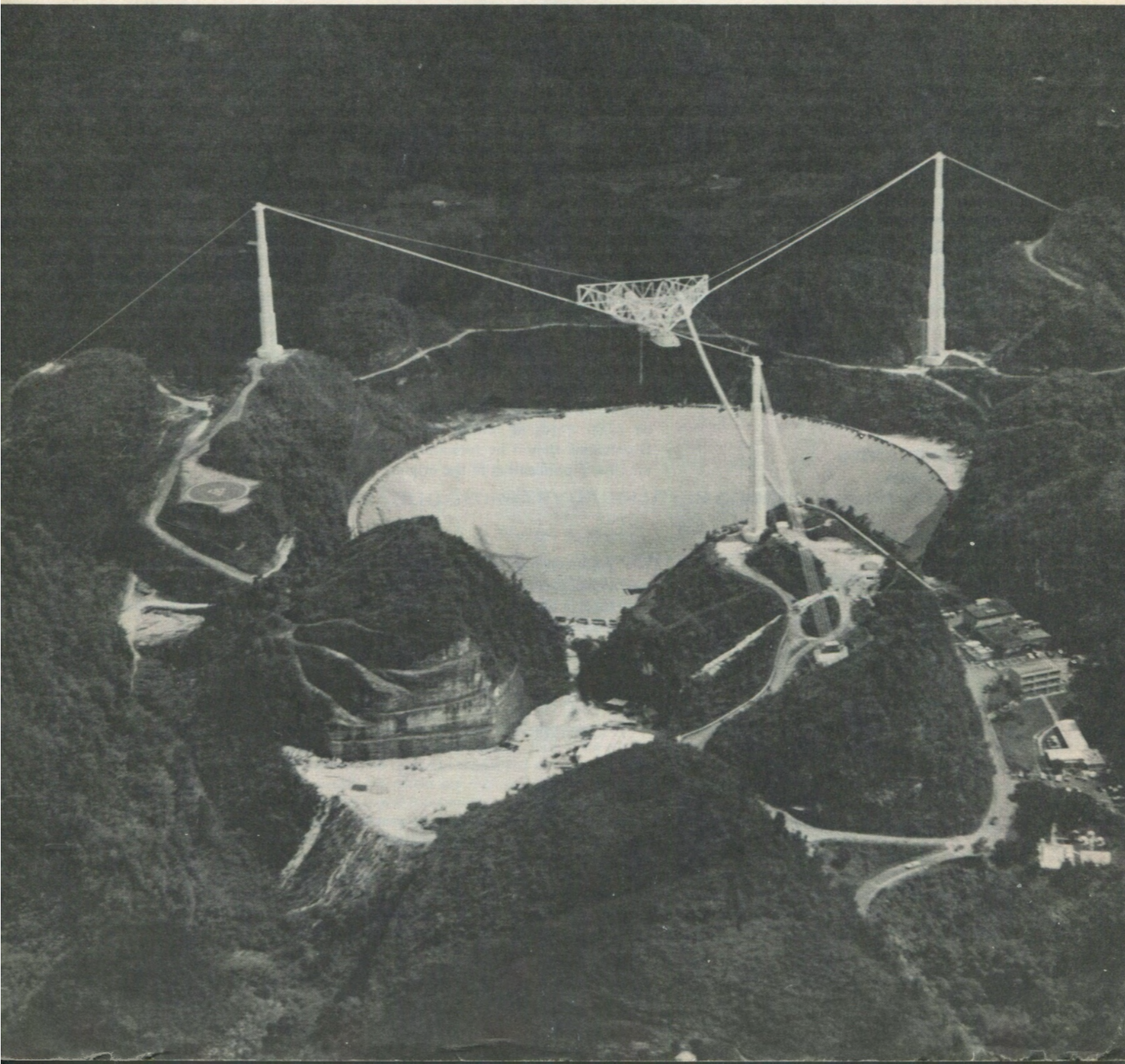

Contents

Cover Photo: Human exploitation of karst: The NASA radiotelescope near Arecibo, Puerto Rico. The telescope reflector occupies a large sink in cockpit karst developed on tertiary limestones on the North Coast. The valley in the background is that of the Río Tamaña, which sinks and begins its subterranean course at the base of the cliff behind the telescope. *Stewart B. Peck photo.*

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Selected Abstracts
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GRANITIC PSEUDOKARST, LLANO COUNTY, TEXAS, WITH SPECIAL REFERENCE TO ENCHANTED ROCK CAVE

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ABSTRACT

Chemical and physical weathering processes have produced a variety of minor granitic landforms on exposed coarse-grained pink granite in the Llano uplift region of central Texas. Many of these features can be viewed as pseudokarstic, as their forms are similar to those of true karst regions. Such phenomena are in abundance on the domed inselbergs in Llano County.

Granular disintegration of bedrock through grusification and physical erosion has created granitic landforms such as gnammas, granitrillen, rock doughnuts, and rock channels which are morphologically analogous to fluviokarst. Weathering has also produced tafoni, arches, and pedestal rocks resembling solutional cavities and associated residual forms. Locally, small A-tent caves, or pop-ups, have formed by compressional forces acting during downslope movement of exfoliated sheets.

An unusual example of pseudokarst is a cave near the summit of Enchanted Rock, a domed inselberg in southwest Llano County. This cave has a multigenetic history which includes: (1) initial fracturing of the inselberg mass; (2) fracture enlargement by grusification; (3) removal of detritus by mechanical suffosion; and (4) roofing by talus accumulation. A unique relationship between the host fracture and a tributary drainage basin has produced one of the largest known granite caves.

HYDRAULIC GEOMETRY OF SOLUTION CONDUITS

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ABSTRACT

Carbonate aquifers have an internal runoff component that drains through well integrated systems of conduits to discharge at large karst springs. Flow in the conduits behaves more like surface drainage than groundwater flow in porous media and many of the same hydraulic properties of the channels obtain. The main distinctions are that underground runoff can have a pressure head as well as a hydraulic gradient, and that the conduits exhibit both pipe and channel flow. The conduits act as rigid rather than erodable channels and, of course, substantial amounts of the earlier history of the system are recorded in abandoned conduits, observable as the present day caves. Both pipe and open channel (canyon) geometrics exhibit sinuosity and braiding, although the braiding is three dimensional and more complex than the braiding of surface rivers. Most of the conduits in the Central Kentucky karst show well-developed scalloping that allows the calculation of paleo-flow velocities and, thus, paleo-discharges. Catchment areas of a few to a few tens of square miles are adequate to account for the discharge through most of the conduits.

SALTPETRE PRODUCTION FROM CAVE SEDIMENTS—AN IMPORTANT AND EARLY AMERICAN CHEMICAL INDUSTRY

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ABSTRACT

The production of saltpetre (KNO_3) has been an important human activity for more than a millenium, providing an ingredient for meat preservation, ceramics, gunpowder, and many other commodities. For America, the availability of saltpetre, especially for gunpowder manufacture, played an important role during the westward movement of the 18th and 19th centuries and during three major wars (Revolutionary, 1812, and Civil wars). Effective blockades during these wars forced utilization of our principal domestic reserves of nitrates—cave sediments. Thus, the conversion of nitrates in cave sediments to saltpetre became one of America's first and most important chemical industries. In this paper, we shall trace the history of domestic nitrate production from its frail beginning to its present enormous role in the modern chemical industry. In particular, we shall discuss the interesting role that caves played in this developing industry and the shifting pattern in use of caves for this purpose.

GEOCHRONOLOGY OF SPELEOTHEMS FROM THE MAMMOTH CAVE—FLINT RIDGE CAVERN SYSTEM

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ABSTRACT

Nine $^{230}Th/^{234}U$ ages have been obtained for five speleothems from the Mammoth Cave-Flint Ridge Cavern System of central Kentucky. The analytical data are given below:

Sample #	Description	$\frac{^{230}Th}{^{234}U}$	$\frac{^{234}U^{234}U}{^{238}U^{238}U}$	$\frac{^{230}Th}{^{232}Th}$	Age (10^3 years BP)
72035: 1	flowstone (base)	1.10 ±.04	1.14±.03	50	>350
72035: 2	flowstone (top)	0.897±.03	1.21±.02	24	213±25
72036: 5	flowstone (base)	1.05 ±.01	0.99±.01	21	>350
72036: 4	flowstone (top)	1.14 ±.08	0.99±.10	75	>350
72037: 1	stalagmite (top)	1.05 ±.08	0.99±.05	20	>350
72041: 5	stalagmite (base)	0.886±.01	1.17±.02	44	204± 8
72041: 9	stalagmite (mid)	0.787±.01	1.12±.02	>1000	159± 6
72041:13	stalagmite (top)	0.697±.02	1.17±.03	37	124± 5
74009: 1	flowstone (top)	0.904±.02	1.05±.03	254	247±26

A flowstone deposit from the wall of the terminal end of Davis Hall (72036) and a stalagmite deposited on fill in Grand Avenue later cut by a canyon passage associated with Colossal Dome (72037) are both more than 350,000 years old. A flowstone deposit capping a silt deposit in Edward's Avenue of Great Onyx (72035) was deposited from some time before 350,000 years BP to 213,000 years BP, while a second flowstone deposit from Great Onyx which overlies a limestone breccia in a side passage (74009) was found to be 247,000 years old. The final specimen dated was an 18 cm portion of a stalagmite from Davis Hall (72041). It was found to have grown at a relatively constant rate over the period 220,000 years BP to about 100,000 years BP. Fluid inclusion D/H and the speleothem calcite $^{16}O/^{18}O$ isotopic variations for this specimen indicate that the cave temperatures during the periods 200,000 to 170,000 and 125,000 to 100,000 years BP were similar to those at present, whereas those during the period 165,000 to 130,000 were 6 to 10° C less than that at present.

The age data from the Mammoth Cave-Flint Ridge Cavern System are unique in the consistent antiquity of the speleothem material preserved. Only in one other area of the ten North American karst regions studied to date, the Nahanni region, N.W.T., is speleothem material older than 200,000 years BP the common occurrence rather than the exception. The fact that such old speleothem material is so abundant in the Mammoth Cave-Flint Ridge Cavern System supports the geomorphological evidence that the cave is quite old, perhaps pre-Pleistocene in age.

A SCANNING ELECTRON MICROSCOPE STUDY OF MOONMILK

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ABSTRACT

Moonmilks in caves are whitish, plastic, wet or crusted, dry, colliform speleothems. The moonmilk group of minerals pose special problems to the mineralogist, because of both their extremely fine-grained nature and their wide variability in mineralogy. Thrity-three samples of calcite, hydromagnesite, huntite, dolomite, gypsum, and quartz from California, Nevada, Utah, Oregon, New Mexico, and South Dakota in the United States as well as British Columbia, Canada, and Somerset, England, were studied.

INTERPRETATION OF CHEMICAL HYDROGRAPHS FOR THE CENTRAL KENTUCKY KARST

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ABSTRACT

Sharp input pulses of water from storms make useful probes of an aquifer system, because they generate a response that is measurable in the discharge and chemical hydrographs of large karst springs. Similar approaches have been used by other workers in Europe and North America to deduce the nature of the flow path in carbonate aquifers. Turnhole Spring drainage basin in the Central Kentucky Karst was instrumented with rain gauges and Turnhole Spring was instrumented for continuous recording of electrical conductivity and temperature. Results indicate that the water moves through the aquifer in a distinct system of conduits. Residence time of recharge is about three weeks, incidating that the system drains quickly and long-term storage is very small. Springs respond to storm inputs within hours. Complex fine structure in the conductivity records can be interpreted as arrival times of discrete sources.

AQUIFER INDEPENDENCE FROM SOLUTION CONDUITS AND THE LACK OF STATISTICAL ASSOCIATION BETWEEN WELL YIELDS AND LINEAMENTS IN THE GREENBRIER LIMESTONES OF MONROE COUNTY, WEST VIRGINIA

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ABSTRACT

One hundred eighteen water wells were inventoried and sampled as part of an intensive hydrogeologic study of the Greenbrier limestone karst of central Monroe County, West Virginia. Cavern data were collected simultaneously in conjunction with West Virginia Speleological Survey activities in the county. Only two wells received water directly from caves. Data plotted on geologic cross-sections reveal three principal aquifers which are completely separate from the subsurface conduit drainage of the large Dickson Spring basin. The three main aquifers are confined and are found just below the Taggard Shale, the Greenville Shale, and an unnamed shale in the Hillsdale Limestone. The Taggard-Patton aquifer overlies the Dickson system; the Hillsdale-Maccrady aquifer is below it. The potentiometric surfaces of the aquifers do not correspond to the depth of the Dickson conduit system.

Productivity of the wells does not show a good relationship to photolineaments. Twenty-three wells were found to be within 200 ft of lineaments. Using the Fisher's Exact Probability Test for comparing nearness to the lineament versus well yield, a significant relationship at $p \leq 0.05$ was not found. Although several studies in folded and faulted rocks have shown a relationship between the two, it is suggested that where rocks are less intensely deformed (as in this study area), a poor correlation will be found.

THE HYDROGEOLOGY OF THE GREENBRIER LIMESTONE KARST, MONROE COUNTY, WEST VIRGINIA

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ABSTRACT

A four year project in a 65 sq mi area of central Monroe County, West Virginia, included the mapping and analysis of stratigraphic units, structural elements, geomorphic features, groundwater hydrology, and groundwater quality. Nine new folds were mapped and seven previously mapped folds were better defined. Caves were found to occur primarily in the Union, Patton, and Sinks Grove limestones, suggesting a lithologic control of cavern development. Joints, lineaments, and stratigraphic strike were not found to be strongly related statistically to cavern orientation treated independently, but by a combination of these factors. Elevations of the cave passages showed a wide scatter, suggesting no long standstills of base level. Dolines, expressed as percent area in dolines versus Greenbrier limestone formation, are also more prevalent in the Union and Patton limestones.

The geology of the area has definite controls over spring locations and groundwater movement. Small springs are usually resting on impervious zones such as the Greenville, Taggard, and Patton shales. Large or higher order springs emerge near base level. Dye traces have shown that water movement to the largest spring (Dickson) passes through several shale units and follows the axis of the remapped Hurricane Ridge syncline. Two other springs emerge along thrust faults that are in shaly zones. Several other springs are located on impervious units along fold axes. The geographical location of springs is therefore controlled by three factors: 1) the outcropping of impervious sections of the stratigraphic column; 2) local base level; and 3) structure.

HYDROLOGIC AND GEOMORPHIC ASPECTS OF KARST FEATURES IN THE BLAINE GYPSUM (PERMIAN), RED RIVER BASIN, NORTHWEST TEXAS

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ABSTRACT

The northwest Texas gypsum deposits crop out within the Osage Plains division of the Great Plains physiographic province. Numerous caves have developed in the Blaine Formation of Permian age, a sequence of thick gypsum strata intercalated with thinner beds of dolomite, shales, and sandstones. Extensive physical and chemical weathering of the Blaine has resulted in many local structural features, including dolines, expansion features, and upwarps due to the alteration of anhydrite to gypsum near the surface. Such deformation has altered the character of gypsum karst springs in the vicinity of the South Fork of the Wichita River. Many springs are highly saline (up to 4100 ppm sulfate) and one has been shown to remove 136,000 kg (150 tons) of salt per day from the subsurface. The U.S. Army Corps of Engineers have been unable to alleviate brine contamination of surface waters by these springs.

Geomorphic features of River Styx Cave, the longest surveyed gypsum cave in Texas (2100+ m), indicate an interesting hydrodynamic development. Most passageways occupy one of two distinct levels, suggesting either former still stands in base level or contemporaneously developed strike-oriented drainage routes later connected through piracy. Apparent correlation of these levels with two Wisconsian-age terraces along the South Fork indicates a two-stage lowering of base level during cavern genesis. Backflooding of the South Fork waters into the cave and flooding by high-runoff waters into recharge points in the headward reaches of the cave have significantly modified passages.

REGIONAL GEOMAGNETIC VARIATIONS AS A DATING AND CORRELATIVE TOOL IN CAVE SEDIMENTOLOGY: PRELIMINARY RESULTS FROM LILBURN CAVE, CALIFORNIA

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ABSTRACT

The declination of the Earth's paleogeomagnetic field has been shown to exhibit regular east-west fluctuations. At Lake Windermere, England, and at Lake Michigan, U.S.A., the period of these fluctuations is 2,800 years and 2,090 years, respectively. It is believed that these fluctuations of declination are due to oscillation of the Earth's nondipole field. The nondipole field exerts only regional influence and is a residual field after subtracting the main dipole field. At Lake Windermere and Lake Michigan, similar periodic fluctuations of inclination and intensity are not present.

Oriented cores were collected from well-stratified clays and silty clays from relict passage fills in Lilburn Cave, Kings Canyon National Park, California. Declination fluctuations of similar form to those from lakes Windermere and Michigan are observed in these cores. Samples from one 30 cm core show at least four cycles of declination fluctuation, and samples from shorter cores from adjacent sediments contain similar fluctuations occurring at nearly the same stratigraphic positions. Fluctuations in inclination do not have as regular a period or the same period as the fluctuations of declination; however, the extremes of inclination also correlate between cores. Intensity measurements show no significant fluctuations within individual cores.

The age of the Lilburn Cave deposits is not yet known. If the period of the declination fluctuations contained in the Lilburn Cave deposits should be similar to those reported elsewhere, it would be possible to derive rates of sedimentation for individual deposits in the cave. It may also prove possible to correlate the deposits throughout the cave on the basis of these declination and/or inclination fluctuations. Both of these studies would lead to a much greater understanding of the deposition of clastic fill in caves. Also, if during further studies material suitable for Uranium series, pollen, C^{14}, or other age-dating techniques were found, paleogeomagnetic fluctuations may provide the framework with which to unravel the cave depositional history.

A PRELIMINARY REPORT ON THE HISTORY OF BIOSPELEOLOGY IN INDIANA

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ABSTRACT

Mention of Indiana cave fauna appeared as early as 1819, when Edmund Dana reported bats from "a spacious cave" (Wyandotte Cave). During the 156-year span from 1819 to 1974, 792 articles containing information pertaining to Indiana cavernicoles (largely systematics and species distribution) have appeared in journals, books, and grotto newsletters. A total of 100 papers appeared prior to 1900, 70 of which were published between 1880 and 1889. The first half of the 20th century was shaken with wars, depressions, etc. These appear to have dampened the efforts of many biospeleologists (only 111 articles appeared between 1900 and 1949). The 1950's produced 85 papers and, during the 1960's, 153 manuscripts mentioning Indiana biota appeared. During the 6 years 1970-1975, 191 articles were published, accounting for 24.1% of all literature concerning Indiana cave biota.

Nearly 5% of the publications were contributed by Europeans, chiefly Bonet, Bresson, Chappuis, Jeannel, Kiefer, Vandel, and Wolf.

Two hundred and thirty-two caves have been reported to contain biota. Of these, 29 have served as type-localities for 74 taxa. The order encompassing the greatest numbers of newly described species was Coleoptera (19 species).

Articles appearing in grotto newsletters have played an important role in presenting observations of cavernicoles; 255 (32%) of the total number of articles have appeared in newsletters since 1950.

PRELIMINARY REPORT ON A THREE-YEAR MICROCLIMATE STUDY OF MALHEUR CAVE, A SOUTHEASTERN OREGON LAVA TUBE

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This 3100 ft lava tube provides a mesic environment in semi-arid Oregon high desert for four endemic cavernicolous species: a flatworm, Kenkia rhynchida *Hyman; an amphipod,* Stygobromus hubbsi *Shoemaker; an isopod,* Assellus sp. *Fleming (ms.); and a pseudoscorpion,* Apochthonius malheuri *Benedict and Malcolm. The lake in the lower end of the tube has a maximum measured depth of 23 ft and is 1300 ft long by 10 to 40 ft wide. It lengthens 800 ft towards the entrance as the water rises 3 ft October through May. Despite the thin overburden of 6 to 20 ft, the entrance of 7 by 30 ft, and the descending passage, the constant temperature zone remains at 16 to 17.5° C, considerably warmer than the 8° C ambient temperature outside. Lake temperatures at 15 to 16° C, within the range of nearby thermal springs. Ion analysis of lake water gives a minimum estimated reservoir temperature of 75° C. These temperatures all suggest that the extra heat in Malheur Cave comes from upwelling thermal waters mixed with cool ground waters.*

DEVIL'S HOLE PUPFISH

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The four species of pupfishes of the Death Valley system live in very restricted habitats and have unusual tolerances to wide fluctuations in temperatures and salinities. Of particular interest to cavers is Cyprinodon diabolis, *of which the world's entire population is estimated at from 200 to 400 individuals. This endemic species is known only from Devil's Hole, a 100-ft long, 50-ft wide, 300-ft deep thermal spring in Nye County, Nevada. The Devil's Hole Pupfish is endangered because agricultural mining of ground water may lower the water level sufficiently to eliminate breeding and reduce the production of their algal food supply. Several conservation measures have been tried: Fencing Devil's Hole, granting Monument status to the surrounding 40-acres, installing artificial breeding platforms and lights in the spring itself, transplanting the fish to other springs, and ordering a temporary water pumping moratorium. None of these measures have solved the problem. A Supreme Court decision of June, 1976, protects water levels.*

STATUS OF ENDANGERED BATS IN THE EASTERN UNITED STATES

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ABSTRACT

Biologists consider four eastern United States bat taxa to be endangered (in danger of extinction throughout all or a significant portion of their range). They are: Myotis sodalis *(Indiana bat);* Myotis grisescens *(Gray bat);* Plecotus townesendii virginianus *(Virginia big-eared bat)* and Plecotus townsendii igens *(Ozark big-eared bat). Three additional species,* Myotis leibii *(small-footed bat),* Plecotus rafinesquii *(eastern big-eared bat), and* Eumops glaucinus *(Wagner's mastiff bat), are considered to be of "special concern" (thought to be approaching the threatened category or the exploitation of which might pose a threat to other species in danger.) Causes of population declines include loss of habitat, direct killing, and disturbances to hibernating and maternity colonies.*

TROGLOBITIC ISOPODS OF THE GENUS *LIRCEUS* (ASELLIDAE) FROM SOUTHWESTERN VIRGINIA

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In contrast to the asellid isopod genus Asellus *s. lat., which is represented by numerous species in both epigean and hypogean biotopes in the Holarctic region, the genus* Lirceus *is represented by comparatively few species, is known primarily from epigean biotopes (especially springs and small streams), and is restricted to the eastern and middle-western United States and southern Canada. Although several species of* Lirceus *have been found in caves, only two appear to be troglobites* (i.e., *obligatory cavernicoles). Both of these are found in southwestern Virginia:* L. usdagalun *Holsinger and Bowman was recently described from three caves in south-central Lee County; a second species is now being described by the authors from a single cave in the Rye Cove karst area of west-central Scott County. These two species are closely allied morphologically and occur in karst areas in adjacent tributaries of the upper Tennessee River drainage basin—*L. usdagalun *from the Powell River Valley and the new species from the Clinch River Valley. Cladistically, these two cave forms appear to be sister-species and are presumed to have been derived from a relatively recent, common ancestor. The ancestral form was probably an epigean species with a range that covered parts of both the Powell and Clinch Valleys. The ranges of the two isopod species are approximately 45 km apart and are physically separated by Powell Mountain and other potential barriers to the dispersal of aquatic cavernicoles.*

Both species inhabit cave streams, where they are found either in gravels or on the flat surfaces of rocks or flowstone. The new species from Scott County has been collected twice from the gravel substrate of a stream in McDavids Cave. The stream in this cave is also inhabited by the troglobitic isopod Asellus recurvatus, *which appears to be much less common than* Lirceus *n. sp.*

BURROWING ACTIVITY IN THE TROGLOBITIC AMPHIPOD CRUSTACEAN *CRANGONYX ANTENNATUS* PACKARD (CRANGONYCTIDAE)

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The troglobitic amphipod crustacean Crangonyx antennatus *inhabits a variety of aquatic cave habitats, including mud-bottom pools and small, gravel-bottom streams, throughout its range in the southern Appalachians. This species is especially common in the caves of Lee Co., Virginia, where its ecology has been intensively studied during recent years. One large population, which lives in pools in Molly Wagle Cave in Lee County, was observed periodically on 33 visits from 1967 to 1975. Amphipods in this population, as well as in other nearby caves with similar habitats, frequently burrow into the soft mud substrate of the pools, where they are able to survive desiccation during periods when the water dries up.*

Drought conditions, similar to those observed in caves, were simulated in the laboratory. Amphipods also burrowed under these conditions and were able to survive desiccation for an extended period of time. In the laboratory, animals collected from stream habitats also burrowed, thereby indicating that stream-adapted populations of this species still retain sufficient flexibility to survive under variable environmental conditions that might be encountered in nature.

It is concluded from this study that burrowing provides a means of survival for C. antennatus *when it is sometimes exposed to drought conditions in cave pool habitats and also provides protection from potential terrestrial predators under similar conditions. In addition, burrowing offers amphipods protection from aquatic predators [such as larvae of the salamander* Gyrinophilus porphyriticus) *during normal water levels and allows juveniles a means of escaping cannibalism by adults. (Supported in part by Grant GB-42332 from the National Science Foundation to J.R.H.)*

BIOLOGY OF THE CAVE CRAYFISH *ORCONECTES INERMIS TESTII* (HAY) (DECAPODA: CAMBARIDAE) IN INDIANA

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ABSTRACT

The troglobitic crayfish Orconectes inermis testii *is restricted to the subterranean waters of Monroe County, Indiana. A relatively large population was observed in Mayfield's Cave on sporadic visits between 1969 and 1974. An intensive mark-recapture study was conducted on individual crayfish from September 1969 to March 1970 and the population size of* O. i. testii *was estimated to be* 128 ± 33 *in the 300 m study area of the cave. The greatest density of individuals occurred in pooled areas with mud-bottom or large-gravel substrates. The "center of activity" (home range) was approximately 10.5 m. Breeding males were more active than Form II males (15.1 and 3.0 m mean total range of movements, respectively) (Form I males probably traveled greater distances in search for mates). Adult females exhibited less movement than juveniles (2.2 and 11.2 m, respectively). Comparing the movements of all males and females, the mean displacement of males (12.9 m) is greater than that of females (5.9 m).*

The tendency to move upstream seemed to dominate over downstream in O. i. testii *(mainly Form I males), possibly in compensation for downstream displacement during spates. Sixty-five percent were observed to move upstream and 35% were found to have moved downstream. Also, burrowing may provide a means of survival during floods and drought, as numerous "holes" inhabited by* O. i. testii *were observed in Mayfield's and other caves of the County.*

The crayfish feed on isopods, amphipods, and organic debris; they also exhibit cannibalism. No amblyopsid fishes occur north of East Fork White River. Thus, O. i. testii *is a detritivore. It occupies the uppermost trophic level of cave ecosystems in Monroe County.*

Only 19 localities are known for this species and many of these (12) regularly receive heavy traffic from spelunkers. During the past 10 years, many of the populations have been greatly reduced and one is presently receiving septic tank leakage. Actions must be taken to protect this troglobitic crayfish.

PROTECTING THE RAPPELLER—THE SAFETY RAPPEL CAM

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Over the years, many reported and unreported accidents have occurred when rappelling cavers lost control of their descent rate. Recently, an improved method of protecting the rappeller has been developed—the Safety Rappel Cam (Gibbs). The device enables both the first and last men down the drop to stop their descent with a cross movement, passing the arm across the chest, and requires no caver to approach the rock fall zone in order to belay the rappel. In contrast with the chest safety prussik, with which it will be compared, the safety rappel cam requires a positive action to activate and does not require constant attention. The chest safety prussik required a negative action, relaxing the grip during a period of accelerating stress, a difficult type of behavior to learn. The safety rappel cam requires an investment of 13 to 16 dollars and 4 hours time to construct. It has been tested on Blue Water II and Goldline. The limitations of overhead belay, chest safety prussik, and bottom belay are discussed.

ELECTROMAGNETIC LOCATING, AN ACCURACY EVALUATION

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Horizontal positions and depths of underground points can be obtained using electromagnetic locating equipment. Accuracy of the results obtained has been mostly speculative in the past. During 1975, work was conducted to obtain quantitative values for the errors associated with positions and depths obtained using this equipment. Sixty locations were made at Blue Springs Cave, Indiana, and Mammoth Cave, Kentucky, determining both horizontal position and depth. These results were then compared with similar results obtained from precise surveys. The surveys were to a precision exceeding 1:5000 but less than 1:10,000 for horizontal position. Elevation differences were determined based on leveling that exceeded third order accuracy requirements.

LAUREL CAVERNS: A BICENTENNIAL HISTORY

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The modern history of Laurel Caverns began about 200 years ago, when James Downard opened a limestone quarry on the ridge adjacent to the cave. The cave has been a local landmark since its discovery in the 1770's. Purchased by the Delaney family in 1814 (from whence the name, "Delaney's Cave), its fame spread widely. It recently was made a registered natural landmark.

Little thought was given to commercializing the cave, however, despite its wide popularity and many visitors. The tract including the cave was bought and sold several times for its (questionable) farming value rather than as a cave property. In 1926, Norman Cale bought the cave with the specific desire of developing it. It required 40 years for his dream to be realized. Delaney's Cave, re-christened "Laurel Caverns", was opened to the public in July, 1964.

It is with these thoughts in mind that we now honor the long and colorful history of the cave that is the Host Cave of this NSS Convention.

RECENT INVESTIGATIONS INTO THE ORIGIN OF NITRATES IN CAVE SEDIMENTS: REPLICATION OF THE SALTPETRE CONVERSION PROCESS AT MAMMOTH CAVE NATIONAL PARK

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Although the existence of nitrates in cave sediments has been known for literally thousands of years and occupied the minds of some of the best 18th and 19th century chemists, certain aspects of the phenomenon remain mysteries. In the summer of 1974, we conducted an "action history" experiment, in which the traditional procedure of the 1800's was replicated, in order to understand better the technical details of the operation. Using traditional hand tools, a leaching vat was constructed and used to convert 200 lbs of cave sediment from Audubon Avenue, Mammoth Cave, to an authentic sample of Mammoth Cave saltpetre. Several chemical intermediates, described in centuries old recipes, were identified for the first time in these experiments. Much insight was also gained into the physical nature of the saltpetre conversion process. Additionally, the following accomplishments will be discussed: The discovery of an original boiling kettle used in the Mammoth Cave saltpetre operations during the War of 1812; location of the foundations for the chimneys used in the Mammoth Cave operation; and a much clearer understanding of patterns of saltpetre production throughout the Mammoth Cave region.

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ARCH SPRINGS AND CAVE

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Arch Springs and Cave was a landmark in Sinking Valley, Blair County, Pennsylvania, long before the first white man entered (in the early 1750's). The valley has a limestone floor and contains many caves, as well as deposits of zinc and lead ore which became valuable during the Revolution. The first written reference to the cave was made in 1788. Much history in the area is closely associated with the landmark. Several attempts to commercialize the system ended in natural disasters. The world's longest soda straws are well secured beyond several sumps that challenge the best of diving teams. Interest in the cavern throughout the years is evidenced by the numerous pictorial arrangements that have been produced.

CAVE HERMITS: VIGNETTES OF AMERICA'S PAST

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The formative years of our country's history are filled with legends and tales of heroic figures who shaped our heritage. There is another side of the story, however, one dealing with individuals who may not have struggled or fought for America's common good, but whose eccentricities have provided interesting vignettes of folklore. These are the great American cave hermits; solitaires who chose to dwell in caves, apart from normal folk. Driven into seclusion, these lonely anchorites sought escape from various hardships, including the anxieties of war, the aches of a lost loved one, persecution by the law, or the general burdens of society.

The greatest number of celebrated troglodytes comes from northeastern caves. Pennsylvania ranks as the number one state in spelean recluses. Among its most notable are Amos Wilson (The Pennsylvania Hermit), Benjamin Lay (The Fiery Gnome), Albert Large (The Love-lorn Hermit of Wolf Rocks), and "Coxey" Bivens (The Delaware Valley Cave Dweller). New York boasts Sarah Bishop (The Atrocity Hermitess), and Jules Bourglay (The Leatherman). Connecticut also hosted Bourglay on his cave-to-cave travels and harbored Edward Whalley, William Goffe, and John Dixwell (The Regicides) in its Judges' Cave. Mike Link and Francis Phyle inhabited two caves in New Jersey. Robert (The Slave Hermit of Massachusetts) became a legendary figure for later day abolitionists. Thomas Parr (The Virginian Hermit) was found in a mountainous western Virginian cave. And then there was an anonymous young woman discovered in a rocky cave in the wilderness of the western frontier by some travelers in 1777.

These are but a dozen or so hermits who have been immortalized in the literature. Undoubtedly throughout the years, others had inhabited rocky places in efforts to forget their burdens and to reflect upon their lives.

SELECTED ABSTRACTS OF PAPERS
1977 NSS CONVENTION, ALPENA, MICHIGAN

AMERICAN CAVE FISHES AND SALAMANDERS

John E. Cooper

N.C. State Mus. Nat. Hist., Raleigh

Many species of troglobitic fish occur throughout the world. There are six in the United States and one in nearby Coahuila, Mexico. The Coahila species is a catfish. Two other catfishes live in deep artesian wells of the Edwards Plateau in Bexar County, Texas. The other four American troglobites are members of the family Amblyopsidae. One occurs in caves of the Cumberland, Interior Low, and Ozark plateaus; another in caves of Arkansas, Missouri, and Oklahoma; a third in Kentucky and southern Indiana; and a fourth in a single system in Lauderdale County, Alabama. In addition to the troglobites, a number of other kinds of fish frequent caves, including sculpins of the genus *Cottus* which are often mistaken for true cave fish.

There are 10 described species and subspecies of troglobitic salamanders known in the world, and all but one occur in the United States. The description of at least one other American species is in press. The non-American form lives in karst regions along the Adriatic Sea. Four of the American species occur in caves, artesian wells, and sinkholes in the Edwards Plateau of Texas; one is known from the Florida panhandle and southwestern Georgia; and another, represented by three subspecies, occurs in eastern Tennessee, northwestern Georgia, and northern Alabama. An undescribed species occurs in a single cave in West Virginia. Another known species occurs in caves of Missouri, Oklahoma, and the southeast tip of Arkansas. This animal, and the West Virginia species, are the only cave salamanders which undergo metamorphosis. As with fish, a number of non-troglobitic salamanders frequent caves in this country.

AMERICAN CAVE CRAYFISHES AND SHRIMPS

John E. Cooper and Martha R. Cooper

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Troglobitic crayfish are known only from parts of Mexico, western Cuba, and the United States. Twenty-six species and subspecies occur in this country, most of them in the southeastern states. Eleven kinds occur in caves, sinks, and wells in peninsular and panhandle Florida, and one of them is also known in southwestern Georgia. Four kinds are in the caves of eastern Kentucky, Tennessee, and Alabama; two described and two undescribed species occur in the Tennessee River valley of northern Alabama; and three forms are found in west central Kentucky, Tennessee, and southern Indiana. A single species is known from Arkansas, and three species occur in Missouri and Oklahoma. A pigmented, eyed species occurs only in subterranean waters of the Greenbrier River drainage, West Virginia. One troglophilic species is distributed from Mammoth Cave, Kentucky to northern Alabama. A number of primarily epigean species may also be found in caves.

Only five species of troglobitic shrimp are known in the United States. One occurs in Squirrel Chimney, Florida, two in Ezell's Cave, Texas, one in Shelta and Bobcat caves, Alabama, and one in Mammoth Cave, Kentucky. No epigean shrimp have yet been found in caves.

POST-GLACIAL CAVES IN THE BURNT-BLUFF GROUP OF MICHIGAN'S UPPER PENINSULA

Rane L. Curl

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A few small caves have developed since glacial retreat and land emergence in pure and dolomitic limestones of the Burnt Bluff (Silurian) Group. Area drainage is mediated by regional rock dip, glacial deposits, and beavers. The result is up-dip cave development in lightly mantled areas of high-calcium limestones. Local speleogenesis is also modified by dolomitic strata within the more easily dissolved limestones. The caves are important in that they present examples of recent and moderately simple speleogenesis.

CAVE REGISTER PROGRAM IN WASHINGTON STATE

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The cave register program in Washington covers three caving areas. The Mt. Adams area, in the south-central part of Washington, has the greatest concentration of caves and is the most frequently visited area. The Mt. St. Helens and the Concrete areas are also significant localities. The register program started in 1975. During the past two years, over 250 forms have been filled out and analyzed. We have found that New Cave is the most heavily visited, with over 100 visitors per year. Only a small amount of register vandalism has occurred. One gallon plastic jars are used, as they are economical to replace. The register program has been an effective way of contacting people who go caving and educating them about the NSS and its policies.

SULFUR HEXAFLUORIDE AS A TRACER GAS

John Baz-Dresch

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There are presently two common methods of connecting separate caves into one system. The first is by physical, human passage or its derivatives of voice or light contact. The second is by stream tracing, using fluorescein or Rhodamine B dyes or lycopodium spores.

These methods might prove unsuitable in certain circumstances, such as where no stream is present. The use of a tracer gas, sulfur hexafluoride specifically, is proposed as a third alternative. Ethyl mercaptan, a very odorous gas, has been used in several instances, but it is very unpleasant to use and might be harmful to the cave environment. Sulfur hexafluoride is an inert, colorless, odorless, non-naturally occurring gas which should be completely harmless to any cave life. It has been studied by the U.S. Bureau of Mines for use as an aid in the analysis of mine ventilation.

To determine if two caves are connected, a quantity of sulfur hexafluoride gas is released at a time when air flow is toward the area in question. Air samples are taken at intervals in the target area. The samples are analysed, using electron-capture gas chromatography. The presence of the tracer gas in the air samples proves that the two caves are connected.

GRYLLOBLATTIDS

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Grylloblattids (*Grylloblatta* spp.) are small, wingless insects belonging to the order Orthoptera, which includes cockroaches, grasshoppers, and crickets. Grylloblattids have been reported from western North America, Siberia, and Japan.

First noted in 1913, in Banff, Alberta, Grylloblattids were regarded as among the rarest insects in the world. It was not until 1963 that the unusual habits and habitats of these insects, rather than a scarcity of individuals, were found to cause their infrequent collection.

Grylloblattids require an unusually low temperature range (-3° to +6°C) and a fairly high humidity (70% or more). Grylloblattids are active in winter when most other insects are dead or dormant. They can sometimes be found foraging on snow, where they find numbed insects offering little resistance to capture.

Grylloblattids move toward the surface or deeper underground according to their physical needs. For this reason, they can be found in many western glacières during late spring, summer, and fall. Their extremely slow metabolism and acute tactile sense makes them well suited to cave life. Migration from caves toward the surface during the winter is caused by a drop in cave humidity and temperature resulting from the flow of cold air into the glacières.

Grylloblattids are considered omnivorous. In caves, they tend to be more aggressive hunters. Their defensive zone is about 1½ feet in diameter; they have few scruples against cannibalism.

RATE AND CAUSES OF DECLINE IN THE ENDANGERED GRAY BAT WITH SUGGESTIONS FOR ITS RECOVERY

Merlin D. Tuttle

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Twenty-two summer colonies of the endangered gray bat, *Myotis grisescens*, were censused in 1968-70 and again in 1976. A conservative estimate reveals a 54% decline in that time period and a 76% decline from past maximum population levels. Some major colonies disappeared entirely within the 6-year period. A strong association between decline and disturbance by people in caves was observed.

TROGLOBITIC TENDENCIES IN PSEUDOSCORPIONS OF THE GENUS *PSEUDOGARYPUS* (PSEUDOGARYPIDAE)

Ellen M. Benedict
and
David R. Malcolm

Although the suborder Monosphyronida includes approximately half of all pseudoscorpion species, it contains less than 3% of all species reported from caves. Further, monosphyronid pseudoscorpions inhabiting caves are generally guanophiles rather than troglobites and exhibit little, if any, of the morphological specialization typical of many cavernicoles. Therefore, it is of special interest that recent studies of the North American genus *Pseudogarypus* Ellingsen have revealed the first three subterranean species of the monosphyronid family Pseudogarypidae: Benedict and Malcolm have recently described *P. spelaeus* from Samwell Cave, Shasta County, California; Muchmore is in the process of describing a new species of the genus from Music Box Cave, Calaveras County, California and a species from Doney Crack, a tectonic earth crack in Coconino County, Arizona. While the total specialization of these three species for subterranean existence is not as marked as that observed for many of the cavernicolous pseudoscorpions of the other suborders, it is still significant. In contrast to epigean members of *Pseudogarypus*, the three subterranean species have somewhat less pigmentation, smaller eyes, more attenuate appendages, and greater size.

DOLOMITE KARST OF MONROE COUNTY, MICHIGAN

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In the Southeastern corner of Michigan, a youthful karst area is emerging from beneath thin glacial lake sediments. The rock is primarily dolomitic, overlying a poorly cemented sandstone. The land surface is flat, sloping gently eastward toward Lake Erie. To permit agriculture in the area, natural surface drainage has had to be supplemented by an elaborate network of artificial field drains.

Sinks and swallow holes are common features in the southwestern section of the county. During periods of high runoff, the limited carrying capacity of underground drainage channels leads to the formation of sinkhole lakes.

Preliminary field work to determine the degree and nature of karst development in Monroe county was carried out in the fall and winter of 1976-1977. Solution channels appear to be small and readily plugged by surface inwash. There are varying degrees of network integration.

EARLY ACCOUNTS OF HOWE'S CAVE SCHOHARIE COUNTY, NEW YORK

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The discovery of Howe's Cave in east-central New York has traditionally been credited to Lester Howe, who entered the cave on May 22, 1842. However, there are references in the literature indicating that the cave was previously known to local Indians, who called it "Otsgaragee," "cave of great galleries." Howe's Cave was later used by Jonathan Schmul, a local Jewish peddler, and Rev. John Peter Resig, a German immigrant pastor, as a home and hiding place from Indians. Just prior to Howe's 1842 "discovery," the cave was known as "Blowing Rock." Less than four months after Howe's visit, E. George Squier referred to the cave as "The Schoharie Caverns" in a newspaper account written in August, 1842. Geologist William W. Mather may have been the first to affix Howe's name to the cave. His description and lithograph of the entrance were published in a report of the New York Geological Survey in 1843. Yet, neither of these names was widely used at first, as suggested by another name, "Cataract Cave," used by A. Eggleston in 1846. One of the earliest published accounts of the cave, following its development for tourism, was written by Professor Simeon North of Hamilton College in 1851. By this time, the name "Howe's Cave" was fully accepted. Several other accounts soon followed, as Howe's Cave joined Weirs, Mammoth, and Wyandotte Caves as one of America's original show caves. One of the most interesting descriptions of a mid-nineteenth-century tour through the cave was hand written in 1861 under the pen name of Pip. This manuscript matches an article by an anonymous author published in 1863. Sentence for sentence, the accounts are the same, but the words and names of individuals were changed in an obvious attempt to conceal plagiarism. Evidence suggests that the hand-written version may have been authored by J. Pierpont Morgan, the celebrated railroad and banking tycoon.

NEW MUMMY RESEARCH AT SHORT CAVE EDMONSON COUNTY, KENTUCKY

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Meloy (1968) has extensively documented the discovery of four mummies from Short Cave, Edmonson County, Kentucky. The revised mummy excavation chronology is as follows: A child, 1811 (Clifford, 1811; Wilkins, 1817); Fawn Hoof, 1811 (Wilkins, 1817); the two Scudder mummies, 1814 (Rice, undated letter; Meloy, 1968). George (1972, 1975) recorded a similar mummy site called the Lexington Catacomb, allegedly located in Fayette County, Kentucky. The story of hundreds of embalmed mummies there is a distorted account written by Thomas Ashe (1808), who visited the Midwest in 1805 to mid-1806. There is enough evidence to support the supposition that Ashe never arrived in Lexington (Leavy, 1875).

Comparative analysis of the Catacomb story suggests a true historic event and site that may have been located in the Mammoth Cave region (George, 1975). Additional research into Ashe's story has shown the Lexington Catacomb and its mummies to be the earliest written account of the first discovery of Amerind mummy burials from the Short Cave site. The exact number is presently unknown, but "hundreds" seems too excessive. Short Cave is the only cave in Kentucky where specific mummy burials have been found and documented. Strength of the Catacomb-Short Cave theory is based on five points: (1) Ashe used an exact description of a real cave mummy; (2) he used a fractured account of a subsoil stone box grave; (3) he employs a dry cave; (4) the geography of the Catacomb matches most of the internal features seen in Short Cave; (5) all of the Catacomb mummies were mutilated and destroyed; this is a parallel event that covers the motive of operation by the petre monkeys in 1811 and 1814 at Short Cave. The superstitious petre monkeys performed ritualistic murders on the mummies to make sure they were not supernatural beings from the infernal regions. Ashe is directly credited with fathering the misconception that the Amerinds embalmed their dead prior to internment. Later, because of this belief, the Mammoth Cave area mummies were considered to be of Egyptian descent. Not until recently were the mummies found to be simple burials preserved by favorable conditions in the cave environment.

Meriam (1844) allows a three year hiatus for renitrification to occur in the cave soils at Mammoth Cave before resuming mining activity. This practice may have also been exercised in other saltpeter caves of the region. Short Cave, being of limited horizontal extent, may only have been worked in 1814, 1811 (as the revised mummy excavation data suggest), 1808, 1805, and 1802. It is entirely conceivable that Ashe's Catacomb-Short Cave story dates toward the 1805 or 1802 work period. The technical source to Ashe's Catacomb story is still unknown and under investigation.

HISTORIC MAPS OF MAMMOTH CAVE

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The history of Mammoth Cave can be read from its maps. Since 1810, over a hundred have been made. These supplement the published histories of the cave and often provide significant information not to be found in other sources.

Only from its maps do we learn that, prior to the erection of the saltpetre vats within the cave, that there were V-shaped vats at the cave entrance; that the prehistoric basket rediscovered by archeologist Patty Jo Watson in 1969 was known in 1813; and that Stephen Bishop, in 1842, was acquainted with the passage rediscovered by the CRF and by them named "Hanson's Lost River," when they connected the Flint Ridge Cave system to Mammoth Cave.

An integrated study of its maps gives us new insight to the history, legends, traditions, and folklore of Mammoth Cave.

THE LEGEND OF STEPHEN BISHOP

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During the 19 years that Stephen guided at Mammoth Cave, he became almost as famous as the cave itself. Then, for a dozen years after his death in 1857, his name was seldom mentioned and his memory all but forgotten.

After 1870, when the status of the black guides was at its lowest ebb, they resurrected the memory of Stephen and embellished it with fictional accounts of daring exploits. Their stories improved with the retelling, until Stephen became a folk hero to the black community at the cave.

Authors repeated these stories in numerous publications. By 1900, the legend of Stephen Bishop had become a tradition at the cave and remains today a classic example of spelean folklore.

MAN'S RESPONSIBILITY TO THE LAND: JOHN LOCKE AND THE PRIVATE LANDOWNER

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Rural landowners often try to counter environmentalist arguments with claims that they have exclusive rights to their land as property and can do whatever they wish with it, even destroy it, without social or moral responsibility to consider the interests of others or the intrinsic value of the land. This paper traces that viewpoint from John Locke's theory of property, in *Two Treatises of Government* (1690), through Thomas Jefferson into the land laws of the 19th century and discusses some of the problems with this view of land.

GLACIER CAVES OF THE QUELCCAYA ICE CAP PERUVIAN ANDES

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Reconnaissance observations on glacier caves were made during three glaciological expeditions to the tropical Quelccaya Ice Cap. This temperate ice cap in the Cordillera Oriental, 105 km east of Sicuani, is 5645 m high. Several outlet glaciers, containing glacier caves, are at 5150 m.

There are three types of caves, two of the obstruction type and one of the crevasse type. The obstruction caves, which may undergo slight ablation during the summer, exhibit two morphologically distinct forms: (1) single passages parallel to iceflow direction, with a large boulder or bedrock protuberance at the head, and (2) single passages perpendicular to ice flow and formed in the lee of bedrock ledges at the margins of the outlet glaciers. The parallel caves were up to 15 m long, with widths and heights of 3 m; the perpendicular caves were up to 30 m long, with widths and heights of 30 m and 3 3 m, respectively.

The crevasse caves, which occur at all angles to glacier flow, resulted from crevasse tops being covered by snow and collapse of the crevasse walls. These glacier caves were up to 40 m long, with widths and heights of 0.75 m and up to 30 m, respectively. Speleothems observed in the obstruction and crevasse caves included: stalactites, stalagmites, columns, and cave coral. The caves are believed to be the highest glacier caves described in the western hemisphere.

FINDING FRACTURES AND CAVES USING SOIL-TEMPERATURE PATTERNS

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Solution of many engineering-geological problems in karst terrain requires the location of fractures and conduits in the soluble bedrock. Foundations for large structures, grout curtains for dams, water wells, and waste lagoons all require accurate determination of the position and spacing of subsurface voids and avenues of enhanced permeability. A theoretical and empirical study has shown that shallow soil-temperature patterns aid in the detection of fractures and caves in bedrock. Presence of a cave at depth may be indicated in the soil temperature through deflection of the geothermal gradient by the cave, or through conduction of heat to the cave from the surface should they have different mean annual temperatures. A fracture will affect soil temperature by its effect on soil moisture, first as the moisture affects the soil's thermal diffusivity, and second as moving soil water carries heat through the soil. Theoretical considerations suggest that a measured soil-temperature anomaly of +1°F at 3-ft and +3°F at 6-ft depths in soil above a fracture-oriented cave 15 ft in diameter whose upper surface is 30 ft beneath the ground is due mainly to the fracture's effect on soil drainage. The measured anomaly results from the higher thermal diffusivity, due to a lower average moisture content, of moist soil over the fracture, and its more efficient conduction of surface temperature changes. In addition, the fracture promotes convective heat transfer in the overlying soil through movement of soil moisture. Soil temperature patterns can be used to efficiently design an exploratory drilling program as part of many engineering projects.

CAVERNOUS STRATA OF ARKANSAS

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Major caves are developed in the gently dipping Ordovician and Mississippian carbonates of northern Arkansas. The Pitkin limestone is the youngest Mississippian formation and generally crops out on the Boston Mountain escarpment. This limestone (0 to 60 ft) is sandwiched between the underlying Fayetteville Shale and the Cane Hill Shale uncomformably above. Caves in the Pitkin limestone are noted for being mazes formed by initially diffuse flow through joints. Several Pitkin caves have over a mile of mapped passage.

The Boone limestone (chert) averages 300 ft thick and is the major cavernous limestone of NW Arkansas, cropping out over most of the Springfield Plateau. Surface karst on the Boone is poor, possibly related to its cherty nature. Boone caves are often short, large diameter passages. The St. Joe member is essentially chert-free and contains many large caves. Caves of the Boone/St. Joe limestones may have developed from unconfined flow, perched above the Chattanooga Shale.

The Boone limestone in many areas lies uncomformably on the (Ordovician) Plattin limestone, allowing uninhibited cave development throughout a large vertical sequence of rocks. Where thin sequences of Silurian/Devonian clastics are present, caves developed on several levels, eventually being connected by narrow breakdown passages through the clastics.

Ordovician caves are found primarily in northcentral/northeast Arkansas, in the Salem Plateau where the Everton, Cotter, and Jefferson City dolomites crop out. Pits are occasionally found at the contact between the St. Peter Sandstone and underlying Everton Formation. Horizontal Everton caves often have ceilings of St. Peter, with collapse sinkhole entrances.

KARST GEOHYDROLOGY OF THE HELDERBERG PLATEAU

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The Helderberg Plateau of Schoharie County, New York is a karsted and glaciated surface developed on Upper Silurian—Lower Devonian limestones. The plateau was divided into two areas for study, the Cobleskill Creek area on the west and the Fox Creek area on the east. The pattern and orientation of the cave systems and their respective master cave passages in the study area are caused by interaction of the regional dip of the bedrock (1 to 2° SSW) with the master surface drainage network. This network is formed by the northflowing Schoharie Creek which bisects the plateau into two sections. These sections are incised on their down-dip sides by Fox Creek on the east (flowing west to Schoharie Creek) and by Cobleskill Creek on the west (flowing east to Schoharie Creek). This configuration results in tributary and master cave passages being equally spaced and oriented down-dip in the Fox Creek portion of the study area. In the Cobleskill Creek portion of the study area, the surface stream configuration resulted in tributary passages equally spaced, oriented down-dip, and feeding a master cave passage oriented along the strike (draining southeast). Headward incision of Cobleskill Creek westward has perched the strike-oriented master cave and resulted in its partition by down-dip flowing tapoff passages.

The surficial karst has been greatly altered by Pleistocene glaciations, but cave conduits have been very resistant to glacially-induced change. Increasing glacial sediment thickness westward has resulted in a transition from diffuse to confluent insurgence (east to west), with large glacially-constructed depressions appearing to the west. Phenomena such as jointing, faulting and lithologic variations are locally important in cave conduit and cave system orientation and morphology. However, they are unimportant to overall cave system pattern and orientation which is controlled by the regional dip.

A FUNCTIONAL CLASSIFICATION OF KARST FEATURES

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Karst features can be classified by their position and function in a hydrological regime. Such a classification is:

I. Surficial Karst Features
  A. Exposed bedrock surfaces
  B. Mantled bedrock surfaces
II. Interface Features
  A. Insurgences
    1. Diffuse
    2. Confluent
  B. Resurgences
    1. Gravity spring
    2. Artesian spring
    3. Overflow spring
  C. Intersection Features
    1. Vertical
    2. Lateral
III. Subsurface Features
  A. Active cave passage
    1. Tributary passage
    2. Master cave passage
    3. Diversion passage
    4. Tapoff passage
    5. Abduction passage
  B. Abandoned cave passage

Surficial karst features develop on exposed or mantled bedrock without regard to the ultimate destination (surface or subsurface) of the water that forms them. Subsurface features are solution conduits which carry (or once carried) water through the subsurface. Interface features are contacts between the two environments and represent points of water input (insurgences) and output (resurgences) for the subsurface environment. Predominantly nonsolutional processes (such as collapse and scarp retreat) cause intersection features, and do not involve substantial water exchange between surface and subsurface. The classification stresses function, and attempts to remove explorationally and morphologically biased terminology. Individual sinking streams, caves and springs can be discussed as part of integrated cave systems, and can be arranged by position and function within a cave system. The placement of a given karst feature within this classification facilitates its hydrological, geomorphological and explorational interpretation.

PALEOLITHIC ROCK ART IN THE UNITED STATES

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From the earliest times, man seems to have had an innate desire to express himself artistically. As a result, engravings and paintings on stone dating from very early times are found world-wide. Although it is known that man has been in the United States for at least 20,000 years, our rock art can not be reliably dated much before about 700 AD. In Europe, Australia, India, and other parts of the world, paintings and engravings have been found that in some cases are as much as 30,000 years old. This very ancient rock art is invariably located deep in caves, where the environment is conducive to its preservation.

It is believed that equally ancient rock art exists in the United States, again deep in caves, but has never really been looked for. The purpose of this presentation is to arouse interest in searching for this art by cave explorers and to present some ideas of where to look, what to look for, and some of the difficulties that might be encountered.

GROWTH, LONGEVITY, AND REPRODUCTIVE STRATEGIES IN SHELTA CAVE CRAYFISHES

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Comparative studies of a troglobitic crayfish triad have been conducted in Shelta Cave since November, 1968. Growth, longevity, and reproduction data were obtained by mark-recapture studies and from specimens confined in the cave. The animals showed slower growth and greater longevity than are commonly assumed for invertebrates (a "Methuselah Strategy"). Published information on growth in epigean crayfishes, expressed as change in carapace length (CL) per unit time, shows rates ranging from 2.8 to 5.2 mm per month. By contrast, maximum growth in any cave crayfish represented a rate of 0.38 mm per month. Troglobites molted less frequently, and growth at any molt was less than half the maximum reported for epigean species. A positive correlation was observed between failure to increase CL and energy demands for repairs. Assuming maximum growth rates observed at various sizes, age of the largest individuals of *Orconectes a. australis* (47 mm CL) is estimated at over 37 years, and 175 years assuming average observed rates. The smaller species, *Cambarus sp. nov.* and *C. jonesi*, have lifespans conservatively estimated at 10 and 15 years, respectively. Recent studies of a sea urchin species in another kind of constant environment also show great longevity under these conditions.

Reproductive cycles occur in most adult-sized female *O. a. australis*, but few are completed, and successful production of offspring appears to be restricted to a few of the largest adults. A linear increase in frequency of form-I males with increasing size, unknown in any other crayfish species, indicates that sexual maturity is delayed even long after the minimum size for its attainment. In *C. jonesi*, sexual activity is apparently not restricted to the largest individuals. Repeated cycles of reproductive activity occur in adult females, but resorption of oöcytes is a common phenomenon. None has ever been found with attached young or ova. All adult-sized males of *C. sp. nov.* appear to have an equal chance of being form-I. This species has the largest and fewest (8 to 12) oöcytes, and, apparently, the young at recruitment may be larger, in proportion to adult body size, than those reported for any other known crayfish species.

TRACE ELEMENTS IN CALCITE—THE ONLY CAUSE OF SPELEOTHEM COLOUR?

Mel Gascoyne

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The presence of trace elements is often cited as the cause of most colours seen in stalagmitic deposits. To some extent, this is based on previous analyses of *strongly* coloured samples, where large concentrations of a particular 'trace' metal were found, *e.g.*: Mn and Ni (White, *NSS Bulletin* 1962 and 1974). A recent study by Beck (NSS Convention, 1976) showed the trace elements of two differently coloured portions of the same speleothem to be almost the same. The colour differentiation was attributed to differences in crystal texture.

In the present work, 36 calcites of varying colour and origin were analyzed by atomic absorption spectrophotometry and matched against mixed element standards made up on a calcium carbonate base (to reduce interferences). The following ranges of concentration were found:

Mg	50 to 8000 ppm
Sr	10 to 1000 ppm
Fe	2 to 80 ppm
Mn	0.3 to 20 ppm
Zn	10 to 75 ppm (plus two samples 4000 ppm)
Pb	30 to 120 ppm
Cu	0.5 to 200 ppm

Calcite colours ranged from clear through dense-white to pale-green, orange, and brown-black. No correlation was seen between dark colours and Fe or Mn content. In fact, often the reverse was found, *i.e.*: dense-white samples contained slightly more Fe and Mn than did other types. The two samples high in Zn were only slightly coloured, and high Cu content samples were generally white. Very high Sr levels were found in samples from cold climate regions—the Canadian Rockies and the N.W.T. This is unusual, because the samples appear to be calcite, not aragonite (X-ray diffraction analyses are in progress.).

The main cause of colour in the dark samples became obvious while dissolving them for analysis: Large quantities of froth were formed (ominously similar to 'sump froth' after a flood), due, presumably, to the high organic content. It is suggested, therefore, that only in certain cases is speleothem colour due to trace elements—it is more likely due to optical properties and/or organic content.

SOCIAL SCIENCE AND HUMAN ASPECTS OF CAVING WITH YOUTH EMPHASIS

Don Platt

A review of research literature indicates that organized group camping can have tremendous growth-inducing-potency effects. As organized camping progresses from recreational to therapeutic stages, more emphasis and questions arise as to the self-development concept in various individuals. Caving should also show this potential for self-development.

Three different groups of youths were selected as the participants. These included delinquent females, and average youths ages 10 to 18. High adventure trips, such as spelunking, were designed to provide both physical and mentally stressful outdoor experiences. Individual as well as group decisions had to be made in a variety of circumstances. Chances to view the "sacred remains" left by other individuals on the environment were pointed out.

The visual observations and conversations overheard clearly showed that the impact of these spelunking trips are sticking with the youths. Significant positive increase in self-concept with a strong decrease in poorly adjusted and delinquent behavior were documented. There were no real differences among the age brackets or female participants. Prejudicial feelings seemed to vanish. Few other situations provide the variety and intensity of group interaction over such an extended period of time. Young people are forming the likes, dislikes, and habits of a lifetime. Unless they are exposed to positive, fulfilling outdoor recreation experiences as children, they probably never will develop a liking for the outdoors and, consequently, will have less interest in helping to preserve some of our natural resources.

The Michigan 4H Challenge Program can be a nearly ideal vehicle for providing a wide exposure to outdoor recreation activities, as well as in determining the activity level of the adult.

INFORMATION FOR CONTRIBUTORS TO *THE NSS BULLETIN*

Papers discussing any aspect of speleology are considered for publication in *The NSS Bulletin*. We particularly welcome articles describing important caves and cave areas, on the history of caves and of speleology, on problems and techniques of cave conservation, and critical reviews of current literature, in addition to papers on the more traditional subjects of cave geology, geography, anthropology, fauna, and ecology. The material presented must be original and of lasting interest. Authors should demonstrate the significance of their work to speleological theory and should elucidate the historical antecedents of their interpretations by reference to appropriate literature. Presentations consisting of raw data, only, will not be accepted.

A narrative style of writing is preferred. Fine prose is terse yet free from lacunae, sparkles without dazzling, and achieves splendor without ostentation. Data and interpretations blend effortlessly along a logical continuum so that the reader, having read, neither knows nor cares how many pages he may have turned while following the author's exposition.

As written language must communicate through time as well as across space, neologisms should be introduced only if needed to express new concepts or to record new percepts. Standard usage, therefore, is required of all authors. For general style, refer to papers in this *Bulletin* and to the following handbooks: "Suggestions to Authors" (U. S. Geological Survey), "Style Manual for Biological Journals" (American Institute of Biological Sciences, Washington, D. C.), and "A Manual of Style" (The University of Chicago Press).

Articles on earth sciences (including pseudokarst), life sciences, conservation, social science (including history), and exploration should be sent directly to the appropriate specialist on the Board of Editors (see masthead); articles not clearly falling into any of those categories may be sent to the Managing Editor. Potential contributors, especially those not professional scientists or writers, are invited to consult with the editors for guidance or aid in the presentation of their material.

Two double-spaced, typewritten copies of each manuscript, including all illustrations, are required. Manuscripts should not exceed about 10,000 words in length (approximately 40 pages of typescript), although this limit may be waived when a paper has unusual merit. Photographs must be sharp, high in contrast, and printed on glossy paper. All line drawings should be neatly rendered in "india" ink or its equivalent; the smallest lettering must be at least 2 mm high after reduction. Typed lettering is not satisfactory. Captions will be set in type and added in proof. The dimensions of original drawings and of cropped photographs should be made some multiple of the length and width of a column or of a page, when possible, in order to avoid problems with the layout. In case of doubt regarding length or illustrations, consult with the editors.

Abstracts are required of all papers; these must be brief and must summarize the author's discoveries and conclusions, not merely tell what he did. Captions are required for all illustrations. All unusual symbols must be defined. Authors should give their institutional affiliation (if any) and address exactly as they are to appear in print. Direct quotations from non-English language sources should be given in the original languages, with English translations (if desired) in footnotes. References to the literature must be by author and date, with specific pages where desirable. Literature cited must be listed in an end bibliography, with entries arranged alphabetically by the author's surname, typed in the format employed in this *Bulletin*. References must contain all information necessary for locating them, with titles and journal names completely spelled out in their original language and including all diacritical marks. Inclusive page numbers of articles and the total number of pages of books must be given. All persons to whom "personal communications" are attributed should be named in the bibliography and a current address provided for each.

Contributed papers will be refereed by one or more authorities in the appropriate specialty and will be edited for style before publication. After being refereed and again after being edited, papers will be returned to the authors for inspection and for any revisions which may be necessary. Please enclose a self-addressed, stamped envelope for the return of your manuscript.

By act of the Board of Governors of the NSS (#81-277, dated 8-12-74), a charge of not less than $25 per printed page will be levied against the author's institution or other funding agency after a paper has been refereed, edited, and accepted for publication. Payment will not be expected of scholars whose research was not sponsored or whose budgets do not include money earmarked to subsidize publication. In no event, will the ability to pay page charges be discussed until after final acceptance of a manuscript.

Reprints may be ordered when galleys are returned by the authors to the Managing Editor; these will be supplied at cost.

Summary: (1) data and/or interpretations must be original; (2) use a narrative style of writing; (3) follow standard English usage; (4) do not exceed 10,000 words (40 double-spaced pages of typescript) without receiving permission from the Managing Editor in advance) (5) submit two complete copies, including abstracts and all illustrations; (6) enclose a self-addressed, stamped envelope for the return of your manuscript.

EDITORIAL: THE SOCIOLOGICAL SCIENCES IN SPELEOLOGY

The sociological aspects of caves and caving (by which we mean the relationships between caves and people, not the parties arranged elsewhere by people sharing a common interest in caves) have been very unevenly investigated. The history of caves and the biographies of prominent explorers and scholars have been an accepted part of the general field of history for many years. Journal articles and books on spelean history have been written by major authors and accepted by leading publishers. Likewise, the anthropological aspects of caves are a standard feature of published research on ancient and on modern primitive societies.

The editors would like to suggest two additional areas of speleo-sociology which are ripe for exploitation: Black studies and women's studies.

Black studies might include (a) history and anthropology of Central Africa and (b) history and anthropology of Blacks in the United States and other non-native countries. Much has been published on the role of caves in Greek, Roman, Christian, and other western mythologies; how have they figured in the tribal myths of Africans? What economic uses have caves in traditional African societies? What parallels have these features with those of western, near-eastern, and oriental cultures? What are the common forces which brought about convergent uses (if any)?

The relationships between caves and American Blacks are more tenuous, but still worthy of examination in spelean literature. Cave "stations" on the underground railway are of historical interest. Caves were used by the Ku Klux Klan as meeting halls in which to decide the fate of Blacks (*cf.* "Caves of Missouri," in which Bretz states that Pantastic Caverns, in Greene County and Ku Klux Cave, in Jasper County were so used). Because both of these activities were illegal, written records are scarce and survivors may be reluctant to grant interviews.

The virtual absence of Blacks, orientals, and Hispanics from North American caving is a striking sociological phenomenon. Why have they not sought to become involved? Why is caving such a WASPish activity?

At least some anthropologists are becoming interested in applying anthropological paradigms and techniques to the study of modern societies. Women in speleology is a potential area for this kind of investigation. The only published reports which come to mind are those of Jerry Vineyard on Luella Agnes Owen (*Missouri Speleology* 10(2) and the introduction to the Johnson Reprint Corporation edition of her "Cave Regions"). Not only would additional historical and biographical research be enlightening, but an examination of the social constraints against women as cavers and of the causes of many women's personal antipathies toward spelunking would have both scholarly and practical interest.

Very few women have applied for NSS membership. However, the ratios of women as Directors and editors have been roughly in proportion to their membership (see tables in *NSS Bulletin* 28:46 and 39:39). The NSS appears to have been relatively barrier-free throughout its existence. At risk of appearing to give ourselves a pat on the back, we should publicize the reason(s) for this.

Most of the American public's total exposure to caves is through one or more visits to commercial caves. Yet, we can recall no study of commercial caves as a socio-economic phenomenon. What are the economics of the privately-operated commercial cave? What image of caves and caving do they project?

How can the psychology of caving and of cave rescue be studied without being biased by the presence of an observer? What personality types are most likely to be attracted to caving? What are the intellectual and emotional rewards of caving?

People who sample caving but who do not become active in the NSS or in another strong organization are likely not to develop a commitment to caving and to drop out soon. Cavers probably could be recruited to the NSS and the best ones retained by using the methods employed by organizers for political parties and volunteer action groups, but the NSS has never published an organizers manual. Such a guide would be extremely helpful in achieving our near-term goal of 10,000 members.

Many of the data relevant to these areas are already available in the sociological literature, but await specific application to speleology. Null results would be publishable, at least in summary form—knowing which lines of investigation have failed (and why) is as important as knowing which ones are fruitful. Socio-anthropo-speleology *ought* to extend much further than the discovery that "quartz" is a measure of grotto consumption of beer. Our pages are available to any and all scholars interested in the social-scientific aspects of speleology. **JH, TL, WBW**; with assistance by John Wilson (Virginia Council on Social Welfare), Evelyn Bradshaw (Friends' Committee on National Legislation), Anita L. Hughes (Chairperson, Dept. Human Ecological Systems and Services, Univ. D.C.), and Barbara Lee Smith (Professor of Counselling, Univ. D.C.).

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