NSS NEWS

AUGUST, 1962
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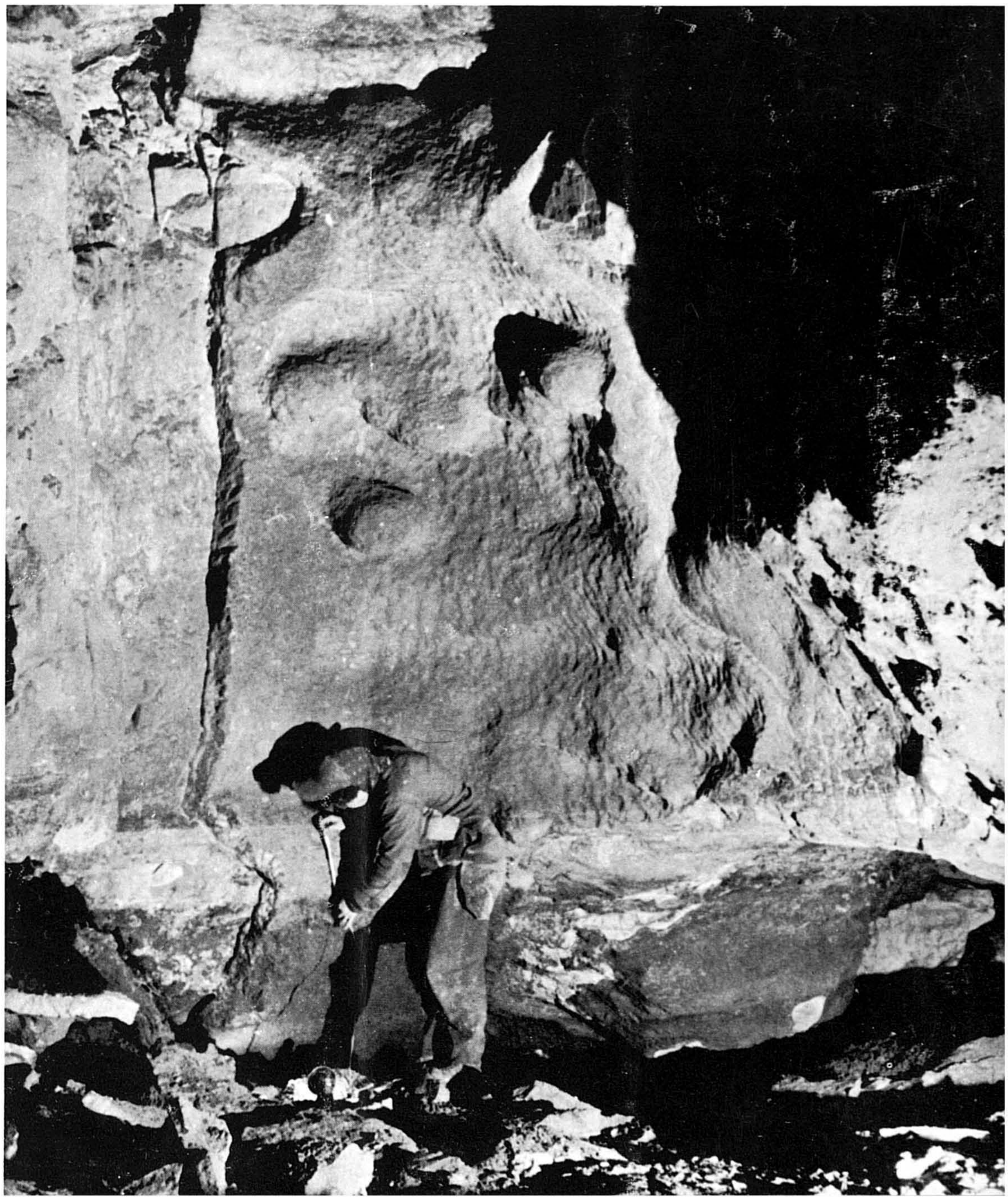
PART II

NATIONAL SPELEOLOGICAL SOCIETY



COVER -- "Jewel Cave Survey", third place winner of the Monochrome Prints, Activities, in the 1962 NSS Photo Salon by Dwight E. Deal.

The photo shows Jan Conn in the small room between "Track Nine" and the "Car Barn". This is a low portion of the cave and Jan is measuring water marks that appear on the cave walls here (see page 117 and following).

The action is taking place as part of the survey and exploration of Jewel Cave National Monument, underway since the Fall of 1959. As of the 1962 NSS Convention, close to 8½ miles of cave passage have been mapped.

Jan's husband, Herb, assisted in taking this photograph by triggering the off-camera flash (one AG-1 bulb) about 15 feet to the right and in front of the camera. The camera was tripod mounted. The print was cropped from a 35 mm negative (Plus X) and intentionally overdeveloped to make it "look more like a cave".

NSS NEWS

NATIONAL SPELEOLOGICAL SOCIETY

Associated with the American Association for the Advancement of Science

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NOTES AND NEWS

NO SAFETY

If the NSS stresses safety so darn much, how come not one safety rule (except for hard hats) was followed at the Climbing Demonstration at the Custer convention?

Dr. Bill Halliday, Jr.
Seattle, Washington

NO CONSERVATION

Having thoroughly persued the new book, *Caves of Indiana* by Richard L. Powell which was issued by the State Geological Survey, Indiana Department of Conservation, one finds a paradox. When publication of cave locations may lead to increased vandalism, why does a book of this type, published by the Indiana Department of Conservation, have absolutely nothing about cave conservation.

Education of possible cavers is the most important aspect of promoting cave conservation. Many people who use this book will not be NSS members and will not hear of cave conservation except by reading about it in the publication.

Possibly a conservation-worded addenda could be included with future books sold if letters are sent to the author and the Director of the Dept. of Conservation, Donald E. Foltz, and the State Geologist of the Geological Survey, John B. Patton. Addresses for each of these persons would be through these various departments in Bloomington, Indiana.

Lyle G. Conrad
Chevy Chase, Maryland

(Ed. Note: Powell's Caves of Indiana *has been briefly reviewed in the July-August issue of* Rocks & Minerals.*)*

MEMPHIS, TENNESSEE

MID-SOUTH FAIR

September 21 through September 29, 1962

For the first time, this year's Mid-South Fair will be carrying a speleological exhibit. This fair has an average annual attendance of a half-million at present, and the number continues to increase. The area of active participation in Mid-South Fair includes the well known cave states of Tennessee, Arkansas, Missouri, Kentucky and Alabama.

Memphis Grotto has taken it upon themselves to set up and man the speleological exhibit (an area about 20' x 20') but they are asking for help and material. Items such as Science Fair Projects on any topic or level of speleology, slides on speleological subjects, new equipment in the field of spelunking, and anything else you think might prove useful would prove useful would be most welcome. All material will be returned as soon as the Fair is over. Those interested in aiding this project should contact: Jack T. Applewhite, 693 West Brentwood Cl., Memphis 11. Phone: FA 3-7965.

NSS members attending the Fair may obtain complimentary tickets by writing to: D. L. Marsh, Asst. Director, Educational Dept., Mid-South Fair, Memphis 14.

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Claims for missing numbers will not be allowed if received more than 60 days from date of mailing plus time normally required for postal delivery of publication and claim. **Note:** No claims allowed because of failure to notify the NSS Office Secretary of a change of address.

Deadline is the **tenth** of the month preceding the month of issue. Send material to be published in the *NSS NEWS* to the Editor. Advertising rates on request from the Advertising Manager.

Other publication of the Society: *BULLETIN* of the National Speleological Society, published twice yearly. Subscription rate: $4.00 per year. Editor: William E. Davies, 125 W. Greenway Blvd., Fall Church, Virginia.

The **ADDRESS** of the **NSS** is 2318 North Kenmore Street, Arlington 1, Virginia. Inquiries concerning memberships and purchase requests for all Society publications should be sent to this address, directed to the Office Secretary.

The address of the **LIBRARY** of the **NSS** is 1251 North Negley Avenue, Pittsburgh 6, Pennsylvania. Gifts to the Library, grotto publications, and foreign publications being sent for exchange purposes should be directed to this address. Out-of-town visitors are welcomed but arrangements prior to arrival should be made with the Librarian.

PRESIDENT of the NSS is RUSSELL H. GURNEE, 231 Irving Avenue, Closter, New Jersey.

PAPERS AND ABSTRACTS OF PAPERS PRESENTED

AT THE 1962 CONVENTION
CUSTER, SOUTH DAKOTA

Below is presented the complete convention program with all the papers, or abstracts of papers, submitted at each of the sessions. It is hoped that some of the papers, which appear here as abstracts, will be printed in their entirety in future issues of the *NSS NEWS* but this remains to be seen. Much depends upon the co-operation of the authors. Credit is due William B. White who acted as co-editor for this effort.

General Session

A UNIQUE REMOTE FLASH UNIT

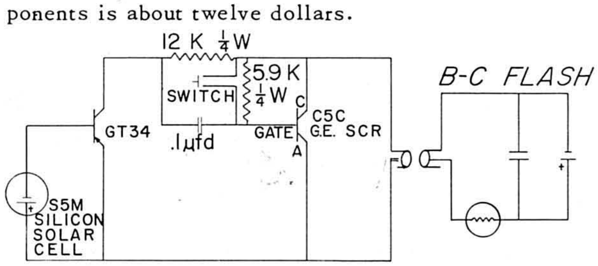
O. J. (Jim) Gossett
Ridgecrest, California

(Abstract)
A small, reliable, remote flash unit can be constructed using new space-age components. One of the unique features is that it responds only to a flash bulb or other fast rise-time light sources. There are no gain controls or other adjustments to make.

A silicon solar cell receives the light and converts it to an electric current which is amplified by a transistor amplifier stage. An R-C network differentiates and triggers a silicon controlled rectifier which acts as a switch for the B.C. flash gun.

The normally open switch must be momentarily closed when plugging in the flash gun or flash bulb.

The entire unit can be built in a case size of 1" x 3/4" x 1 3/4" with the solar cell cemented to the outside of the case. A small micro-switch or doorbell switch may be used in the circuit. Cost of the components is about twelve dollars.



MONTANA UNDERGROUND

Montana Speleological Survey and
Treasure State Speleological Society

(Abstract)
A slide series with tape recorded narration, produced by the two major caving groups of Montana, the TSSS and the MSS. This presentation shows many facets of Montana caving, including the caves themselves and difficulties encountered in locating and exploring same. Emphasis is placed on work performed by the TSSS in the Pryor Mountains of Montana and Wyoming, with additional views of Lewis and Clark Cavern, the only commercially developed cave in Montana. Cave scenes vary in nature and subject and include speleothems, classic and unusual, cavers in action, and touch briefly on the vandalism problem.

CAVING IN NORTHERN NEW JERSEY

Richard R. Anderson
Red Bank, New Jersey

(Abstract)
A slide series produced by the Northern New Jersey Grotto for exchange with other grottos and eventual deposition with the NSS Visual Aids Committee. The slides attempt to show many aspects of the caves of New Jersey. The script gives some of the history of the Grotto, some archaeology and folklore of the caves, and discusses conservation and safety by means of examples. The series ends with slides showing Leigh Cave, discovered in 1959, the largest cave in New Jersey.

CABLE LADDER CONSTRUCTION

Ron Pering and Dean Dale
Billings, Montana

(Abstract)
The cost of cable ladder has long been a problem to grottos with varied budgets and incomes. In this presentation, a simple and economical method of constructing a cable ladder that meets or exceeds commercial standards is demonstrated. Problems of obtaining material and construction methods are covered, as well as reports concerning actual field use of the ladder and associated experiences with it in some of Montana's most difficult caves. A section of ladder, suitable for actual use is constructed as a part of the demonstration.

1963 NSS CONVENTION SITE

Gregg Marland
Charlottesville, Virginia

(Abstract)
A preview of the scenery, caves, and convention headquarters for the 1963 NSS National Convention to

be held at Mountain Lake in Giles County, Virginia, was presented in the form of a slide show. The convention has been tentatively scheduled for June 7-16 and will be headed by John R. Holsinger, Convention Chairman.

The slides emphasized the mountain scenery and the multitude and variety of caves in the area. Large rooms, tight squeezes, stream passages, beautiful speleothems, big pits, and the remnants of saltpeter mining were all illustrated. You describe the cave and we'll take you to it, in southwest Virginia.

Biology Session

PROGRESS OF THE BIOLOGICAL SURVEY OF VIRGINIA CAVES*

John R. Holsinger
Biological Survey of Virginia Caves

The following report will cover the activities of the Biological Survey of Virginia Caves (BSVC) for the preceding year, June 1961 - June 1962. The BSVC was organized by the author in April 1961 and was made a research project of the National Speleological Society in the summer of 1961. The Survey is now operating on a small grant from the Society's research fund. The primary purpose of the BSVC as originally outlined in its official plan, is to systematically collect, organize, and analyze bio-speleological data, to promote ecological investigation, and to facilitate studies on systematics, geographic distribution, and evolutionary patterns of cavernicoles.

NEW DATA

A great deal of collecting and other biological investigations had been performed by the present members of the BSVC prior to its official organization in April 1961. Much of this data provided the pertinent material which has been used in the Contributions (see elsewhere this report) published to date.

To date, much of the Survey's field work has involved extensive collecting of troglobitic invertebrates and cavernophilous salamanders from the caves of Virginia. Some work, but chiefly bat banding, has been carried out in West Virginia. Further operations, however, will include more emphasis on the invertebrate, cave fauna of that state.

More than fifty caves have been investigated in the past year for cavernicolous organisms. In many instances, not only specimens but important ecological data were obtained. Numerous range extensions and several new species have been uncovered as a result of this work. A brief summary of these findings, excluding ecological data, is presented in the following list. All caves noted are in Virginia unless otherwise designated.

1. Planarians - Additional specimens of the rare troglobite, *Spalloplana virginiana* Hyman (fam. Kenkiidae), were collected from Showalter's Cave, Rockbridge Co. *Phagocata subterranea* Hyman (fam. Planariidae) was collected for the first time from a Virginia cave (Rock House Cave, Russell Co.) in November 1961. A population of epigean planarians have since been noted in Newberry-Bane Cave, Bland Co.

2. Annelid Worms - Five species, not previously recorded from Virginia caves, have been obtained. Many more have been observed but not collected.

3. Snails - No troglobitic forms have been collected, but epigean species were collected from Surgener's Cave, Lee Co. and Crossroads Cave, Bath Co.

4. Amphipods - Troglobitic amphipods have been collected from at least five different caves but specific determination is not forthcoming at the present time. Most, however, have been tentatively assigned to the genus *Crangonyx* (fam. Gammaridas).

5. Isopods - Six new locations have been established for the troglobitic isopod, *Asellus pricei* (Levi) (fam. Asellidae). A new species of *Asellus*, discovered in Lee and Wise Counties during the summer of 1960, was uncovered from two Russell County caves during the summer and fall of 1961. This marked a substantial range extension for this rare troglobite. Specimens (probably troglophiles) belonging to the genus *Lirceus* (fam. Asellidae), a genus previously unrecorded from Virginia caves, were collected from two Lee County caves. These forms may be a new species.

Terrestrial isopods, resembling *Miktoniscus racovitzai* Vandel (fam. Trichoniscidae) from Luray Caverns, Page Co., were obtained from three localities.

6. Crayfish - Many cave streams have yielded specimens of *Cambarus bartonii ssp.* (fam. Astacidae). All forms are probably of epigean stock but show some modification for a subterranean existence. A curious, burrowing form, *Cambarus carolinus* (Erichson), was collected from Jessie Cave, Russell Co.

7. Diplopods - Millipeds of the genus *Pseudotremia* (fam. Cleidogonidae) have been collected from ten caves. Some have been determined but others, especially from southwestern Virginia, await further taxonomic study. All ten caves are new records for this genus and several collections undoubtedly represent new subspecies.

**This paper is Contribution No. 10 from the Biological Survey of Virginia Caves.*

Seven new locations have been obtained for the troglobitic, zygonopid millipeds (fam. Conotylidae), including *Zygonopus whitei* Ryder (one cave), *Z. wayeriensis* Causey (three caves), and *Z. packardi* Causey (three caves).

A troglophilic form, *Cambala sp.* (fam. Cambalidae), has been found in several caves.

8. Crickets - A large amount of new material has been obtained for *Hadenoecus puteanus* (?) (fam. Gryllacrididae), essentially from caves in southwestern Virginia.

9. Collembolans - A large amount of collembolan material has been obtained and ten new locations have been recorded, including four for *Sinella hoffmani* Wray (fam. Entomobryidae) and six for *Tomocerus bidentatus* Folsom.

10. Beetles - Emphasis has been placed almost entirely on the troglobitic genus *Pseudanophthalmus* (fam. Carabidae). A new species or subspecies was collected in Showalter's Cave, Rockbridge Co., and two new records for *P. hubbardi limicola* Jeannel have been obtained from Shenandoah Wild Cave and Shenandoah Caverns, Shenandoah Co.

A large amount of staphylinid material has also been accumulated.

11. Phalangids - Cave opilionids are rare but several specimens of the troglophilic *Phalangodes flavescens* (Cope) (fam. Phalangodidaa) have been collected.

12. Pseudoscorpions - Almost every cave that harbors these scarce organisms has, upon close investigation, yielded a new species. A few examples are *Apochthonius sp.* (fam. Chthoniidae) and *Pseudozaona sp.* (fam. Chernetidae) from Cave Run Pit Cave, Bath Co., and *Kleptochthonius (Chamberlinochthonius) sp.* (fam. Chthoniidae) from Porter's Cave, Bath Co.

13. Spiders - Many collections have been made of the linyphiid spiders and a few of the nesticids. *Phanetta subterranea* (Emerton) (fam. Linyphiidae) has been recorded from nine new localities, *Porrhomma cavernicolum* (Keyserling) from three new localities, and *Nesticus pallidus* Emerton (fam. Nesticidae) and *Nesticus carteri* Emerton from one new locality each.

14. Salamanders - New records have been accumulated for nearly all of the thirteen species of plethodontid salamanders (fam. Plethodontidae) known to inhabit Virginia and West Virginia caves. The following new records are of significant interest: *Eurycea lucifuga* Rafinesque, nine new locations; *Pseudotriton p. porphyriticus* (Green), seven new locations - mostly in southwestern Virginia; *Plethodon w. wehrlei* (Fowler and Dunn), two new locations; and *Aneides aeneus* (Cope and Packard), one new location.*

15. Bats - Significant range extensions have been obtained for *Myotis sodalis* Miller and G. M. Allen. Two small winter colonies were observed in Clover Hollow Cave, Giles Co. and Newberry-Bane Cave, Bland Co. in January and February respectively. A large summer colony of *M. sodalis* was observed in Grigsby Cave, Scott Co. in August.

One new record, Bennet's Cave, Tucker Co., West Virginia, was obtained for *Plecotus townsendii virginanus* Handley in April.

Two specimens of the rare Leib Bat, *Myotis subulatus leibii* Audubon and Bachman, were sighted in Starr Chapel Cave, Bath Co. in February.

CONTRIBUTIONS

A total of nine papers have been written as a result of the work completed by members of the Survey. A list of these numbered contributions follows:

No. 1 – Cooper, John E., 1962, Cave Records for the salamander *Plethodon r. richmondi* Pope, with notes on additional cave-associated species: *Herpetologica*, 17:250-255.

No. 2 – ________ 1961, Some accumulated biospeleological data: *Baltimore Grotto News*, 4:87-91.

No. 3 – Holsinger, John R., 1961, Southwestern Virginia caves; Part III - biospeleological data: *D. C. Speleograph*, 17:91-93.

No. 4 – Cooper, John E., 1962, A discussion of practical and theoretical categories in biospeleology: in manuscript.

No. 5 – Conrad, Lyle G., 1961, Distribution problems concerning the long-eared bat, *Plecotus townsendii virginianus: D. C. Speleograph* 17:49-52.

No. 6 – Cooper, John E., 1962, Cave-associated salamanders of Virginia and West Virginia: *Baltimore Grotto News*, 5:43-45.

No. 7 – ________ 1962, Wehrle's Salamander, *Plethodon w. wehrlei*, from a Highland County, Virginia cave: *Baltimore Grotto News*, 5:53.

No. 8 – Holsinger, John R., 1962, Annotated checklist of the macroscopic troglobites of Virginia with notes on their geographic distribution: *Bull. Nat. Speleol. Soc.*, in press.

No. 9 – ________ 1962, The biology of Virginia Caves: In Caves of Virginia. Virginia Division of Mineral Resources, in press.

More contributions are planned, and papers will be published as the accumulation of new data warrants.

**This species was collected in Johnson Cave #2, Russell Co. in August 1961. This was the first cave record for* Aneides aeneus *in Virginia.*

CONSULTATION

The following systematists have been actively engaged in the identification of the taxa noted: Dr. Thomas C. Barr, Jr., Carabidae; Dr. Nell B. Causey, Diplopoda; Dr. Willis J. Gertsch, Araneae; Dr. Libbie H. Hyman, Turbellaria; Dr. Ashley B. Gurney, Gryllacrididae; Dr. Horton H. Hobbs, Jr., Astacidae; Dr. Clarence J. Goodnight, Phalangodidae; Dr. David L. Malcolm and Dr. William B. Muchmore, Chelonethida; Dr. G. E. Gates, Lumbricidae; Mr. Harrison R. Steeves, III, Asellidae; and Dr. David L. Wray, Collembola.

INSECTS AND SPIDERS OF CAVES OF COLORADO AND SOUTH DAKOTA

Robert W. Ayre
East Northport, N. Y.

(Abstract)
A semi-popular account of recent field work by Members of the NSS and the Colorado Chapter of the NSS. Stress was on the spider fauna of Fly Cave, Colorado.

NOCTURNAL MIGRATION OF *HADENOECUS SUBTERRANEUS*

Brother G. Nicholas, F.S.C.
Department of Biology
University of Notre Dame

(Abstract)
A study was made on the population fluctuations of the cave cricket, *Hadenoecus subterraneus*, in Cathedral Cave (37° 12' 50"N.; 86° 03' 11"W.), Mammoth Cave National Park, Edmonson County, Kentucky. Daily observations, averaging three hours each, were made from 26 November, 1960, to 28 February, 1962. Twelve quadrats were established at 10 foot intervals throughout the cave. Three of these are in the entrance zone, three in the twilight zone, and six in the dark zone. All observations of activities of *H. subterraneus* were made in these quadrats.

Over 3,000 crickets were marked with pigmented shellac. A coding system was developed so that time and place of marking, and place of recapture could be determined. Supplemental observations were made on cave crickets in twelve nearby caves. Data were obtained on mortality, mating behavior, migration, homing tendencies, predation and food habits, although only nocturnal migration is considered in this paper.

All observations made in Cathedral Cave have been codified on 3,400 I.B.M. cards. A program was written for use in an I.B.M. 1620 computer that enabled determination of total population; mean densities, standard deviation and standard error of each species (including *H. subterraneus*) per quadrat and per zone; weekly, biweekly and monthly means of all environmental parameters; and correlation of these parameters with population fluctuation of all species.

H. subterraneus comprises approximately 75% of the total population of Cathedral Cave considered on an annual basis. It is troglophilic, periodically leaving the cave to feed. Its droppings constitute an important nutritive source for troglobitic (obligative cavernicoles) species within the cave. Minor fluctuations of the *H. subterraneus* population occur in each zone of the cave with an overall decrease of about 10% during the summer compared to the rest of the year.

A daily nocturnal migration occurs with one-third of the total population of *H. subterraneus* from all quadrats leaving the cave after twilight and returning before dawn. This movement is for feeding purposes. It does not occur when the temperature is below -5°C and/or the relative humidity is less than 85%. 97% of all marked individuals recaptured during the day were found in their home quadrats. Similar migrations have been noted in surrounding caves within the Mammoth Cave National Park and in caves of the Edwards Plateau in Texas, although no marking has been done on individuals in these latter caves.

The other species of cave cricket present, *Ceuthophilus stygius*, constitutes less than 2% of the total population and displays no migratory movements.

BAT BANDING IN VIRGINIA AND WEST VIRGINIA*

Lyle G. Conrad
Biological Survey of Virginia Caves

Needless to say, Virginia and West Virginia contain numerous caves. This area is one which has had only preliminary investigations made in respect to the study of bats. In fact, determinations of the life histories of bats throughout the United States leaves much to be desired.

Knowledge of the habits of bats is important for various reasons. In the biological consideration of caves, knowledge of bats is necessary if various ecological studies are to be made. Since the rabies problem appears to be increasing, it will be profitable to know ranges and migratory routes of various species of bats. Further information is also desirable from an academic standpoint.

Cavers can help biologists interested in bats by taking note of approximate population sizes, locations, dates, possibly identification of species. If

**Contribution No. 11 from the Biological Survey of Virginia Caves, a research project of the National Speleological Society.*

the bats are banded, they could, with the aid of gloves, read the band numbers and send them to the Fish and Wildlife Service, Department of the Interior, Washington, D. C.

Bats often found in the Virginia caves include the Little Brown Bat, *Myotis lucifugus;* Big Brown Bat, *Eptesicus fuscus;* Pipistrelle, *Pipistrellus subflavus;* Indiana Cave Bat, *Myotis sodalis*; and the Bigeared Bat, *Plecotus townsendii virginianus.*

Others appear from time to time. Relatively rare cave species include the Leib's Bat, *Myotis subulatus leibii;* Gray Bat, *Myotis grisescens;* and Say's Bat, *Myotis keeni septentrionalis.* These are all very similar to the Little Brown Bat and are difficult to distinguish. The Say's Bat has slightly longer ears.

Tree bats are probably as common as cave dwelling bats in the Virginias, but are not easily caught. A report has been made of the Silver-haired Bat, *Lasionycteris noctivagans,* as having been seen in a Virginia cave. This is a tree bat and is rarely found in caves. It's dark brown pelage, tipped with silver makes it easy to identify. Two other tree bats, the Red Bat, *Lasiurus borealis* and the Hoary Bat, *Lasiurus cinereus,* would also be worth looking for. The Red Bat is about the same size as the common Little Brown Bat, but has a reddish tinge, whereas the Hoary Bat has a whitish tinge on almost black pelage and is much larger. Having a wingspan of about fourteen inches, it is the largest of the bats in the eastern United States. LeConte's Big-eared Bat, *Plecotus raffinesquii,* supposedly not found in caves, is similar to the cave dweller of the same genus.

Wayne Davis indicates that populations of the Indiana Cave Bats and the Big-eared Bats of the East, *Myotis sodalis* and *Plecotus townsendii* respectively, are decreasing in numbers rapidly. (*BAT BANDING NEWS,* Vol. 3, No. 1, January 1962, pp. 2-6). Various causes may exist: spelunking pressure, collecting by zoologists and physiologists, "sporting cavers" who like to golf bats off ceilings, and possibly disease. It would be helpful to find more populations of these species so that they might be protected.

The author started to band bats in the Virginias in 1960. So far, a meager dent has been made in the banding of bats and the determination of their life histories. It is hoped, that with the use of mist nets and other apparatus, more knowledge will be gained soon.

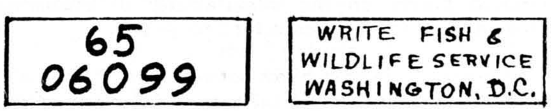


Figure 1
Different size aluminum bands are usually clamped on the wings of bats. The size of the band depends upon the size of the bat. When recording band numbers, be sure to read as many digits as possible. Sometimes skin grows over part of the band. The numbers are on the outside of the band, as seen on the diagram on the left. When uncurled, one will find the information in the diagram on the right on the inside of the band.

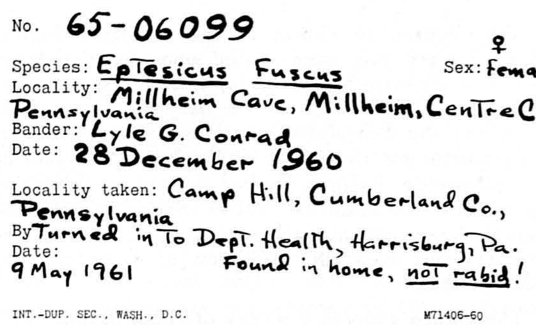

No. 65-06099
Species: Eptesicus Fuscus Sex: ♀ Female
Locality: Millheim Cave, Millheim, Centre Co., Pennsylvania
Bander: Lyle G. Conrad
Date: 28 December 1960
Locality taken: Camp Hill, Cumberland Co., Pennsylvania
By Turned in to Dept. Health, Harrisburg, Pa.
Date: 9 May 1961 Found in home, not rabid!
INT.-DUP. SEC., WASH., D.C. M71406-60

Figure 2
Actual example of card kept by the Fish and Wildlife Service after bander sends in data. Information on returns is recorded under "Locality taken."

Geology Session

ON THE DEFINITION OF A CAVE

Rane L. Curl
Department of Statistics
University College, London

(Abstract)

A cave is a space rather than an object and consequently its definition involves the specification of its boundaries. This can be done in various ways for different purposes, but all definitions must involve a minimum dimension, if only to separate "cave" from such contiguous spaces as intercrystalline pores. It is proposed therefore to specify a defining dimension or module for a cave for its entrances. The problem of associating a suitable shape with the module is discussed.

Caves defined by a module of human size and shape are termed Proper Caves as they are customarily given proper names when assessible. Proper entrances may be defined similarly although proper caves may or may not have proper (and natural) entrances.

Because this concept provides a uniform basis upon which other cave properties may be studied it is useful in applications. In addition it suggests a possibility of reasonably clearly separating caves into groups according to their module range.

SOME CONSIDERATIONS ON THE USE OF NATURAL CAVES AS FALL-OUT SHELTERS IN NORTH ALABAMA

W. W. Varnedoe, Jr.
Huntsville, Alabama

INTRODUCTION

The Huntsville Grotto of the National Speleological Society has been called upon by the Army, the National Guard of Alabama, the Madison County Civil Defense Director, and the Mayor of Huntsville as well as the Brown Engineering Company, who is the contractor for the Corps of Engineers conducting the nation-wide Fallout Shelter Survey and Marking Program in North Alabama. All of these agencies and officials have sought information on caves in the North Alabama area with the view of using them as fallout shelters.

The Grotto adopted a policy of cooperation. With any other approach, the various organizations would merely go off on their own and with improper knowledge might get hurt or damage the caves.

To properly aid these people, however, we must understand the nature of their requirements and make known to them the limitations of caves to meet these requirements.

CONSIDERATIONS

In order to evaluate the effectiveness of caves as shelters from atomic explosion fallout containing radiation hazards, the nature of the danger must be understood.

Utilizing this understanding, cave types that are not suitable without extensive work or modifications are listed. The caves' relative abundance for each type is used to obtain a per cent figure of caves that might offer protection. This data is taken from the caves of Madison County, North Alabama, as listed on the Alabama State Cave Survey.

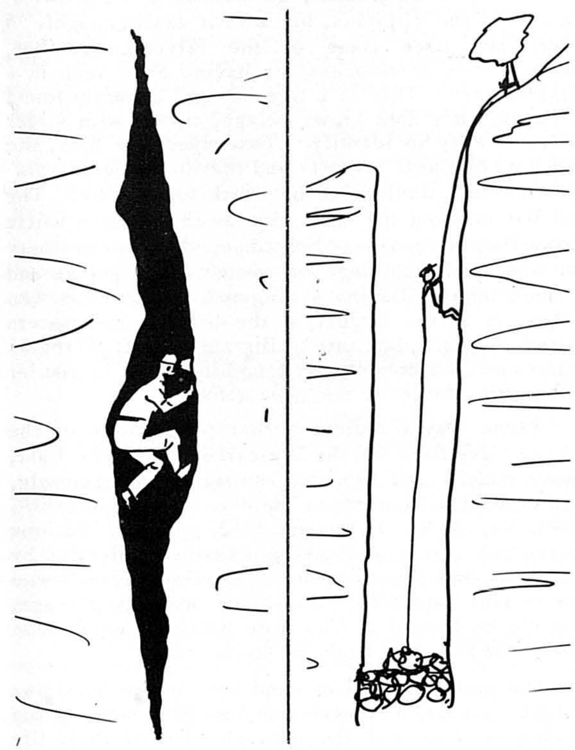
Atomic explosions cover such extensive areas and the modern means of delivery are so swift that in this paper no consideration is given to blast protection. This paper will assume that the bomb missed, or was aimed elsewhere.

Explosions of this nature generate radioactive clouds composed of debris of the bomb as well as dust sucked up into the cloud and contaminated there. This dust and/or rain later falls out and becomes a radio-active hazard. This dangerous fallout area is many times the blast damage area.

Most of the atomic debris that concerns us has a short half-life. This means, according to Civil Defense authorities, that if we can protect ourselves for about two or three weeks, the radioactivity will have fallen to within tolerable limits.

The radioactivity itself, consists of three kinds; α, β, and γ rays. γ rays are the strongest and, dependent on their energy, can penetrate 2 feet of concrete. α and β rays can be stopped by cardboard, plastic, or almost anything. They are however, present in abundance and *must not be ingested.* If radioactive dust is breathed, rests on the skin, or is drunk in contaminated water, the radioactivity lodges in the body. Since radiation dosage is accumulative, such ingestion, even small amounts, can be fatal.

In the light of the nature of the hazards, caves can be broken down into eight categories that are not suitable as shelters for the following reasons:



Type 1 (left above)
Too small in cross section or floor area. These are eliminated purely on the unsuitability of cramming humans in such environments for two weeks.

Type 2 (right above)
There is no protection from fallout at all in open pits, therefore, these pits are not suitable. If horizontal passages exist at the bottom, these are listed with Type 7.

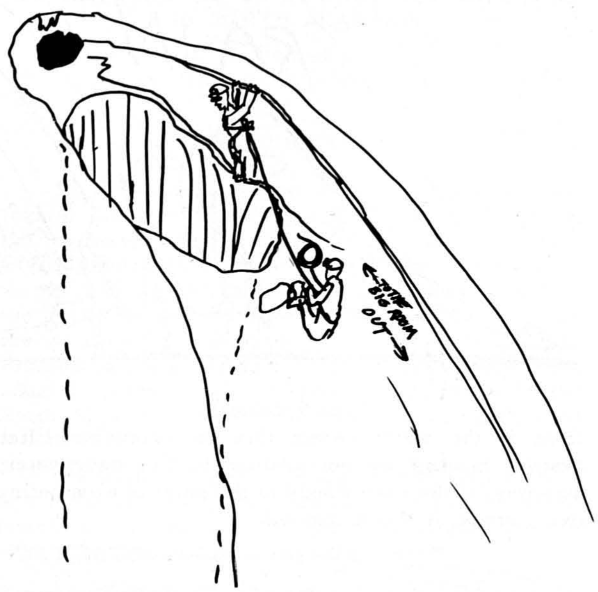
Type 3
Blowing caves, which includes both those based on the heat sink effect with elevation difference of entrances and two-entrance caves with a wind blowing into one of the entrances. An "entrance", here, is taken to mean any crack thru which wind can enter, whether or not spelunkers can follow. Any wind entering the cave can and will bring in radioactive dust. In many such caves sealing all the cracks is not feasible. Since dust will be a prime source of rays, these caves are not useful. The dust is assumed to be of the consistency of face powder.

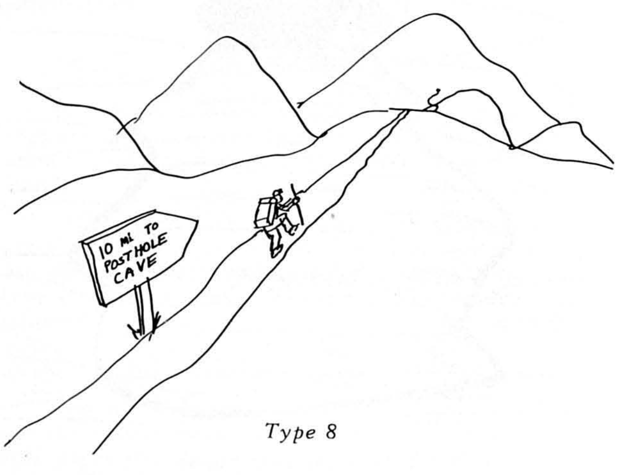
Type 4 (above)
If a surface stream enters the cave directly, it will wash in all types of radioactive debris and may even accumulate radioactivity inside the cave.

Type 5 (below)
What was true of Type 4 is also true of these caves, with streams flowing out. This contamination can include the ceiling drips too, since it would be difficult to determine the amount of filtering the water has had.

Type 6 (below)
Even if the water enters thru an extensive filter system, humans are not adapted to live underwater; therefore, if the cave floods to the point of eliminating living areas, it was discarded.

Type 7 (on next page)
Can you imagine a hypothetical huge dry room at the back Schoolhouse Cave, suitable as a fallout shelter in every way, except, how to get there? Anyone who has had experience in the expense of putting paths into commercial caves, knows the problems with this type cave. Since Civil Defense Projects are notoriously short of funds, caves with suitable rooms, but only accessible after difficult muddy crawling, pitwork or other strenuous activity, have been dropped from consideration.





Type 8

The problems encountered in just trying to get to some caves are a part of the tall tales of every spelunker. So, if the cave would require construction of bridges and long roads, or is just too remote from population centers, it has not been considered.

The caves of the Alabama Cave Survey were tabulated and typed according to these eight classifications in Table I. Since to a certain extent these types are independent of each other, the Cumulative Percent Suitable is the product of the previous Remaining Percent and the Percent Left by that particular feature. That is, if 85% of the caves are too small, then 15% are big enough. Of these, 6% flood (and 94% don't) so of the 15% big enough, 94 don't flood, and thus, .15 x .94 = .14, so, 14% are suitable from these two standpoints. This procedure is carried out for all eight types of elimination and the conclusion is reached that 1.8% of the caves are suitable to convert to shelters. In Madison County, there are 98 caves thus; one would expect to find two suitable caves. In fact, there is only one, in the author's opinion.

Table I

No.	Type	Percent of Total	Percent Remaining	Cumulative Percent Suitable
1	Too small	85	15	15
2	Pits	25	75	11
3	Blowing	15	85	9.5
4	Stream in	14	86	9.25
5	Stream out	15	85	7
6	Floods	6	94	6.5
7	Too difficult	70	30	2
8	Inaccessible	10	90	1.8

The word "convert" is used because even commercial caves need some work to be suitable. They must be stocked with supplies, food, and medicine. Water must be stored inside. (Most cave water is not potable even without fallout) and the entrance must be sealed, not just secured, and a filtered air source installed.

For those few caves that do turn out to be suitable, it might be easier to construct some sort of frame and chickenwire house or rooms with connecting tunnels in the cave, then cover these with plastic sheets to make an effective seal against atomic dust and moisture. Of course, these houses, or rooms, would need floors to smooth out the breakdown or keep out the mud. Such flimsy houses, however, might be cheaper and easier to build than 2-foot-thick concrete or excavated shelters outside.

With the work involved in even the good caves, the shelter should handle a sizeable number of people to justify the effort, which further restricts those caves left over from Type 1.

The Corps of Engineers' nationwide survey has set a minimum of 50 people per shelter with a minimum living area of 500 square feet.

Considering the population of North Alabama, caves cannot be a prime shelter source and only in isolated cases can they be used as auxiliary shelters after some work.

Civil Defense authorities believe that in urban areas, there will be enough, in fact a surplus, of suitable buildings. Caves would be most useful in rural areas where big buildings are scarce or non-existent.

APPLICATIONS OF EXPERIMENTAL GEOLOGY TO PROBLEMS IN CAVERN DEVELOPMENT

Ralph O. Ewers
Cincinnati Museum

(Abstract)
Prevailing theories of cavern development have been based largely on the analysis of data collected in field observations of caves in which an uncertain and probably highly complex series of events and conditions have played important formative roles. An analysis of a single genetic factor is nearly impossible in a natural cavern due to the super-position of the factor on pre-existing features or the subsequent addition of still more factors.

Therefore, experimental geological techniques involving a limited number of controlled variables may serve to clarify our recognition of specific factors in speleogenesis.

The author has attempted to evaluate experimentally the effects of phreatic solution on a wide variety of joint and bedding plane configurations under graded and artesian conditions, emphasizing the early formative period, and comparing these effects to observable cavern features. These experiments indicate that phreatic solution takes place in all joint and bedding plane systems which is maximum at or nearest the upper surface of the phreatic zone, decreasing roughly exponentially with depth and favoring a shallowest-possible phreatic origin for most caverns.

SUBMERGED KARSTIC FEATURES IN THE FLORIDIAN PLATEAU

Louis A. Hippenmeier
University of Florida

(Abstract)
Many flooded caves in Florida contain evidence that they have been dry at some time in the past. In addition, sinkholes have been detected in the Straits of Florida and in the Gulf of Mexico at a depth of as much as 1,500 feet below sea level. It is believed that many of these sinkholes and caves developed under vadose or shallow phreatic conditions and were inundated by eustatic changes in sea level during the Cenozoic, coupled with a gradual downwarping of portions of the Floridian Plateau as a result of isostatic compensation for the Ocala Uplift and regional downwarping of the earth's crust as a result of the developing geosyncline in the Gulf of Mexico.

A METHOD OF PREPARING CAVE INDICES AND SOME PRELIMINARY RESULTS ON LOCATION AND SIZE DISTRIBUTION FOR CAVES IN THE UNITED STATES

Richard R. Anderson
Red Bank, New Jersey

(Abstract)
Information on more than 11,000 caves in the United States, plus many foreign caves, is now in the NSS Cave Files. A method of indexing much of this information is described. The cave name and location is given in full. Other data, as cave type, size, entrances, and special equipment needed, is coded to conserve space, and the key to this code is described. Provision is also made for extending the indexing system to include biological, geological, and other special data, and to provide for such problems as caves with multiple names, or with multiple entrances.

As of July 1, 1962, the information for over 6,000 caves, representing 43 of the states, has been indexed.

With the method described, the data can be processed by regular accounting machines, and several examples of the possible results are shown. One is a map of the U. S. (not printed here) showing the distribution of caves within the country. A second sample (to be found on the next page) is a table showing the length distribution stages, with a rough breakdown by types. This table also shows how the number of known caves has increased since 1943, when Morgan published an index to the caves known at that time.

Some conclusions are drawn as to the usefulness of this type of index, and the effects of making the indices available to cavers (and possibly to others). In particular, conservation is stressed, and a special provision is made so that in certain cases the exact location can be deleted before the index is printed.

OBSERVATIONS OF HIGH ALTITUDE CAVES IN GUATEMALA

Russell H. Gurnee
Closter, New Jersey

(Abstract)
Guatemala, largest of the Central American Republics, has three distinct regions: the lowlands

(continued on page 109)

PRINTED 7/22/62

STATE	B05 + B06	FILES 1960	FILES INDEX 1962	MAPS	SØLN	NØN-SØLN	RØCK SHLTR	RUMØR ØR RPTD	LENGTH DISTRIBUTIØN 0	1	2	3	4	5	6	7	8	9	ST
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ALABAMA	51	69	550	329	428	16	2	68	24	86	81	87	67	14	14				AB
ALASKA	1	15	27	0	11	10	1	5	0	2	4	7	.	.	.				AL
ARIZ	22	74	156	22	104	9	15	24	2	6	22	19	16	6	.				AZ
ARK	18	21	187	6	32	1	6	82	0	1	4	7	3	5	0	1	1		AK
CALIF	102	381	796	70	163	451	89	270	28	90	81	48	13	3	1				CF
CØLØ	9	32	118	25	69	20	11	36	2	14	16	15	6	7	.				CD
CØNN	27	8	60	18	7	28	15	28	3	16	5	2	1	.	.				CT
DEL	0	1	1	1	0	1	0	0	0	0	1	.	.	.	.				D
FLA	1	17	187	20	153	0	0	13	5	20	19	17	4	0	1				FL
GA	4	38	57	12	26	5	0	12	0	8	8	6	11	2	1				GA
HAWAII	0	1	50*	0					0	0	2	.	.	.	.				H
IDAHØ	36	42	70	7	10	55	1	8	1	0	1	0	4	8	4				ID
ILL	17	34	116	22	101	3	4	10	6	13	13	14	14	3	1	1			IL
IND	67	108	498	62	407	7	9		4	10	44	48	37	19	11	1	1		IN
IØWA	10	128	274	105	242	10	2	30	10	117	65	24	5	3	6				IA
KANSAS	6	5	44	5	37	0	2	11	2	4	4	4	3	4	1	1			KA
KY	109	148	197	2					0	2	10	5	5	4	.			(2)	KY
LA	0	0	1	0	1				0	1	.	.	.	.	.				LA
MAINE	29	33	34	2	1	8		25	0	5	0	2	.	.	.				ME
MARYLD	19	30	64	16	44	6		8	4	17	16	9	7	.	.				MD
MASS	78	76	86	15	28	29	5	30	2	12	14	5	.	.	.				MA
MICH	0	1	19	1	3	5		11	5	2	0	4	.	.	.				MC
MINN	3	4	100	0	81	11	1	81	4	11	38	5	16	6	2	1			MN
MISS	2	2	11	0	4	1		1	0	2	2	3	2	.	.				MS
MØ	132	225	1100*	250*					-										MØ
MØNT	15	40	152	19	92	1	1	1	0	4	9	10	4	4	.				MT
NEBR	1	1	3	0	0	3	1		0	1	.	.	.	.	.				NB
NEVADA	27	45	130	27	66	12	16	17	6	13	14	10	9	2	1				NV
N H	23	9	29	2	0	10	9	16	2	3	0	1	.	.	.				NH
N J	4	30	98	39	72	11	11	6	15	35	15	7	1	1	.				NJ
N M	13	50	148	18	71	22	28	32	1	8	8	6	5	4	2	1	1		NM
N Y	22	135	400*	71					-						(3)				NY
NØ CAR	7	4	7	1	1	4		2	0	1	2	.	.	.	.				NC
NØ DAK	1	2	5	0	3	1		1	0	2	1	.	.	.	.				ND
ØHIØ	37	48	46	4					-										Ø
ØKLA	1	174	174	4					-					(2	0	1)			ØK
ØRE	4	24	112	4	24	65	8	62	1	22	12	8	4	5	2				ØR
PENNA	154	346	458*	169					-										PA
R I	3	2	0	0	0	0	0	0	0	.	.	.	.	.	.				RI
SØ CAR	3	2	2	0	2	0	0	0	0	0	1	.	.	.	.				SC
SØ DAK	13	19	39	9	31	1	3	11	0	3	6	4	4	0	0	1			SD
TENN	137	174	700*	38					-					(10	4)				TN
TEXAS	9	268	1031	21					7	53	28	14	15	5	4	1			TX
UTAH	7	87	228	89	125	54	18	37	9	40	50	22	15	2	1				UT
VT	42	29	83	9	44	23	0	31	2	14	17	10	0	0	1				VT
VA	154	.	1783*	250*					-										VA
WASH	0	24	116	33	34	53	20	0	18	32	18	9	7	6	3				WA
W VA	114	188	500*	67					-								(1)		WV
WISC	6	6	122	17	53	25	1	42	0	30	21	13	12	2	.				WC
WYØMING	2	10	34	4	22	1	2	8	0	3	4	3	2	0	1				WY
* = CATALØG NØT CØMPLETED. NUMBER ESTIMATED.																			
TØTAL	1563	3217	11203	1881					153		656		292		64	9	4	2	US
CATALØGED - 6195 - 43 STATES										703		448		125					US

LENGTH ØF CAVE/ TØTAL TRAVERSABLE PASSAGE

0= 1-20 FEET	6= 1-3 MILES
1= 20-60 FEET	7= 3-10 MILES
2= 60-200 FEET	8=10-30 MILES
3= 200-600 FEET	9=30-UP MILES
4= 600-2000 FEET	L=BELIEVED LARGE
5=2000-5280 FEET	S=BELIEVED SMALL
*=PIT/ NØ HØRIZØNTAL PASSAGES	

CAVES IN GUATEMALA cont.

(Pacific and Peten), the midlands, and the highlands. These regions, brought about by volcanic activity and block faulting, have made the east-west chain of mountains the highest in Central America.

Cretaceous limestone, laid down on the present midlands, has been fractured, twisted and thrust up to elevations in excess of twelve thousand feet by faulting action and earth movement.

The Cuchumatanes Highlands are a limestone horst thrust up to 13,000 feet, and cover an area of about 1,200 square miles. Erosion of this plateau has taken place underground and many of the springs and rivers 5,000 feet below have their source in the plains of the Cuchumatantanes.

Exploration by the NSS in November, 1961, resulted in the recording and photographing of six caves above the 8,300-foot-level and one cave at 11,400 feet. Samples of limestone, fossils and karst development were noted at 12,100 feet.

An Indian sacred ritual cave was mapped, and underground stream surveyed and many pits and chasms explored.

A selection of color slides showed some of the terrain and interior cave scenes.

FURTHER WORK ON THE TOLLY PROJECT

William J. Stephenson
Bethesda, Maryland

(Abstract)

At the 1960 Convention, a report was given on preliminary work which had been done at Tolly Cave, Va., in an effort to obtain a reasonable figure for the minimum time required to form a cave. Tolley Cave being a simple, one channel cave which was probably formed by free surface stream solution, it was thought possible to compute the present volume of the cave, measure the rate of stream flow and the amount of solids added to the stream while passing through the cave and from these factors, compute the minimum time required to form the cave.

The first readings gave a time of about five million years. Further work has shown that solution conditions are not constant as previously presumed but tend to vary greatly. Additional observations would give figures requiring a length of time which would appear to be inconsistent with other known geological data. It is quite possible that at some time during the life of the cave, conditions must have existed which would have promoted cave formation much faster than the present rate. Another interesting fact is the discovery that under some conditions the stream is depositing material in the cave rather than removing it.

SPELEOLOGICAL POTENTIAL OF THE BOB MARSHALL WILDERNESS AND ADJACENT AREAS

C. Howard McDonald
Montana Speleological Survey

Ever since serious cave study began in Montana, the Bob Marshall Wilderness Area has been the subject of considerable interest and speleological speculation. Here is one of the most remote areas of the United States, larger than the state of Delaware, and containing immense potential for both surface and subterranean exploration. Information currently on file with the Montana Speleological Survey would seem to indicate extremely favorable conditions for the development of extensive cave systems, both vertical and horizontal.

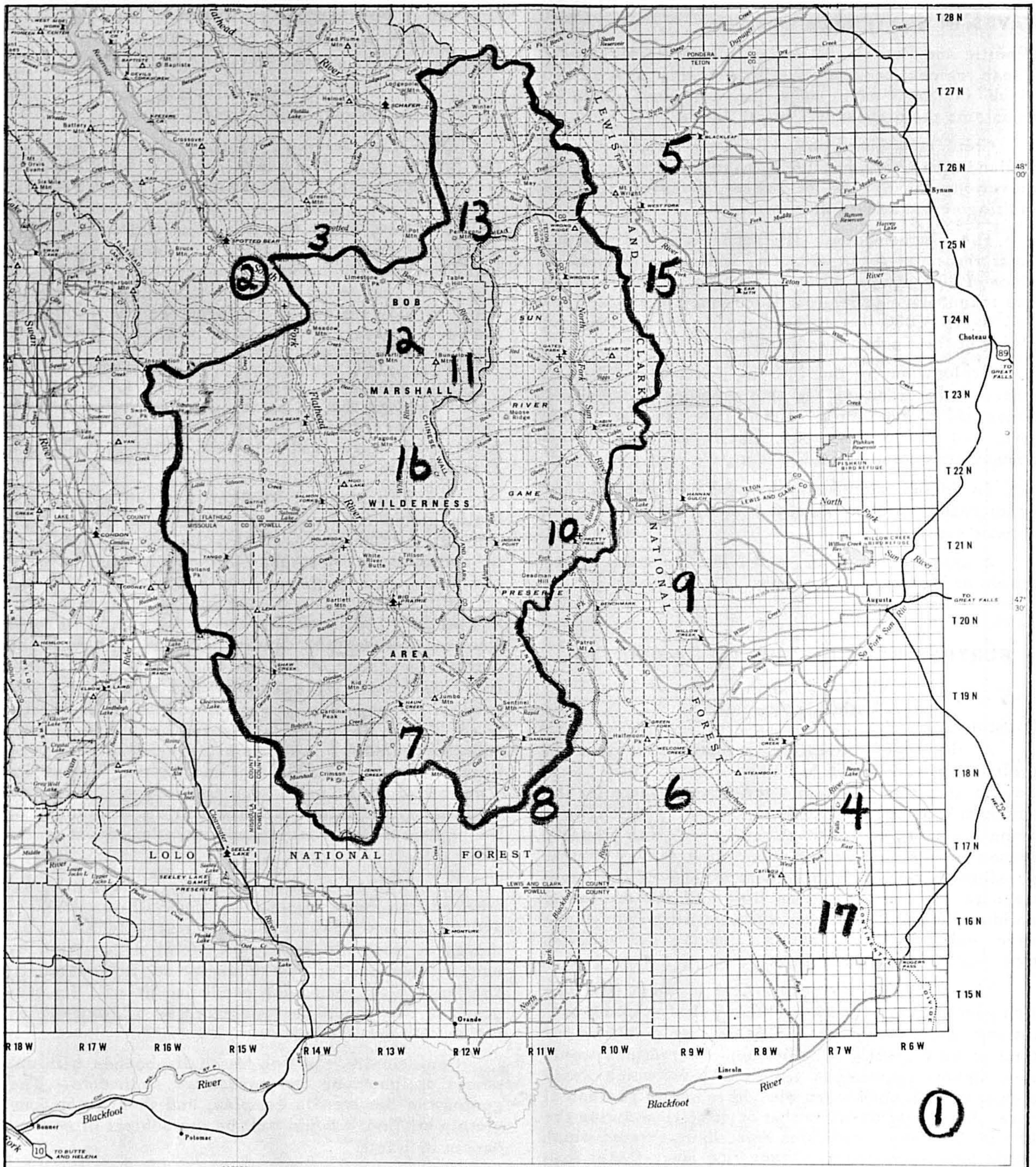
While admittedly, a portion of this speculation is based on data that in some cases is not completely verified, the information on hand should be put in proper perspective and analyzed. This is the intent of this paper.

The Bob Marshall Wilderness is a tract of Federally owned land containing approximately one million acres. The area straddles the continental divide in northwestern Montana. An erratic boundary encompasses nearly all territory between 47° 15'' and 48° 10'' North, bounded east and west by 112° 50'' and 113° 40'' West. It is carved from parts of three National Forests and several counties. Here is the northern backbone of the nation, with waters flowing into numerous river systems and eventually, two oceans. Topography is varied, and consists chiefly of the Rocky Mountains, and several sub-chains; high mountain meadows and basins, divided by towering peaks that achieve 9000 feet and higher. Except for a number of trails, occasional fire lookouts and a few seasonal ranger stations, this area is wilderness of the highest degree, unchanged since the advent of the white man.

In addition, an area measuring practically another million acres adjoins Bob Marshall on all sides, and for all practical purposes is true wilderness, although it does not possess Federal designation as such. Because of its proximity to Bob Marshall, similar geology and wild condition, it will for purposes of this report be considered as a homogeneous region with the Marshall Area.

Geologically, the Bob Marshall abounds with deposits of limestone and associated sediments. The geology of the area is complex, and though not completely studied, it could well be the subject of several papers by itself.

Limestones of Cambrian age, including the Helena limestone, occur throughout the area. The "Chinese Wall", a mighty escarpment that forms the continental



Reprinted from the Forest Service map "Flathead National Forest, Northern Region"
Forest Supervisor, Kalispell, Montana

divide for 15 miles, runs through the area, and is composed chiefly of Cambrian deposits. This natural barrier reportedly has but a single crossing in its entire length, and varies from 50 to 200 feet in height. Caves have been reported along the wall in widely separated areas.

The Jefferson Limestone of Devonian age is widely scattered throughout the area, and while no caves are known to definitely exist in the Bob Marshall deposits of the Jefferson, they do occur elsewhere in this formation.

The Madison Limestone of Mississippian age is common across the Bob Marshall and is the most speleoiferous limestone in the region. Numerous caves have been reported and studied within the area and along its fringes, all in the Madison formation. It is interesting to note that nearly all major Montana caves occur in the Madison.

A preliminary study of the Bob Marshall and adjacent areas indicates that at least three major conditions exist that are conducive to cavern formation. They are: Existence of an abundance of limestones, known to be cave-bearing; the existence of major faults and associated features, the Lewis Overthrust being the prime example; and the tremendous surface and subsurface drainage from the run-off of abundant snow and rain fall the year around.

Actual exploration of the Bob Marshall area would be a formidable task for any cave-hunter, geologist or prospector. Its size makes systematic research, except in small areas, an impossibility. Those of the caving fraternity accustomed to improved roads to cave areas, with a mile or so hike beyond the limits of an automobile, may well turn away in dismay when confronted with a 40, 50 or even 60 mile hike along primitive trail, traversable only on foot or by pack train. Even the avid outdoorsman may think twice before attempting a trip that requires weeks of wilderness living, far from the trail. These are the chief reasons that Bob Marshall Area holds its secrets well.

However, we are indebted to a small but determined handful of souls who have ventured out to view this area's wonders, and returned to report their impressions. Fortunately, many have had more than just a passing interest in caves, and have made it possible for us to compile a preliminary survey, thus pinpointing areas that hold speleological promise. To these adventurers we are indebted.

For purposes of this paper, the reports on file with the Montana Speleological Survey were divided into two categories. Caves known definitely to exist, which have been, at least partially explored, and cave locations that have been reported by reliable sources, but where little or no exploration and study has been accomplished. Unverified rumors, for the most part, were discarded for the time being and are not included.

Several sizeable caves exist on the fringes of the Bob Marshall and its adjacent areas. While quite removed from the Wilderness, Ophir Cave (1 on map), near Helena, Montana, lies practically on the continental divide, and is located in a region geologically similar to Bob Marshall. Ophir is basically a cave consisting of two rooms, both quite large, and located one directly above the other. These chambers are connected by a breakdown filled crevice that opens into the ceiling of the lower room. This connection can be traversed by extensive crawling through breakdown and rigging the 40 foot drop into the lower room. Ophir Cave is quite speleothemic and very interesting, presenting a few complex problems of speleogenesis. A report published in an NSS Bulletin several years ago, speculated that Ophir was quite deep. The ensuing activity by Montana cavers to disprove this report led to the formation of the Montana Survey.

Two caves near Spotted Bear Ranger Station, on the northwest corner of the Bob Marshall are of interest, and both possibly indicative of the types of caves the Wilderness may contain. Spotted Bear Lookout Cave (2 on map) was first explored by a crew led by Basil Hritsco in July of 1955. The cave is reported to be only 40 feet deep, with a 200 foot room at the bottom. However, it can be considered typical of the small sinkhole caves found elsewhere in Montana.

Limestone Cave (3 on map) is nearby by Montana standards, a scant 15 miles up the Spotted Bear River from the Ranger Station. It has been described by the Forest Service as a rather extensive cave, but no thorough exploration has been recorded. It is known to contain several sizeable chambers, but the exact size is unknown. Limestone Cave is located in a major limestone area, and other caves in the area are highly probable.

Several caves on the eastern edge of the Rockies were explored in the early 50's by a Hritsco crew. The two major caves, Bean Hole and Foggy Brennan Cave are the chief caverns in this group. Although not sizeable by Montana standards, these two caves contain much of speleological and possibly archaeological interest. The story behind the naming of Foggy Brennan Cave has become a part of Montana caving folklore.

The discovery of Volcano Reef Cave (5 on map) was the result of a story that began over 50 years ago when residents of the Blackleaf Canyon area reported a volcano in action on the north side of the canyon. This caused considerable consternation among the local population, and was the subject of several sensational pieces of early day journalism by the Great Falls Tribune. Inasmuch as this phenomenon occurred in the coldest months of winter, in a known limestone area, latter day cavers postulated the existence of a cave. Volcano Reef proved to be limestone and the cave was located by Hritsco with a minimum of effort in the summer of 1961. The cave appears to be quite deep, but exploration has been hampered by the instability of one wall inside the entrance. A steady and quite strong draft issues from the cave, indicating the possibility of chambers below.

Other caves are known to exist on the outlying reaches of the Northern Rockies, but most are of minor interest, at least for purposes of this report.

Deeper into the Bob Marshall, our cave reports grow more numerous, while at the same time more indefinite. Some reports border on the tall tale category. Others seem too logical to be untrue, leading therefore to considerable speleological speculation.

Scapegoat Mountain (6 on map) on the southern reaches of the area has been reported to be partially honeycombed with caves. There are positive indications that there is underground drainage from its summit to base. Cave Creek on the northeast slope of Scapegoat reportedly has many cave entrances along its bands. An old-time guide and packer quite familiar with the area told of taking hunting parties into the Scapegoat country. He reported the parties would camp in a high alpine meadow between two of the three peaks of Scapegoat. Horses were always tethered at night because of the numerous crevices in the area. These openings reportedly vary in width from several inches to 10 and 15 feet. The bottoms are not visible. Perennial ice or snow is, according to the reports, lacking in these fissures, indicating the possibility of drainage of the discharge of a high volume of air at periodic intervals. This is supplemented by another report of a cave entrance about halfway up Scapegoat, containing a waterfall that disappears into a sizeable pit.

West from Scapegoat Mountain, cave entrances have been reported on Foolhen Mountain (7 on map) by the USGS. Apex Mountain (8 on map) between Scapegoat and Foolhen reportedly contains a huge cave entrance on one face. To the north, caves have been reported at Sheep Sheds (9 on map) and Pretty Prairie (10 on map). Information from USGS files indicates many entrances leading to small caves. However, thorough investigation has not been made in either area.

A pilot, and also a prospector, both report a huge sink "with overhanging sides" south of Gladiator Mountain (11 on map) near the Chinese Wall. If this sink was observed by the pilot at a safe flying altitude, it is probably quite large. This site could have a connection with the legend of a huge blowing hole that the Indians reportedly avoided when crossing the mountains in this general area.

Silvertip Basin (12 on map), between Silvertip Peak and Wall Creek contains many sinkholes, according to at least two reliable reports. According to what geological data is available, this area is part of the Silvertip Syncline, an extensive limestone deposit.

Reports of varying reliability place caves on or near Pentagon Mountain (13 on map), Pinnacle Point, and Ear Mountain (15 on map).

Various other points throughout the Bob Marshall offer challenge. There are several Cave Creeks, Limestone Creeks, and Cave Mountains as well as other place names suggesting caves. Only on the spot investigation will reveal the reason for these topographical designations, as no records are available, and those responsible for them have long since passed on.

The aforementioned Chinese Wall, the best known geologic feature of the area, is reported to contain caves (16 on map). One seemingly reliable report tells of water gushing from a hole in the wall. Other reports tell of sinks along the summit and base of the wall. The Little Chinese Wall contains a cave that defied the best attempts of an exploring crew several years ago, and remains unexplored to this date.

In conclusion, let us state that while the number of reported and verified caves does not in itself qualify the Bob Marshall Wilderness as a major Western cave area, the geologic make-up of the area is definitely conducive to cavern development. Additionally, trails through the area are for the most part, along stream grades and through mountain passes, leaving the areas where countless numbers of caves might exist far from the normal routes of hikers and camping parties. Very few caves have been reported at stream level in Montana. In other areas such as the Pryor, Snowy, and Belt Mountains, extensive karst areas exist atop mountain ranges with sinks fed by melting snow. Very few trails cross areas of this nature in the Marshall Wilderness.

It is therefore reasonable to speculate that this huge, remote and sometimes foreboding region may prove to be the last frontier of American speleology, holding tight to its secrets, yet willing to share them with the speleologist possessing a good pair of hiking legs, considerable free time, and determination. Perhaps in the divine scheme of things it is intended that this area be left for future generations who will tire of the well worn trails through the vandalized caves of the 21st Century. In any event, the hundreds of caves of Bob Marshall, if they truly exist, are preserved, along with the towering mountains, crystal clear streams, and uncut forests that make up one of America's finest Wildernesses. In an era of superhighways, suburbia, shopping centers and billboards, what better reason can we give for these wilderness areas, and their preservation for all time.

SOME LIMITATIONS ON SPELEO-GENETIC SPECULATION IMPOSED BY THE HYDRAULICS OF GROUNDWATER FLOW IN LIMESTONE

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Department of Mathematics
The Pennsylvania State University

(Abstract)

This paper analyzes some aspects of ground water flow in limestone in terms of known principles of fluid mechanics. It is shown that limestone and sandstone aquifers are no longer described by the same equations at approximately Reynolds Number = 4, long before the onset of turbulence. Turbulence sets in at Reynolds Number near 2000. Both limitations are passed in limestone channels before the channel reaches the dimensions of a cave. Most caves must have been opened by water in turbulent flow.

Weyl has shown that the controlling factor in limestone solution is the rate of diffusion of ions through the laminar streamlines. His formulae are applied to show that the efficiency of solution is good while the fractures are very small (less than .01 cm.) but that the efficiency falls off very rapidly as the fracture grows. For fractures of gentle slope (1°) the flow will become turbulent when the fracture width reaches 0.5 cm. In turbulent flow there is efficient mixing in the center of the stream and the rate controlling factor becomes the rate of diffusion of ions across the laminar boundary layer. The efficiency of solution undergoes a sort of hydraulic jump at the critical passage width for the laminar-turbulent flow transition and increases by seven orders of magnitude.

Kay's principle of the self-acceleration of an optimum flow path through the limestone is rephrased in terms of the hydraulic jump of the solution efficiency. In a set of possible paths, the first to achieve turbulent flow will enlarge orders of magnitude faster than the others, thus explaining why there are fewer passages than fractures in the bedrock.

Cavern development will take place along those flow lines that permit the highest velocities. It is suggested that speleogenetic theories might better be couched in terms of the flow velocities and hydraulic gradients which directly control the rate of solution rather than karst water tables which control cavern development only indirectly.

The complete text of this paper appears in the *Nittany Grotto Newsletter,* 10 (9):155-167, May 1962.

CAVE OCCURRENCES IN THE PRYOR MOUNTAINS, MONTANA*

Jerold K. Elliott
Billings, Montana

INTRODUCTION

This paper is designed as a reconnaissance study of the Pryor Mountain caves. Most of the caves studied are rather small, and it is felt that more benefit may be derived by studying them as a whole, in relation to the regional geology, rather than individually.

None of the Pryor caves have been previously mapped and no exact locations were known. All mapping and exploratory work has been undertaken by the Treasure State Speleological Society of Billings, Montana, and acknowledgement is given to them for their assistance, and especially to Mr. Royce Tillett, a Treasure State Speleological Society member, and a local rancher in the Pryor Mountain area, who made several original discoveries. He and other ranchers have been most helpful in locating most of the known caves, but several remain to be located. Many of the caves will be described in the last section of the paper.

The Pryor Mountains are located north of the Wyoming-Montana border in Townships 5 to 9 South, and Ranges 25 to 29 East, Carbon and Bighorn Counties, Montana. The Pryor Mountains are a separate structural unit from the Bighorn Range. They are moderately dissected block mountains with gentle dip slopes to the west and steep scarp faces to the north and east. These dip slopes are mostly stripped surfaces of the Madison limestone of Mississippian age (Blackstone, 1940).

The Pryor Mountains may be divided into 4 major and 3 minor parts. The major parts are: Big Pryor Mountain, East Pryor Mountain, West Pryor Mountain and the Northeast block. The minor parts are: Shiveley Hill Dome, the Southeast block (or Sykes Spring area), and Little Mountain (a minor anticline on East Pryor Mountain).

Big Pryor Mountain is a southward-plunging, asymmetric, faulted anticline bounded by the Sage Creek fault, a high-angle normal fault downthrown to the north, on the north and by the Crooked Creek fault on the east.

East Pryor Mountain has been elevated and rotated more than any of the other segments of the uplift. Fault movement has taken place on the eastern

**Ed. Note: This paper contained many illustrations that could not be reproduced in the NSS NEWS, including many photographs and maps of most of the caves. The original manuscript has been deposited in the NSS Library and may be referred to there.*

part of the Sage Creek fault zone and on the Dryhead fault and the Sykes Spring faults. The downthrown block is to the west. This block has been modified by low-angle thrust faults. Approximately 1500 feet of displacement has been noted along the Sage Creek Fault.

The Southeast block, or the Sykes Spring area, is an area of extensive faulting, which resulted in the springs bearing their name. West Pryor Mountain, the Northeast block, and Shively Hill dome are a series of three southward-plunging, asymmetrical anticlines divided by synclines. All three are terminated on the north by the North Pryor fault. West Pryor Mountain is bisected by the deep windgap known as Pryor Gap, the ancestral course of the Shoshone River (Mackin, 1937).

STRATIGRAPHY

The caves are localized in the upper Madison, or "cave member", of Mississippian Age. The Lodgepole, Lower Mission Canyon, and upper Mission Canyon formations have been heavily dolomitized during diagensis of the original limestone, which has resulted in high densities of the carbonates. These beds are relatively little fractured, and do not contain caves, save one, (a faulted situation), which will be mentioned later. The "cave" member contains small "patch" reefs, or shelf bioherms, as they may be more correctly called, which forms the stratigraphic "horizon" for most of the cave development. The "cave" member is overlain by the Amsden Shales, much of which contain reworked Madison limestone.

GENESIS OF THE CAVES

Toward the end of Osagian time, there occurred a general deepening of the Williston Basin in Northeastern Montana and North Dakota, which resulted in the evaporatic Charles sequence. At the same time, broad, but minor, uplifting occurred in areas off the edge of the Williston Basin. Such an area was the Pryor Mountain area. Minor folding occurred, possibly two low anticlines. In the relatively shallow waters occasional "patch" reefs grew, where conditions of salinity and depth were right. Original cavities (Grabau, 1924), were formed by branching arms of coral, along with the original porosity. Much of these spaces were filled in, however, with silts and clays, which underwent secondary silicification during diagenesis. Some original cavities were left, which served as "starters" for future cavern development.

Figure 1 is a diagram of the genesis of the caves, starting with these original cavities, from bottom to top.

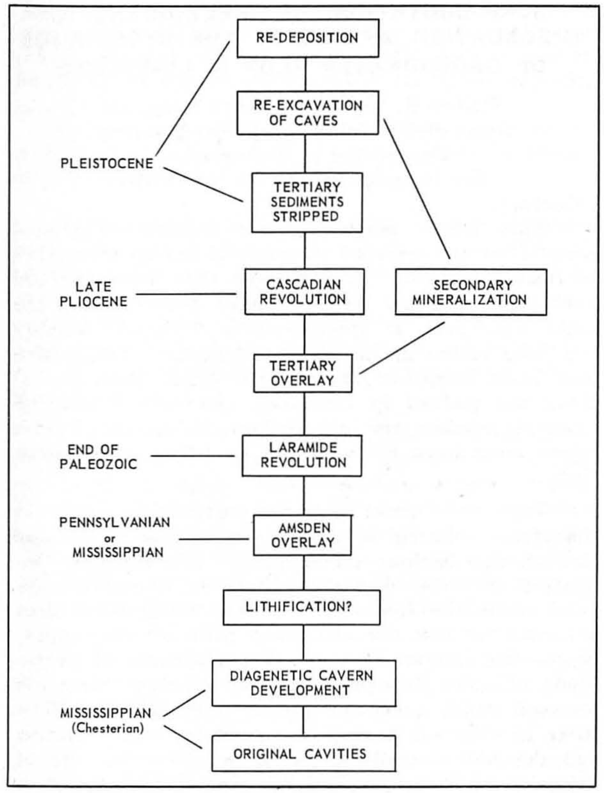


Figure 1
Genesis of the caves in the Pryor Mountains, Montana

During the diagenesis of the sediments, an extensive karst topograph was formed. Many of the beds were secondarily dolomitized. During this process, a reduction in volume occurred, because of Ca ion replacement by Mg ions, creating further porosity and collapse of overburden, leaving additional cavities. Density currents in the sea acted as a dissolving medium, enlarging the original cavities into caverns. The reefs formed limited porosity zones, being enclosed by dense basinal-type limestone, which were leached out by the density currents, forming caverns. Small remnants of the coral may be seen occasionally on some of the cave walls.

After consolidation of the beds, at the end of Meramecian time, the Amsden formation was laid down, filling up the Karst topography, and incorporating chunks of Madison limestone.

At the end of Cretaceous time, the Laramide Revolution uplifted the Pryor Mountains almost as it exists today. Subsequently much of the surrounding area was covered by Tertiary deposits (Hauptman, 1961 and Schulte, 1962), leaving the Pryor Mountains (and the Big Horn Mountains) sticking up as monadnocks. Late in the Pliocene the Cascadian Revolution further uplifted the Pryor Mountains to their present position. The then abundant waters stripped off most of the beds overlying the Madison limestone and re-excavated the caves. The ground water "zone" was erratic, existing only in more porous sections of the limestone such as those created by the small "patch" coral reefs and by areas of extensive fracture systems. Some of the cavities were opened to the surface through fractures occurring during the Cascadian Revolution. Royce Cave is a good example of this. A narrow passage leads into a dome-shaped circular room lined with calcite crystals. Additional solutional activity occurred in the shallow phreatic zone, opening up these fractures, re-excavating the caves, and further enlarging them.

Perennial ice is found in Red Pryor Ice Cave, Crater Ice Cave, Big Ice Cave, and Little Ice Cave. Apparently, the mean annual temperature is low enough and the density of the limestone is such as to maintain freezing temperatures in the caves the year around. These temperatures range from a few degrees below freezing in the winter to a few degrees above freezing briefly in late summer. Some melting of the ice has been observed late in the fall and a build-up of the ice in early spring in Little Ice Cave. The ice floor on the upper level of Big Ice Cave seems to be decreasing from year to year. Reports from local ranchers indicate that twenty years ago the ice here was at least six feet higher than at present.

Beginning with the Cretaceous and lasting until the Pleistocene, the Beartooth-Yellowstone area contributed much volcanic debris, especially ash, to the area. This material migrated across the then-existing peneplane toward the drainage of the Big Horn River. The slightly acidic waters picked up uranium salts from this ash and carried it towards the Big Horn River. As the pH of these waters became alkaline, the uranium salts precipitated out in the vicinity of the Pryor Mountains and on Low Mountain (west spur of the Big Horn Mountains). Subsequent waters concentrated these salts in the more porous limestone of the Pryors, and especially in cave fill as Tyuyamunite (a uranium-vanadium oxide).

DESCRIPTIONS OF THE CAVES

Crater Ice Cave has one room 200 feet long by 130 feet wide, with a semi-dome shaped roof approximately 25 feet high. There is much cave fill and no speleothems. Some perennial ice is found towards the rear. There are two entrances, one in a small limestone outcrop and the other in a sink-hole from the roof near the first entrance. It is on the east face of the scarp created by the Crooked Creek Fault.

Red Pryor Ice Cave has a single dome-shaped room 320 by 220 feet. There are very few speleothems and much coarse fill. There are two entrances, both sink holes. There is a snow cone under one with a drop of 10 feet from the hole to the cone. From the other, a snow and ice slope extends from the surface to the floor. Perennial ice practically covers the entire floor, which requires rope and ice crampons to negotiate. A mountain lion skull was found among the fill. There were bear tracks on the snow cone.

Blackie Ice Cave is a vertical sink hole approximately 40 feet deep with a small, domed room at the bottom. There is some ice in the bottom. A pile of bones, including bison, horse and cattle, is found on the floor.

Karst Area Sink Hole is similar to Blackie Ice Cave in the same general area on top of Big Pryor Mountain. It is a vertical shaft, approximately 40 feet deep, going nowhere.

Old Glory Mine is the uranium discovery mine of the Pryor Mountains. The mine shafts intersect with caverns, where most of the uranium is found. Some of them contain ice columns.

Big Ice Cave has two rooms, the upper 320 feet long by 70 feet wide, 25 feet high, covered with ice. An 18 foot drop down a hole in the rear of this chamber, down an old rickety ladder, leads to the lower room, which is 200 feet by 65 feet. The floor is covered with ice, and the walls are covered with ice crystals. Crampons are required in the lower room, due to sloping floors.

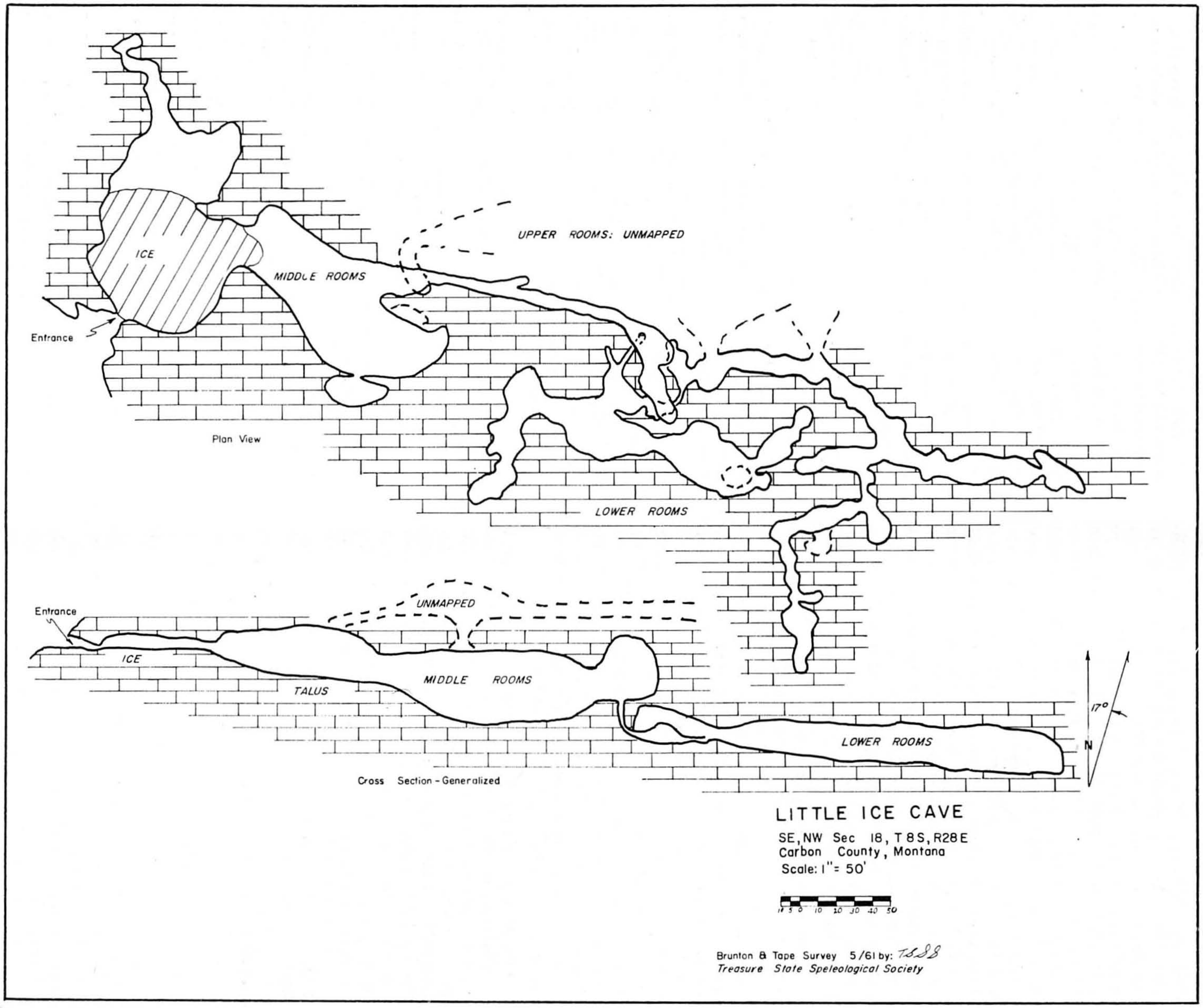
Little Ice Cave is probably the most extensive cavern in the Pryor Mountains. The entrance is in a small limestone outcrop. Ice is found on the floor of the first room and in the second room. The cave is a maze of tunnels and small rooms, with much crawling. Much of the cave has not been mapped.

Mystery Cave is primarily one large room 500 feet by 50 feet, 30 feet high. The entrance is a large opening, leading down a steep slope into the large room. There is much fill and some spectacular speleothems. This area is only partially explored, and unmapped, as is another area toward the rear of the cave.

Frog's Fault is a vertical pit 270 feet to the lowest measured depth. The drop is in series. Rope work is required for entry. There is some popcorn formation in the lower depths. The entrance is a wide slit in the side of a hill. As the name implies, this cavern is a faulted situation with some solution.

Keyhole Cave is a large slit in the vertical face of the east canyon wall of Crooked Creek. It is shaped like a keyhole, hence the name. The entrance is 80 feet by 20 feet, closing rapidly to nothing. A

(continued on page 117)


UPPER ROOMS: UNMAPPED
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LITTLE ICE CAVE
SE, NW Sec 18, T 8 S, R28 E
Carbon County, Montana
Scale: 1" = 50'
Brunton & Tape Survey 5/61 by: TSSS
Treasure State Speleological Society

small water seep at the rear indicates a vadose origin.

Sykes Cave is a small, narrow crawlway-type cave, with one larger, domed shaped room at the front. The entrance is in an obscure canyon, high up on the canyon wall.

Four-Eared Bat Cave, so-called because of the presence of the California Lump-nosed Bat, has several rooms approximately 100 feet by 60 feet, 10 feet high, with flat sandy floors and some speleothems around the edges. The entrance is obscure, lying on top of a rolling flat.

Other caves in the Pryor Mountains are Salt Lick Cave, Royce Cave, Little Sink Cave, Four by Four Cave, and the small, geode-like cavities of the Lisbon Mine tunnels.

What's for the future in the Pryor Mountains? A number of other caves have been reported, but their locations are obscure. It will take a lot of hunting to find all of them. Teton Cave and Star Cave are known. Other caves reported, but not yet located are: Sage Creek Cave, Summit Cave, Bear Canyon Cave, and Nameless Pryor Cave. Several other "holes", not previously known, have been reported. All of these need to be found, mapped and studied. Many more caves will surely be found in the process. We have much work to do in the Pryor Mountains.

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CAVERN FORMATION IN THE BLACK HILLS OF SOUTH DAKOTA, WITH SPECIAL REFERENCE TO JEWEL CAVE*

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Department of Geology
University of Wyoming

The caves and cavernous rocks of the Black Hills of South Dakota have a more complex geologic history than any other caves or cave region known to the author. Although the majority of the field work for this paper was done in Jewel Cave, all the other developed caves in the region were visited. It is thought that the conclusions reached are regionally valid.

The cooperation of the National Park Service and the commercial cave owners in the area is greatly appreciated. The field work was partially supported by a $100 grant from the NSS.

The following sequence of events has affected the development of caves in the Black Hills:

Deposition of the Pahasapa limestone. During early and middle Mississippian time the Pahasapa limestone was deposited in the warm shallow sea that occupied this region. Chert replaced horizontal zones of the limestone prior to its final compaction.

Pre-Minnelusa unconformity. During late Mississippian and early Pennsylvanian time the area was emergent and an extensive karst surface was developed upon the Pahasapa limestone.

Deposition of the Minnelusa formation. The Pennsylvanian and Permian Minnelusa formation, composed of interbedded sandstones, siltstones, shales, and limestones, was deposited on top of this karst surface.

Deposition of brown calcite. During some later period of erosion, possibly at the time of the pre-Opeche unconformity, solution cavities were formed in the Pahasapa limestone and collapse features were developed in the overlying Minnelusa sandstones. Coarsely crystalline red-brown to brown calcite was then deposited, cementing cave breakdown and filling many fractures in both the Pahasapa limestone and the limestones of the Minnelusa formation. Figure 1 is a photograph of a wall in Jewel Cave in which a breccia, composed of angular limestone and chert fragments, is cemented by coarsely crystalline brown calcite. The brown calcite is identical to, and apparearly continuous with, the brown calcite veins that

**This paper is based on part of the field work undertaken for a Masters thesis to be presented to the Department of Geology at the University of Wyoming. A limited number of reproductions of the entire thesis will be made available to interested members of the Society this Fall.*

Figure 1
Angular limestone breccia exposed in the wall of Jewel Cave. Note hand for scale. *Photo by D. Deal*

form the cores of boxwork. Note the hand for scale.

Emplacement of pre-cave fill. The Black Hills were uplifted during the Laramide Orogeny and the present caves were formed sometime during Tertiary time. After the deposition of the red-brown to brown calcite veins and prior to the development of the present caves, solution again affected the Pahasapa limestone. Poorly cemented fills containing fragments of limestone, sandstone, and chert were emplaced in solution cavities. These fills contain material derived from the Minnelusa formation, cut the angular limestone breccia, and are themselves cut by the present caves. Such fills may be seen along the stairs above the "Trap Door" in the developed portion of Jewel Cave and in the ceiling behind the "Frostwork Ledge" in the "Fairgrounds" section of Wind Cave.

Solution of the present caves. The gross outlines of the present caves were dissolved beneath the water table by slowly circulating ground water. The coarsely crystalline red-brown to brown calcite veins were more resistant to solution than the Pahasapa limestone and were left standing in relief from the cave walls. These veins, usually paper-thin, form the cores of the boxwork found in almost all the Black Hills caves.

Brown calcite deposition and oxidation of the cave walls. In some cases the cave-filling solutions then deposited a coating of red-brown to brown calcite, identical in texture and color to the calcite veins in the limestone, upon the boxwork cores and bedrock cave walls. Oxidation took place and resulted in the red coloration of the limestone bedrock parallel to, and up to several inches in depth behind, the original cave walls.

Accumulation of sediment. Sediment accumulated on all the upward facing surfaces in the caves. This was accompanied by the simultaneous deposition of calcite which cemented the sediment and allowed thick deposits to accumulate on the fragile boxwork cores. Rather thick deposits have accumulated in those caves on the northeast flank of the Black Hills and have been mistakenly thought of as the original boxwork cores. Close examination of the massive boxwork from Bethlehem, Wonderland, and Stage Barn Caves reveal the paper-thin extensions of the red-brown to brown calcite veins that initially supported the sediment. Figure 2 shows the accumulation of sediment on all the upward facing boxwork fins in Wind Cave. A later deposit of calcite covers the sediment.

Draining of the caves. Many of the caves seem to have been drained at this time. There is evidence of mud cracks in Wind Cave and flowstone in Wonderland and Bethlehem Caves having existed prior to the deposition of the thick layers of spar.

Deposition of spar. The caves again became filled with water, and large scalenohedrons and

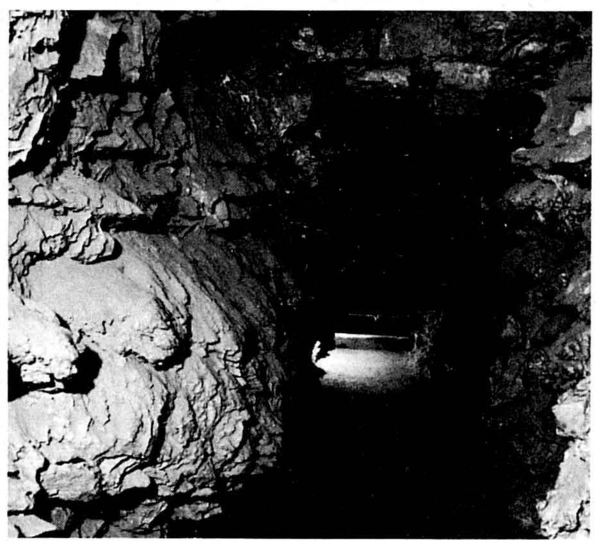

Figure 2
Sediment deposited on upward facing surfaces of boxwork fins in Wind Cave. *Photo by D. Deal*

rhombohedrons of clear to white calcite (dogtooth and nailhead spar) were deposited in most of the caves. This is referred to as the period of spar deposition. The thickness of this coating varies greatly, ranging from 6 to 8 mm. in Wind Cave to over 18 inches in Sitting Bull Cave. There is no crystal lining in Rushmore Cave, and Stage Barn Cave may have experienced crystal deposition only in its lower portions. The boxwork cores and sediment accumulations became crystal coated. The boxwork was completely obliterated in those caves that received very thick coatings of spar. Clastic material was deposited a number of times during the period of spar deposition, causing banding in the crystals and the occasional interruption of crystal growth on the upward facing surfaces, both of which vary from cave to cave.

Period of resolution. Most of the caves experienced a period of resolution during which the spar crystals were etched and rounded, and occasionally completely removed. In the uppermost levels of Jewel Cave the spar coating has been completely removed by resolution. Figure 3 shows a typical upper level

Figure 3
Upper lever of Jewel Cave from which the coating of spar has been removed during the period of resolution. *Photo by D. Deal*

Figure 4
Janny's Cranny, Jewel Cave. The spar above the caver has been partially removed by resolution; the spar below the caver has not. *Photo by D. Deal*

passage in Jewel Cave. This is the "Rainbow Keyhole", so named for the horizontal band of red limestone, apparently stratigraphically controlled, seen in the bottom of the picture. The limestone above and below is white. In general, resolution has been much more effective in the upper levels of Jewel Cave than in the lower levels. Very localized resolution has also commonly taken place. Figure 4 is a photograph of "Janny's Cranny" in the intermediate levels of Jewel Cave. This shows the thick coating of spar, which is about 6 inches thick in the bottom of the bottom of the photograph. The crystals below the caver have not been redissolved and still show good terminations. Those above the caver have been rounded and smoothed by the resolution. Much of the boxwork found in Jewel Cave was left standing in relief, sometimes in a gap between the layer of spar and the present cave walls, at this time. This boxwork has no extensive secondary coatings and usually consists only of the extensions of the brown calcite veins. In Jewel Cave, this period of resolution has also truncated calcite anthodite deposits. If these deposits were formed sub-aerially, they imply that Jewel Cave was drained and then filled again prior to the time of resolution.

Clay deposition. Red-brown cave clays and extensive deposits of black manganese minerals were deposited on the cave floors.

Silica deposition. In the caves on the southwest flank of the Black Hills silica was leached from the chert in the Pahasapa limestone and deposited in the clays and manganese minerals. Silica was also locally deposited on the cave walls. Figure 5 shows some of the silica cemented clays draped over the top of the large crystals of spar in Jewel Cave.

Figure 5
Silica cemented clay draped over the spar in Jewel Cave. *Photo by D. Deal*

Draining of the caves. The caves were drained. In Jewel Cave, much of the uncemented clay was transported to the lower levels. Figure 6 (cover photo of this issue) shows some of the water markings on the walls in the low levels of Jewel Cave. Breakdown occurred.

Sub-aerial cave deposits formed. These include the normal varieties of dripstone and flowstone in locally wet areas, calcite globulites, calcite, aragonite, and gypsum anthodites, gypsum flowers and "dust", moonmilk, and cold water dolomite deposits. Many of these deposits may still be forming.

This summary is generalized, incomplete, and does not discuss certain problems considered in the thesis. The caves in the Black Hills are astonishing in their complexities and it is hoped that others will be stimulated to investigate them and criticize this author's work. There are still many details to be worked out.

Practical Session

A COMPACT SPELEO-SURVIVAL KIT

Glen K. Merrill
Austin, Texas

(Abstract)

Obviously no one can carry all the items which might prove helpful to resolve a given crisis when underground, but a small and very useful kit can be simply constructed that will provide aid and comfort to man and beast (carbide lamp) in most situations. In keeping with the current trend toward micro-miniaturization, this kit is essentially contained in in one 35 mm film cassette can.

CAVING EN ROUTE TO WORLD'S FAIR

William R. Halliday
Seattle, Washington

(Abstract)

A considerable number of eastern cavers have indicated that they intend to continue west to Seattle and its World's Fair after the Convention. For their benefit, the Cascade Grotto is sponsoring two special trips in Washington state the weekends of June 23 and June 30, to lava tube caverns of exceptional interest, on a one-day and two-day basis.

En route to the Pacific Northwest from the Convention, there are a number of interesting caverns, both wild and developed, which cavers may wish to visit. Their locations are indicated and their special features discussed briefly.