The AMERICAN CAVER

BULLETIN FOURTEEN of The National Speleological Society

Affiliated with the American Association for the Advancement of Science

IN THIS ISSUE . . .

Accurate and informative articles on caves including

SEPTEMBER 1952

THE AMERICAN CAVER

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To stimulate interest in caves and to record the findings of explorers and scientists within and outside the Society

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Inquiries relating to the publication of manuscripts in the BULLETIN should be addressed to the Editor; those relating to the distribution of the BULLETIN should be addressed to the National Speleological Society, 1770 Columbia Road, N.W., Washington 9, D. C.

THE NATIONAL SPELEOLOGICAL SOCIETY was organized in 1940. It now has members scattered throughout the United States, and also has many members in foreign countries.

THE SOCIETY is a non-profit organization of men and women interested in the study and exploration of caves and allied phenomena. It is chartered under the law of the District of Columbia. Its energies are devoted to the unlocking of the secrets of the world underground.

THE SOCIETY serves as a central agency for the collection, preservation and publication of scientific, historical and legendary information relating to Speleology. It arouses interest in the discovery of new caves and encourages the preservation of the natural beauty of all caverns.

THE AFFAIRS of the Society are controlled by a Board of Governors. The Board appoints the national officers. The Board also approves committee chairmen—who are chosen not only for their proved ability in a particular field, but also for their activity in the work of the Society.

LOCAL SECTIONS of the Society are called Grottoes. They serve to stimulate and coordinate activity and increase the interest, enjoyment and productiveness of caving.

LIBRARY: An excellent speleological library is owned by the Society and is being constantly enlarged. Items on hand may be borrowed by NSS members. Extensive collections of cave maps, photographs and slides are being gathered and are available on a loan basis.

Membership helps to support the publications, special investigations, and the operation of the Society.

Associate	$ 3	Sustaining	$10
Regular	$ 5	Institutional	$ 10
		Life	$100

PUBLICATIONS include the BULLETIN published at least once a year, and the NEWS appearing monthly. All members receive the BULLETIN and the NEWS.

Preface

The widening public interest in speleology has brought to the Society increased responsibility for disseminating knowledge in this field. Facts concerning speleology are sought by a variety of consumers —hobbyists, naturalists, and scientists.

In order to serve better the needs of such different groups, the Society last year increased the number of its officers. There are now four vice-presidents, responsible respectively for administration, science, public relations, and publications. The good results of their specialized labors are already becoming evident.

A proposal to enlarge the publication program, to mention one, has been approved by the Board of Governors. In reviewing the development of the present-day NEWS and BULLETIN, the Board gave its support to pleas that every effort be made to further improve the NEWS by budgeting a larger amount for it. This will permit the use of more pictures and the printing of more extra-page issues. Also more timely news stories will be sought from the grottoes and individual members. The NEWS will continue to be the Society's best medium of timely information. Since many of its items are of lasting interest, an index is being prepared.

The BULLETIN, from now on to be known as THE AMERICAN CAVER, will continue to bring to the members and to an expanding group of non-member readers popularly written articles on a large variety of speleological subjects. These will include articles on exploration of caves at home and abroad, interpretation of the findings of scientists as they apply to caves, and the descriptions of caves and cave regions of general interest. The finest available photographs will be a feature of each issue.

With this number a new regular feature is being added: a section for *General Notes.* Under this category are included items too short to justify their use as general articles, but nevertheless of sufficient importance to warrant the wider attention that publication here will bring. The notes may be of a more technical nature, but strictly technical papers, long or short, will not be published here.

Instead, reports on substantial research in the field of speleology will be published in a new series of OCCASIONAL PAPERS. Published at irregular intervals, they will be distributed only to members who request them. To non-members they will be priced according to the cost of publication of the individual papers.

Scientists, graduate students, and amateur speleologists, whether members of the Society or not, are invited to submit material for the OCCASIONAL PAPERS. A more detailed description of the scope of the new publication will be mailed upon request.

Serious concern has been expressed over the decline in the number of published reports in the field of American speleology. The dearth of papers has been attributed to the lengthened work week of

(continued on inside back cover)

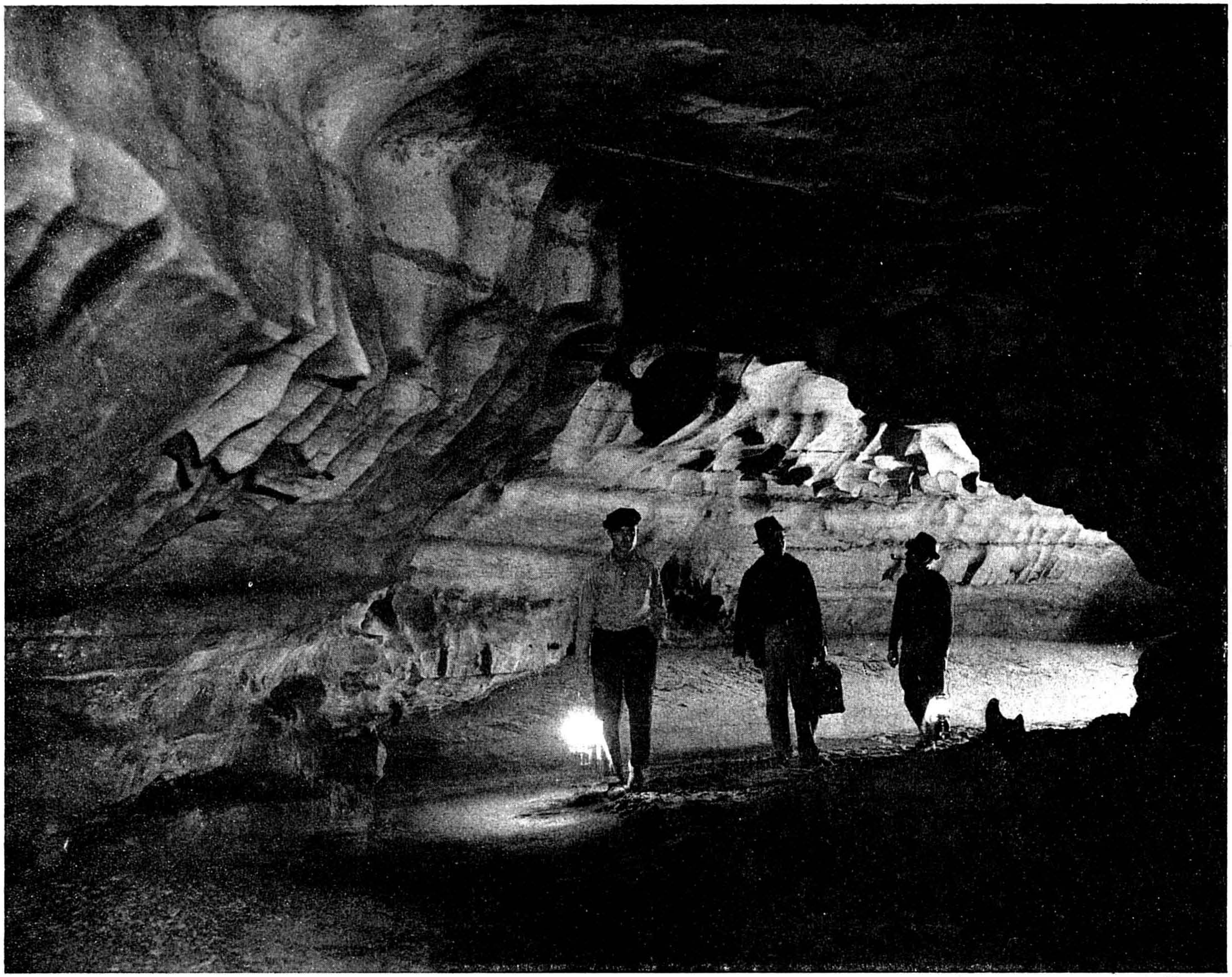

Photo by Thomas V. Miller, Jr.

This photograph, entitled "First Glimpse of a New World," received the First Award in the Fifth International Photographic Salon (1952) of the National Speleological Society. It was taken by a photographer for the Louisville Courier-Journal in the so-called "New Discovery" of Mammoth Cave, Kentucky, and ably portrays the effect he sought which, in his own words, was to depict "a feeling of mysticism, of wonder, of enchantment, of awe."

A Survey of Bat Banding in North America, 1932-1951

By CHARLES E. MOHR
Director, Audubon Center, Greenwich, Connecticut

All photos by the author

Probably few cave enthusiasts realize the extent to which bat banding has been carried on by scientists in the last twenty years. During that time nearly 70,000 bats have been banded (nearly three quarters of them from caves) for the purpose of studying their life history and habits. The extent of this banding activity, its methods, procedures, objectives and results is told here for the first time by one of the nation's top ranking chiropterists.

The marking of bats began in 1916 when ornithologist Arthur A. Allen (1921) attached bird bands to the legs of five bats. In California in 1922, A. B. Howell banded 4 bats, and in 1923, Luther Little banded 37 (Howell and Little, 1924). Harold Wood in Pennsylvania used two bird bands on bats in 1929 and in the same year H. B. Sherman (1937) banded 76 juvenile bats in Florida. None of these persons continued banding however.

In 1932, Donald Griffin (1934) in New England, and Earl L. Poole (1932) and I (Mohr, 1933) in Pennsylvania, began banding activities which proved to be the first sustained endeavors in this field in America. These studies were carried out almost simultaneously. In both areas there had been experimentation with marking methods, including the use of histological stains and tattooing. In both areas aluminum bird bands were finally selected as the best marking medium.

On the evening of May 21, 1932, I captured and tagged a series of 14 bats of three species as they flew into Schofer Cave, near Kutztown, Pennsylvania. This appears to be the first time that cave bats were marked so that individuals could be recognized![1] One of the Pennsylvania projects was the banding of 763 bats of four species in seven abandoned, incomplete tunnels of the South Penn Railroad as engineers began to transform them into Pennsylvania Turnpike Tunnels (Mohr 1942).

On September 7, 1932, Griffin (1934) began using bird bands in a summer roost on Cape Cod, and in 1934 undertook the banding of bats hibernating in caves in New England and New York. With the aid of well-organized banding teams, he was eventually to band about 8,500 bats in caves and mines, and about 5,000 in summer colonies in buildings.

Not until 1936 did banding activities spread to other states. In September 1936, Mary Guthrie (1937) banded 731 bats in Marvel and Rocheport Caves, Missouri, and the late W. A. Welter, in April 1937, banded 2,000 in Bat Cave, in eastern Kentucky. In 1938, H. I. Shreve began banding a series of 242 bats in West Virginia caves.

In 1939, G. N. Rysgaard (1942) in Minnesota, initiated a study of 464 cave bats, and in New Jersey and Pennsylvania, Harold Trapido banded the first of some 5,300 bats, using many of them in a series of homing experiments. Also in 1939, Harold B. Hitchcock launched an extensive program which, by 1951, resulted in the banding of 13,125 bats. In Texas, Nicholson banded 200 free-tailed bats but never continued with additional operations. Five banders (Cagle, Cockrum, Elder, Engler, and Greeley) received banding permits in 1940, and four additional (Llewellyn, Riney, Southam, and Storer) in 1941.

During the war banding activities were greatly curtailed. No new permits were granted until 1948. From that time until the present, 30 banders have been supplied with bands by the U. S. Fish and Wildlife Service.

The bat banding records were in charge of Dr. H. H. T. Jackson until late in 1947, and since then have been under the supervision of

[1] C. A. R. Campbell (1924) wrote of capturing 2004 free-tailed bats in a Texas cave daubing them with whitewash and releasing them 30 miles away. He reported that they flew directly to the cave in about one hour.

Stanley P. Young until September of 1951. During this month the Section referred to as Biological Surveys was combined with the Section of Distribution and Migration of Birds, and is now known as the Section of Distribution of Birds and Mammals, under the supervision of Dr. John W. Aldrich.

In October 1951, in an effort to ascertain the current status of bat banding activities, I sent a questionnaire to all persons to whom the U. S. Fish and Wildlife Service had sent an allotment of bands.

This paper is based on 44 replies, supplemented by earlier correspondence with several bat banders who no longer are active, and by data in the Service files. The prompt response of the banders, and their generous assistance and valuable suggestions are gratefully acknowledged. The data are incomplete because four of the banders are out of the Country (Trapido, Koford, Pearson, and Riney), and their detailed records on nearly 11,000 bats are not available. Nevertheless, the following summary is believed to be a reasonable approximation of the banding situation as of the end of 1951. The full list of banders will be found in Table 1.

Total banders, 1932-1951 53

Active banders, 1951 (including 6 cooperators about to begin) 33

A grand total of about 67,279 bats have been banded. Of these about 50,000, almost exactly 75%, were found in caves or mines, generally in hibernating colonies.

The importance of caves and mines to bat banding is further emphasized by the fact that 30 of the operators have banded some cave bats, while 18 operators have worked with cave bats exclusively. The 12 operators known to have worked solely outside of caves generally have been in areas where caves were scarce or absent.

METHODS AND PROCEDURE

With few exceptions the bats have been banded with aluminum bird bands, generally No. 0 for *Pipistrellus* and *Myotis,* with No. 1 usually reserved for larger species. For some years they were used as *leg bands,* being placed around the bat's tibia (Griffin, 1934) with or without cutting through the interfemoral membrane.

In 1939 Trapido adopted wing banding (Trapido and Crowe, 1946), introduced in Germany in 1932 by the pioneer European bat bander, Eisentraut (1934). This method quickly supplanted leg banding since it has the advantage of making the bands more visible as the bats hang in clusters. Like leg bands, however, they will cause irritation if closed unevenly or too tightly. As pointed out by Trapido and Crowe, "the bands should be closed around the forearm so as to encompass the bones, but leaving a sufficient aperture to permit the band to slide freely along the forearm without pinching the wing membrane". When inexpertly applied the bands cause inflammation. Such bands often are chewed until the numbers are partly or completely obliterated.

The serial number is inscribed around the band. This prevents the number from being read without handling the bat. Bels (1952) reports that a cooperator of Eisentraut recently has manufactured bands with the numbers "engraved in the opposite direction", that is, vertically on the band instead of horizontally. The number then is parallel to the forearm of the bat and at close range can be read without wakening a hibernating bat.

When the bats hang in large clusters, however, it is impossible to see all the bands. One method that offers a greater possibility of observing and recording numbers (at very close range) without arousing the bats from hibernation is the *ear-tagging* method (Mohr, 1934) in which stainless steel fingerling fish tags are used. Tags used thus far have been purchased privately.

Since the ear is so important in flight, and since a sliver of metal penetrates it, a question arises as to possible hindrance to the animal's navigation. The only data that throw any light on the subject were secured at Durham Mine in Pennsylvania. Of a series of 202 *Myotis l. lucifugus* tagged in 1940, 25% were recorded as returns in subsequent years. Of a larger series of 899 bats of this species *banded* in 1942, 44% returns were recorded in later years. On the other hand, tagged bats have been retaken after 9 and 12 years.

It is important when handling hibernating bats for banding purposes to reduce the period

of disturbance to a minimum. Excessive and prolonged activity on the part of the bat reduces its chances of surviving the hibernation recommended (Griffin, 1940a). No more bats should be put in a cage than can find places to hang in it.

TABLE 1

A LIST OF BAT BANDERS IN THE UNITED STATES AND CANADA, 1932-1951

Bander	*Year Began*	*Active Now*	*Bats Banded*	*Banded in Caves*
Baker, Ross S.	1944	Deceased	11	——
Banfield, A. W. F.	1946	No	42	42
Barbour, Roger W.	1937	Ready	——	——
Barkalow, F. S.	1950	Yes	7	7
Barnes, W. E.	1948	No	——	——
Barr, T. C.	1951	Ready	——	——
Beer, James R.	1947	Yes	1,000	1,000
Broadbooks, Harold E.	1951	Yes	119	119
Cagle, Fred R.	1940	No	1,922	——
Childs, Henry E. Jr.	1951	Ready	——	——
Cockrum, E. Lendell	1940	Yes	2,000	2,000
Constantine, Denny G.	1946	Yes	446	——
Cope, James B.	1951	Ready	——	——
Crawley, Eugene	1940	No	——	——
Davis, Wayne	1950	Yes	1,141	1,000
Elder, William H.	1940	Yes	86	86
Engler, C. H.	1940	No	246	——
Gardner, Robert J.	1950	Yes	1,000	1,000
Glass, Bryan P.	1949	Ready	——	——
Goehring, Harry H.	1951	Yes	301	——
Greeley, Frederick (and Beer)	1940	Yes	6,400	5,800
Grierson, Stanley	1948	Yes	87	50
Griffin, Donald R.	1932	No	13,000	8,500
Guthrie, Mary H.	1936	No	731	731
Hitchcock, Harold B.	1939	Yes	13,125	9,827
Jackson, William B.	1949	No	163	158
Koford, Mary R.	1947	No	4,000	2,000 E
Llewellyn, Leonard M.	1941	No	468	468
Mason, Charles	1946	No	400	400
Miller, Jerome S.	1948	Yes	350	——
Mohr, Charles E.	1932	Yes	3,880	3,645
Mumford, Russell E.	1951	Ready	——	——
Negus, Norman C.	1947	Yes?	2,700	2,700 E
Nicholson, A. J.	1939	No	200	200
Olson, Andrew C.	1950	Yes	74	——
Orr, Robert T.	1947	Yes	59	——
Pearson, Oliver	1948	Yes	1,400	500 E
Raynor, Gilbert Sidney	1947	Yes	61	——
Riney, Thane A.	1941	No	——	——
Rogers, Nancy	1948	Yes	1,016	1,016
Rysgaard, George N.	1939	No	464	464
Shreve, H. I.	1938	No	242	242
Sister M. Talitha	1950	Yes	236	——
Sloane, Howard N.	1951	Yes	24	24
Smith, Elizabeth W.	1947	Yes	1,500	——
Southam, Herbert H.	1941	No	27	——
Storer, Robert W.	1941	No	50	——
Trapido, Harold	1939	No	5,350	5,350 E
Ulmer, Frederick A.	1950	Yes	152	20
Welter, W. A.	1937	Deceased	2,000	2,000
West, Fenton T.	1951	Ready	——	——
Wood, Sherwin F.	1949	Yes	513	——
Young, Howard F.	1951	Yes	286	286
E—Estimated	Total bats banded	....	67,279	50,021

period. Energy reserves and moisture content of the bat seem to be dangerously lowered.

Both to reduce activity and heat and to simplify handling, screened collection cages are

In banding a large series it is advantageous to have the bands already spread and stored on metal rods. Hitchcock (1941) has described a useful device for opening small bands and a

method for transferring them to rods. The storage rods may be stuck into the ground and the bands removed from the free end. It is desirable to use a continuous series for one sex, a different series for the other. This greatly simplifies record keeping.

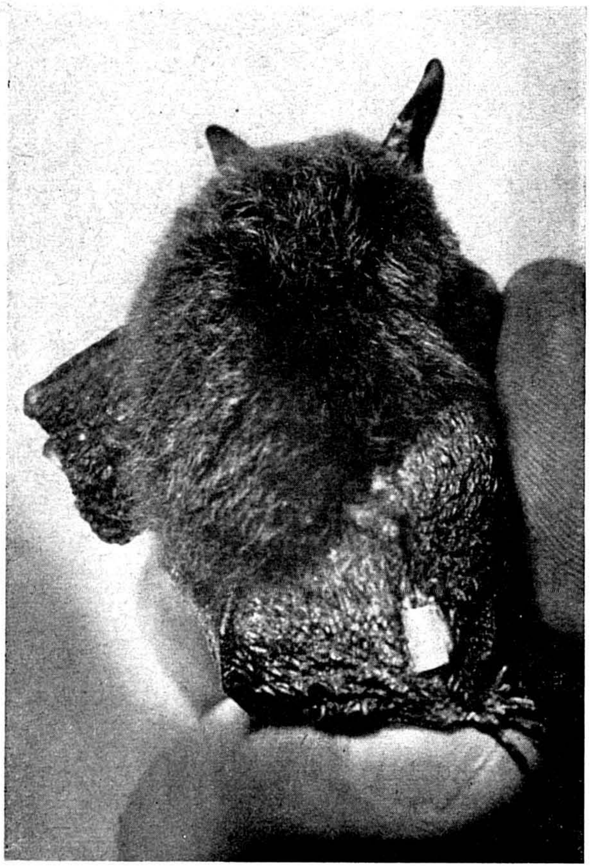

Fig. 1. LEG BANDING was first marking system used in this country. The band was closed around the tibia, with or without cutting a slit in the interfemoral membrane. The bands usually could not be seen as long as the bat hung up.

OBJECTIVES OF BANDING

Griffin (1936) cited three principal objectives in undertaking bat banding:

"1. To determine whether the same individuals return annually to the summer roosts from which they were absent in winter, and likewise to determine whether the same bats return in succesive winters to the caves where they hibernate;

2. To ascertain whether bats released at a distance from their summer roost will return to it; that is, whether they have a homing instinct.

3. If possible to trace the movements of individuals by recoveries of marked bats."

Many of the banders today likewise are interested in these objectives but a number of additional objectives are reported:

4. To determine the average and maximum length of life.
5. To determine the extent of the disproportionate sex ratios quite generally found among hibernating bats;
6. To chart the growth of young bats;
7. To add to the meager knowledge of the life histories of various species;
8. To investigate the physiology of hibernation;
9. To trace the life history of blood parasites in banded individuals;
10. If possible, to follow the day to day shifts of bats that occupy no regular roost.

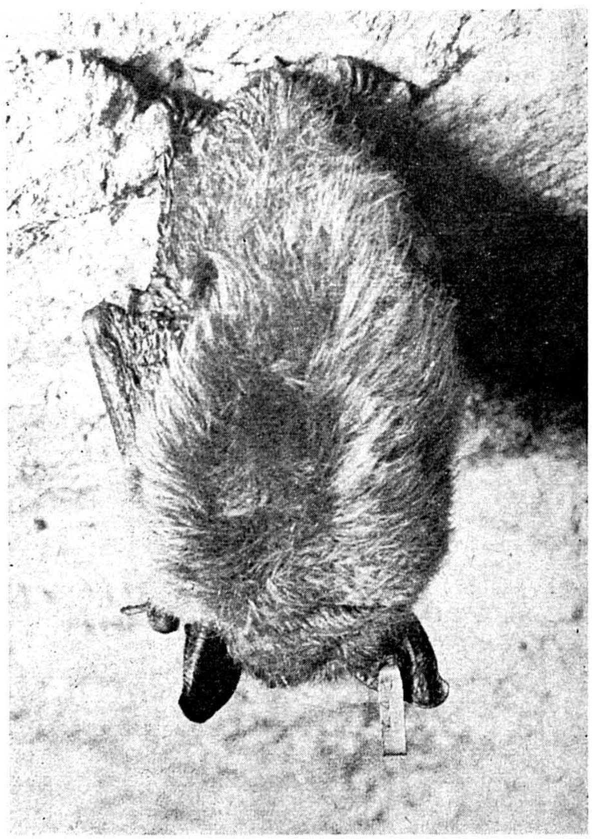

Fig. 2. EAR TAGS were used on nearly 3000 bats in Pennsylvania. Expense of the tags, privately purchased, limited their use despite their increased visibility.

RESULTS OF BANDING

Considerable information is now at hand under many of the various categories just listed. It is possible to answer at least partially, some of the following questions:

1. *Do the same individuals return annually to the caves in which they were banded?*

Recaptures of banded bats have conclusively proved that they do come back to the same hibernating quarters year after year. Likewise bats may occupy the same summer roosts for a period of years.

In describing the recapture of bats it seems advantageous to adopt terminology consistent with that now well established in bird banding, as follows:

Return: The taking of a banded bat at or close to the place of banding after the conclusion of the season (summer or hibernating) during which it was banded. This corresponds to the "later-season local return" of Griffin (1945).

Repeat: Recapture at or close to the place of banding during the same season ("same-season local return" of Griffin).

Recovery: Recapture far enough away from the place of banding so that the movement might be considered significant ("foreign return" of Griffin, with movements of 10 miles or more).

Due to the extensive nature of most caves and mines it is obviously difficult to recapture a large proportion of banded bats. The following records constitute the highest percentage of returns in series of significant size:

In a cave at Fourth Chute, Ontario, Hitchcock (1949) recorded returns of 73.5% of a series of 27 *Eptesicus f. fuscus,* but only 52% of a total of 316 banded in several different caves. Hitchcock noted 41.7% returns from a single year's banding of 15 *Myotis subulatus leibii,* at Fourth Chute, but only 25.4% of the remarkably large series of 252 bats of this species which he banded between 1942, and 1947.

Griffin (1940a) reported returns of 56.8% and 36.7% of both *Myotis l. lucifugus* and *M. sodalis* "at two small caves in Vermont where it is possible to catch all the bats".

Rogers has had 24% returns on 504 *Corynorhinus r. rafinesquii* banded in several West Virginia caves.

The largest series that has been under observation continuously is a population of 899 *Myotis l. lucifugus* at Durham Mine in eastern Pennsylvania (Mohr 1942). During the year following banding, records compiled on three visits totalled 25% returns. In subsequent years additional returns increased the percentage to 44%. Five of the bats were retaken in five consecutive winters, one in each of six following winters, and one in seven of eight different winters, further demonstrating the regularity of the return of bats to their seasonal quarters.

In caves and mines in Devonshire, England, a return of 55.7% was reported on a series of 697 banded *Rhinolophus ferrum-equinum* and a 30% return has been maintained for *R. hipposideros* (Hooper, Hooper and Shaw, 1951).

2. *Do bats have a homing instinct?*

At least 17 of the bat banders have performed homing experiments of some kind. Griffin (1940a, 1945) transported a total of 479 little brown bats for distances up to 156 miles, and had nine returns from the longest distance.

Beer and Greeley have retaken two *M. l. lucifugus* after homing flights of 250 miles. One of these bats crossed Lake Michigan. Hitchcock and Reynolds (1942) report finding 3 out of 76 *M. l. lucifugus* released 180 miles from their summer roost.

In Pennsylvania, Trapido took about 1525 bats from Aitkin Cave at the beginning of the hibernation period in 1940 and 1941 and released them at various points up to 125 miles from the cave. The results of this experiment unfortunately are not available, but the few records on file with the Survey indicate that many returned immediately to the cave in October and November.

Griffin (1940a) found, and meager data on the Trapido experiment also indicate, a *higher percentage of returns* from bats *carried away from the roost* (for distances under 50 miles) *than from banded bats released at the cave.* Hitchcock and Reynolds (1942) had the same experience with bats released as much as 68 and 76 miles from their summer roosts. As already reported, 44% of the 899 little brown bats band-

ed at Durham Mine were retaken there in subsequent years. Of these returns, 70 were later released at a point 55 miles away. Over a period of several years 41% of these bats have been taken as returns. Since all of these bats were nearly *three* years old, at the least, when used in the homing test, 41% must be considered a very high return.

Griffin has suggested that the bats *released at the cave* may scatter as a result of the disturbance. On the other hand, "for some reason those carried to a distance seem to be less likely to associate the discomfort of being banded with the home roost".

Several attempts have been made to determine the *speed of the homeward flight*. The only data obtained from banding [1] are a 40-mile return flight of a little brown bat in three days in Pennsylvania (Mohr, 1942), and a 76-mile return in six days by both young and adult of the same species in southern Ontario (Hitchcock and Reynolds, 1942).

3. *Can the movements of individual bats be traced?*

As already reported, banding has established the regularity of return of cave bats to their hibernating quarters and proven the existence of a remarkably strong homing instinct. On the other hand it has indicated that some banded bats do not return to the same cave in successive winters. At Durham Mine, 8% of the 395 banded bats retaken were found after apparent absences of four or more years (20 after intervals of 4 years, 16 after 5 years, 4 after 6 years, 6 after 7 years, and one each after 8 and 9 years). It is unlikely that they all escaped notice during the frequent inspections despite the extensive nature of the mine.

In New England, Griffin (1940a, 1945) has established the fact that some bats move from cave to cave during the winter. Bats banded at the exposed East Dorset cave in early fall have been found later the same winter in caves as much as 125 miles away. Other fairly long winter flights have been reported in the same region. Griffin (1945) estimates however, "that for every bat retaken after a shift from one cave to another about 100 were recovered in later winters at the same cave where they had been banded." In England, many winter flights of 1 to 17 miles have been reported for the greater horseshoe bat, *Rhinolophus ferrum-equinum* (Hooper, Hooper and Shaw, 1951). In West Virginia, Rogers notes some shifting of *Corynorhinus r. rafinesquii* from one cave to another during the hibernating period.

It has been observed quite generally (Folk, 1940; Swanson and Evans, 1936; Guthrie, 1933; Hahn, 1908) that considerable population changes occur within a cave during the hibernation period. In Belgium, Verschuren (1949) marked the position of hibernating bats on the cave wall without disturbing them and noticed that after a few days these bats had disappeared and new individuals had arrived. These spontaneous shifts and the appearance of new bats at various times during the hibernating period indicate a greater population change in winter than has generally been supposed.

The proportion of recoveries of banded bats from caves other than the ones in which they were banded is too small to account for the population changes observed by Verschuren, Folk, and others. Rather than hanging in other caves unknown to the banders, it can be assumed that they find other places of hibernation. The strongest likelihood is that they hibernate in crevices smaller than man can enter in quarries, in talus accumulations, and other places which remain above the freezing point. That many of these sites must be inadequate in this

Fig 3. AN EAR TAG identified this Leib's bat, trapped and drowned by flood waters in Stover Cave, Pennsylvania.

[1] Campbell's white-washed bats in Texas reportedly flew 30 miles in about one hour. Dubkin (1952) described the flight of an albino bat from Milwaukee to Chicago, 90 miles, in less than 150 minutes.

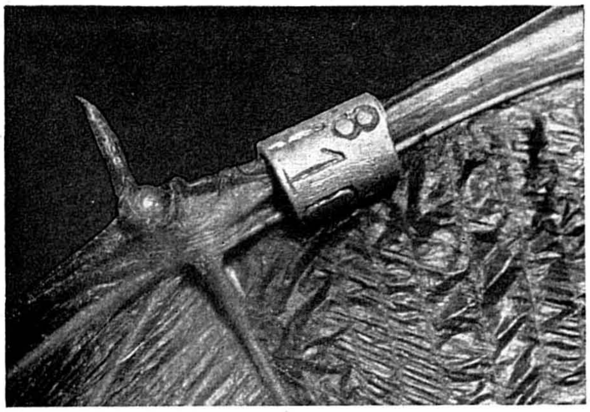

Fig. 4. WING BANDING, originally used in European experiments, became the accepted technique in this country after 1940. If properly applied the band is free to slide along the forearm and does not disturb the bat. The projecting thumb aids the bat in getting a grip in climbing or, sometimes, as it hangs upside down.

latter respect, probably accounts for the influx of bats into caves after sharp temperature drops in early winter (Folk 1940).

The movement of individual bats between their summer roosts on Cape Cod to caves in the mountains of Vermont has been established by Griffin (1940a, 1945). At least 5 bats have made seasonal flights of 168 miles in one direction. The percentage of such recoveries, between summer and winter quarters, has been disappointingly small—slightly under 2% for the most successful operations; for most banders no recoveries whatever.

As Griffin (1945) pointed out: "The data obtained do not satisfactorily indicate either the summer range of the bats banded in caves or the winter quarters of those marked in summer colonies."

Three possible explanations are put forward by Griffin:

"1. The coverage may have been too thin to sample more than an insignificant fraction of the caves or summer colonies . . .

2. The bats may migrate entirely outside the area studied . . .

3. There remains a speculative possibility that these bats may use other places than caves for hibernation, at least in areas where caves are lacking . . ."

While it must be admitted readily that coverage of summer colonies is inadequate, the location of accessible caves in the Northeastern United States seems to be well known. Most cave colonies numbering 100 bats or more are visited annually. No evidence has been found to indicate that the banded bats migrate beyond the area studied by Griffin. It seems reasonably certain, as already pointed out, that bats use hibernating quarters other than caves and mines.

For studying the shifts of individual bats from one portion of a cave to another part, *ear tags* offer a greater opportunity for observation and recording without disturbance than do bands which are more often hidden from view.

4. *What is the maximum life span of bats of various species?*

To persons familiar with the extremely short lives of small insectivores and rodents—few live as much as two years—or with small birds, in which five or six years is an old age, bats reach quite remarkable ages. Data in Table 2 have been extracted from the U. S. Fish and Wildlife Service files or have been furnished by the banders.

With the exception of one *Eptesicus,* all longevity records in Table 2 were for cave bats and represented returns at the point of banding.

The ages tabulated above are calculated from the *date of banding,* during hibernation, so the minimum age may be from 4 to 10 months greater. Actually the bats were of unknown age when banded.

Scant attention has been paid to the possibility of recognizing bats of the year during hibernation. Consequently it is difficult to determine the average age of groups of bats, the proportion of young to adults being unknown.

One may arrive at a basis for estimating average longevity if the survival rate is known. Eisentraut (1947) reports the annual loss among *Myotis myotis* in Germany to amount to 40% with striking regularity. His calculations were based upon the number of dead bats found throughout the year. Since his findings are comparable to those in this country in so many other respects it seems reasonable to assume a comparable mortality rate for *M. l. lucifugus,* for example.

Survival rate, then, would be 60%. Nice (1937) has calculated the theoretical age-group composition for stable populations, basing the

TABLE 2
LONGEVITY RECORDS FROM BANDED BATS

Species	*Age Record*	*Locality*	*Bander*
Myotis l. lucifugus	Many 10, a few 11, 12, 13—one 14 years	New England Pennsylvania	Griffin Mohr
M. sodalis	Two—ten years	Kentucky	Welter Hitchcock
M. subulatus leibii	9 years	Pennsylvania	Mohr
M. keenii septentrionalis	5 years	Ontario	Hitchcock
Pipistrellus subflavus obscurus	10 years	Wisconsin	Greeley-Elder
Eptesicus f. fuscus	Four—9 years	Ontario Wisconsin	Hitchcock Greeley-Elder

calculations on the annual survival rates and assuming that there is no difference in death rate among the various age groups. Adapting the data presented by Nice in the tabular form used by Farner (1945) the theoretical ages would be as shown in Table 3.

Sixty per cent survival theoretically gives an extreme longevity of ten years. But it may well be with bats, as Nice suggested for the Song Sparrow, that the survival rate rises somewhat in the later years as the bats become more experienced. This would increase the number of years that the last survivors would live, and account for the fraction of one per cent which attain an age of 12 years or even more.

While not comparable to longevity records for wild bats, maximum ages recorded for captive individuals are of some interest. Flower (1931) reported that a female African collared fruit-bat, *Rousettus leachii,* born in the London Zoo, died at an age of at least 19 years, 9 months, and 25 days. Indian fruit bats, *Pteropus giganteus,* do very well in European zoos, one female living 17 years, 1 month and 26 days. The next longest record was for *Rousettus aegyptiacus*—12 years, 7 months and 29 days. Trapido (1946) reported an extreme age of 12 years and 9 months for the vampire bat, *Desmodus rotundus murinus,* kept in captivity at the Gorgas Memorial Laboratory, in Panama. Two other individuals survived for more than 10 years.

It is not surprising that the larger species of bats have a longer life span than the smaller species. This difference has been demonstrated also through bird banding as well as through

TABLE 3
THEORETICAL AGE-GROUP COMPOSITION AND AVERAGE LONGEVITY
ACCORDING TO ANNUAL SURVIVAL RATES

Survival rate	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	*Average longevity*
75%	25	19	14	11	8	6	5	4	3	2	1	1	1	4.0 years
60%	40	24	14	9	5	3	2	1	1	1	0	0	0	2.5 years
50%	50	25	13	6	3	2	1	0	0	0	0	0	0	2.0 years
40%	60	24	10	4	1	1	0	0	0	0	0	0	0	1.7 years
25%	75	19	5	1	0	0	0	0	0	0	0	0	0	1.3 years

records of captive animals of various vertebrate groups.

5. *To what extent is the sex ratio disproportionate?*

As reported in the first survey of Pennsylvania hibernating colonies (Mohr, 1932), a preponderance of male bats was noted, sometimes as high as 3 to 1. Data from nine hibernating colonies in caves, mines, and tunnels (Mohr, 1945) definitely established this disproportionate sex ratio. The average predominance of male *Myotis l. lucifugus* was 62.3%; of *Pipistrellus s. subflavus,* 74.7%. In the case of *M. s. leibii* alone, the ratio has been almost exactly 1 : 1. One of the few examples of female predominance so far reported, was in a series of 56 *Eptesicus f. fuscus* in Blue Mountain Tunnel, Pennsylvania—68% female. But a larger series, 292 *Eptesicus,* showed 72% male.

During the winter of 1947-1948, Hitchcock (1950) visited 20 caves and mines, from Ontario to West Virginia and Kentucky, including the major known bat concentrations. He examined 4987 bats and found that the more northern colonies had the highest proportion of males. The explanation for the sexual unbalance advanced both by Griffin (1940b) and Eisentraut (1947), and considered by Hitchcock is that females have a higher mortality rate than males. Canadian returns bear out this belief, since returns on females are much lower than on males.

The most complete data available, however, from the Durham, Pennsylvania, colony, shows that the number of female returns in each of the following three winters was consistently 3% less than that of males. This suggests that if a higher mortality rate does exist among females, hibernating in Pennsylvania, it operates *only* in the year following banding. Eisentraut's report bears out this supposition. The number of losses of females is far higher than males during the first year—"nearly double the corresponding number of males". Eisentraut attributes the higher mortality rate of females to the increased perils of pregnancy and parturition, noting a preponderance of deaths during the months of May and June.

There is no reason to believe that the sex ratio at birth is unbalanced. Griffin (1940b) examined 890 juvenile *Myotis l. lucifugus* in a summer colony in Massachusetts and found 450 males and 440 females. In Illinois, Cagle and Cockrum (1943) examined 432 juveniles of this species and reported 213 females and 219 males.

It is encouraging to note that 13 of the banders indicate an interest in this field of investigation.

6. *Can the growth of bats be charted?*

Only in the South have maternity roosts been found in caves. Northermost is *Corynorhinus r. rafinesquii,* in Virginia and West Virginia. In eastern Tennessee, *Myotis grisescens* occurs in large "maternity wards". In the Southwest, *Tadarida mexicana, Myotis v. velifer,* and other species can be found at this season, but in the North caves generally are completely devoid of bats in summer.

Wing bands applied shortly after birth have established the fact that *Myotis l. lucifugus,* for instance, reaches full adult size in about four weeks (Cagle and Cockrum, 1943). The banding of juvenile bats offers one of the most promising fields for banding activities. Data obtained will throw light on many an unsolved problem. One of the most surprising discoveries was made by Sherman (1937) who banded 76 juvenile *Tadarida cynocephala* in Florida and found that one of them gave birth to young within the year.

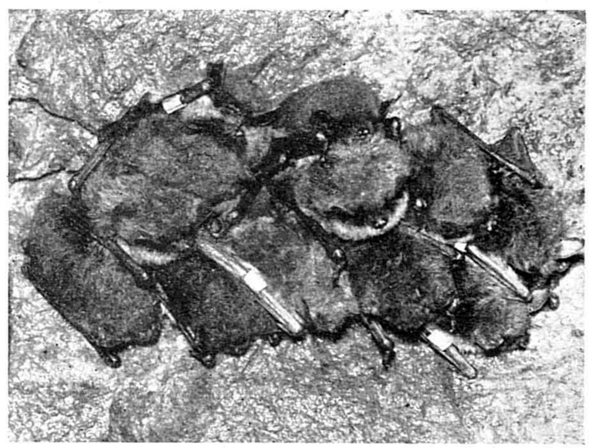

Fig. 5. BANDED BATS in a hibernating cluster viewed from beneath. Seven of these twelve bats were banded but several bands are completely out of sight. Torpid, in 50 to 60 temperature, they arouse quickly when disturbed. Durham Mine, Pennsylvania.

7. *What can be determined about life histories?*

It is a surprising fact that no one yet knows precisely where certain species of bats spend

half their lives. Where for instance does *Myotis sodalis* spend the summer? Bat Cave, Carter County, Kentucky, harbours 90,000 of these bats in winter. This and other winter haunts are empty during the summer.

Another example: At least 90% of all *Myotis subulatus leibii* ever seen, between 800 and 900, have been found hibernating in two very restricted cave areas, in central Pennsylvania and in eastern Ontario, about 325 miles apart. The dozen or so ever found in summer have been long distances from these hibernating centers. Observations by banders have indicated that *M. s. leibii* and *Eptesicus f. fuscus* are extremely hardy and spend only the coldest part of the winter in caves.

Fig. 6. EQUIPMENT for banding includes screened cage with cake mould top, and cylinder for long metal rods each containing 100 partly spread aluminum bands. Here recorder Bruce Sloane assists author Charles E. Mohr in checking banded bats at Durham Mine.

Pipistrellus s. subflavus, on the other hand, may begin hibernation in early September and not emerge from the caves until May or June. The pipistrelle is a solitary species widely distributed in caves. In fact, almost every cave has a few hibernating individuals. Populations of several hundred are being found in certain areas such as West Virginia. This relative abundance hadn't been suspected. Since this species is very easily recognized, all spelunkers can help by reporting the number they find in every cave, on every visit.

Extensive studies on the life history of *Corynorhinus rafinesquii intermedius* in California have been greatly aided by banding. Reports by Mary Koford and Oliver Pearson are nearing completion.

In Florida a good-sized cave colony of *Myotis austroriparius* was reported about 20 years ago but efforts to find it in recent years have been unsuccessful. Several small colonies are under observation by Indiana banders. There are no records from any of the intervening states.

Other promising projects already underway include:

An investigation of the physiology of hibernation, by James R. Beer in Minnesota.

An attempt to trace the life history of blood parasites in banded bats, by Sherman F. Wood, in California.

Tracing the day-to-day shifts of roving bands of bats, by Jerome S. Miller, in Michigan.

Studies in endocrinology, and other laboratory investigations, by Elizabeth W. Smith in Ohio, and Denny G. Constantine, in California.

Conclusion

With 30 active bat banders in the United States and Canada, it is reasonable to expect that our knowledge of bats will steadily advance. This report should demonstrate the need for some clearing house for information. The monthly NSS NEWS provides a timely channel for announcements and reports concerning the banding of cave bats, while the BULLETIN and the newly instituted OCCASIONAL PAPERS are available for completed papers on the subject. Also, help is available for certain types of investigations. Scores of individual members of the NSS are willing to cooperate in various ways. Some NSS grottoes are in a position to provide valuable aid to the bat bander.

Several points relative to investigations on cave bats must be borne in mind:

1. Bands are provided by the U. S. Fish and Wildlife Service to cooperators who give evidence of being able to identify the various species of bats and who have a definite project in mind. The Service has suggested that better coordination of bat banding activities will result if members of the NSS who wish to become co-

operators submit their applications either to Dr. Hitchcock or to the author for approval.

2. Extreme care should be taken to avoid unnecessary disturbances to hibernating colonies. There is considerable evidence that a number of bat colonies have seriously decreased in size due to disturbances of various kinds. Also there have been alarming reports of unwarranted removal of bats from caves. Members of the NSS are urged to do everything possible to safeguard remaining bat populations and to discourage the removal of any bats from hibernating quarters.

3. Cooperation is asked in reporting band numbers. The number must be read very carefully to make sure that it is complete. Most numbers will have two parts, as: $\frac{48}{58275}$. Reporting of the *species* and *sex* if known, will provide an additional check, especially if part of the number is obliterated. Reports should be sent promptly to the *U. S. Fish and Wildlife Service, Washington 25, D. C.* The reports will be acknowledged and information as to the time and place of banding will be furnished.

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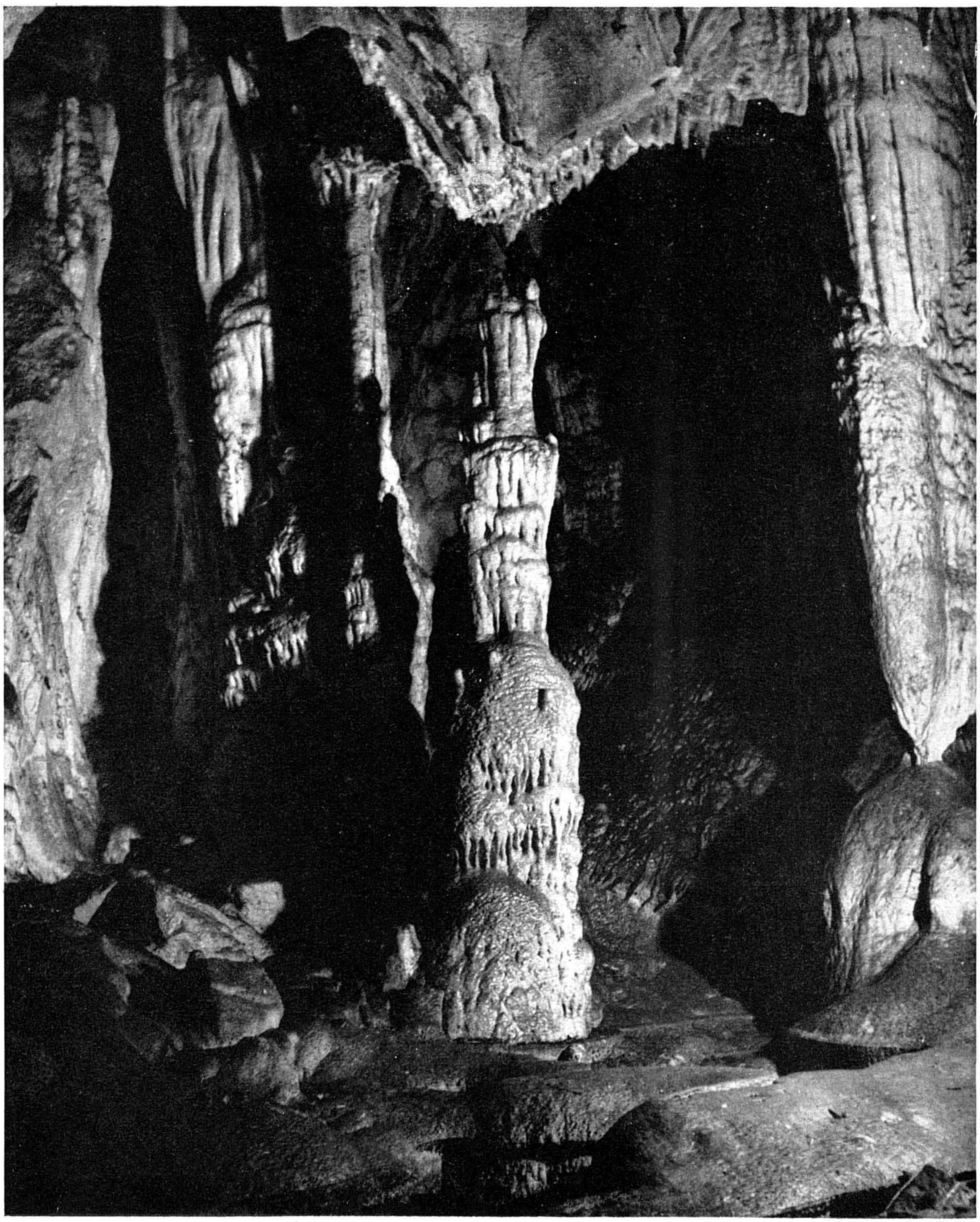

Photo by Werner Cohnitz

The Tower, a magnificent stalagmite 15 feet high about 800 feet from the entrance of Guacharo Cave.

The Guacharo Cave

By EUGENIO de BELLARD PIETRI

The amateur naturalist is probably not unfamiliar with the guacharo, or oil bird, which inhabits the northern portion of the South American continent, but knowledge of the existence of such a nocturnal cave-dwelling bird may come as somewhat of a surprise to the North American spelunker. This account is presented not so much for its treatment of the guacharo as for its thrilling record of hazardous cave exploration by an expert Venezuelan speleologist. For his many contributions to speleological knowledge the author was recently awarded a Certificate of Merit by the National Speleological Society.

Guacharo Cave, the largest so far discovered in Venezuela, is located in the northern part of Monagas state, near the village of Caripe. Its entrance, possibly one of the largest in the world, is 85 feet wide by 76 feet high. The total length of the cave has not been measured, but the author and two friends, Juan Antonio Tronchoni and Roberto Contreras, walked the whole cavern, estimating it to be about 2 miles long. It has not been possible to carry precision instruments or appropriate measuring devices through the narrow and dangerous "Wind Pass".

The cavern, as a whole, can be subdivided into two sections: (1) the better known portion of the cave and (2) the so called Hall of the Wind. A characteristic of the study of the first section is its practically straight course to the very end of the Precious Hall, there being three galleries in succession following almost exactly the same axis. Thus Guacharo Cave is more of a tunnel cave than anything else.

The first of the above mentioned sections has been rather accurately measured to be 3,678 feet, and can be subdivided into 3 large portions: The Guacharo Hall (also known as Humboldts Hall), is 2,685 feet long, the Hall of Silence is 622 feet long and the Precious Hall, 370 feet long.

The first hall is called The Guacharo Hall because it is inhabited by the famous Guacharo Birds (*Steatornis Caripensis;* Family Steatornithidae, Order Caprimulgiformes). This room is more of a huge and straight gallery than a hall in the accurate sense of the word.

Its dome, of great height, can only vaguely be seen even with the powerful beam of a flashlight containing five new dry-cells. This gallery is inhabited by thousands of birds which scream constantly after the first light starts probing their dark empire. The room itself has a more or less constant width of 68 feet, varying in height from 83 feet to 99 feet. The cavern floor is interrupted periodically by huge rocks, thus elevating the floor of the cave constantly. In this section of the cavern only massive stalactites can be seen; there is an absence of stalagmites. A very remarkable group of stalactites are The Elephants Feet. This part of the cavern is coursed throughout its whole length by a river, the Guacharo River, about 4 yards wide and one foot deep. Following the ecological classification of Thomas C. Barr, Jr. I would include it without hesitation (and in general all the cave as well) in the Hydrospoele division.

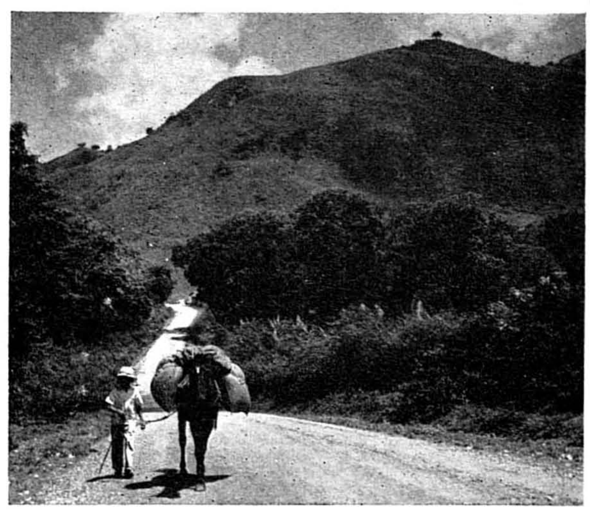

Photo by Werner Cohnitz

Fig. 1. The road to Caripe, where Humboldt spent nearly a year as his headquarters. At base of mountain a little path leads to cave.

Ecologically, this part of the cavern presented Troglophiles and Trogloxenes. In the first group, The Steatornithidae were the only members found, since no Chiroptera were seen anywhere. The second group presented a zoological individual, a white rat, and a great many plants belonging to a few species growing from the seeds that the Guacharo birds drop from their perches after eating. Particularly noticeable were palm seeds, some of which must have been gathered in remote places such as the valley of the Orinoco River, a fantastic distance of 131 miles away. These particular palm trees have not been identified in the surrounding forests. The little, pale, almost colorless plants grow in pitch darkness, and have therefore no chlorophyll whatsoever, attaining scarcely 18 inches in height at the most.

The passage to the Hall of Silence, a Hydrospoele, is through a short but narrow aperture. This short crawlway is inhabited by hundreds of crickets (Family Gryllidae) which I shall classify as Troglobious biota, since no light ever reaches within 1,500 feet of this fissure, and both their environment and anatomical characteristics suggest that classification.

The Hall of Silence itself is so-called because of its vivid contrast with the tremendous noise constantly kept up by the shrill screams of the birds inhabiting the previous room. It is 622 feet long, being also traversed by the same river mentioned before. To the left a small opening connects it with the Precious Hall,

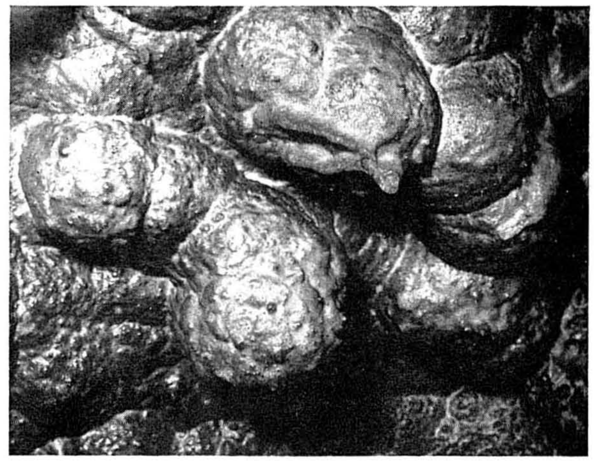

Photo by Werner Cohnitz

Fig. 3. Precious Hall contains hundreds of these unique formations which cover a low gallery at its end.

loveliest of the first section of the cavern, and at its very end a pool of frigid waters, Humboldts Pool, marks the apparent end of this gallery. This part of the cave is only 24 feet high and 21 feet wide.

The Precious Hall is considered a Mesospoele since it possesses quite a humid environment though it lacks constant water deposits or streams. It is 370 feet long, presenting lovely formations of pure calcium carbonate. The height of this hall is considerable, being in some places nearly equal to that of the Guacharo Hall; the width varies constantly, averaging about 45 feet.

To the right of the hall is a pit nearly 20 feet deep, which connects this great room with a lesser known part of the cavern, the "Caribe Vidal's Room", also a Mesospoele. This gallery, nearly 120 feet long, has beautiful helictites all over one of the walls. The passage to this dream room is quite dangerous for inexperienced explorers since one must climb into a narrow

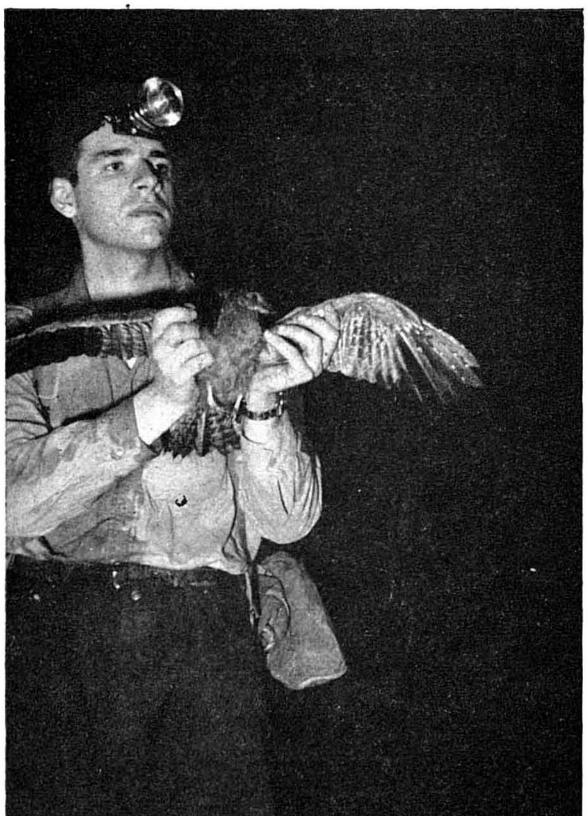

Photo by Roberto E. Contreras

Fig. 2. The author holds one of the famous Guacharo, or oil birds.

crevice at the very brink of a 26 foot pit. The helictites are so pure that they resemble crystal flowers more than anything else.

The second section of the cavern is reached by climbing a steep boulder in the Hall of Silence just at the end of Humboldt's Pool. Being a narrow and ugly crevice, few explorers venture farther. On the other side the river is met again in a narrow gallery. Here one must remove his equipment since two nasty passes must be traversed, one by diving. Here it is advisable to strip down to swimming trunks in order to avoid all possible weight. Scharffenorth's Pass is rather easy, since the icy-cold water merely reaches the spelunkers neck! Arriving at Wind Pass we were quite shocked at its formidable, forbidding appearance.

This crevice is so-called on account of a steady air gush that constantly flows through its opening, from the depths towards the mouth of the cave. It is elipsoid in shape, presenting only

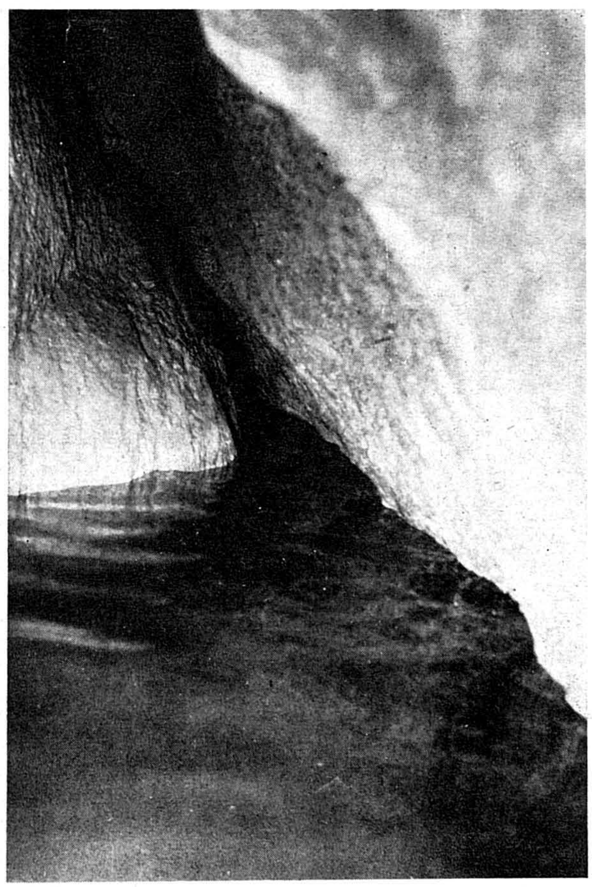

Photo by Roberto E. Contreras

Fig. 4. The forbidding approach to Wind Pass is 700 feet from the Guacharo birds.

a triangular opening above the water's surface measuring 9 inches wide and 16 inches high. Here, before this somber gap, the frigid waters reach the explorer's armpits. Below the waterline, the opening widens just enough to permit the explorer to dive through sideways at a point 2 feet below the surface for the full 4 yards distance of the Wind Pass. In the middle of this pass the air gap at the water surface decreases to a scarce 2 inches high by 3 inches wide, thus forcing the explorer to actually dive a treacherous 12 feet where anything can happen.

We spent the most dangerous minutes in all our speleological explorations in getting through such a dangerous crevice. One member of our party nearly drowned in attempting to swim in a prone position in going through. As soon as he turned he was held fast between both walls of the pass. Sheer luck and ability in swimming saved his life. In such a spot he was virtually helpless and we were almost unable to drag him from the death trap due to the very narrowness of the fissure. Necessary equipment was passed through in sealed auto tire inner tubes.

Behind the Wind Pass a low gallery led us to the Waterfall Room, and from there, after a nasty climb in the Room of the Rope Stone (a vertical shaft that requires a strong rope lift to be traversed) we reached the Great Room of the Hall of the Wind. An immense room, quite a bit wider in all respects than the previous ones of the Guacharo Hall, opened before us. Blood red crystaline stalactites, stalagmites and spaghetti-like formations met our astonished eyes. These formations glowed like frozen embers as soon as the flashlight beams fell upon them. Our Coleman gasoline lamp (500 candle power) gave us only a poor conception of the magnificence of this huge hall. A white rat was seen here, to our utmost amazement.

Toward the right, Alen's Room left us dumbfounded: helictites, stalagmites, columns, stalactites, all were unspeakably beautiful. Every square yard of the floor differed from the preceding one with lovely lace formations.

From there on, the cavern seems to shrink into a narrow but tall gallery thousands of feet long. Thus we arrived at the Hall of Towers, the dangerous Pass of the Knives, the Hall of

the Vaults and the Final Hall, so tall that all our lights combined failed to give us a glimpse of its dome. This part of the cavern is dangerous, since the river flows silently 25 feet below and one must walk on slabs barely balanced that constantly threaten to cause your fall into the narrow gorge that the river through centuries of action has cut in the rocks below.

This being the end we turned back at 6:30 p.m. after a very light lunch of sausage and bread that had been soaked in the icy waters of the Wind Pass. The return trip was without incident.

In this section of the cave, we only found as biota a white rat (about 4,050 feet from the

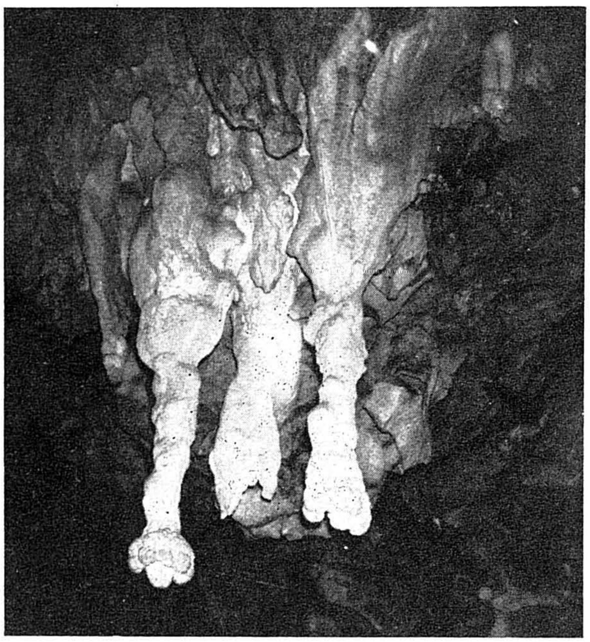

Photo by Werner Cohnitz
Fig. 5. The Elephants Feet.

entrance) and "Lapa" tracks. The Lapa, a rodent (*Cuniculas paca;* Family Dassyproctidae, Sub-Order Simplicidentata, Order Rodentia) is an animal very similar to a beaver, minus the tail. Both the rat and the lapa evidently come from the mountain side, whose surface must be quite near to the end halls of the cave through some still undiscovered crack in the rock. Their presence in the cave at this depth, otherwise would be absolutely unexplainable. Thus, these specimens of zoological fauna must be included as Trogloxenes, that is, accidental speleological fauna, possibly lost or astray in the dark cavern

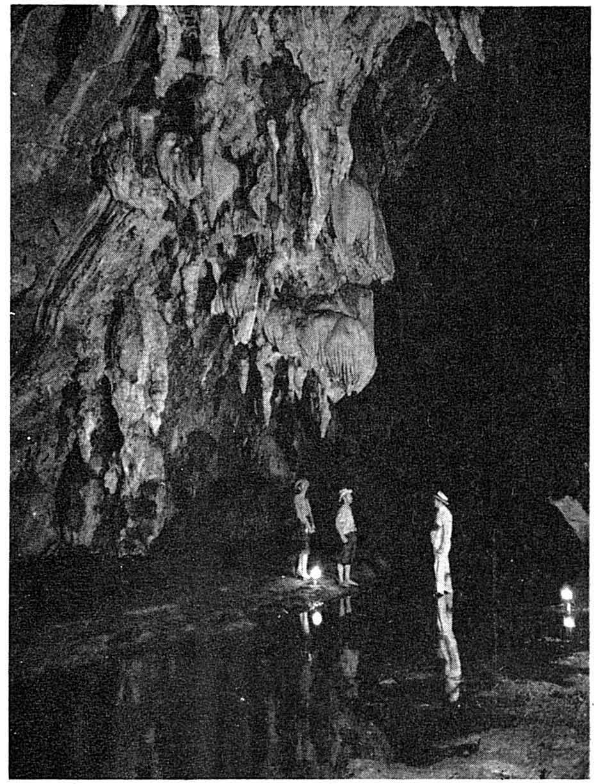

Photo by Werner Cohnitz
Fig. 6. The entrance room.

after failing to find the fissure through which they came in.

In fairness to previous explorers we must admit that we were not the first to venture through the Wind Pass, but we were undoubtedly the first to reach and explore the end of the cave and the very first to photograph its somber breathtaking magnificence.

The total exploration of the Hall of the Winds took 16 hours, while the exploration of the better known part of the cave a mere 6 hours. The exploration of the Hall of the Winds was begun at 9:45 a.m., returning 16 hours later at 1:45 a.m. The Wind Pass was traversed first at 10:30 a.m. and then at 12:30 a.m., after 14 hours of exploration.

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A Further Description of The Guacharo Cavern

By DR. GEORGE HARTWIG

This account of the famous Guacharo Cave was found in a book entitled "The Subterranean World" published by Longmans, Green, and Co., in London in 1871 and is reprinted herewith as a companion piece to the preceding article because it throws light on some of the earlier explorations in this cave.

In the class of birds we find many cave-haunting species. The pigeons like to nestle in grottoes, which also serve as welcome retreats to the moping owl; and various swallows and swifts breed chiefly in the darkness of caverns. One of the most remarkable of these troglodytic birds is the Guacharo, which inhabits a large cave in the Valley of Caripe, near the town of Cumana, and of which an interesting account has been given by Humboldt, who first introduced it to the notice of Europe.

The Cueva del Guacharo is pierced in the vertical profile of a rock, and the entrance is towards the south, forming a noble vault eighty feet broad and seventy-two feet high. The rock surmounting the cavern is covered with trees of gigantic growth, and all the luxuriant profusion of an inter-tropical vegetation. Plantain-leaved heliconias, and wondrous orchids, the Praga palm, and tree arums, grow along the banks of a river that flows out of the cave, while lianas, and a variety of creeping plants, rocked to and fro by the wind, form elegant festoons before its entrance. What a contrast between this magnificently decorated portal and the gloomy mouth of the Surtshellir, imbedded in the lava wildernesses of Iceland? As the cave at first penetrates into the mountain in a straight direction, the light of day does not disappear for a considerable distance from the entrance, so that visitors are able to go forward for about four hundred and thirty feet without being obliged to light their torches; and here, where light begins to fail, the hoarse cries of the nocturnal birds are heard from afar.

The guacharo is of the size of the common fowl. Its hooked bill is wide, like that of the goat-sucker, and furnished at the base with stiff hairs directed forwards. The plumage, like that of most nocturnal birds, is sombre brownish grey, mixed with black stripes and large white spots. The eyes are incapable of bearing the light of day, and the wings are disproportionately large, measuring not less than four feet and a half from tip to tip. It quits the cavern only at nightfall, especially when there is moonlight; and Humboldt remarks that it is almost the only frugivorous nocturnal bird yet known, for it does not prey upon insects like the goat-sucker, but feeds on very hard fruits, which its strong hooked beak is well fitted to crack. The horrible noise made by thousands of these birds in the dark recesses of the cavern can be compared only to the wild shrieks of the sea-mews round a solitary bird mountain, or to the deafening uproar of the crows when assembled in vast flocks in the dark fir-forests of the North. The clamour increases on advancing deeper into the cave, the birds being disturbed by the torch-light; and as those nestling in the side avenues of the cave begin to utter their mournful cries when the first sink into silence, it seems as if their troops were alternately complaining to each other of the intruders. By fixing torches to the end of long poles, the Indians, who serve as guides into the cavern, show the nests of these birds, fifty or sixty feet above the heads of the explorers, in funnel-shaped holes with which the cavern roof is pierced like a sieve.

Once a year, about midsummer, the Guacharo Cavern is entered by the Indians. Armed with poles they ransack the greater part of the nests, while the old birds, uttering lamentable cries, hover over the heads of the robbers. The young which fall down are opened on the spot. The peritonaeum is found loaded with fat, and a layer of the same substance

reaches from the abdomen to the vent, forming a kind of cushion between the birds' legs. The European nocturnal birds are meagre, as, instead of feasting on fruits and oily kernels, they live upon the scanty produce of the chase; while in the guacharo, as in our fattened geese, the accumulation of fat is promoted by darkness and abundant food. At the period above mentioned, which is known at Caripe as the 'oil harvest,' huts are erected by the Indians with palm leaves near the entrance, and even in the very porch of the cavern. There the fat of the young birds just killed is melted in clay pots over a brushwood fire, and is said to be very pure and of a good taste. Its small quantity, however, is quite out of proportion to the numbers killed, as not more than 150 or 160 jars of perfectly clear oil are collected from the massacre of thousands.

The way into the interior of the cavern leads along the banks of the small river which flows through its dark recesses; but sometimes large masses of stalactites obstruct the passage, and force the visitor to wade through the water, which is, however, not more than two feet deep. As far as 1,458 feet from the entrance the cave maintains the same direction, width, and height of sixty or seventy feet, so that it would be difficult to find another mountain cavern of so regular a formation. Humboldt had great difficulty in persuading the natives to pass beyond the part of the cave which they usually visit to collect the oil, as they believed its deeper penetralia to be the abode of their ancestors' spirits; but since the great naturalist's visit, they seem to have abandoned their ancient superstitions, or to have acquired a greater courage in facing the mysteries of the grotto, for, while they would only accompany Humboldt as far as 236 fathoms into the interior of the cave, later travellers, such as Codazzi and Beaupertuis, have advanced with their guides to double the distance, though without reaching its end. They found that beyond the furthest point explored by Humboldt the cave loses its regularity, and has its walls covered with stalactites. In the embranchments of the grotto Codazzi found innumerable birds. It was formerly supposed that the guacharo was exclusively confined to this cave; latterly, however, it has also been found in the province of Bogota.

The Orca Goes Underground

By PHIL C. ORR
Santa Barbara Museum of Natural History

Photos by Walter S. Chamberlin

Nowhere will one find a more fascinating account of a perfectly organized and administered speleological expedition than in this reprint of an article from Volume XXVI, No. 2 of MUSEUM TALK, published by the Santa Barbara Museum of Natural History. Frontiers of speleological research were advanced on the memorable voyage herein described and much credit is due to Joseph W. Sefton, Jr., owner of the ORCA and to the author and his companions who give us an insight into the secrets of the caves of the Santa Barbara Channel Islands.

As the research ship Orca of the Sefton Foundation of San Diego dropped anchor in Santa Barbara Harbor the first of June, 1950, a big four-wheel drive truck labeled "National Speleological Society," escorted by the Museum jeep, pulled up at the breakwater and proceeded to unload. Soon several conventional cars arrived with more scientists and gear.

"What in the world!" wondered people on the breakwater as microscopes, diving helmet, cameras, batteries, picks and plant presses were loaded into a skiff and ferried out to the Orca.

The Orca is dedicated by her Master, Joseph W. Sefton, Jr., to scientific research in coastal waters from Santa Barbara to Mexico and the writer has been fortunate to have joined her expeditions at least once a year.

This time it was the Sefton Speleological Expedition. This expedition, the culmination of about ten years planning on the part of the author, was made possible by the generosity of Mr. Sefton and the cooperation of the National Speleological Society through Ed Danehy and Art Lange of the Stanford Grotto, and Walt Chamberlin of the Southern California Grotto. Botanist Dr. C. H. Muller, zoologist Dr. Don Wootton and students Charles Stasek and Charles Judson, all of Santa Barbara College, the author and R. S. Finley, of the Museum staff, completed the scientific crew.

Our purpose was to investigate the sea caves of Anacapa and Santa Cruz Islands—to map them, determine their size and to investigate the cave life.

Caves of the islands have been known since 1890, when Lorenzo Yates described several.

Fig. 1. Research ship Orca at West Anacapa Island. Foreground: Phil C. Orr, Curator of Geology and Anthropology at Santa Barbara Museum of Natural History and assistant, R. S. Finley. Dr. C. H. Muller, Botanist from Santa Barbara College and Charles Stasek, student.

Other writers have mentioned or described some of them but apparently few have actually visited them. Four caves had been recorded for the Anacapas, but we found fifty.

Captain Kandy set a course for the west island of Anacapa, then cruised in close to shore. With Art Lange and the writer at the maps and notes, Dick Finley and Walt Chamberlin handling color and black and white cameras and the remainder of the crew with binoculars, we made a preliminary survey of the west, middle and east islands of Anacapa.

Anchoring at Fisherman's Camp on West Island we worked out with small boats and a canoe, entering the sea caves, measuring, mapping, photographing, collecting minerals and algae, and observing marine life.

The most interesting cave is on West Island. Dr. Yates mentioned it in 1890, so we named it Yates Cave. This huge room, hollowed out by wave action along a fault plane, measures 200 feet across with an arched ceiling 100 feet high. Water occupies most of the cave and a forty-foot boat could ride at anchor in it. At each end is a pebble beach.

The remarkable coloring on the roof and walls is a blending of the yellows, greens and browns of algae and minute crystals of aragonite.

Sea Lion Cave, also on West Island, must be entered by its six-foot tunnel at low tide or during periods of no surge, for the ceiling is too low to risk being smashed against it by a heavy wave. The tunnel goes back a hundred feet, then turns to the left.

The heavy resonance of sea lions barking within the cave is depressing to the ear and makes one wonder if one of these five hundred-pounders will land in the boat. However, they gathered on the little beach at one end of the cave and posed for flashlight pictures and, while some made frantic efforts to escape, none landed in the skiff.

Keyhole Cave, which we named for its shape, looked enticing and the author attempted twice to enter it in a canoe but waves ten to fifteen feet high at its mouth prevented even a peek.

Abalone Cave on Middle Island is small, with barely room for a skiff. It is the only cave in which we found live abalones.

Weather, as usual on the islands, was bad. Northwest winds kept the channel in a choppy condition and ground swells dashed on the rocks and completely filled the smaller caves, so we weighed anchor and coasted along the north shore of Santa Cruz Island from San Pedro Point, on the east end, to West Point.

More than a hundred caves were located in this distance. After a hazardous attempt off Coche Point to investigate caves in what looked like a sheltered spot, we anchored in Pelican Bay where a shore party collected plants, lizards, mollusks and minerals. Another small party in a boat investigated Algae Cave, a small cave in a protected cove. Its walls and ceiling were coated with a brilliant red algae, a species of

Fig. 2. In Yates Cave, West Anacapa Island.

Rhodochorton first known from McKinnon's Tomb in Scotland and found in Finley Cave last year by the Museum's San Miguel Island Expedition. We found this algae again later in Babys Cave and Sponge Cave.

High winds prevented us from making investigations of any but the more sheltered caves, so while the Orca went off on a porpoise hunt, the speleologists went ashore at Ladys Harbor which, with its companion, Babys Harbor, form one of the nicest spots to be found on the islands. The deep blue waters of the two harbors meet the beach where a steep rocky canyon comes from the hills. A running stream is banked with ferns and mosses and the little island tree frogs play in the pools.

Babys Cave is located on the point of rock separating the two harbors and can only be

entered by boat. The ceiling is covered with red algae and the water within the cave is indirectly lighted by hidden underwater passages to the outside, so that the water along the edges of the rock gives off a soft greenish glow.

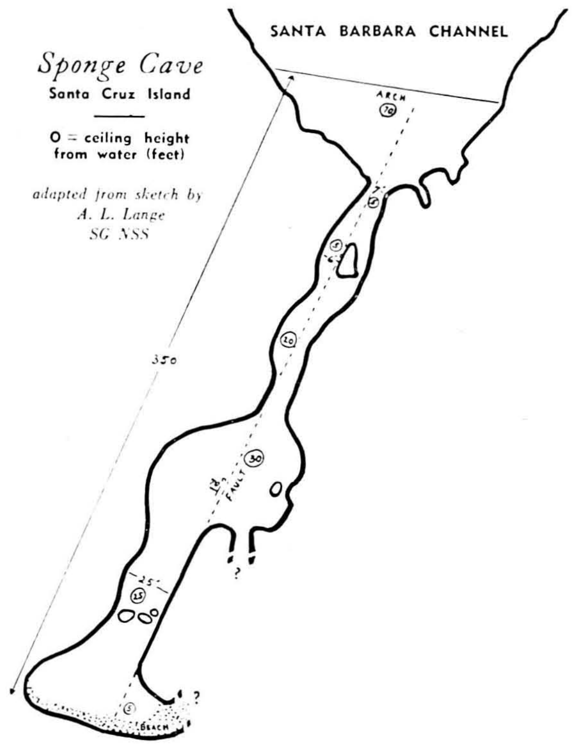
Sponge Cave, to the west of this, is entered through an opening just large enough to take a skiff. The roof is supported by pillars and our boat floated in the narrow passage, going into total darkness for a hundred feet and then the light of our flashes no longer reached the walls. We seemed in the middle of nowhere, until our eyes became accustomed to the dim light and we saw a large room with another larger passage leading back into the mountain.

With our flashlights we could see the bottom of this passage four to twenty feet below us through the crystal-clear water and the rocks were covered with brilliant white objects of many sizes. Wondering what they were, we tried probing with an oar until Dick Finley went overboard to wade in the cold water, hoping a moray eel wouldn't come out of a crevice. He brought up small white sponges that live here by the thousands in darkness.

This cave is about 350 feet long, up to 50 feet wide and, like Babys Cave, is coated with red algae. Deep inside is a small beach where we collected barnacles and mollusks.

Tres Bocas at Valdez is one that has been visited by many people, for the best landing to the canyon is made through this four hundred-foot cave. Boats can be beached in one mouth, which is about forty feet wide, and then you can walk dry shod through another entrance into the canyon.

Nearby is a dry gulch which is concealed from land and sea, but which opens only through a short tunnel—just the place for small boys to play pirate and for big ones to be speleologists.



The Occurrence of Quartz Stalactites in The Rock Creek District of Douglas County, Oregon

By ROBERT HOUSLEY
Freshman, Reed College

Research in the field of cave minerals needs the attention of all who can throw light on the relationships that exist in the building up of the varied formations. One little detail may not seem important but, added to many other little details, each idea contributes toward the solution of the most baffling problem. A glimpse into the complexity of some of these problems is given in this article so ably written by a young high school student who, because of his obvious ability, is a member of the Committee on Formations and Mineralogy of the National Speleological Society.

INTRODUCTION

Well-formed quartz stalactites have recently been found at four localities in the Rock Creek District of Douglas County, Oregon. These four localities, the Lone Rock quarry, the Rock Creek quarry, a gravel pit near Rock Creek, and a cut along the new North Umpqua Highway are shown on the accompanying map. They have all been exposed recently by logging and road building activities. The region is fairly mountainous and heavily timbered. The rock is of an igneous nature and overlies the Umpqua Formation sediments of the Eocene period.

DESCRIPTION OF LOCALITIES

Locality number one, the Lone Rock quarry, is in columnar diabase immediately above the Umpqua Formation. With the exception of a large vein of calcite with a little associated pyrite all the minerals occurred in gas formed cavities up to about 10 cm. in diameter. There were few of these cavities and the only minerals found in them were quartz and calcite.

The one quartz stalactite found here was 3.5 cm. in diameter and 4.6 cm. long. It is broken off at both ends and was found loose. It is made up of a 5 mm. chalcedony center surrounded by quartz crystals approximately 1.5 cm. long. In the middle of this chalcedony center is an area 1 mm. in diameter which is softer and less transluscent than the rest of the chalcedony.

Locality number two, the Rock Creek quarry, is located in diabase similar to that of the Lone Rock quarry except that it is not columnar. Here the minerals are found in gas formed cavities up to about 50 x 30 x 8 cm. in size. These cavities were all lined originally with chalcedony, quartz, or calcite, which did not follow any order of deposition. In some cases calcite formed first followed by chalcedony and druzy quartz, while in other cases chalcedony formed first followed by druzy quartz and calcite. The last minerals to form were the zeolites, laumontite, heulandite, and stilbite. Of these, laumontite is the most common, forming crystals up to 1.5 cm. long in many of the cavities, while only a few small crystals each have been found of heulandite and stilbite.

Three cavities containing quartz stalactites and one loose stalactite group have been found here. The whole top of the largest cavity, which measured about 50 x 30 x 8 cm., was covered with stalactites up to 6 cm. in length. Many of these stalactites were speckled with small laumontite crystals. On the bottom of the cavity were several calcite crystals, some coated with quartz, others not. There were no stalagmites—at least none sufficiently developed to be differentiated from normal surface irregularity. However, there was what appeared to be several stalactites that had broken off the top, cemented haphazardly onto the bottom.

The average diameter of these single stalactites is from 2 to 4 mm.; however, many of them formed together in sheets which are between 1 and 2 cm. wide. The single stalactites are made up almost entirely of druzy quartz,

which radiates outward from the center. In some of the single stalactites, a hollow chalcedony center was visible under 20x magnification; in others none was seen. The stalactitic sheets seemed to be made up of single stalactites joined together by a thin sheet of chalce-

up to about 90 degrees. Several have branches at approximately 90 degree angles; then these branches in turn have stalactites hanging from them. There are other stalactites that have forks out at acute angles, and some that split so that both forks are acute to perpendicular.

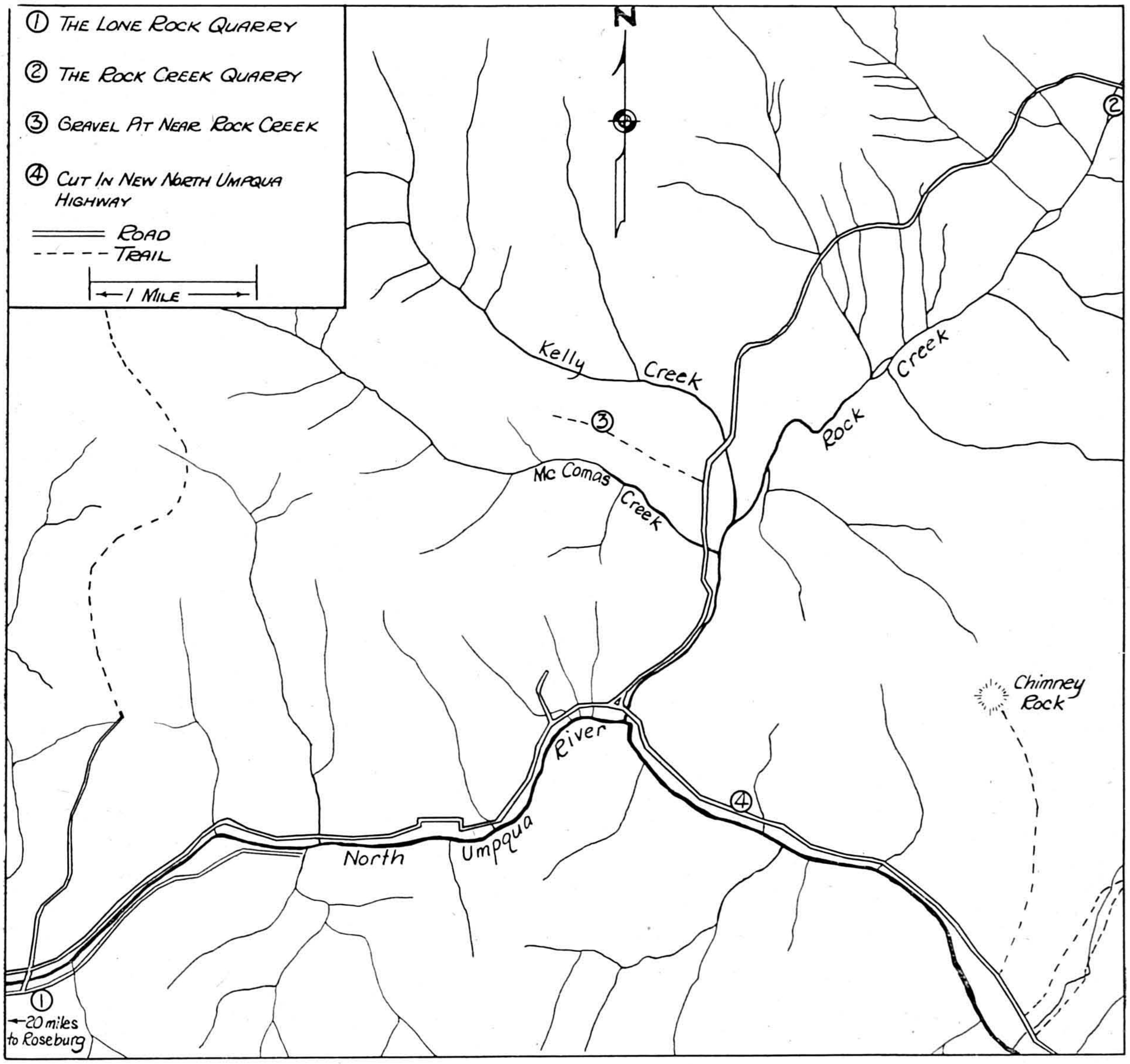


Fig. 1. Map of Rock Creek District of Douglas County, Oregon.

dony coated with druzy quartz. In some cases this sheet of chalcedony is indistinct or possibly absent, and the stalactites appear to be joined only by druzy quartz.

An interesting characteristic of these stalactites is their tendency toward turning and branching. Many of them have curves ranging

The next largest cavity containing quartz stalactites found at the Rock Creek quarry was about 8 x 8 x 5 cm. It contained stalactites that are approximately 6 mm. in diameter and 2 cm. long. These stalactites hang vertically with no tendency toward abnormal growth. They are made up of druzy quartz crystals radiating from

a center that is just visible in a few specimens under 20x magnification.

The smallest stalactite-containing cavity found here was about 5 x 5 x 3 cm. in size. The stalactites found in it are approximately 2mm. in diameter and 1 cm. long. They consist of a hollow chalcedony shell covered with radiating quartz crystals. This chalcedony shell is approximately 0.125 mm. thick, and the hollow center is about 0.25 mm. in diameter. Most of these stalactites hang straight down; however, a few have sharp curves near the end, and several are growing out at angles from the sides. There were also two stalagmites growing up from the bottom. These stalagmites seem to be identical with the stalactites, including the hollow center surrounded by the chalcedony shell. One of

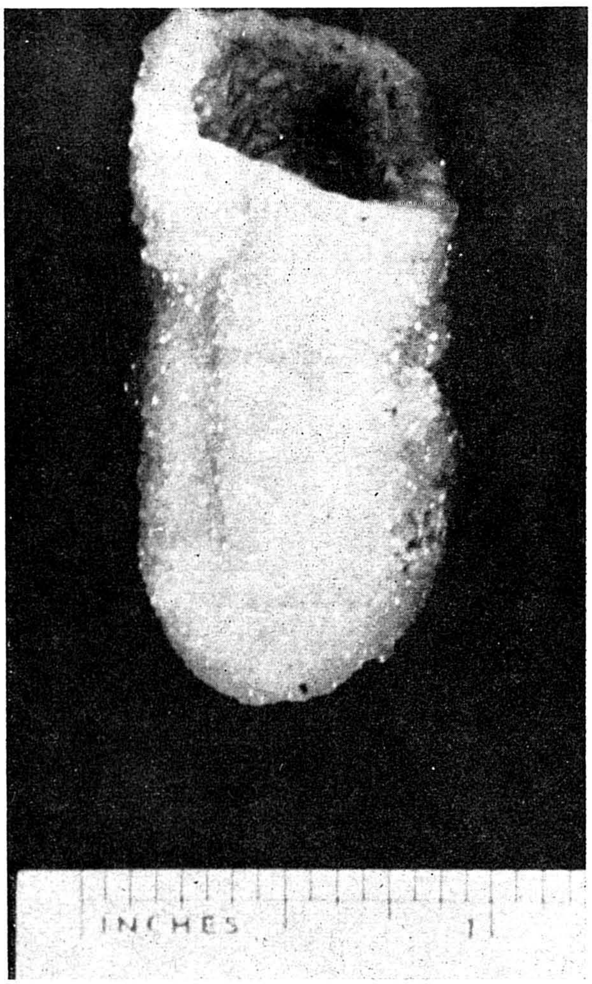


Photo by William J. Foster

Fig. 2. Single quartz stalactite from the gravel pit near Rock Creek.

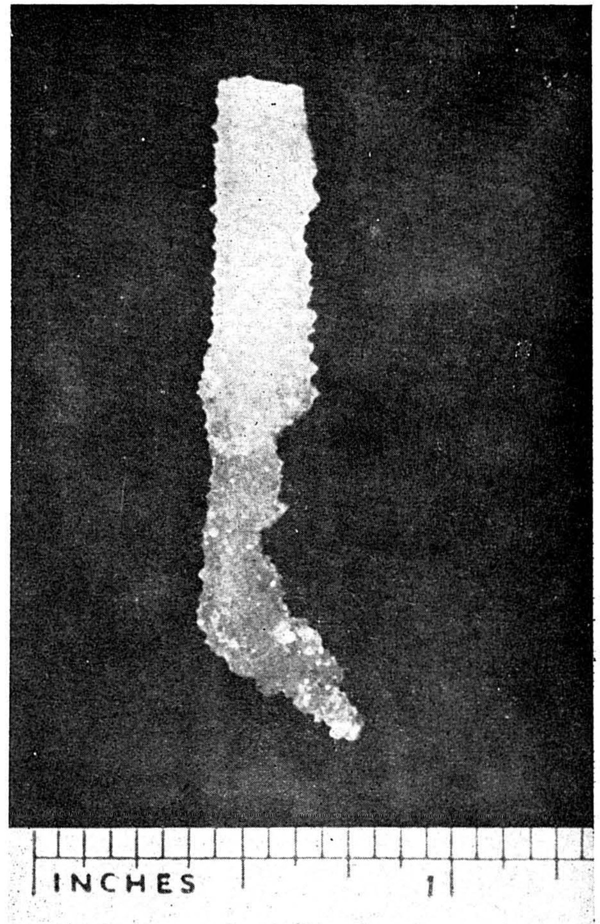


Photo by William J. Foster

Fig. 3. Single stalactite showing curve; from the Rock Creek Quarry.

them even has a short projection out at a right angle.

In a small corner of the cavity was a space approximately 0.5 square cm. in area where the stalactites consisted only of the hollow chalcedony shell without the coating of druzy quartz. These stalactite shells are approximately 0.5 mm. in diameter and 5 mm. long. Some of them show curves identical with the curves shown by the normal stalactites in the cavity.

The loose stalactite group found here is about 18 x 15 x 8 cm. in size. It consists of pale blue stalactites approximately 8 mm. in diameter of a soft dark material surrounded by a 2 to 3 mm. layer of chalcedony and druzy quartz. On top of this has been deposited a heavy coating of laumontite. Many of these stalactites are grown together in sheets, and a few of them have long, smooth curves. The

stalactites in the sheets are joined by a thin layer of dark material coated with chalcedony and druzy quartz.

The third locality, a gravel pit near Rock Creek, is in a layer of loose rock and clay left by the original rock decaying in place. The material has shifted so little that most of the pieces of a broken geode will be found close together.

Minerals found here include agates, jasper, quartz crystals, amethyst, and opalescent quartz crystals. This opalescent quartz is a pale blue color with some specimens showing a faint play of colors. The play of colors is caused by internal flaws, while the opalescence is thought to be due to systematically arranged inclusions.

The four single quartz stalactites and the one stalactite group found here all seem to have formed in large quartz geodes. From the casts left, it is obvious that calcite also formed in these geodes; however, it is all weathered out now. The largest of the single stalactites is 12.5 cm. in diameter and 18 cm. long. It has a hole 3 cm. in diameter and 17 cm. long in the center. On one side of this hole, the smooth faces of a negative quartz crystal extend for most of its length. The other sides are rough.

The second largest stalactite from here is very similar to the first. It is 6 cm. in diameter and 7 cm. long. It contains an irregular central cavity 1.5 cm. in diameter and 6 cm. long.

The third largest stalactite is 2.7 cm. in diameter and 6.5 cm. long. It has a negative quartz crystal (hole the shape of a quartz crystal) 9 mm. wide and 5.7 cm. long in the center. On one side of the negative quartz crystal and separated from it by a thin layer of chalcedony are the impressions left by some weathered out calcite crystals. Surrounding the negative quartz crystal and the calcite impressions is another layer of chalcedony followed by druzy quartz.

The remaining single stalactite from this locality is approximately 2 cm. in diameter and 4 cm. long. It contains an internal cavity 1.5 cm. in diameter and 3.5 cm. long, which is completely lined with calcite impressions.

The one stalactite group from here is a pale amethyst color. It consists of stalactites between 2 and 3 mm. in diameter and from 2 to 3 cm. long. These stalactites are composed almost entirely of radiating druzy quartz.

The fourth locality, a roadcut on the North Umpqua Highway near Rock Creek, is also in diabase. The only minerals that have been found here are quartz and calcite.

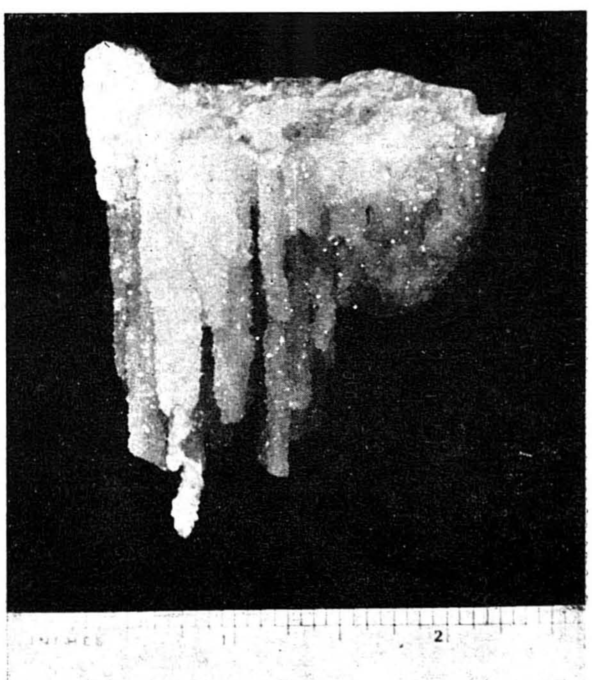


Photo by William J. Foster

Fig. 4. Group of quartz stalactites from the largest cavity at the Rock Creek Quarry.

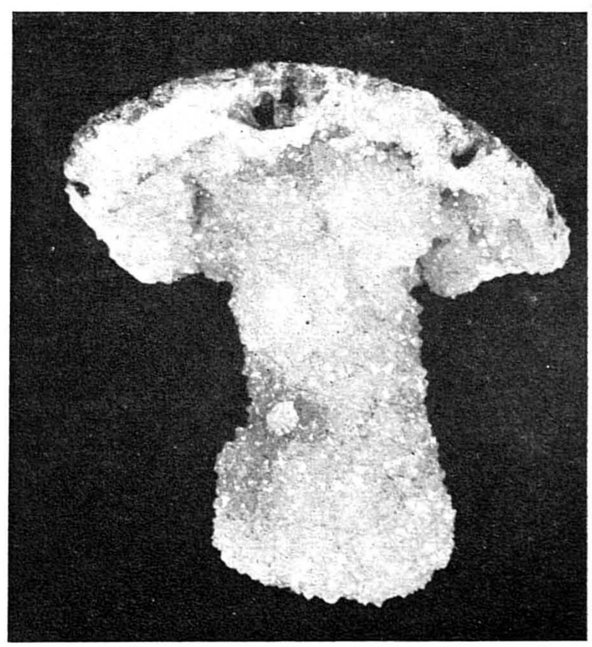


Photo by L. B. Hicks

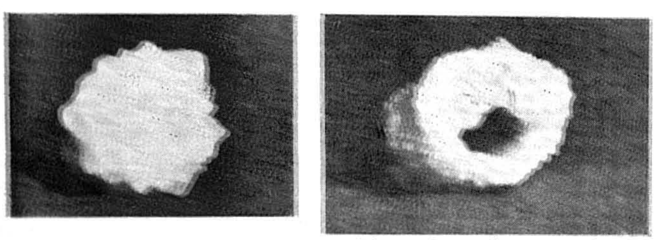
Fig. 5. Large single quartz stalactite from the gravel pit near Rock Creek.

The largest of the three cavities containing quartz stalactites found here was about 50 x 30 x 15 cm. in size. It contained stalactites which are 4 to 5 mm. in diameter and 2 cm. long. These stalactites consist of druzy quartz crystals radiating from a center that is visible under 20x magnification. While none of these stalactites curve, many of them grow out at various angles from the sides.

The second largest cavity found here was about 50 x 25 x 15 cm. in size. It contained three medium sized stalactites. The largest is 1.5 cm. in diameter and 4.3 cm. long; the next is 8 mm. in diameter and 3 cm. long; and the smallest was 8 mm. in diameter and 2 cm. long. When broken open, this smallest one was found to consist of a hollow quartz or chalcedony center 1 mm. in diameter surrounded by small irregularly distributed calcite crystals, then a layer of chalcedony, followed by the usual coating of druzy quartz.

The other cavity of quartz stalactites from this locality was about 15 x 15 x 5 cm. in size. In it, many of the stalactites were growing from quartz-coated calcite crystals and a few were growing out from the sides of the cavity. These stalactites are approximately 2 mm. in diameter and up to 22 cm. long. Some of them have curves and a few have projections at right angles to the original. The druzy quartz in these stalactites radiates from a center that is visible under 20x magnification.

Also found in this general area was an agate which has what appear to be quartz stalactites encased therein. These encased stalactites are about 3 mm. in diameter and 1 to 2 cm. long. They have a 2 mm. hollow center, which, when they were sawed so as to expose it, along its entire length, showed several restrictions where the tube was partly sealed off by thin layers of chalcedony.



Photos by Robert Housley

Fig. 6. End views of single stalactites: left, from Lone Rock Quarry showing chalcedony center; right, from gravel pit near Rock Creek showing negative quartz crystal in center.

Of the four localities described, it is possible that more stalactites will be found at the Rock Creek quarry, and at the gravel pit near Rock Creek. The Lone Rock quarry is abandoned, and of course, no more work will be done at the road cut.

HYPOTHESIS OF FORMATION

Any satisfactory hypothesis of formation of these stalactites will have to explain the following points: the visible hollow center in some of the stalactites, the fairly sharp curves which many of them exhibit, the stalactite-like formations that grew out from the walls or up from the bottom of the cavity, the long, smooth curves in the stalactites of one group, the stalactites that grew together in sheets, the forked stalactites, the restrictions in the center of the stalactites in agate, and the negative quartz crystals in the center of two of the large stalactites. It will also have to explain how they were formed in these small cavities deep in the earth and why one cavity will contain quartz stalactites, while one within two feet of it will not.

The explanation that the quartz stalactites were built up by the precipitation of crystalline quartz or chalcedony around the orifices where solution entered the cavity fulfills most of these requirements. It necessitates an original central cavity in all of the stalactites. This cavity could remain open or could later be filled with quartz or some other material.

With this hypothesis, it can readily be seen how stalactite-like formations could grow out from the sides or up from the bottom of the cavity. The tendency for stalactites from two of the cavities to form in sheets can possibly be explained as being caused by small cracks or weaknesses in the roof of those cavities where solution could enter more easily. The restrictions in the central cavity of the stalactite enclosed in agate probably represent times when this central cavity was partly sealed off. Obstructions of a similar nature in the central cavities of other stalactites could have deflected the flow of solution in such a way as to account for the few that are forked and for the numerous curved ones.

It is obvious that whether the original stalactite was large or small and whether it was composed completely of crystalline quartz or partly of chalcedony, were dependent on the physical and chemical nature of the solution from which it was derived and on the size of the orifice through which the solution entered. It is quite likely, however, in the case of the larger stalactites, that additional material was deposited on the original.

The main weaknesses of this hypothesis are its inability to explain the negative quartz crystals found in two stalactites and its inability to explain the long smooth curves in the stalactites of the one group.

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to Mr. Milo E. Godfrey and Mr. Everett Teater for allowing me to examine their quartz stalactite specimens; to Mr. Leslie E. Roberts for help in identifying rocks and obtaining geological information; and to Mr. William J. Foster of the National Speleological Society for necessary encouragement.

LIST OF GROTTOES

Wherever sufficient interest in speleological activity exists members of the National Speleological Society are encouraged to form regional organizations or local "grottoes". These regions and local units generally select their own officers, organize and conduct field trips, carry on research projects or otherwise implement the efforts of the parent body. A list of such regions and local grottoes, with the names and addresses of persons to contact for information, follows:

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1. *Northeastern Region*
   Roger C. Dorn,
   23 Linden Ave.,
   Oneonta, N. Y.
2. *Virginia Region*
   Col. Robert P. Carroll,
   305 Letcher Ave.,
   Lexington, Va.

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   F53 Dunster House,
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4. *Cascade*
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   2206 Crescent Drive,
   Seattle 2, Wash.
5. *Cazenovia*
   Stella F. Pierce,
   29 Nelson St.,
   Cazenovia, N. Y.
6. *Charleston*
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   706 Forest Circle,
   South Charleston, W. Va.
7. *Charlottesville*
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   Linwood House Hotel,
   Box 37,
   Colonial Beach, Va.
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   28923 Westwood Road,
   Bay Village, Ohio
9. *Colorado*
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   1611 Quebec St.,
   Denver 7, Colo.
10. *Cornell*
    Richard E. Kenyon,
    14 Hazel St.,
    Oneonta, N. Y.
11. *Dartmouth*
    21 Robinson Hall,
    Hanover, N. H.
12. *Duke*
    Jack Gibbons,
    Physics Department,
    Duke University,
    Durham, N. C.
13. *Elkins*
    Robert Lutz,
    210 Center St.,
    Elkins, W. Va.
14. *Enterprise Dilettante Speleology*
    155 Elm St.,
    Kearny, N. J.
15. *Indiana*
    George Jackson,
    Box 111, R.D. 5,
    Hillsdale Road,
    Evansville, Ind.
16. *Iowa*
    Dorothy M. Newfang,
    613 Iowa Ave.,
    Iowa City, Iowa
17. *Lexington*
    M. M. Pettyjohn, Jr.,
    Box 407,
    Lynchburg, Va.
18. *Metropolitan, N. Y.*
    Ida V. Sawtelle,
    1030 83rd St.,
    Brooklyn 28, N. Y.
19. *Morgantown*
    J. J. Eichenmuller,
    P. O. Box 319,
    Morgantown, W. Va.
20. *Natty Bumpo*
    Clifford N. Forman, Jr.,
    Richfield Springs, N. Y.
21. *New England*
    LeRoy Foote,
    R.D. 1,
    Middlebury, Conn.
22. *Nittany*
    William Devitt III,
    Sigma Alpha Epsilon,
    State College, Pa.
23. *Northern New Jersey*
    Howard N. Sloane,
    181 Wildwood Ave.,
    Upper Montclair, N. J.
24. *Philadelphia*
    Mary F. Pearsall,
    2126 Walnut St.,
    Philadelphia 3, Pa.
25. *Pittsburgh*
    Robert Dunn,
    R.D. 2, Shannon Rd.,
    Verona, Pa.
26. *Rensselaer*
    Edward J. Stofka,
    No. 6 Peoples Dr. E.,
    Rendael Farms,
    Troy, N. Y.
27. *Richmond*
    Betty Loyd,
    R.D. 2, Waynesboro, Va.
28. *Sierra*
    Ethelyn Fusselle,
    2506 Leavenworth,
    San Francisco, Calif.
29. *Southern California*
    Richard Logan,
    2801 Virginia St.,
    Santa Monica, Calif.
30. *Stanford*
    School of Mineral Sciences,
    Stanford, Calif.
31. *Tarevac*
    T. L. Carr,
    202 Taylor St.,
    Cannelton, Ind.
32. *Tri-County*
    Charles Hanor,
    84 Elm St.,
    Oneonta, N. Y.
33. *Twin City*
    David S. Gebhard,
    1665 Montreal Ave.,
    St. Paul 5, Minn.
34. *University of Texas*
    Box 1625,
    University Station,
    Austin, Texas
35. *V. P. I.*
    Sam M. King,
    Box 4944 Va. Tech. Sta.,
    Blacksburg, Va.
36. *Washington, D. C.*
    Elaine Higgins,
    1233 37th St., N.W.,
    Washington, D. C.
37. *Wytheville*
    Elizabeth Sabatinos,
    102 Faculty St.,
    Blacksburg, Va.
38. *Salt Lake*, Dr. Wm. R. Halliday, 184 4th Ave., Salt Lake City, Utah.

The Origin of the Palettes, Lehman Caves National Monument, Baker, Nevada

By CHARLES J. KUNDERT
Mining Geologist, California State Division of Mines

Photos by National Park Service

The unusual and rather striking cave formations known as palettes apparently exist, in quantity at least, in only two known localities, i.e., in Grand Caverns at Grottoes, Virginia, and at Lehman Caves National Monument at Baker, Nevada. The author of this article, after an extensive study of the Nevada palette formations, presents herewith a scholarly hypothesis to explain their origin.

Lehman Caves National Monument is located on the eastern flank of Wheeler Peak (Elev. 13,060 feet, second highest mountain in Nevada) in the Snake Range of eastern central Nevada near the Utah border. The caves are in eastward dipping middle Cambrian limestone. Underlying the limestone are well bedded quartzites of lower Cambrian and perhaps pre-Cambrian age. Granite of unknown age has intruded the sediments along the limestone-quartzite contact. The last datable geologic event took place during the Pleistocene when glaciers cut deeply into the flanks of Wheeler Peak. Magnificent cirques and large U-shaped valleys are primary evidences of past glaciation. The excessive moisture conditions of the Pleistocene probably initiated the cavern development.

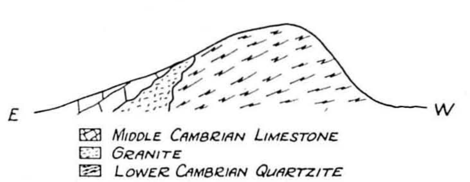


Fig. 1. Sketch section through Wheeler Peak.

Lehman Caves National Monument is noteworthy for the palette type formation which, to the author's knowledge, is unique except for a much larger similar type found in the Grand Caverns at Grottoes, Virginia. The palettes are most commonly circular in shape, range in diameter from 6 inches to 5 feet, and vary in thickness from 1/4 inch to approximately 1 inch. They are usually tilted at an angle, and are frequently fastened to the wall. Some of the palettes are completely free from the surrounding rock and stand away from the floor by means of a dripstone base. Later dripstone commonly obscures a portion of the palette, often that part attached to the wall rock.

The palettes appear to be dripstone fillings along joints with the wall rock later being dissolved away leaving the palette jutting forth. In support of this theory of development along joint planes, it will be demonstrated that the palettes do exhibit continuity with the joint pattern.

The accompanying map locates approximately 215 joints and palettes. It is divided into convenient units which will be dealt with individually. Only joints with at least two feet of exposed length were mapped. This size limitation was necessary because of locally abundant joints in highly shattered areas where the occurance of an unfractured piece of limestone more than a few inches across was a rarity. Other areas of country rock, measured in feet, were relatively free from fractures. In the following tabulation of joints and palettes, the latter are followed by a letter. Palettes attached to or in close proximity with highly fractured country rock are succeeded by a capital F. Palettes with obscured country rock areas are followed by a capital D to indicate a dripstone cover. In each unit the joints and palettes are loosely grouped according to their attitudes (strike followed by the dip if available).

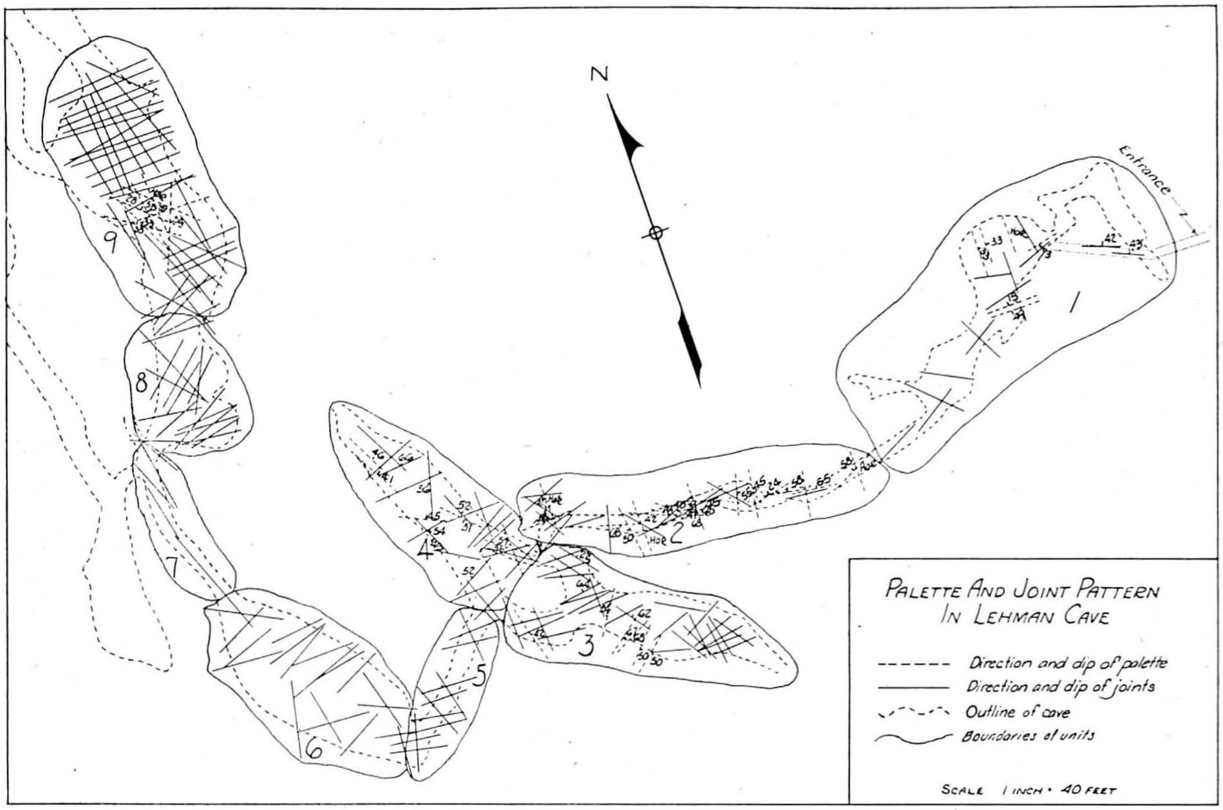


Fig. 2. Map showing location of approximately 215 joints and palettes in Lehman Cave.

TABULATION OF JOINTS AND PALETTES

Unit 1—			Unit 2—			N72W	60S	D	N87E		
N67W	43N		N63E			N71W	30E	D	N87E		
N69W	92N		N63E	58N	D	N68W	66N	D	EW		
N63W			N69E			N65W	42S	D	EW		
			N70E						N87E		
N78W			N60E			N80E	29N	D			
N88W	49S	F	N65E	48N	F	N78E			N2W		
N89W	15N	F				N85E			N12W		
			NS		F	N75E			N5W		
N78E	73S	F	N10E	steepW	F	N75E			N6W		
N70E			N10E	45E	F				N2W		
N76E			NS	?	D	N8W	50W	F	N82E	64N	
N10W			NS	?	F	N15E	55E	F	N82E		
NS	?E	F	N83W	55N	D				N83E		
NS	33E	F	N83W			N22W			N81E		
NS	33E	F	N80W	58N	D	N40W			N75W		
N1E			N78W	63N	D				N82W		
			N74W			Unit 3—					
N58E						N88W			N30W	22N	
N58E			N48W	?S		N86W			N35W		
			N50W	40N	D	N87W			N35W	62N	
N27W			N58W	19N	D	N85W			N30W		
									N35W		
N45W			N88E						N41W	42N	D
			N87W								
			N88E	47N	F						

N67E	68S	F
N70E		
N71E		
N62E		
N55E	67S	F
N50E	50S	F
N45E	50S	F
N25W		
N25W		
N60W		
N35E	49S	F
Unit 4—		
N30W		
N25W	52N	
N28W		
N26W	46N	F
N23W	41N	F
N24W	48S	
N20W		
N64E		
N68E		
N70E		
N62E		
N70E		
N62E	52N	
N65E		
EW		
N85E		
N86E		
N87E		
N80E	54S	
N65W	45N	D
N60W		
N57W		F
N54W		
N52W	35S	F
N43W	51S	F

NS	
N5E	56W
N84W	
Unit 5—	
N88E	
N83W	
N87W	
EW	
N80W	
N85W	
N20W	
N12W	
N5W	
Unit 6—	
N77W	52N
N82W	
N78W	
N87W	
N85W	
N17E	
N5E	
N12W	
N15W	
N17W	
N20W	
N62E	
N65E	
N71E	
N60E	
N70E	
N65E	
N75E	
N80E	
N75E	
N86E	
N65W	
N62W	

EW
Unit 7—
N11W
N9W
N22W
N30W
N68W
Unit 8—
N48E
N48E
N48E
N51E
N68E
N60E
N71E
N82W
N81W
N85W
N87W
N80E
N82E
N24E
N42W
Unit 9—
N83E
N86E
N81E
N86E
N86E
N80E
N80E
N88E
N86E
N88E
N87E
N86E

N82W		
N89W	28N	D
N85W		
N88W		
N89W		
N86W		
N80W		
N7W		
NS		F
N8W	58E	F
N4W		
N10W		
N10W		
N10W		
N3W		
N61E		
N65E		
N18W		
N18W		
N12W		
N13W		
N21W		
N17W		
N45W		
N46W	28N	D
N46W	23N	F
N55W	35N	D
N44W		
N24E	53E	D
N23W		
N28W		
N25W	33N	F
N42W		

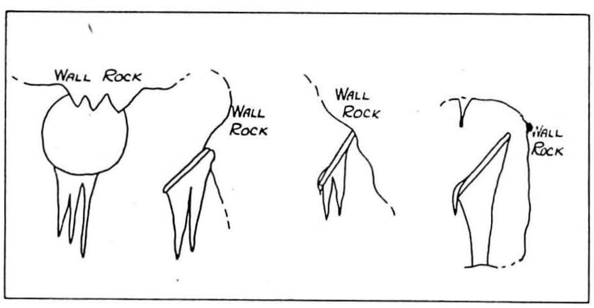


Fig. 3. Views of palettes, with later deposits of dripstone.

An examination of the map and a study of the grouped data demonstrates an accordance between the palettes and joints except perhaps for Unit 2. The discrepancy in Unit 2 is probably due to lack of exposed joints. A thick dripstone cover obscures all but a few major joints.

Forty-six palettes were mapped and of that number 18 were obscured by dripstone and 28 were found with highly fractured country rock. The apparent restriction of palettes to areas of shattered country rock indicates that the rock has been rendered more soluble because of the fracturing and that the shattered zone permitted percolating water to move freely thus avoiding further control by master cracks after the master cracks had been at least partially obliterated by dripstone.

Suggested history of a palette—

1. The limestone was subjected to pressure developing numerous joints.

2. Locally the rock became shattered with numerous small joints in addition to master joints.

3. During the initial period of deposition of the cave cycle, the cracks were partially or perhaps completely filled (future palettes), i.e. the master cracks because they would govern the flow of the lime rich solutions.

4. In the shattered areas a later period of dissolving solutions percolated through the minor cracks and only slightly disturbed the sealed master joints.

5. Gradually the rock around the filled master cracks (future palettes) was removed. The rounded forms of the palettes are probably due to attack of a lesser degree by the percolating waters.

Dripstone is more soluble than country rock, thus if secondary passages were not available in the country rock for percolating solutions, the dripstone material (future palettes) filling the master joints would probably be redissolved. A lack of palettes in other limestone caves may be due to paucity of shattered areas of country rock.

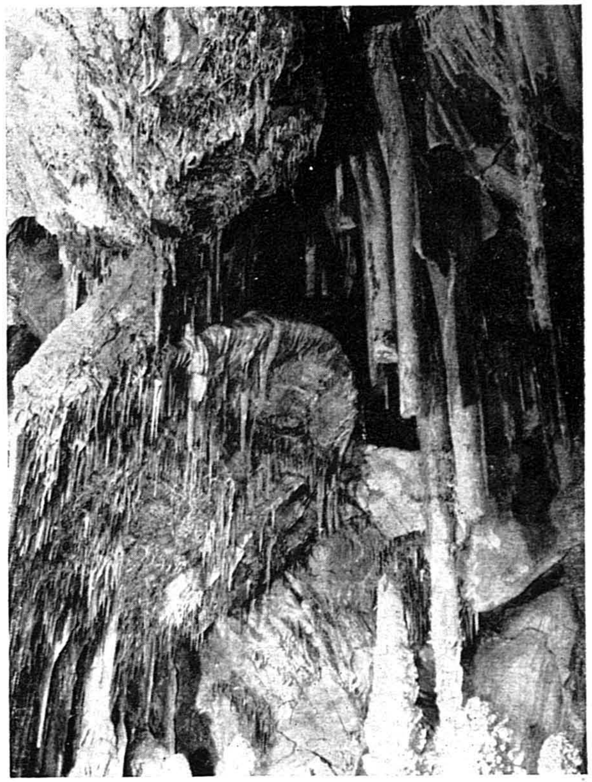


Fig. 4. Dripstone obscured example of palette jutting forth from wall in Lehman Cave.

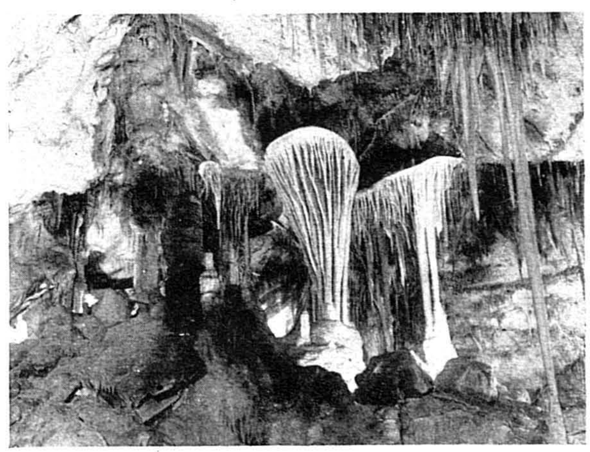


Fig. 5. The Parachute in Lehman Cave; a beautiful example of a palette standing free from the wall.

The Caves of Malta

By T. R. SHAW
Royal Navy

All photos by the author

Unlike Gibraltar and Majorca, Malta cannot be regarded as one of the main cave areas of the Mediterranean. It does have a speleological history, however, in which stories associating its caves with the myth of the Cyclops and of the nymph Calypso are intermingled with the fact of the shipwreck on that Island of the Apostle Paul. The author ably describes a number of the caves located on both the island of Malta and its adjoining island of Gozo, some of which were supposedly used by all three of the above mentioned personages.

Malta cannot be regarded as one of the main cave areas of the Mediterranean, to the same extent as Gibraltar and Majorca. Nevertheless there are a number of caves in the island; fifteen can still be located definitely, and it appears from the older books that at one time as many as thirty-eight were known. A few of these are known to have been quarried away; others may have collapsed, and it is possible that different writers may have described individual caves under several names.

The caves were first mentioned in 1647 by F. F. Abela in his book "Della Descrittione di Malta". No particular cave is named but the author speaks of the discovery in the hollows and fissures of the rock of enormous bones, which were regarded at that time as remains of the Cyclops, an ancient race of giants supposed formerly to have lived in Sicily: "But lastly what further testimony can we desire of the habitation here of the Cyclops, without the need of borrowing from the ancient scriptures, involved in the obscurity of time, than that given us by the gigantic bones found in Malta, and their hollow burial-places cut in the living rock . . ."

The first book to contain a general account of several of the caves was written more than a hundred years later by G. F. Abela, and published as two folio volumes in 1772, under the title of "Malta Illustrata". It includes descriptions of twelve caves, but several of them are small sea-caves and of very little interest.

Then in 1804 several cave references appeared in a history written in English by one of the Knights of Malta, Louis de Boisgelin de Kerdu. This book, "Ancient and Modern Malta", was followed in 1840 by Miège's "Histoire de Malte" which contained considerably more information than its predecessors. Since that date numerous guide-books and small histories have appeared, but they contain very little that had not been written before.

In general the caves are small by comparison with European or American standards, and to some extent this can be attributed to the waterless state of the island. Between May and September no rain falls at all, and in winter the water sinks almost immediately into the porous limestone. At the present time no permanent rivers or streams exist, though the formation of the gorge-like valleys which intersect the island in all directions is often attributed to a period of greater rainfall in the past. The caves themselves appear mostly to have been formed by phreatic action when the land lay very much lower relative to the water table.

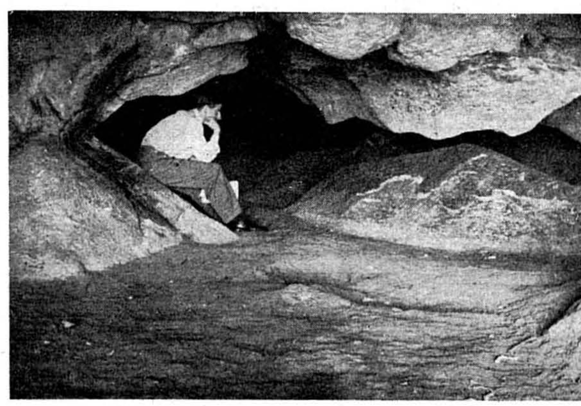
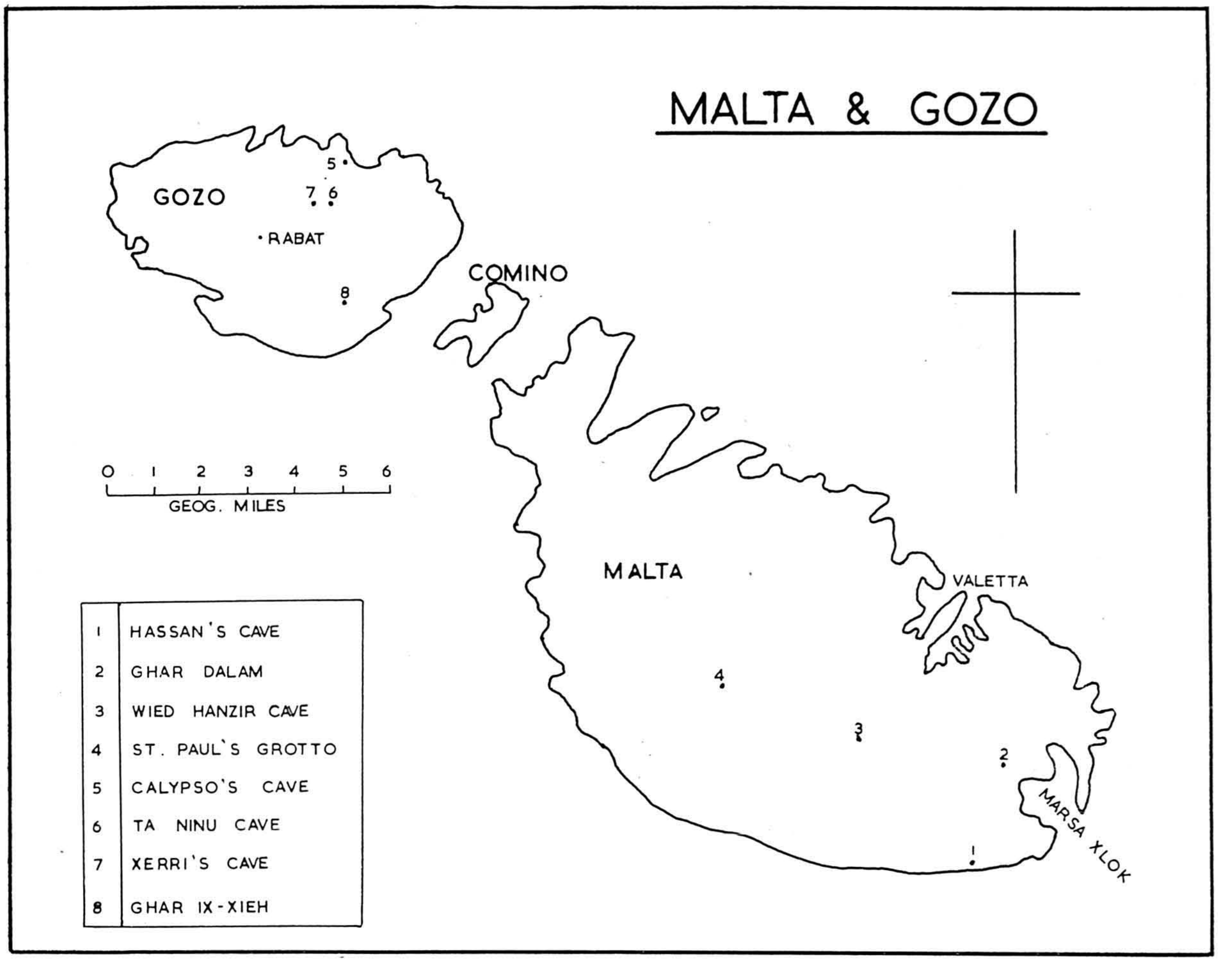
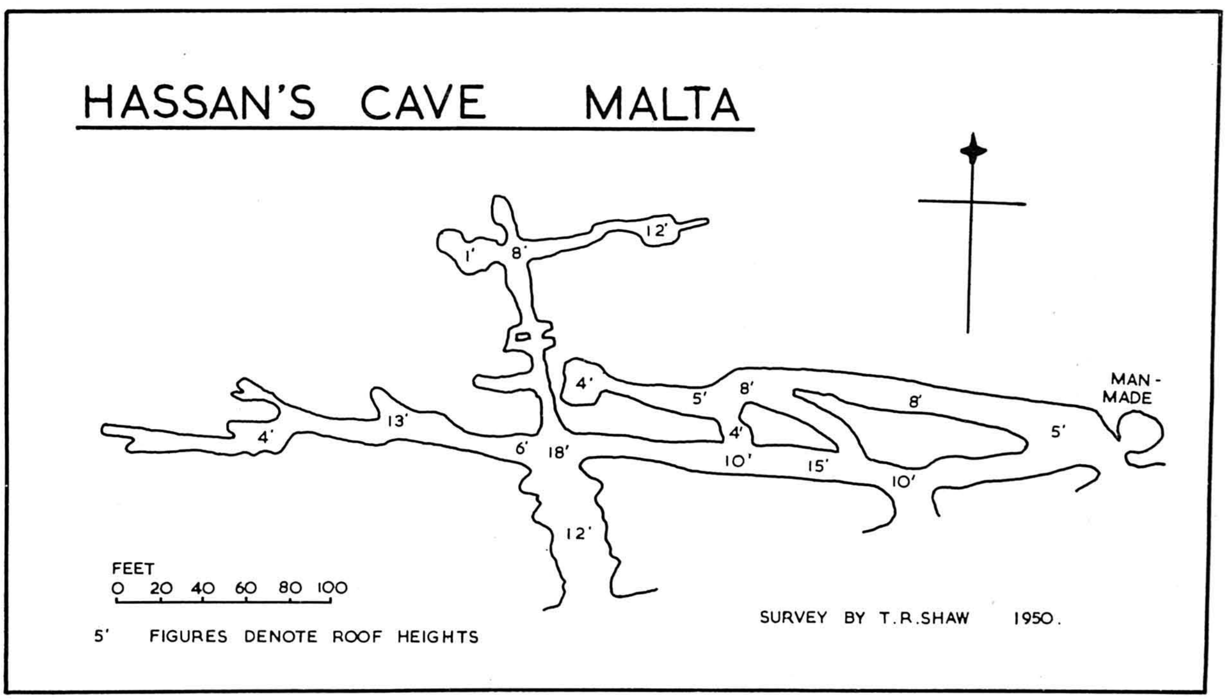


Fig. 1. Ghar Hassan, Malta; East Chamber.


MALTA & GOZO
GOZO
5
7 6
RABAT
8
COMINO
MALTA
VALETTA
4
3
2
1
MARSA XLOK
0 1 2 3 4 5 6
GEOG. MILES
1 HASSAN'S CAVE
2 GHAR DALAM
3 WIED HANZIR CAVE
4 ST. PAUL'S GROTTO
5 CALYPSO'S CAVE
6 TA NINU CAVE
7 XERRI'S CAVE
8 GHAR IX-XIEH


HASSAN'S CAVE MALTA
MAN-MADE
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0 20 40 60 80 100
5' FIGURES DENOTE ROOF HEIGHTS
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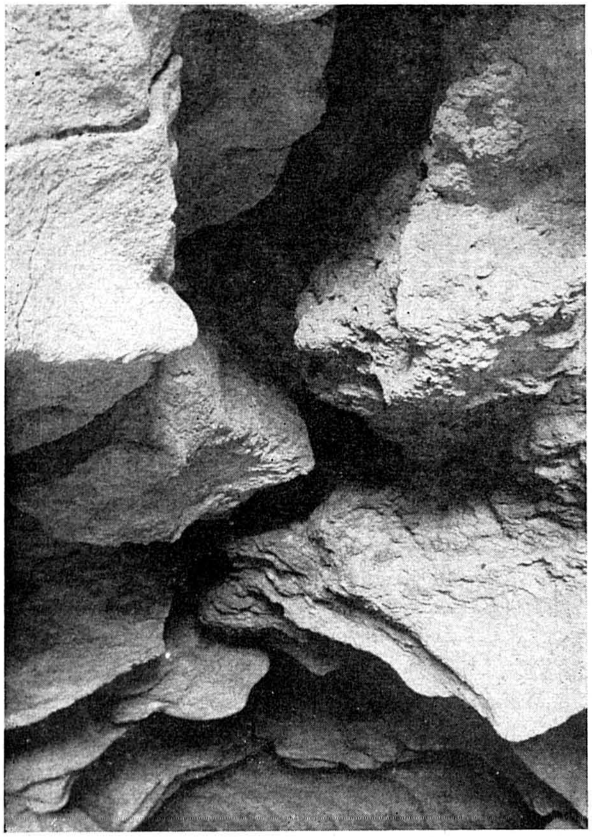

Fig. 2. Ghar Hassan, Malta; Roof channel in East Chamber.

The largest cave in Malta is Hassan's Cave or, as the natives call it, "Ghar Hassan" ('Ghar' being the Maltese word for a cave). The entrance lies in a high sea-cliff of Oligocene coralline limestone near the south-east corner of the island, a few hundred yards from the Royal Naval Air Station at Hal Far. The level of the cave is over a hundred feet above the sea, and it is reached from the ground above by a ledge along the cliff face. There are in fact two other entrances further east along the same cliff, but they are quite inaccessible from outside and one has been railed off for safety by the authorities.

The total passage length amounts to 1270 feet, the general shape of the cave being a rectangular network as shown in the accompanying plan. A broad passage extends from the main entrance and after a few yards it is crossed by another at right angles. To the right the tunnel runs parallel to the cliff face and emerges eventually at the second and third entrances. By the larger of these there is a low chamber some 40 feet by 30 feet, lit entirely by daylight (see fig. 1), and from the back there extends another passage nearly parallel to the first and interconnected with it in several places.

Beyond the crossroads the entrance tunnel narrows considerably, then turns right into a rift passage as far as the final chamber. A small circular tube continues for some 16 feet and then that too closes.

Evidence of phreatic solution is clear all through the cave. Maximum width occurs everywhere at the principal bedding plane which persists throughout the whole cave, usually a foot or so above the floor. Most of the joint planes are open for some distance above the passages, and in many places semi-circular channels can be seen meandering across the otherwise flat roof. One of these roof channels in the chamber by the east entrance is shown in fig. 2.

The name Hassan's Cave is derived from the legend that the cave was used as a refuge by an Arab of that name when his countrymen were expelled from the island. A small circular chamber has been excavated by hand near the eastern entrance and is shown as Hassan's actual dwelling. He is said to have kept a small boat at the foot of the cliffs, a hundred odd feet below, and his only means of reaching it was by swarming up and down the face on a vertical rope.

No prehistoric bones have been recorded from Hassan's Cave, but about 1865 several trial trenches were dug by Leith Adams, a zoologist who was serving as a doctor with the garrison. He tells an amusing story of the Maltese people who used to stand watching the excavations and trying to make out their purpose. One afternoon he surreptitiously dropped a Spanish dollar on the shovelful of earth, and next moment

Fig. 3. Ghar Hassan, Malta; Excavating floor sections.

it lay with the soil on the heap. He picked it up quite casually and put it in his pocket, and soon the spectators, whispering to each other, walked off. Next day when Leith Adams returned, he found that not only had his own trench been continued down a further four feet, but that several other excellent floor sections had been made by them in the hope of finding money!

Ghar Hassan is the only cave in Malta in which I was able to find bats. A number of them used to frequent an inaccessible fissure not far from the main entrance, and though they used to squeak lustily at every approach I could never get close enough to identify them. In another part of the cave, however, I handled a number of *Myotis myotis* (Bechstein)—the bat referred to by Casteret as a Murin—and on one wall were sets of quintuple scratches where their claws had perhaps slipped in their attempts to alight.

Another of the larger caves, Ghar Dalam, is frequently mentioned in the literature, on account of the enormous masses of prehistoric animal bones and pottery that have been unearthed there. This cave also is situated in the south-eastern corner of the island, 600 yards from Birzebuggia and the shores of Marsa Xlok. The entrance has been gated by the government Museum Department, which has built a house above to contain some of the relics and provides a guide to show visitors round the cave.

The first 250 feet consists of a straight passage at right angles to the valley outside, some 20 feet wide and varying in height from 12 to 27 feet. It is in this section that the remains have been discovered and the floor consists of a mass of trenches of different depths running into each other and flanked by complete sections of fill left as controls. At one point is a strange mushroom-like stalagmite whose upper half continued to increase in size after the bottom was protected by the earth.

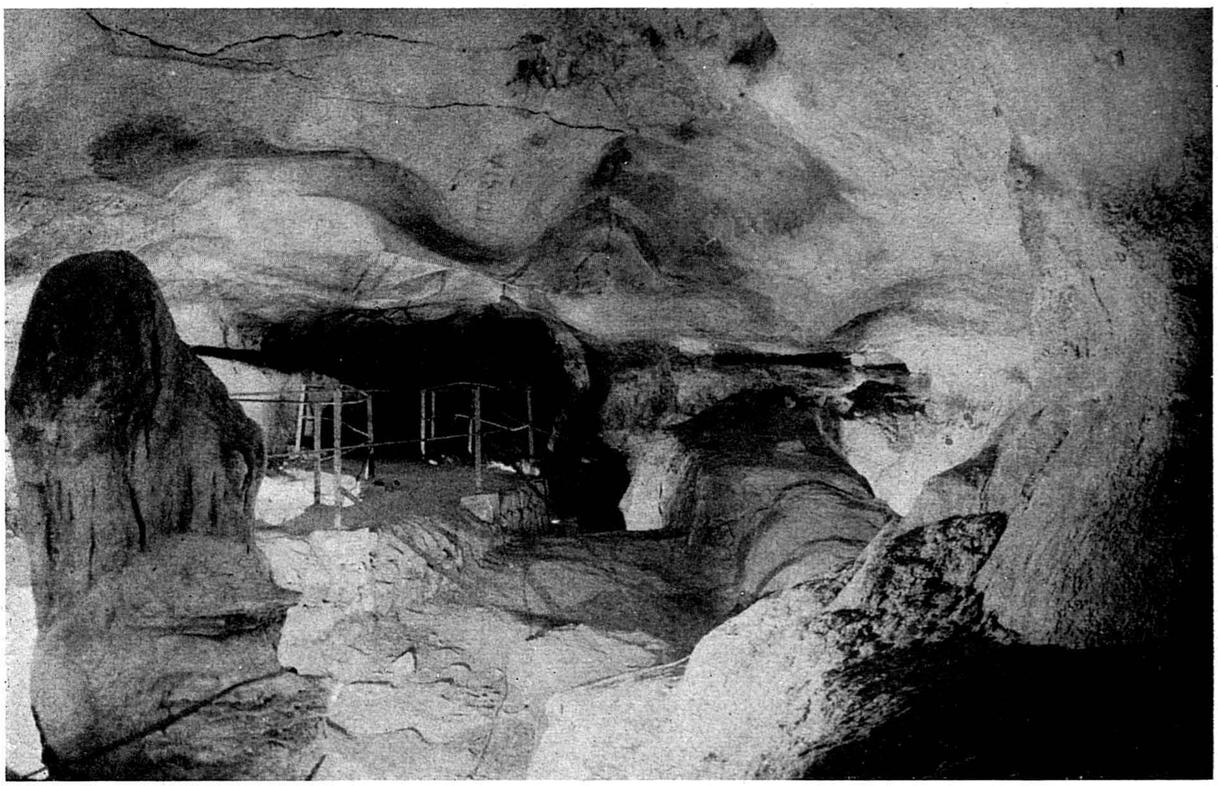

Fig. 4. Ghar Dalam, Malta; showing excavations for bones.

The bone deposits were first noticed in 1865, but the first large scale excavations were not made until 1892 (Cooke, 1894). More work was done during the first World War and in several of the succeeding years, and in 1917 considerable interest was aroused by the discovery

of what were thought to be two molar teeth of Neanderthal Man. No other human remains earlier than the Neolithic period have ever been found in the islands, and the identification of these teeth has not been universally accepted.

Beyond the ossiferous section of the cave, the passages become much smaller and a number of narrow tunnels branch off in different directions. The continuation of the main entrance passage is almost blocked by a line of immense boulders fallen from the roof, but it is possible to scramble over these and down the other side to a low bedding chamber whose roof is intersected by some meandering roof channels, like miniature editions of those in Hassan's Cave.

On the opposite side of the valley and in line with Ghar Dalam is a wide cave entrance, but the passage beyond is totally blocked with earth. It has been suggested that the two caves were formed as a continuous passage beneath the water table at a time before the valley bottom reached its present level or perhaps before it existed at all. Then as the channel was cutting downwards it eventually broke through the top of the cave passage which then acted as a collector for all the bones and rubbish being swept down by the river.

The little cave at the junction of Wied Hanzir and Wied il Kebir, in the centre of Malta, is very different to the two preceeding ones. It is quite small, not more than 76 feet long, and at least part of it has been excavated by hand in the soft rock. The entrance lies a few feet above the valley bottom and has been shaped into a rectangular doorway 7 feet wide by 5 feet high. Inside, it opens into a chamber 48 feet by 27. It is highest in the centre where a fissure in the roof appears to be natural, but the walls have been cut back artificially, and both sides have been decorated by vertical ribs a little less than a foot wide and separated by recesses of about the same size. At the farther end of the chamber the pick marks on the walls cease and a natural passage continues for 28 feet before being completely blocked by a boulder choke.

I have not been able to find any reliable description of the cave, but a short article by the Rev. J. Farrugia appeared a few years ago in the Times of Malta. He supposed that the

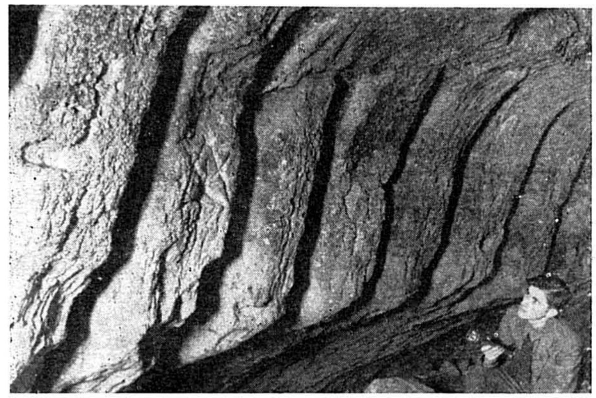

Fig. 5. Wied Hanzir Cave, Malta; Main Chamber showing ribs and incised star.

large boulder just outside the cave and half blocking the entrance indicated that it was inhabited at one time by prehistoric man. The decorative ribs and other markings on the walls he thought were added later when primitive Christians used the cave as a church. One of these wall markings can be seen in the photograph (fig. 5.), a five-pointed star incised on one of the ribs; and near the entrance there are a large number of small crosses cut similarly in the rock.

Another of the more interesting caves in Malta is completely artificial—St. Paul's Grotto, where the Apostle is said to have lived for three months after his shipwreck on the island. A church has been built over the grotto, in Città Vecchia, and a statue in white marble placed in the cave itself. The rock of the walls is a soft limestone and the miraculous property has been attributed to it of growing again wherever the stone is cut away. And as this new rock was supposed to be supplied by St. Paul it was in great demand, being valued as a cure for fevers and all kinds of snake-bite. At one time this stone, known as "pietra della grazia", used to be sent out not only all over Europe but as far as India and the East.

Also in and around Città Vecchia there are several series of catacombs, but they are outside the scope of this article.

The smaller of the Maltese Islands is called Gozo and lies about four miles to the north-west of Malta itself. It contains several small caves in the Miocene coralline limestone, one of great antiquity and the others discovered within the last century.

Overlooking Ramla Bay on the north coast of Gozo is Calypso's Cave. It is reputed to be the very same cave as was occupied by the nymph Calypso in the fifth book of Homer's Odyssey. The entrance is low, however, and not very easy of access, and the interior of the cave consists of a series of low crawlways between shattered chambers floored with angular fragments of rock. It certainly cannot be imagined as the home of a self-respecting nymph, although several of the early writers, who had possibly never visited the place, repeated the legend without comment. Sir Walter Scott, who passed near the cave on his way to Malta shortly before his death, was by no means complimentary when he described it in his diary.

Two of the Gozo caves are found within a few hundred feet of each other in the village of Xaghra, and both were broken into accidentally when the villagers were sinking wells.

The first, discovered in 1888, is known as the Ta Ninu Cave from the local name of the property, and lies a little to the west of the parish church. The cave consists of only two chambers reached by a flight of steps from the yard above, but it is well furnished with stalactites. The roof is studded with straws, many of them now broken, and in places it is joined to the floor by stalagmite columns several inches thick.

The other cave in Xaghra is called Xerri's Cave. It was discovered in 1924, and the name of the cave is now displayed over the door of the owner's house. A set of regulations is hung inside the building, including one which forbids the visitor 'to damage the inside of the Grotto' with the optimistic requirement that he must 'make good any damage done'.

The cave itself is some 30 feet below ground and is reached by a spiral stone staircase. It consists of a succession of passages about six feet high arranged at right angles. At one point a low tunnel branches out from halfway up the wall and extends for 15 feet into the side of a well, presumably the well from which the cave was discovered. The calcite formations occur in separate groups in this cave, the largest being at the end farthest from the entrance stairway—a fine stalagmite flow and a number of stalactites and curtains, many of which will ring when struck. There are also a small number of helictites.

The most interesting formation and one which has still not been satisfactorily explained, is a group of thin-walled calcite tubes formed round hanging roots. In some of these the original roots have disappeared completely, and in others there remains only a decayed fibrous substance. In section these formations are not simple tubes, as might be expected, nor do they resemble a woody skeleton; but their structure is in fact very complex. In the typical case it consists of two concentric shells of calcite joined together on one side either by a single partition or by another tube; while in other specimens there are several internal tubes, irregularly arranged within an outer shell.

An interesting legend is associated with two small shelter caves overlooking Wied Mgarr ix-Xini in the south-eastern corner of Gozo. It is near this spot that the first settlers in Gozo are reputed to have lived, and their chief is said to have administered justice in an open shelter cave called Ghar ix-Xieh. A few yards away is another cave, El Habs, now partly walled up and used for housing goats, where the prisoners are supposed to have been kept.

Most of these caves in Malta and Gozo have been described recently in "Cave Science", the journal of the British Speleological Association. These references are given at the end of this article together with a short selection from the bibliography of the Maltese caves.

There is still opportunity for more work underground in Malta, and particularly in the lesser known island of Gozo.

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The Kuh-I-Shuh Caves

By JOHN H. D. HOOPER

All photos by the author

This fascinating account of a visit to some little-known caves situated in a gorge of the Karun River in southern Persia is replete with history, both geologic and human, though not too much is known of the latter. The caves described herein, once inhabited, lie along a narrow ledge, in one place only 12 inches wide, which runs across the face of precipitous cliffs at a height of 1200 feet above the river!

The Karun river, rising amongst the rugged Zagros mountains of southern Persia, careers through many spectacular gorges before it leaves the hills behind and flows across 150 miles of desert to the Persian Gulf. One such gorge lies 10 miles to the northeast of Masjid-i-Sulaiman, the once busy town that formed the centre of the extensive oil fields recently operated by the Anglo-Iranian Oil Company. In this gorge, the Karun, perhaps 200 feet wide in summer, flows between two great conglomerate massifs, each roughly 3000 feet high, known as the Kuh-i-Jariak and the Kuh-i-Shuh, the latter forming the northern wall. Their cliffs, which rise in precipitous steps on either side to a height of 1500 feet above the river are completely unscalable for many miles, although access can be occasionally gained to rocky terraces where narrow beds of sandstone have been exposed. Along these terraces there are small caves and often springs of fresh water, trapped by the impervious sandstone. Probably the most interesting—and certainly the most sensational—are the Kuh-i-Shuh Caves, which lie along a precarious ledge, 1200 feet above the river. These caves are too far from civilisation to be reached in the summer when the sun temperature attains 160°F and the rocks are too hot to be touched with the bare hand, but in the cooler weather of the late autumn, the trip although arduous becomes possible. The caves bear clear traces of human habitation, but even now it is doubtful if they have been visited by more than a score of Europeans. During 1949, I was temporarily stationed in Masjid-i-Sulaiman and in November of that year I was able to make two trips to these caves: both expeditions were in the company of Mr. T. St. John Eve, of Masjid-i-Sulaiman and on the second occasion we were joined by Mr. R. L. Cowley, also of that town.

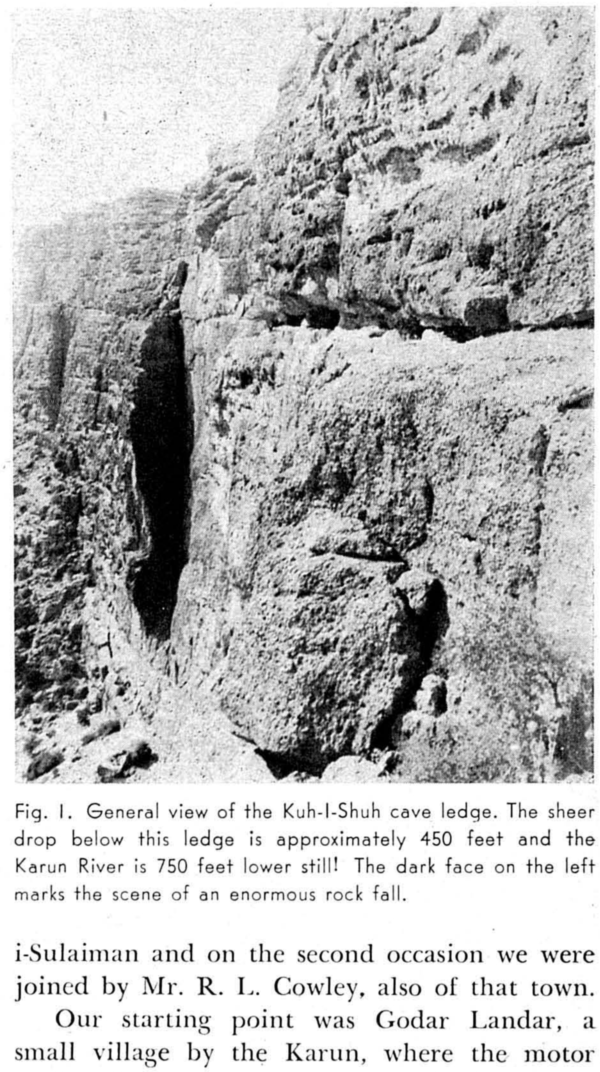


Fig. 1. General view of the Kuh-I-Shuh cave ledge. The sheer drop below this ledge is approximately 450 feet and the Karun River is 750 feet lower still! The dark face on the left marks the scene of an enormous rock fall.

Our starting point was Godar Landar, a small village by the Karun, where the motor road ends at a pumping station which supplies water to the oil fields. We crossed the river at a nearby ferry, this being a raft, some 6 feet square, made from thin poles and supported on inflated goatskins—at first sight a very flimsy craft on which to entrust oneself to the fast-

moving waters. The two or three passengers crouch as best they can on the wet poles and the ferryman, kneeling at the 'front', scoops the water towards himself with a spade-like paddle, making skilful use of back eddies to prevent the raft from being swept too far downstream.

The Kuh-i-Shuh Caves lie some four miles upstream from Godar Landar and can, in fact, be reached by skirting along the base of the cliffs of Kuh-i-Shuh and then climbing for nearly 1000 feet through a sensational gully which leads directly to the cave ledge. We however preferred to approach by a longer but rather less precipitous route which took us over the top of the mountain and into the gully from above. In order to bypass the cliffs which form such an impenetrable southern facade to Kuh-i-Shuh, we had to ascend a side valley, following a small river—the Ab-i-Andakah—until we reached a pass giving access to the more gentle northern slopes of the mountain. To enter this valley however we were forced to climb for

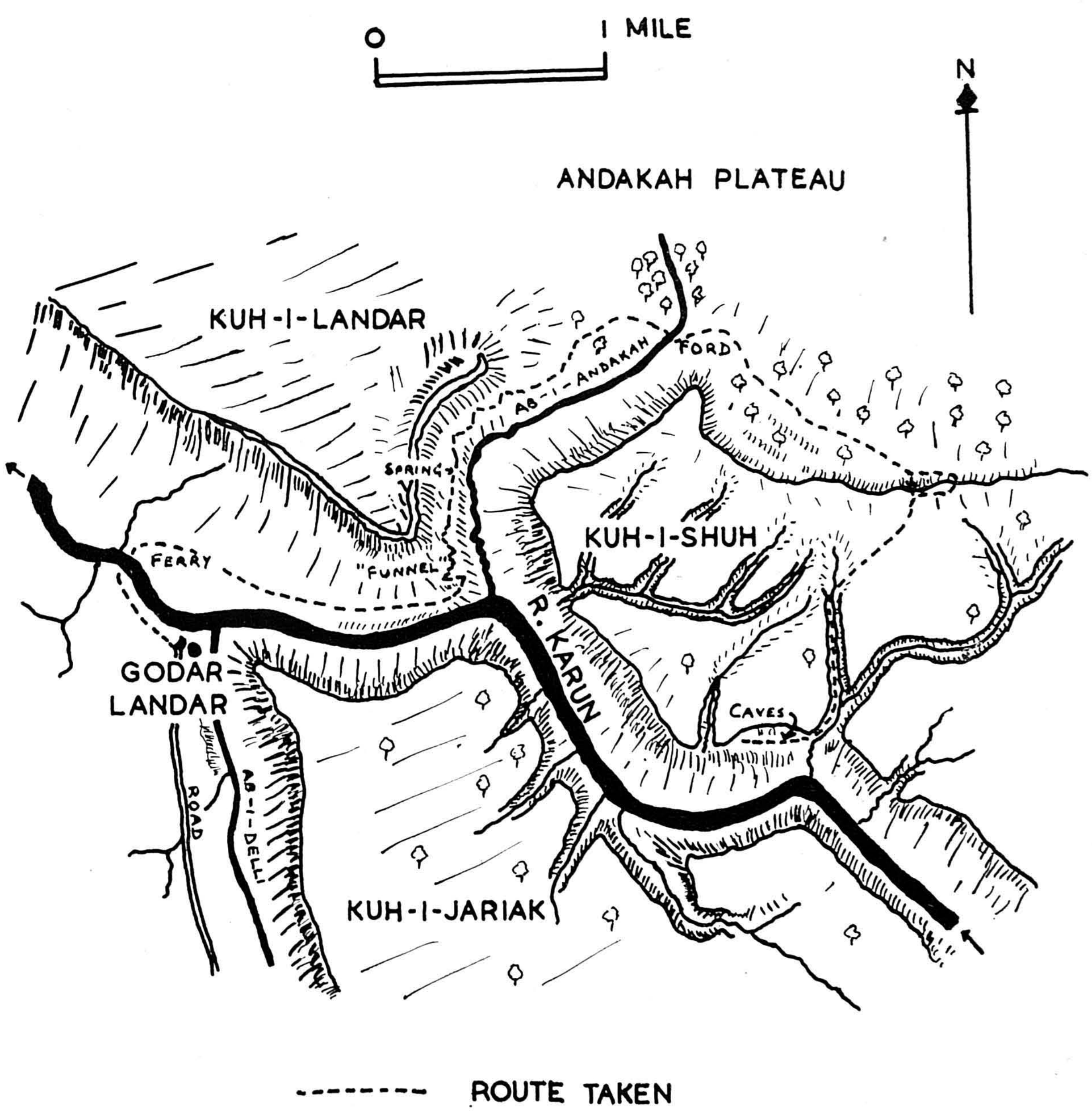


Fig. 2. Map showing location of the Kuh-I-Shuh Caves in southern Persia.

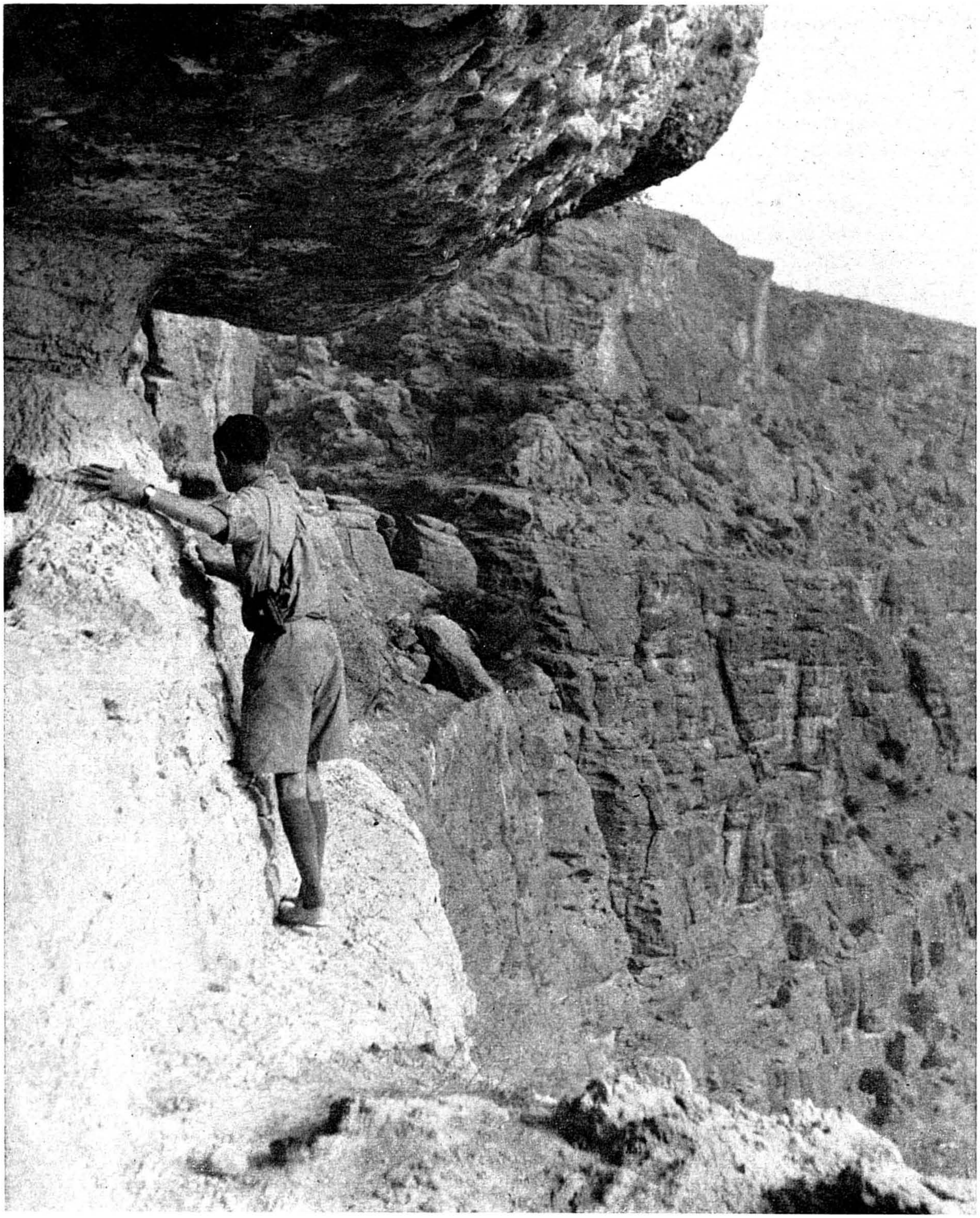


Fig. 3. R. L. Cowley starts the return journey across the narrowest section of the Kuh-I-Shuh cave ledge. This traverse is 12 feet long, but it is well provided with secure handholds.

nearly 1200 feet up a steep scarp of conglomerate forming the southern end of an intervening mountain ridge known as the Kuh-i-Landar.

This climb began, about a mile beyond the ferry crossing, as a well-defined zigzag track and ended with a succession of hard scrambles up long rock faces where hands were as important as feet. The crest of Kuh-i-Landar was broken by a deep cleft, nearly 100 feet high and barely 15 feet wide at its mouth. This was known as "The Funnel" and inside, a dark cave and a narrow chimney brought us out on a terrace at the top of the cliff. Beyond lay a broad, winding track which continued up the Andakah valley. The rocks composing this stony path were polished and shiny from the passage of countless pairs of sandals, as it was one of the ancient Bakhtiari highways to the mountains where the tribesmen had their summer quarters. As we followed its sinuous, ever-climbing course we often had the friendly company of small groups of these tribesmen, or had to step aside to give way to a caravan of heavily laden mules or a flock of obstreperous goats.

Giant boulders of yellow conglomerate clung to the mountainside and wild almond bushes and an occasional "Kal-Kang" tree lent a welcome touch of greenery to the otherwise arid scene. The latter tree (*Pistacia khinjuk*) had shiny resinous leaves and big clusters of orange-yellow berries. One hundred feet below on our right, the Andakah river tumbled through a succession of crystal-green pools and beyond, the sheer crags of Kuh-i-Shuh towered high overhead, their jagged skyline clear-cut against a dazzling blue sky. The river looked very inviting, but its waters were laden with gypsum and undrinkable. However, thirty minutes walk from the top of "The Funnel" there was a spring beside the path, a curtain of clear but tepid water flowing over the sun-baked rock from some hidden outlet in a tangle of ferns and vines above. We filled our water bottles here as this was the last source of drinking water until the caves were reached.

After plodding uphill for a further half an hour, we reached the head of the valley: here, the path flattened and the ravine billowed out into the Andakah Plateau—a bleak expanse, many miles across, where thinly covered hummocks of gypsum were broken only by the dense groves of tamarisk that bordered the river. We now left the path and after crossing the river by a line of unstable stepping stones, we made a two mile ascent of the grassy northern slopes of Kuh-i-Shuh—slopes far less forbidding than the cliffs that overhung the Karun and even partially covered with oak trees. Some of these trees were as high as 30 feet—an unusual sight in such a barren district where trees of any size were a rarity. This species *(Quercus aegilops)* produces bullet-shaped acorns, 2 to 3 inches long, from which the Bakhtiari tribesmen prepare a flour and a rather unpalatable bread in times of crop failure.

The summit of Kuh-i-Shuh was a broad and stony plateau, gashed by numerous characteristic stream defiles which began in gentle fashion but soon deepened and gained sheer and unbroken walls, several hundred feet high. These ravines all looked very much alike on that featureless landscape and our problem was to select the one which would take us down to the Kuh-i-Shuh cave ledge. Fortunately, we chose well and after a mile or two of tedious scrambling along a rudimentary track we came in sight of the Karun gorge. The high crags which hemmed us in merged into the walls of the gorge and the dry stream bed on our left dropped into an ever-deepening gully that disappeared behind frightening cliffs falling away to the river, far below. Our track, skirting the very edge of these cliffs, ended at a shelving terrace of smooth rock, 50 feet wide, that was partly roofed over by an enormous archway, 100 feet high and 200 feet long—presumably the result of some cataclysmic rock fall. A tiny spring seeped out from the greenery at the base of this arch and trickled down to an artificial trough, roughly 3 feet square. As we rested here, great eagles soared effortlessly backwards and forwards only a score of feet away from us, but with nearly 1200 feet of empty space beneath their outstretched wings.

The terrace finally dwindled to a shelf about 6 feet wide, with the rock above overhanging to form a low half-tunnel and this led to the main cave ledge. On my first visit, I explored it alone, for my companion preferred to save his breath for the three and a half hour return journey: instead, he stayed talking to some Bakhtiari nomads who had assured us that there was no

possible route along the cliff face and who were duly impressed when I walked along the ledge without difficulty and still more impressed when my reappearance, forty minutes later, put an end to their gloomy forebodings as to my probable fate.

For the first few hundred feet the ledge consisted of a series of broken, irregular terraces which, although narrow, could be traversed with confidence as the immediate drop was only a matter of 10 feet or so and hence the feeling of exposure was slight. Amongst the great wedged boulders on my right there were a few small chambers and I found that their dark archways provided effective frames through which to view the gorge. Particularly fine was the vista upstream with the pale blue waters of the river, broken at intervals by the white flecks of rapids and cascades, tapering away into the distance until a bend in the towering cliffs hid it from my sight. In the afternoon light, the great precipices of Kuh-i-Shuh were tawny and golden but the river itself and the cliffs of the Kuh-i-Jariak on the far side of the gorge were dimmed by misty, blue-grey shadows.

Presently the terraces and boulder piles merged to form a single rocky platform, smooth and level. Near this point a low arch in the vertical crags on my right led into a large, dark chamber, roughly 40 feet in diameter. The flat roof, 8 feet high, was blackened by smoke and the floor was littered with goat dung, for this cave is still used by present day tribesmen. It appears, however, that they do not venture farther along the ledge which, beyond this cave, narrowed to six feet and less. Overhead, the rock overhung as an almost continuous roof, so low that I often had to stoop. Walking shirtless because of the hot sun, I suddenly felt a vicious stab in my shoulder and found that I had been stung by a hornet—an unprovoked assault which almost discouraged me from penetrating any farther. The continuing section moreover was a place where—especially when alone—

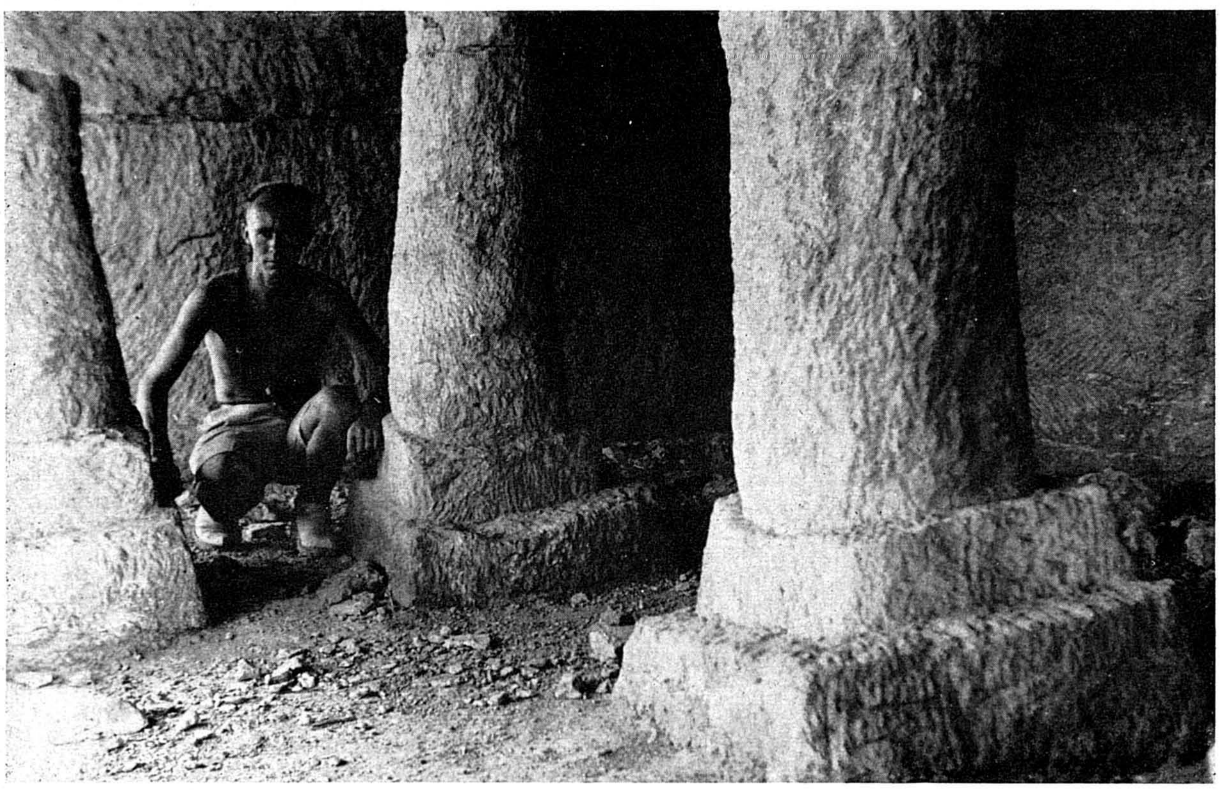


Fig. 4. One of the artificial caves, showing the pillars hewn from the living rock. The adze marks show clearly on the pillars and walls. The author provides the scale—and considers that the morose expression must be due to the fact that he had been stung on the back by a hornet only a few minutes previously! Note the shoes—the Persian cloth-soled 'Giveh' which give an excellent grip on almost any rock.

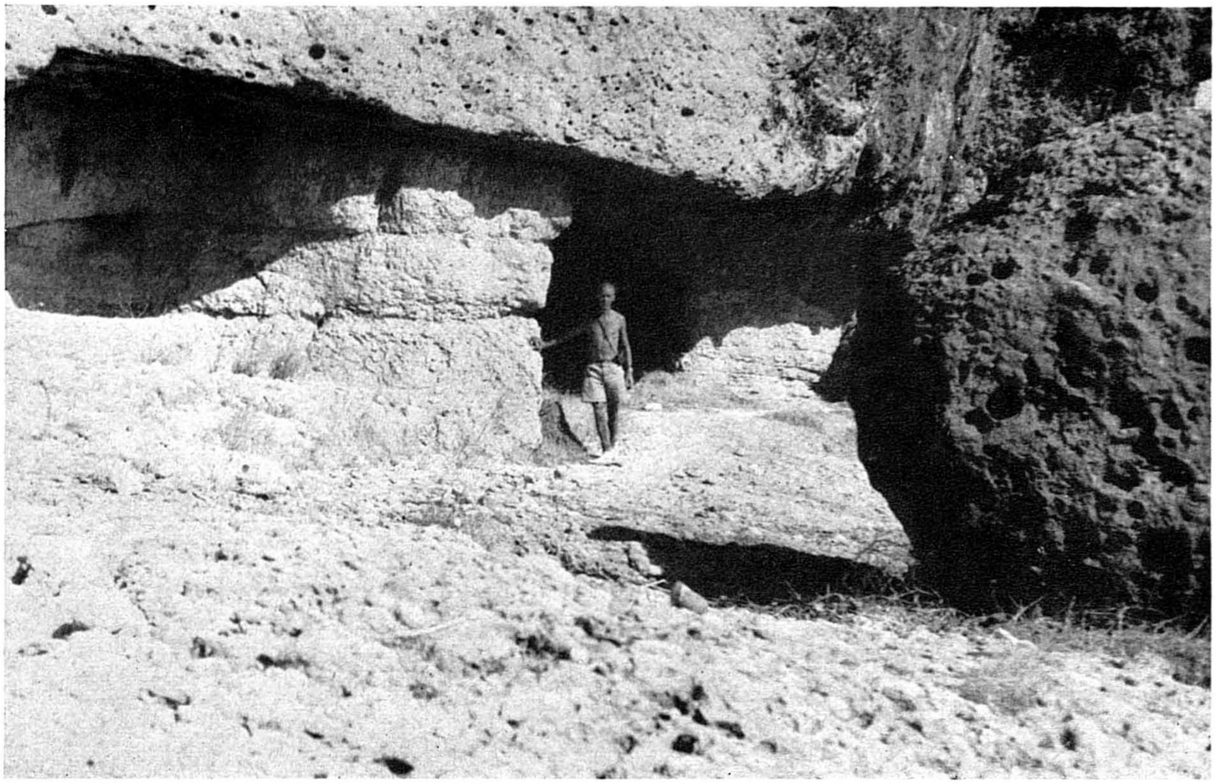


Fig. 5. The author, hair awry, poses by a cave entrance while a delayed-action device on his camera shutter takes the picture. This photograph shows the rough, pockmarked conglomerate overlying the beds of softer rock (calcareous sandstone) in which the caves are formed. The base of the ledge is conglomerate again and a large boulder of the same rock stands at the right.

every possible encouragement was needed. Here, beneath a jutting fig tree, the reassuring levelness of the terrace gave place to a hold-less slope, perhaps 15 feet across and barely 4 feet wide, where the rock funnelled invitingly downwards and outwards. Feeling my way cautiously across this depression I was only too conscious of the fact that 450 feet of sheer face lay immediately below and although I could not see the base of the cliff but only the river 750 feet lower down, I felt that the difference in drop was a matter of academic rather than practical interest!

Beyond this obstacle, the ledge became level again and remained a comforting width for the next 40 feet, apart from a corner which it was necessary to step around on a tongue of rock only 18 inches wide. This however was merely a rehearsal for the next traverse—little more than a mantleshelf and fully 12 feet long. Being less than 12 inches wide, it really did give me an opportunity to appreciate the precipitous nature of the cliffs beneath! Fortunately there was an excellent line of handholds and I soon stepped off onto a wide and grassy terrace which served a succession of small caves. The most striking was the first—a rectangular chamber, 8 feet deep and 16 feet long, with a low wall along its open front. Three broad pillars, carved from the living rock, joined the floor to the flat roof, while a fourth, which did not extend quite to the roof, was truncated at the level of a bedding plane visible in the surrounding walls. These pillars, roughly 18 inches in diameter and rising from double-tiered plinths, had been carved with amazing precision: their surfaces and also those of the walls were clearly patterned with diagonal adze marks.

A few yards beyond this chamber there was a semi-circular recess in which was mounted a raised, rectangular trough, although the spring which fed it was almost dry and in the floor nearby there was a shallow, cylindrical hole which had presumably been used for the grind-

ing of corn. Another recess opened at the back into an artificial chamber, 10 feet square and 6 feet high and beyond this the terrace passed two further alcoves, one leading through a neatly carved opening into a circular cell, barely 6 feet in diameter.

Passing this line of caves, I negotiated another narrow ledge and then rounded a corner where I was able to walk with ease, first across a wide terrace of bare rock and then on to what can best be described as a hanging meadow. Bounded by sheer cliff on the right and open space on the left, this was a spacious terrace, 20 to 30 feet wide and thickly overgrown with long grass and even small bushes throughout its length, which amounted to over 100 yards—certainly it was roomy enough to provide grazing for a few animals. This terrace ended in a slippery grass-covered shelf which petered away into nothing after a few yards. At one time it had evidently been possible to continue beyond this point, but an immense slab had peeled away from the rock face below, not only interrupting the ledge, but also reducing considerably the width of the 'meadow' itself.

On my first visit, time was pressing if we were not to be caught by darkness while still on the mountains and I had to hurry back along the quarter mile of ledges and narrow traverses to rejoin my companion, but on our second trip, a fortnight later, we were able to examine the numerous caves more thoroughly. It is interesting to speculate on the people who inhabited them, but I have been unable to obtain any information on this point. It is possible however that the ledge provided an inaccessible and easily defended stronghold for one of the Bakhtiari tribes, as the tribesmen who dwelt amongst these mountains were notoriously warlike and banditry and inter-tribal strife were commonplace even as recently as 100 years ago.

Lava Caves of Central Oregon[1]

By WILLIAM R. HALLIDAY, B.A., M.D.

The Cascade Grotto of the National Speleological Society has rendered invaluable service to the cause of speleological research by the intensity of its effort and the quality of its work in the area of its activity. The importance of its reconnaissance will become immediately apparent to the readers of this article, written by one of its most dynamic members.

The Deschutes lava plateau of central Oregon, just to the east of the high peaks of the Cascade mountains, presents to the vulcanospeleologist one of the finest and largest groups of lava tubes in the continental United States. Repeated flows of pahoehoe lava under optimum conditions have produced at least 20 noteworthy caves, and in view of the profusion of confusing sinks in the individual flows, it seems likely that many remain unreported and undiscovered. As will be seen, a great variety is to be encountered, horizontal and vertical, rough and easy, wet and dry, long and short, straight and branched. Significant paleontological and archaeological finds have been made in several of these caves. Ice crystals and formation frequently add beauty to the impressive vistas. All characteristics of lava flows are here revealed, even though multilevel formation is perhaps less prominent here than in Lava Beds National Monument. In short, here is an area encompassing all speleology, and a refreshing change for the spelunker skilled only in limestone.

Phil Brogan, chairman of the Oregon Geographic Board, of Bend, has probably more knowledge of these caves than any other man. H. R. Tonseth, Fort Rock District Ranger, also has extensive field knowledge particularly of the southern group, and has proven himself a good friend of the Cascade Grotto. Much of the information herein contained was obtained from these gentlemen and from the staff of the Deschutes National Forest.

Best known and most accessible of the lava tubes is *Lava River Cave,* once known as Dillman's Cave, right beside U. S. Highway 97 about 12 miles south of Bend. Designated as a state park, a caretaker is at hand with gasoline lanterns for the convenience of the public. Wooden stairways have been installed leading down into the sink which is the entrance. The tourist portion of the cave leads northwest for over 5000 feet in gentle curves over a sand floor into which it eventually sinks. The opposite end is extremely rough and defied exploration until the Summer of 1951 when a local group reached its end after 1,500 feet of exhausting travel. Apparently first described by Ira Williams in Nature Magazine about 30 years ago, it is mentioned in NSS Bulletin 3.

Quite different but almost as well known locally is *Arnold Ice Cave,* to the southeast of Bend. This cave served as the source of ice for Bend in pioneer days, and even then, despite its mining, the total extent of cave beyond and beneath the ice was unknown.

Entered through a small hole in the north end of a lava sink, a dangerous 60-foot ice slope at a 60 degree angle is immediately encountered. Safety ropes are essential. At the floor, the ice slope levels off while the cave descends, thus blocking progress after some 100 feet. A duck-under, then a crawl on the ice lead to two tiny rooms with frost crystals on their roofs.

Somewhat similar to Lava River Cave is *Skeleton Cave,* located between Bend and Arnold Ice Cave. Much of its 2000-foot length is sand-floored, providing comfortable camping in wet weather. Entered via a wooden ladder in a sink, a blind 250-foot passage leads toward the right, the main portion to the left. About 1200 feet back, a side passage on the left leads to a short section where, according to Brogan, a fossil bear *(Arctotherium?)* was found many years ago, thus giving the cave its name. Of interest is the evidence that this passage leads into, not out from the original flow. In the main cave, one

[1] Reprinted from Cascade Cave Report No. 2, (June, 1951) Cascade Grotto, National Speleological Society; Washington state.

cupola, deposits of aa lava, pulled stalactites and contraction fissures are of note. The cave has been mapped by the Cascade Grotto of the National Speleological Society.

Close to Arnold Ice Cave and confused with it in NSS Bulletin 4 is *Wind Cave,* which measures about 5000 feet in length and is extremely rough. At about 500 feet from the entrance is a hole in the roof 50 feet overhead, below which were seen ice stalagmites April 29, 1951. Beyond this point, the floor which previously consisted of huge boulders piled indiscriminately, presents about every 100 feet a 30-foot wall of aa lava which must be laboriously scaled and descended. Many of the rooms thus formed are 60 feet high and very impressive.

Located in the same general area is *Charcoal Cave,* where charred wood, cut with stone axes, has been dated to the 13th Century. A full report on this cave is available in the March 1938 Oregon Historical Society Quarterly.

Some 20 miles to the south, on the southern flanks of the Paulina Mountains, is *Surveyor's Ice Cave,* accessible only in midsummer due to its higher elevation. The description of the area as given by Tonseth is similar to that of South Ice Cave (see below).

To the east, three ice caves are shown on the USGS Newberry Crater quadrangle, two on the Forest Service map. According to a letter from Brogan "these were discovered by Fred Matz and crew while cruising timber", and have not been found since. They will therefore be referred to as *Matz's Ice Caves. East Ice Caves,* mentioned by Brogan, may be the same.

Only about 3 miles east of Bend, *Horse Cave* is said to resemble *Skeleton Cave* on a smaller scale, but aside from its accessibility has no other attraction. *Barlow Cave,* 4 miles east of Bend on the Butler road, however, has yielded artifacts of the Fort Rock type (see below). No other information is currently known of these or the *Redmond Caves,* near that city.

Northwesternmost of the entire group is *Skylight Cave.* Entered through a vertical opening 15 x 30 feet, after a 20-foot descent a 65-foot tunnel leads to a room with a 2 x 2-foot opening in the ceiling responsible for the name of the cave.

Three miles west of Wanoga Butte just within the Bachelor Butte-Sheridan Mountain lava field is *Edison Ice Cave.* Not known to have been visited in recent years, its entrance is a small vertical shaft usually filled with ice and snow. Bischoff in NSS Bulletin 4 mentions artifacts buried in the ice here.

Seen only from the air, on the summit of the ridge between Sheridan Mountain and Kwolh Butte is the large entrance of a cave referred to as *Kwolh Butte Cave.* In the same general area, on the southwest point of Round Mountain is a 20 x 30-foot cave, partially filled with rock debris, with a 1-2-inch projections of unidentified mineral deposits on its ceiling. It is known as the *Round Mountain Cave.*

South Ice Cave, in the Cabin Lake area, is well marked by the Forest Service. Its main (southeast) section has been mapped by the Cascade Grotto. Three hundred and fifty feet long, two deposits of stratified ice are present while early in the season temporary formations abound throughout its three rooms. A considerable inward draft was noted between the first and second rooms. The shorter western passage is entered through a narrow 20-foot crawl and is said to be much more difficult.

Farther south, a shelter near Fort Rock, known locally as *Cow* or *Menkenmeier Cave,* has received national archaeological attention recently because artifacts found there were dated back some 9000 years, earlier than any others in America. The geiger counter radioactive carbon calendar was employed in these studies.

About 15 miles east of the Cabin Lake Ranger Station is *Derrick Cave,* a pleasant 1800-foot trip over a sand floor from the large entrance. This area is not included in any USGS quadrangle, but is shown on the Fort Rock Ranger District map of the Deschutes National Forest.

Some two miles to the northeast of Derrick Cave on a sagebrush flat is the obscure entrance of *Button Springs Cave,* discovered in 1941 by Tonseth and party, which, entering via a 20-foot ladder, explored about ½ mile of large roomy passages despite large piles of rough rock.

Other caves in this rough area undoubtedly exist. In view of the significant finds to date, it is obvious that the region and its caves are deserving of further study.

Hydrologic and Atmospheric Studies in Schofer Cave[1]

By CARL H. GAUM

Almost two years of time and many man hours of work went into the planned research project herein described. It was accomplished by the cooperative effort of more than a dozen cavers from the Trenton, N. J. area who, with scientific equipment loaned to the National Speleological Society by the Office of Naval Research, and with the cooperation of Pennsylvania's Game Commission, of its Department of Health, and of other organizations, were able to make this contribution to speleological knowledge.

Introduction

The Schofer Cave project was originated by a group of Trenton, New Jersey, speleologists who undertook to make a complete study of one cave. This paper pertains to the hydrologic and atmospheric studies. Schofer Cave was chosen for study because of its accessibility for weekend trips (seventy miles from Trenton). It contained a fairly large amount of water, which made it feasible to collect hydrologic data. Its relative inaccessibility to visitation made it less likely that instruments would be disturbed as only seriously interested persons would take the trouble to crawl into the cave's one large room.

Location and Description of Cave and Area

Schofer Cave is located two miles northwest of Kutztown, Pennsylvania, about half way between Allentown and Reading. The cave is located in the north side of Umbrella Hill near the site of the old Schofer mill on Sacony Creek. It was discovered during quarrying operations. The quarried limestone was used for agricultural purposes and an old lime kiln still stands near the cave.

The location of Schofer Cave can be determined from the Hamburg, Pa. U. S. Geological Survey topographic sheet. It is in Greenwich Township in Berks County at Lat. 40° 31′ 54″ N and Long. 75° 48′ 55″ W.

To reach Schofer Cave from Kutztown, Pennsylvania, turn north at the brick pillars at the northeast end of the grounds of the Kutztown State Teachers College. The entrance is in a small cliff created by quarrying operations about twenty feet up a talus slope which is covered with vegetation. The entrance is high and wide, opening like an inverted V, but soon it narrows to a crawlway twenty feet down a 30° slope which is composed of small blocks that have fallen from the ceiling. The cave then opens into a small room littered with large fallen blocks. By crawling through a keyhole-like opening about thirty-five feet from the cave entrance it is possible to continue into a long narrow corridor barely high enough in which to stand. This corridor continues for about eighty feet, alternately narrowing and widening, to a point where the ceiling suddenly lowers to about eighteen inches (above the floor) and it becomes necessary to crawl through a ten-foot long passage in snake-like fashion.

Beyond this low point one can crawl on hands and knees and, after several more sharp turns the so-called Big Room becomes visible to the left through several openings. Large fallen blocks lie scattered about everywhere. They are surrounded by water, one to six feet deep depending on the height of the water level. Ex-

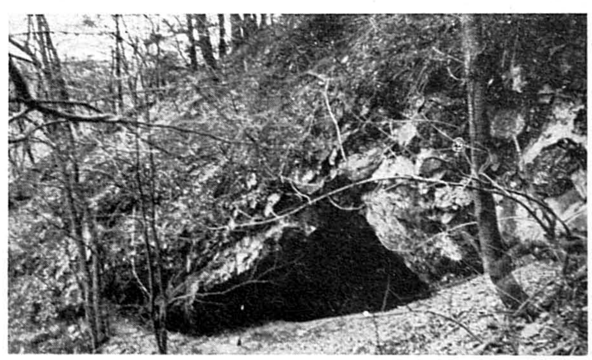


Photo by Jerome M. Ludlow

The entrance to Schofer Cave, near Kutztown, Pa.

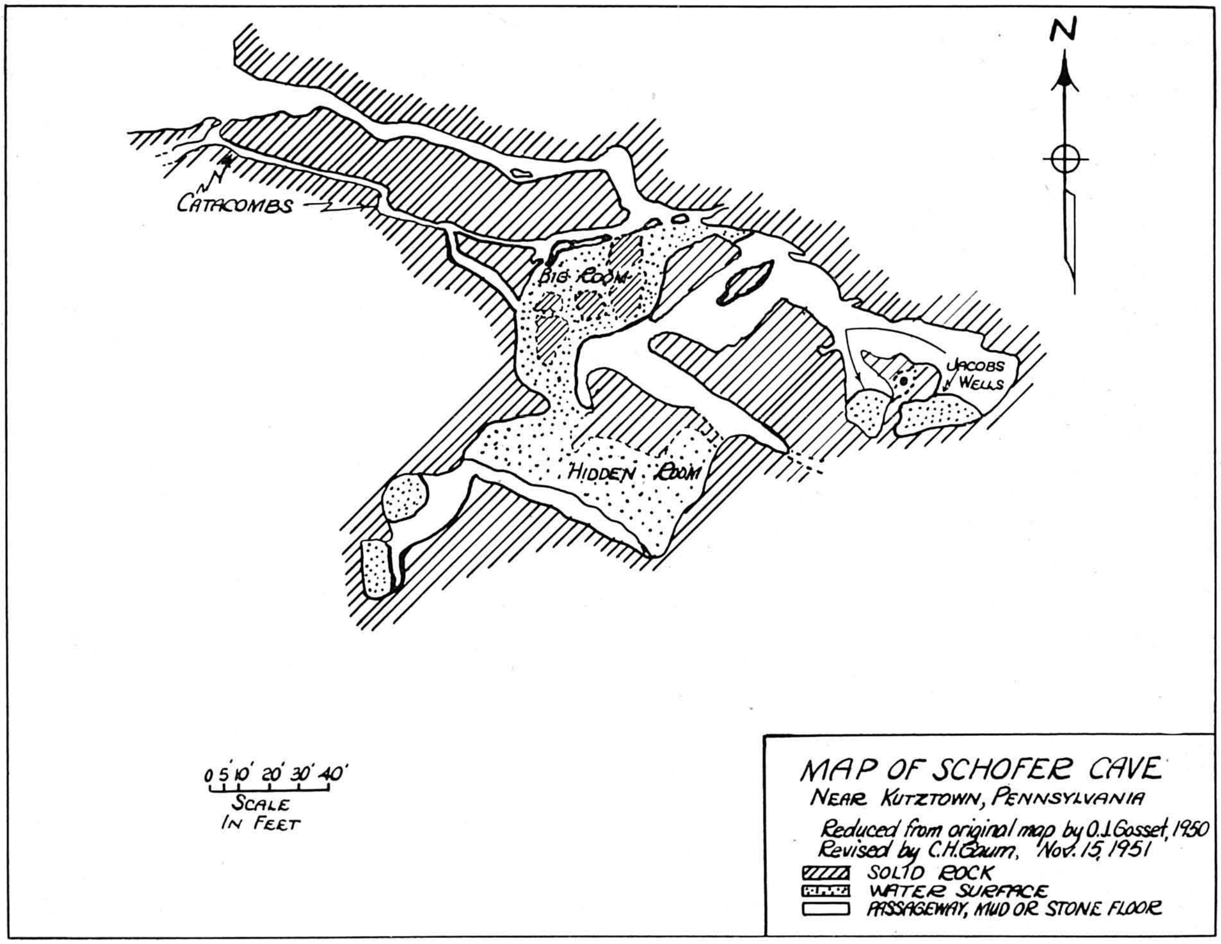
[1] Paper presented at annual meeting of American Association for the Advancement of Science, Philadelphia, Pa., December 28, 1951.

treme care is necessary in climbing over them. Several sections of the roof look unsafe but since flowstone has begun to fill the cracks it is likely that it has been this way for a considerable period of time. There is very little limestone formation in the cave.

Continuing east in the Big Room more breakdown is encountered but on a smaller scale. Climbing over this and then through several small passageways one reaches Jacobs Wells, two separate pools which are connected by a passageway completely filled with water. A flashlight beam directed into one of the pools can be seen by an observer at the other. The deepest sounding, about eighteen feet, is obviously not the bottom.

South of the Big Room another section of the cave can be reached only during periods of extremely low water. It may be entered by crawling beneath a low overhang though it is not possible to negotiate it without partly submerging. Because it is usually inaccessible, this chamber is called the Hidden Room. It contains some flowstone and many anthodites or cave flowers.

West of the Big Room lie the Catacombs, a series of inter-connecting crawlways which finally ascend to the cave entrance. Accurate mapping of this portion showed that some sections were directly under station 1, located at the entrance, and that in places the Catacombs cross their own path at lower levels. Among the debris found in the Catacombs was a large broken stalagmite.



Map of Schofar Cave

It is probable that at one time the cave was larger, extending out into the present valley of Sacony Creek. Erosion and cave breakdown evidently have filled the lower portion of the

ancient cave. The present entrance probably is very close to the former cave roof.

Geology

Schofer Cave lies in the cave belt of Berks County, Pennsylvania, on a line with Crystal, Dreibelbis, Dragon, and Onyx Caves. It seems probable that there are other caves along this line, but as most of the afore-mentioned caves were discovered by quarrying operations it is unlikely that solution cavities which are large enough to admit a grown person connect with the surface. Careful reconnaissance has failed to locate any new caves.

According to Barnsley[2] the country rock of Schofer Cave is variable and very impure. Some beds are limestone conglomerate, others are sandy limestone or, locally, true shale. The cave lies in the lower part of the Martinsburg formation which is Ordovician in age.

The cave has been developed by solution along joint and bedding planes and also in fractures caused by local faulting. Evidence of this faulting may be seen on the cliff near the entrance of the cave and also in the entrance passageway.

Barometric Pressures

At various times during the course of the investigation a barograph was placed in the cave and another at the entrance. Barographs are instruments for recording changes in air pressures. The instrument consists of an aneroid barometer with a pen so attached as to record the pressure on a chart. The chart is mounted on a drum which is clock driven and records time. The clock must be wound and the chart changed weekly, on the particular instruments used. Normally the Big Room air pressure varied directly and in the same magnitude as outside atmospheric pressure, but occasionally for short periods (24 to 72 hours) the lines on the charts did not coincide. A difference in pressure of four millibars was noted.

No time lag in pressure effect was noted on the weekly charts, the only variation being one of magnitude. The instruments were changed to a daily scale for several days, and still no time lag was noted. Time lags must certainly exist but probably are of very short duration, perhaps only a few seconds or at the most only a few minutes. Such lags could not be determined with the instruments available. Barometric pressures in the Big Room of the cave were higher than pressures at the entrance due to the difference in elevation. Variations in the magnitude of pressure did not seem to have any direct relationship with surface temperatures. About fifty feet from the cave entrance barometric pressures varied directly as outside pressures for the period of record.

Air currents have often been observed coming from the cave in gentle gusts. The air-current velocity was so low that a small hand anemometer would not rotate when the recording dial was engaged. When the recording dial was disengaged, however, the propeller would turn but additional friction from the recording device quickly slowed it to a halt. Two different anemometers were used, with identical results. Air current was estimated by observing smoke drift at twenty feet per minute.

Smoke bombs could not be used to trace air currents because of possible danger to personnel. Air currents were so low and rooms and passages were so small that it was believed that personnel could not safely have gotten out of the cave before it would have completely filled with smoke. There was no way of placing a bomb in the cave by dropping it through an opening.

Temperatures

Thermographs (clock driven instruments which record continuous temperatures) were placed in several positions in the cave and just inside the entrance at various times. In the Big Room, about two hundred feet from the entrance (measured along the passageway) no apparent temperature change of any magnitude occurred during a four-week test period. Variations of about 0.25°F. were noted on the chart, but they may have been due to instrument variation. However, the minute temperature fluctuations did show a diurnal pattern coinciding with outside temperatures.

The thermographs stabilized very slowly. On one occasion it took six hours for one to stabilize from 55°F. to 50°F. when it was

[2] Barnsley, E. R., Stone, Ralph W., in *Pennsylvania Caves*, Commonwealth of Pennsylvania, Dept. of Internal Affairs, Topographic and Geologic Survey Bulletin G-3, p. 31, 1932.

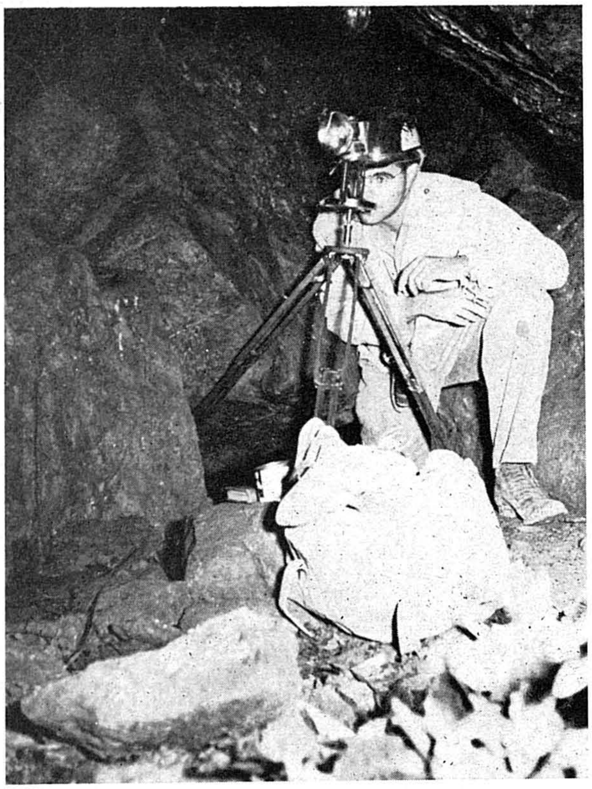


Photo by Rudolph F. Gaum

The author using Foresters compass during survey of cave.

Photo by Carl H. Gaum

Water samples are collected from nearby spring by Jerome M. Ludlow.

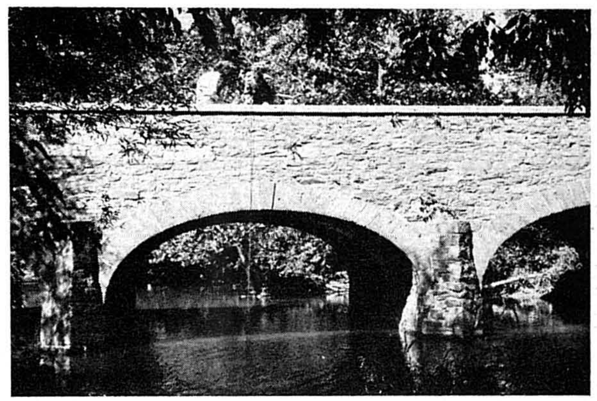


Photo by Jerome M. Ludlow

Water levels are measured in Sacony Creek by Rudolph F. and Carl H. Gaum.

This series of photographs, taken during the course of the investigation at Schofer Cave, near Kutztown, Pennsylvania, shows the wide variety of data collected.

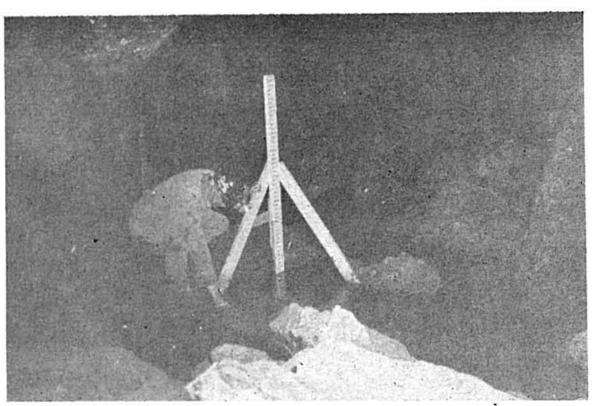


Photo by Rudolph F. Gaum

Installing staff gage to obtain data on fluctuation of water levels in cave.

Photo by Jerome M. Ludlow

Norma Lipman enters data in field note book after reading barograph.

brought in from outside. A person approaching the thermograph or just crawling past it made the temperature rise about 0.3°F., and each time someone approached or crawled past the instrument the temperature rise was recorded by a tick on the chart. If someone stopped near the instrument long enough to read temperature from a thermometer the recorded temperature on the thermograph jumped up about 0.5°F., again showing a tick on the chart.

Some addressed postal cards were left with a thermometer in the Big Room. A note requested all explorers to mark the temperature on the cards and mail them. Ignoring high readings apparently due to the thermometer being held in the hand, a difference in temperature of the cave air of about 1°F. between winter and summer months was noted, the temperature being higher in late summer than in early spring when it was at its lowest.

Water temperatures in the pool in the Big Room varied about 2°F. from spring to summer. The average or normal water temperature is 50°F. but in the spring after heavy rains and after considerable water had percolated into the cave, water temperatures were slightly lower. Air temperature also could be influenced by the dripping water after heavy rains in the spring.

In other sections of the cave, temperatures were slightly different; at Jacobs Wells, for instance, air temperature several feet above the water surface was 51°F., and in the cave entrance passageway it dropped as low as 48°F. even during the warmest summer month. These fluctuations from the normal of 50°F. in the Big Room probably were due to the effects of air currents and to proximity to the surface.

At Jacobs Wells the air temperature averaged 1°F. higher than air temperature in the Big Room. This was probably due to the fact that the former station is in a drier, higher location, and that evidently it connects with the surface. The skeleton of an opossum was found here. It is quite unlikely that the animal could have gained access to the cave through the main entrance, through the water filled room, to the rear portion of the cave. Nuts and other food found near the skeleton gave further evidence of a connection with the surface.

When a thermograph was left inside, about forty feet from the cave entrance, the temperatures fluctuated in the same pattern as outside temperatures, but at much smaller magnitude. During a single test of thirty-six hour duration the instrument on the surface fluctuated from a high of 38°F. to a low of 32°F., and the one inside the cave from a high of 46°F. to a low of 45° F. The farther one goes into the cave the less the magnitude of the fluctuation becomes.

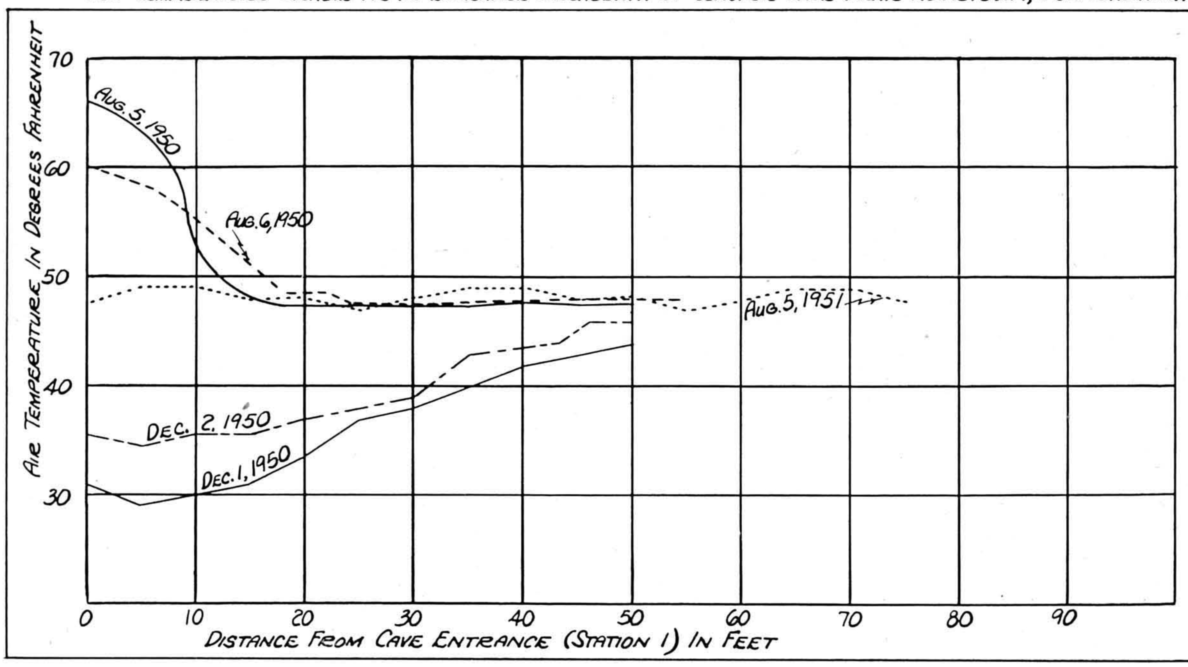
A time lag in temperature effect was noted, but because of the small scale of the chart and the slight change in temperatures recorded on thermographs in the cave it was difficult to read this time lag accurately. It took from forty-five minutes to an hour for a peak outside temperature to show up on the thermograph forty feet inside the cave. Small changes in outside air temperatures, of course, did not show up on the thermograph in the cave passageway.

During five trips to the cave, air temperature gradients from the entrance to the Big Room were determined. Thermometers were placed at 5-foot intervals for the first fifty feet, and then about every ten feet for the remaining distance. Thermometers were placed on wire racks and left for several hours. During two trips outside air temperature was higher than 50°F., and on two other trips lower than 50°F., and on one trip just about 50°F. (See Fig. 1.) No definite temperature gradient could be determined. The temperature approached 47°F. to 48°F. in the rear of the entrance passageway. While it rose in some locations and fell in others it did not follow a uniform rise or decline.

Deviation from a smooth heat transfer curve may be due to the many large blocks of roof breakdown which expose more surface area to air currents, i.e., the air in passing through the cave must circulate a greater distance than would otherwise be necessary and it therefore comes in contact with more rock surface, some of which is covered with moisture. This condition tends to cool the air more rapidly if it is warm when it comes in, or to retard heating it if the surface air temperature is lower than cave rock temperature.

On each trip temperatures were taken at a spring which is believed to be fed by cave

FIG. 1 TEMPERATURE GRADIENTS IN ENTRANCE PASSAGEWAY OF SCHOFER CAVE NEAR KUTZTOWN, PENNSYLVANIA



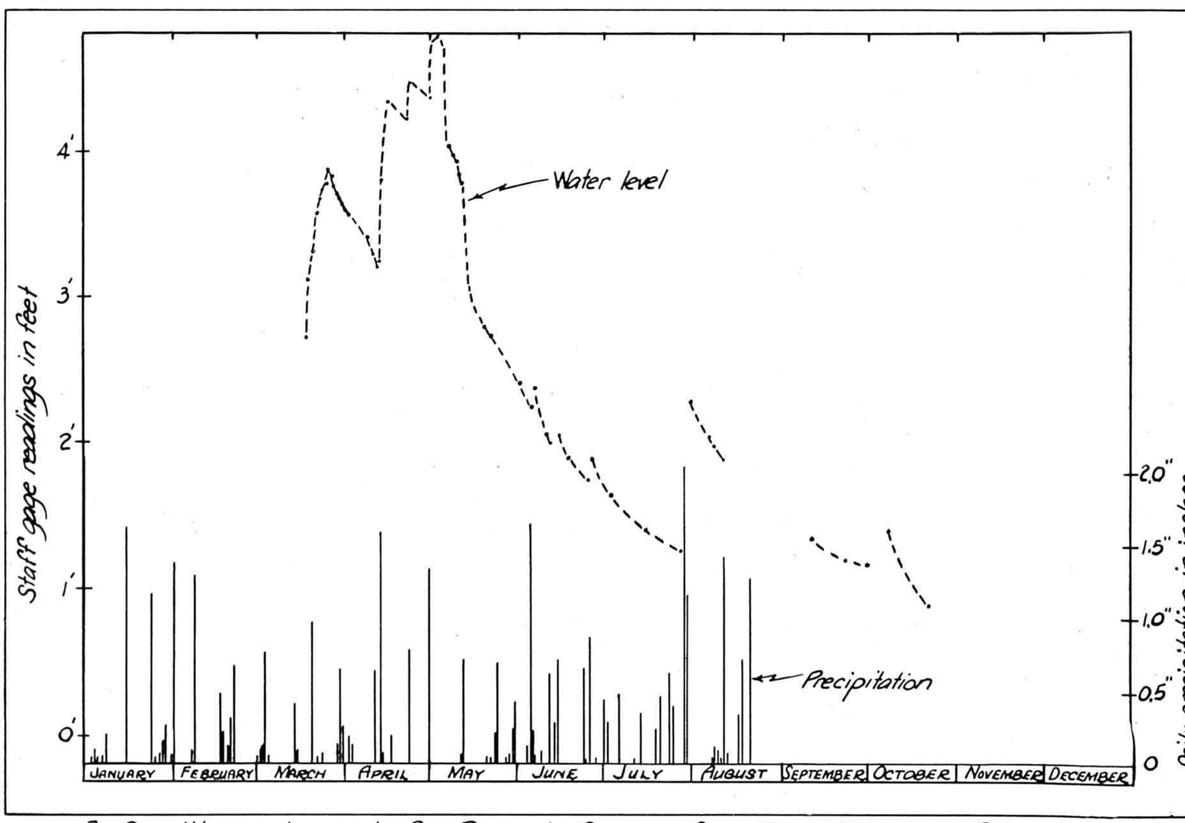


FIG. 2 WATER LEVELS IN BIG ROOM, IN SCHOFER CAVE NEAR KUTZTOWN, PENNSYLVANIA, AND PRECIPITATION AT VIRGINVILLE, PENNSYLVANIA, 1951.

water. Nine out of twelve readings were exactly 50°F. Three deviations of 0.5°, may have been due to the observer or the thermometer being in error.

Humidity

Relative humidity in the Big Room has varied from 95% to 100%, the normal humidity being fairly close to 100%. The variations may be due to discrepancies in thermometer readings since a 1°F. error in the wet bulb temperature will make 5% difference in calculated relative humidity at the normal cave temperature.

Water Levels

A three-foot section of steel staff gage was installed on September 23, 1950 and for a few weeks gave a record of water-level fluctuations. On March 11, 1951, however, the water had risen to such an extent that this gage was completely submerged. Its value, therefore, was partially nullified by our inability to estimate the probable rise in water level prior to its installation.

On March 18, a water-stage recorder was installed on the pool in the Big Room. The instrument consists of a float attached to a tape so that a rise or fall in water level rotates a drum to which a chart is attached. A clock driven time mechanism moves a recording pen across the chart so that a continuous change of water level is recorded and an accurate graph results. This instrument was of a "weekly" type and it therefore became necessary to visit the cave every seven or eight days in order to change the chart thereon if a continuous record was to be obtained. A break in the record occurred, unfortunately, because of the inability of the available personnel to visit the cave weekly. As shown by the charts for four consecutive weeks, however, there was a maximum fluctuation in water levels of 1.21 feet from March 18, 1951 through April 15, 1951. An effort was made to correlate this change in water level with U. S. Weather Bureau records of precipitation from the nearest Weather Bureau station located at Virginville, Pennsylvania, a distance of approximately three miles from the cave.

On June 10, 1951, a six-foot graduated steel staff gage was placed in the pool in the Big Room. A quantity of postal cards was left for explorers to send in water-level data read from the staff gage. Cards came in quite regularly at about two-week intervals until the gage was knocked over.

From water-level recorder charts and staff gage readings a hydrograph for the period of record was drawn. (See Fig. 2.) Precipitation at Virginville was plotted on the same diagram. Maximum high water of 4.78 feet occurred on May 2, 1951, after a period of several heavy rains. At that time springs appeared in the meadow along the road adjacent to Umbrella Hill and water level in the spring at the campsite was 0.2 foot above normal. After this date, however, water levels dropped quite rapidly and rainfall had little effect on pool level in the cave. This undoubtedly reflects the increased absorbtion of water by rapidly growing vegetation on the hillside above the cave and also rapid runoff of rains of high intensity.

After heavy rains a considerable quantity of water drips from the ceiling of the Big Room, but some water is found percolating through the cave roof even after periods of prolonged drought.

On each visit to the cave a tape measurement from the edge of a railing on the upstream side of a bridge over Sacony Creek was made to the water surface. No direct relationship between fluctuations in creek level and the water level in the cave pool was apparent. Both rose after heavy rains, but Sacony Creek rose more quickly and also fell quite rapidly. The cave pool level apparently rises more slowly and also drops at a much slower rate, sometimes requiring several months to fall a few feet. Heavy rains on July 28 and 29, 1951, caused nearby Sacony Creek to overflow its banks, and the creek level rose several feet above normal. The cave water level rose only about one foot, not an appreciable amount.

The observed record low for 1951 occurred on October 21, with a reading of 0.85 foot. This differed by 3.93 feet from the observed high of 4.78 feet, on May 2nd. Water levels in three nearby observation wells, measured by U. S. Geological Survey personnel, were compared with the water levels in Schofer Cave. The general trend of both was found to be the same,

TABLE 1

Chemical Analysis of Water in Schofer Cave

(Samples collected August 1, 1951)

Location	Sample Number	pH	Versenate Total Hardness Calcium Carbonate ppm	CO_3 ppm	HCO_3 ppm	Cl ppm	Sp. Cond.*
Drip from roof of Big Room	IIIA	8.10	146	9.8	110	2.0	286
	IIIB	8.2	144	9.8	112	2.0	270
Pool Big Room	IIB	7.8	85	0	80	2.2	185
Spring	IA	7.4	82	0	86	2.2	199
Spring	IB	7.4	86	0	85	2.2	194

*Specific conductance at 25°C (micromhos)

TABLE 2

Bacteriological Analysis of Water in Schofer Cave

(Samples collected June 16, 1951 in sterile bottles and according to instructions of Pennsylvania Department of Health.)

	Total Bacteria per cc.	Coliform M.P.N. per 100 cc.
1. Dipped sample from spring at campsite	5000	240
2. Dipped sample from private well	5000	240
3. Drip from cave roof	50	0
4. Dipped sample from pool in Big Room	2000	0

indicating the similarity between cave pool level and general ground water levels.

Water Analyses

Water samples from the cave and its surrounding area were collected and analyzed for their chemical and bacteriological content. (See Tables 1 and 2.)

The spring and a private well showed marked evidence of pollution, but the cave waters were free of gas producing bacteria. The spring and well evidently are polluted by surface and privy contamination. It is believed that uncontaminated water can be obtained in the area by drilling a cased well.

The pH decreases from 8.1 to 7.4 as the water travels outward from the cave-roof drip toward the spring. Hardness decreases also as do most other constituents examined. Chlorides, however, increase slightly.

Surveying

A map of the cave and its surrounding area was drawn and levels were run from the pool in the cave to the bridge over Sacony Creek, so that comparative water-level data could be obtained. At the time the survey was made the water level in the cave was 6.80 feet higher than that in the spring and 11.05 feet higher than that at the bridge over Sacony Creek. These comparisons were based on figures for August 5, 1951 when the water-level reading on the 6-foot staff gage in the pool in the cave's Big Room was 2.05 feet and the depth to water from the bridge was 13.37 feet. Even if slight errors were made in surveying due to discrepancies in reading angles the errors would not be great enough to change the relationship of the surface of the cave pool to the spring or creek surface.

An Abney level and Foresters compass were used for surveying in the cave and all angles were checked. Distances were measured with an engineers tape graduated to 1/100th of a foot. On the surface an engineers transit and level were used for surveying.

It can be stated definitely that there is no direct connection between Sacony Creek and the pool in the Big Room of Schofer Cave other than the fact that the water from the cave ultimately finds its way into the creek.

Summary

In Schofer cave air temperatures at a particular location remain fairly constant throughout the year. Temperatures vary from place to place in the cave because of air currents and proximity to the surface. Water temperatures of the pool in the Big Room vary slightly immediately after heavy rain and have some effect on air temperature. The temperature of water from a spring believed to be fed by waters in the cave remained constant for the period of record. Relative humidity was always observed as 100 per cent in the Big Room but varied as one approached the entrance or other air passageways. Definite air currents have been noted with the currents observed to be coming in gusts at times.

Barometric pressure in the cave generally varies directly as barometric pressure on the surface with no perceptible time lag noted on the instruments used. For short periods differences in the magnitude of change in barometric pressures were noted.

The temperature gradient from the entrance to the Big Room was studied during several periods. No definite pattern was observed. The variation from the theoretical pattern was probably due to air currents in the cave being diverted around large fallen blocks with only small spaces between, hence exposing more surface to the air than would otherwise be the case in its normal travel through a straight passageway.

Water level in a large pool of water in the cave fluctuated with the seasons and the rainfall pattern. Almost immediate rise was noted in water levels during spring and winter months when little precipitation is absorbed by soil and plants. During the summer months rainfall has only slight effect.

There was no apparent connection between the water in Schofer Cave and that in Sacony Creek. The water surface in the cave pool was several feet higher than creek level.

Acknowledgments

Many persons and organizations contributed, both directly and indirectly, to the Schofer Cave Project. Special recognition must go to Oscar J. Gossett who conceived the project and to Jerome M. Ludlow for arousing the author's interest in cave hydrology, for acting as coordinator of the project, for writing the preliminary report, and for editing this final manuscript. Assistance in getting the project under way and for the perliminary mapping of the cave by Oscar J. Gossett and Robert P. Lipman is acknowledged. Rudolph F. Gaum participated in most of the trips. Henry Herpers wrote a brief report on the geology of the area. Mr. and Mrs. Richard Stamm, near whose home Schofer Cave is located, were most cooperative in assisting with information. The following persons participated on several trips for the collection of data: Richard Booz, Richard Brillantine, Elizabeth S. Gaum, Eve Herpers (nee Keller), Jerry H. Lieberman, May Ludlow, Norma Lipman and Walter T. Sittner.

The Office of Naval Research furnished barographs, thermographs, psychrometers, anemometers, and other equipment for use in the work. Cooperation of the Pennsylvania Game Commission on whose lands the cave is located and of the Pennsylvania Department of Health for bacteriological analysis of the water in the cave and from nearby areas is also acknowledged. Advice and records were freely furnished by the field personnel of the United States Geological Survey in both New Jersey and Pennsylvania.

General Notes

The Eggs of TYPHLOTRITON SPELAEUS Stejneger, Obtained by Pituitary Gland Implantation

Mittleman (Mittleman, M. B. 1950. Cavern dwelling salamanders of the Ozark plateau. Bull. of the Nat. Speleological Soc., No. Twelve, p. 13) says that the eggs of **Typhlotriton spelaeus** have never been described. As a matter of fact, the eggs of this remarkable salamander were described by Barden and Kezer (1944) from material obtained by pituitary induced ovulation. It is true that the eggs of **Typhlotriton** have never been collected from the caves in which this salamander lives, but there is no reason to believe that the eggs obtained by Barden and me in the laboratory differ in their structure from those deposited by this species in its natural habitat. However, it is quite possible that the attachment and grouping of the eggs that we secured by induced ovulation may be decidedly atypical.

We collected the specimens that were used in the experiment from River Cave, Camdenton, Missouri, during the last week of March 1942. In our collection were four females which showed large ovarian eggs through the partially transparent body wall. Three of these females were implanted in the subcutaneous space beneath the tongue musculature with pituitary glands that had been taken from various species of salamanders and from the leopard frog, **Rana pipiens.** The implants were made at intervals over a period of 15 days. We kept the implanted animals in covered glass dishes containing a layer of water and several rocks at a temperature of 18-22 degrees C. Two of our experimental animals failed to ovulate but the third deposited a total of thirteen eggs. The first four eggs were deposited in the water, singly and unattached, seven days after the original implantation. Six salamander pituitary glands and one from **Rana pipiens** had been required to induce the laying of these four eggs.

Eleven days later, following the implantation of two more anterior lobes from **Rana pipiens** donors, nine more eggs were deposited by this female. Dr. Barden and I had the good fortune to observe this **Typhlotriton** as she moved over the surface of the moist rock, laying these eggs just above the level of the water. The accompanying photograph shows the eggs as they were deposited by this female. It is interesting to note that she continued with the laying of these nine eggs regardless of the disturbance of photography. The accompanying photographs show clearly the general nature of the **Typhlotriton** egg with its surrounding layers of material. A detailed description of this egg has been presented by Barden and Kezer (Barden, Robert B. and Kezer, James. 1944. The eggs of certain plethodontid salamanders obtained by pituitary gland implantation. Copeia 1944 (2): 115-118.) and need not be repeated here.

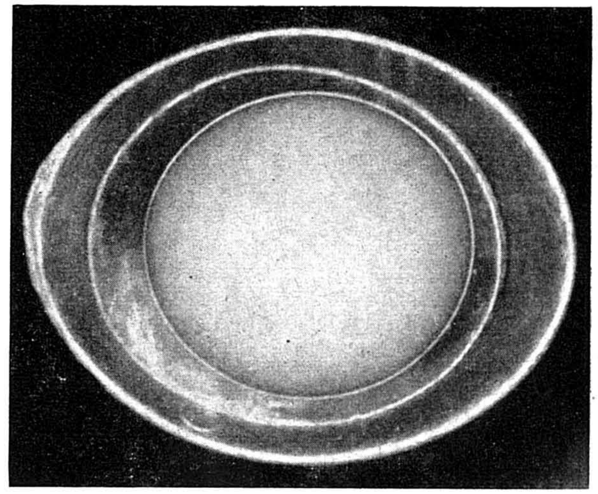
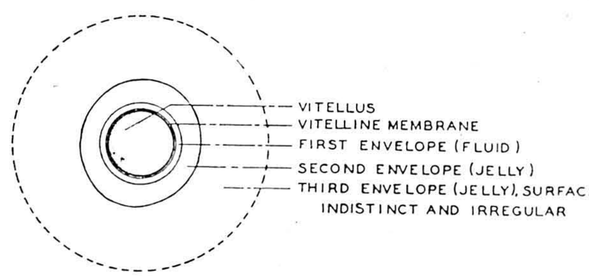


Photo by R. B. Barden

EGG of **Typhlotriton spelaeus**, photographed chiefly by reflected light. X4.5. This egg was removed from the rock to which it had been attached; consequently the third (outer) envelope is torn and somewhat misshapen. The slightly eliptical boundary between the second (middle) envelope, and the very thick third (outer) envelope, also can be seen.



Typhlotriton spelaeus

Drawing from Barden and Kezer

DIAGRAM of the egg of the blind cave salamander, **Typhlotriton.**

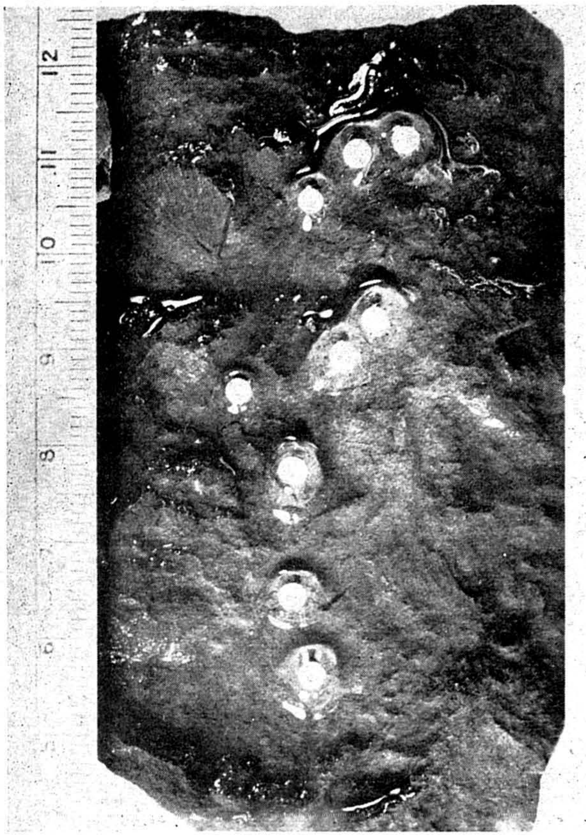


Photo by R. B. Barden

EGGS of **Typhlotriton spelaeus** attached to the moist upper surface of a rock, shown with millimeter scale. The eggs were obtained by induced ovulation.

There is no doubt that life-history information obtained in the laboratory by experimental procedures must be evaluated with considerable caution. However, when the reproductive processes of a cave salamander consistently escape the eye of the inquiring speleobiologist, it is a good idea to get a start on the solution of the problem by bringing the animal into the laboratory. Very simple experimental technics, such as the one described here, can sometimes provide valuable information regarding the fascinating animals that the speleologist learns to know during his underground explorations.

JAMES KEZER, *University of Missouri, Columbia, Mo.*

The Eggs of the Zig-Zag Salamander, PLETHODON CINEREUS DORSALIS

The red-backed salamander, **Plethodon c. cinereus,** is the most abundant terrestrial salamander in eastern North America, southward to Georgia. To the southwest of its range, specifically from southern Ohio to southeastern Illinois, and from central Kentucky to Alabama it is replaced by its near relative, **P. c. dorsalis.** The latter subspecies has a noticeably zig-zag dorsal stripe rather than a uniform band. It also occurs in a lead-backed phase, like **P. c. cinereus** but can be recognized by its more slender form.

The zig-zag salamander has been found under logs and stones in the woods but in cave country it often occurs in and about the mouths of caves. In Mammoth Onyx Cave, near Horse Cave, Kentucky, a regular seasonal migration of this salamander has been noted, and the eggs have been discovered. The eggs were first called to my attention in 1937 by Dr. E. R. Pohl, operator of the cave, and were illustrated and mentioned by me in a popular article (Natural History, vol. 43, pp. 199-200, April 1939). A more detailed description of the eggs and the habitat is now given.

During three visits, June 29, 1937, June 28, 1938, and July 5, 1946, a total of at least 12 nests were found, each with an adult salamander in attendance. All the nests were found in small cavities in fluted cave formations. The site most frequently occupied in the side of such a column, 5 feet above the floor, consisted of three triangular grottoes 30 to 45 mm. wide and about 60 mm. deep. The three cavities lay side by side, measuring 6 inches across. Each year two of the three cavities contained nests. In 1937, one salamander had the zig-zag pattern; in 1938 neither; in 1946 both. In 1937 a total of 4 scattered nests were found, each with 3 eggs; in 1938 eggs were found only at this site, both being clusters of 4; while in 1946, the nests totalled 6 and contained from 2 to 5 eggs.

Unlike the eggs of **P. c. cinereus,** which number up to 13 and hang from a gelatinous stalk attached to the rock or wood roof of the nest cavity, the eggs of **P. c. dorsalis** have no stalk or pedicel and adhere to the floor or wall of the little grotto due to the adhesiveness of the outer envelope.

The body of the attendant salamander encircles the eggs, or the tail may be curled around them. The individual egg is indistinguishable from that of **P. c. cinereus.** It measures 4 to 4.5 mm. in diameter and is surrounded by the vitelline membrane and by two transparent but distinct envelopes. The individual eggs adhere to each other.

The eggs observed on July 5, 1946, appeared to be in the neural groove stage of development. Two eggs collected on August 21, 1946, showed well developed embryoes, both exhibiting the strong zig-zag pattern characteristic of the red-backed phase. Dr. Pohl estimated the period of incubation to be about 12 weeks. Since the uniform cave temperature is about 58° F., it is not surprising that incubation of **P. c. dorsalis** may take 3 or 4 weeks longer than **P. c. cinereus** whose incubation is influenced by warmer surface temperatures.

CHARLES E. MOHR, *Audubon Center, Greenwich, Conn.*

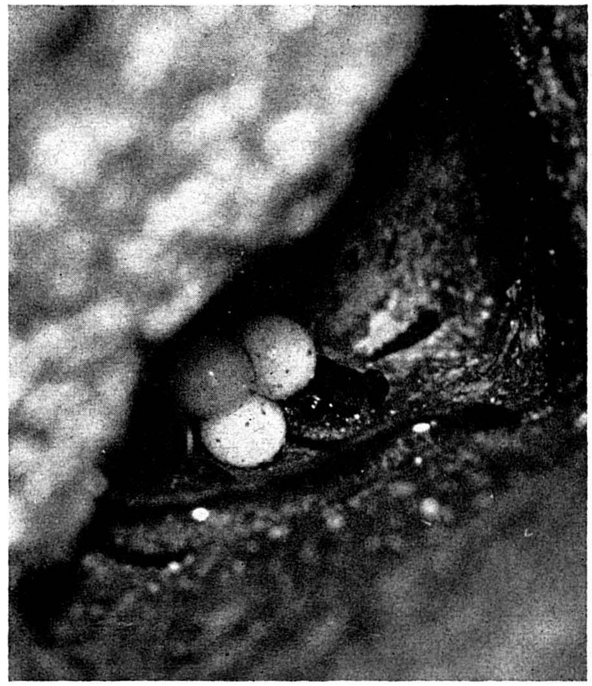


Photo by Charles E. Mohr

EGGS in a cavity in a flow-stone formation in Mammoth Onyx Cave, Kentucky, attended by the adult zig-zag salamander. June 29, 1937.

EMBRYO salamanders, **Plethodon c. dorsalis,** showing well developed structure and characteristic zig-zag pattern on back. The external gills can be seen on one embryo. Part of outer envelope of left egg is torn. The outer envelopes fuse to form a common layer between the two eggs. August 21, 1946.

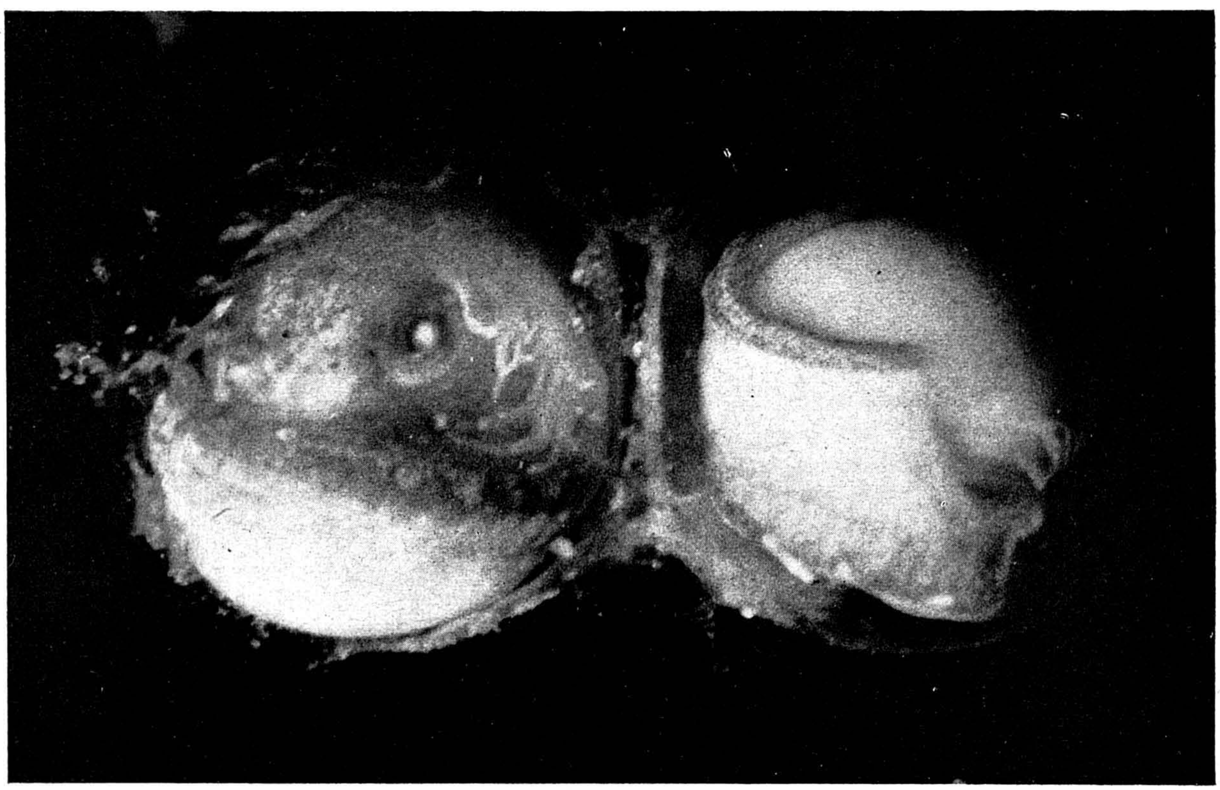


Photo by Charles E. Mohr

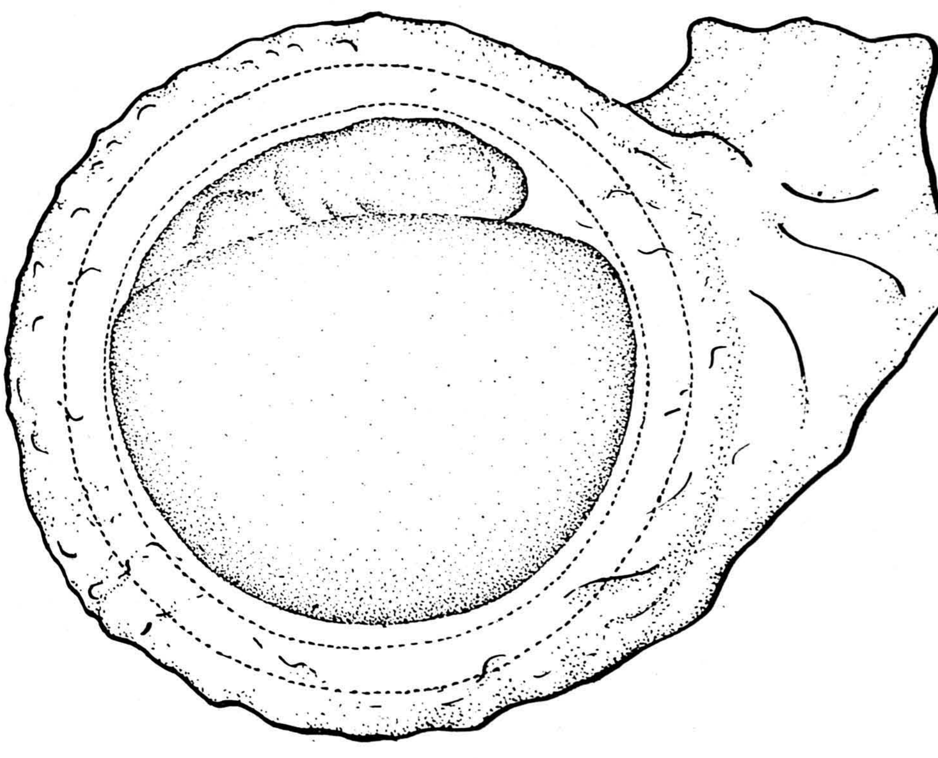
The Eggs of PLETHODON DIXI

Plethodon dixi was described from Dixie Caverns and New Dixie Caverns near Salem, Roanoke County, Virginia by Pope and Fowler (1949 Nat. Hist. Misc., Chicago Acad. Sci., No. 47, pp. 1-4). On August 19, 1948 the writer, accompanied by Robert Sutcliffe, visited Dixie Caverns. On this occasion a female **P. dixi** with a clutch of six eggs was discovered in a cavity at the base of the massive flowstone formation on which these salamanders are particularly abundant. The eggs were attached about two inches from the bottom of a perpendicular wall which formed one side of this cavity. The cavity was three and one-half inches long, one inch wide, and three inches deep.

The eggs of **P. dixi** are quite similar to those of **P. cinereus** as described by Bishop (1941, The Salamanders of New York, p. 207) as far as the envelopes surrounding the yolk are concerned. Thus, in addition to the customary vitelline membrane, two other envelopes are present. Of these, the inner (first) is more rigid and hyaline in appearance. The outer (second) envelope is rather membranous and irregular in shape. This outer envelope forms a common envelope with adjacent eggs by means of which the individual eggs are held together in a bunch. Unlike the eggs of **P. cinereus,** however, this common envelope does not form a stalk by which the eggs are suspended.

The eggs of **P. dixi** are considerably larger than those of **P. cinereus,** approaching the size of **P. glutinosus** eggs as described by Noble and Marshall (1929, Amer. Mus. Novit., No. 347, pp. 6-9). An average egg of **P. dixi** is 5.0 mm. in diameter. The diameter of the vitelline membrane surrounding the egg is only slightly larger. The inner (first) envelope measures 5.5 mm. in diameter. The outer (second) envelope averages 6.0 mm. but is quite variable especially where it fuses with the outer envelope of adjacent eggs to form a common envelope. Here the outer envelope is drawn out into a tubular extension which fuses with a similar extension from an adjacent egg. In this respect the eggs of **P. dixi** are much like those figured for **P. glutinosus** by Noble and Marshall (loc. cit., p. 7, Fig. 3). The eggs of **P. dixi** are also like those of **P. glutinosus** in that they are unpigmented and creamy white in color. The small embryos in each of the eggs are also without pigment.

James A. Fowler, *Academy of Natural Sciences, Philadelphia, Pa.*



An individual egg of **Phethodon dixi** showing the vitellus and its envelopes, and an embryo. X14. The dotted lines indicate the vitelline membrane and inner (first) envelope, respectively. The outer (second) envelope forms the outer surface of the egg and fuses with the outer surface of adjacent eggs to produce a common envelope holding the eggs together. Grace L. Orton, del.

A Cave Record for the Red Bat, LASIURUS B. BOREALIS

From time to time visitors to caves during winter have reported seeing what they consider to be "red bats", and one or two such reports, unsupported by specimens, have been published. Without exception, however, investigation has proved that the reports were based on the pipistrelle or Georgian bat, **Pipistrellus subflavus.**

On the other hand, two finds of bones and other skeletal remains, positively identified as **Lasiurus borealis** have been reported. Bailey (Animal Life of the Carlsbad Cavern, p. 123, 1928) discovered two skulls "on the floor of the deepest room in Carlsbad Cavern, New Mexico. They were old and fragile and had been there many years". Hahn (Biological Bulletin, pp. 141-147, Aug. 1908) found more than 200 skulls of **L. borealis** and two of **L. cinereus** scattered among the rocks on the floor of the large room of Shawnee Cave, Mitchell, Indiana. They were scattered "in a manner indicating that the animals had probably died where they hung suspended from the roof of the cave and that they had not reached the place by accident nor been killed all at one time by a single catastrophe." Hahn reported that the bones were covered by a deposit of calcium carbonate more than a millimeter in thickness. He speculated that the remains "may indicate that the red bat is a decadent species, represented by fewer individuals at present than in the past, or they may indicate that it has abandoned the cave dwelling habit in recent times."

The first "complete" specimen taken in a cave was found by the author in Nickajack Cave, Shellmound, Tennessee, on December 14, 1950. While searching for **Myotis grisescens,** only three specimens of which were seen, a strange-looking bat

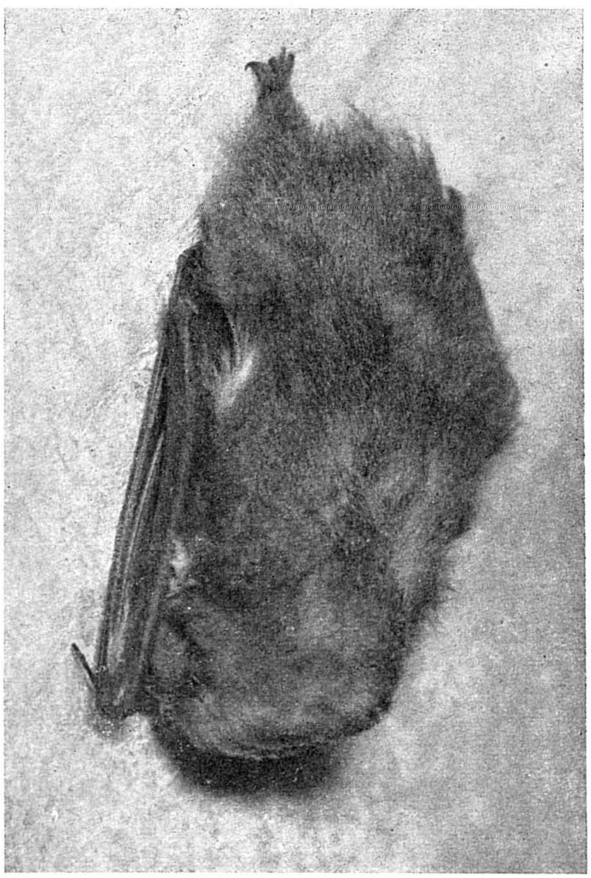


Photo by Charles E. Mohr

RED BAT hanging dead, as it appeared when found in Nickajack Cave. Fox red in color, it is brighter, larger, and more furry than the **pipistrelle** and has quite inconspicuous ears. It belongs to the so-called tree-bats.

Photo by Charles E. Mohr

PIPISTRELLE which sometimes is mistakenly identified as a red bat. The pointed nose and conspicuous ears are characteristic of the cave bats. **Pipistrellus s. subflavus.**

was observed hanging from a perpendicular wall a few feet back from the main stream and perhaps 900 feet from the entrance. It was hanging about 15 feet up on a sheer limestone wall. When dislodged it proved to be a dead, female, red bat, **Lasiurus b. borealis.**

The specimen was in an excellent state of preservation but may well have been dead for many months. It seems likely that it entered the cave during the summer or early fall for a short stay and died there. Both the Carlsbad and Shawnee Cave skulls also may represent the remains of bats which ventured into the caves during summer, or during migratory flights, and not during the hibernation period.

CHARLES E. MOHR, *Audubon Center, Greenwich, Conn.*

A West Virginia Cave Record for the Silver-Haired Bat

On April 12, 1952, a Silver-haired bat, **Lasionycteris noctivagans,** was found in Greenville Saltpeter Cave, Greenville, Monroe County, West Virginia, by Christy A. Weiland, Jr., while he was collecting bats for banding. The animal was an adult male and was hanging by itself approximately 1000 feet from the cave entrance and was brought to me by Weiland. The specimen was sent alive to W. Gene Frum and is now No. 1848 in his collection. Nearby were found **Pipistrellus s. subflavus** and the only colonies of **Myotis l. lucifugus** and **Myotis sodalis** which were seen in the cave. The Silver-haired bat is one of the so-called tree bats and it is unusual to find it in a cave.

WAYNE H. DAVIS, *307 Duquesne Ave., Morgantown, W. Va.*

Two Silver-Haired Bats, LASIONYCTERIS NOCTIVAGANS, Found In a Virginia Cave

In November 1951, a collecting party sent out by the Division of Parasitology, Army Medical Service Research and Graduate School, found two male silver haired bats, **Lasionycteris noctivagans,** in Rumbolt Cave, near Covington, Virginia. Since this bat has not previously been reported from a cave, this find is of considerable interest. Identification was confirmed at the U. S. National Museum. The bats were turned over alive to Ernest P. Walker, of the National Zoological Park.

NANCY ROGERS, *1841 R. Street, N.W., Washington, D. C.*

Additional Notes On the Sternberg-Belding Dry-Peel Technique[1]

This technique of making plastic impressions of bryozoans and small cross sections of fossils, minerals and cave formations has proven very satisfactory. For bryozoans and similar textures, acetone is applied to the specimen. A piece of celluloid is then pressed against it while the dissolved plastic forms a mold of the specimen and hardens. After drying, the celluloid is pulled free. Before making impressions or peels of cross sections, the flat surface of the specimen should be polished with #600 carborundum abrasive and water, then lightly etched with dilute acid and dried. (Carbonates can be etched with hydrochloric acid.) To make impressions of etched surfaces of cross sections, a piece of celluloid is placed on a firm flat surface (i.e. a piece of plate glass). After applying acetone to dissolve the top side of the celluloid, the etched surface is pressed against the plastic and held firmly a few minutes while the impression sets. These are called "dry-peels" since a thin sheet of celluloid is used instead of several applications of liquid collodion. The latter method would produce "wet-peels" which would be dry when the collodion hardened.

Dry-peels are preferred to wet ones when either can be made. The thickness of the celluloid sheet permits dry-peels to be made in a matter of a few minutes. Several applications of liquid collodion (often requiring hours to dry) are usually needed to produce a film of substantial thickness. Also of advantage are the extended edges of the celluloid sheet (Fig. 1). These can be easily held when the peel is to be removed. Edges of wet-peels often shred or tear when stripped from the specimen.

Apparently Sternberg and Belding restricted the dry-peel technique to small surfaces and cross sections. With a little experimentation, I have been able to use their technique for making dry-peels of cave pearl cross sections 35 mm. in diameter. This saves much time and effort over that required for making wet-peels of the same size and quality. Although the latter can be made of surfaces having any degree of deformity, the dry-peel does not prove too satisfactory when irregularities are higher than about 0.5 mm. Very few materials and tools are needed for making these larger dry-peels. Celluloid and acetone comprise the materials, and a "C" clamp and a piece of plate glass the tools.

The procedure, although simple, must be carried through with care and patience. For making a large dry-peel, lay a piece of celluloid on the plate glass. If the celluloid is slightly curved, it is best to have the edges curl upward (Fig. 1). Acetone should be applied with great care; if too much is used, there is a tendency for it to flow between the celluloid and glass. This is to be avoided since all

of the irregularities in the surface of the glass would be reproduced, and the back side of the peel would have a frosted appearance; this area should be clear if one plans to photograph the peel.[2] The acetone should cover an area equal to, or greater than, that of the specimen. When a thin film of plastic has been dissolved, press the specimen against it with a firm steady pressure. A slight rotation often helps force the air from between it and the plastic. Apply a "C" clamp to hold the pressure (Fig. 1) until the acetone dries (sometimes a matter of a few hours for large peels). The contacting ends of the clamp should be covered with about four layers of adhesive tape. Although any smooth surface can be used to support the celluloid against the specimen, plate glass is best since it permits observation of the impression. If undesirable bubbles have formed, the plastic can be removed immediately and a new peel made.

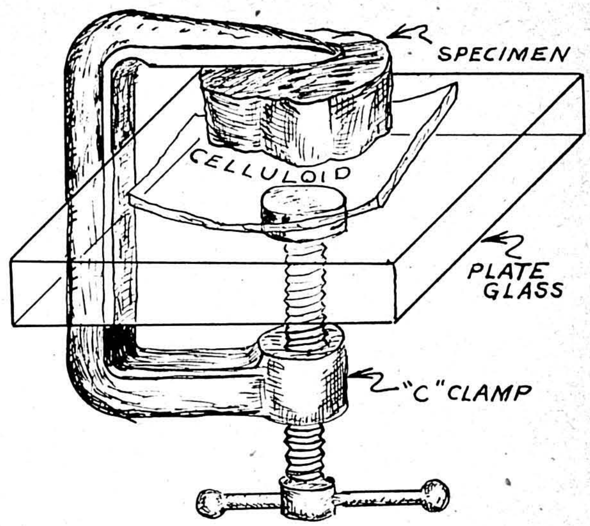


Fig. 1

It is very important to have bubble-free impressions if they are to be photographed. When the plastic is dry, remove the peel with a steady, continuous pull. Any hesitation during the removal will leave a mark across the impression. (These marks will also show on a photograph.)

The last and very important step is to mount the peel between glass plates. If the excess celluloid around the edges of the impression is thick or curled, it should be trimed with a razor blade. Mounting must be done before the peel becomes brittle or warped.

Dry-peels offer many opportunities. They are inexpensive; duplicates can be sent to interested people; micro-details can often be seen that were not noticed on the original specimen, and they can often be projected as slides for lectures and discussions.

DONALD M. BLACK, *Box 144, Grand Canyon, Ariz*

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[1] STERNBERG, R. M., and BELDING, H. F. 1942. Dry-peel technique: Jour. Paleontology, Jan., pp. 135, 136.
[2] EASTON, W. H. 1942. Improved technique for photographing peel sections from corals: Jour. Paleontology, March, pp. 261-63.

Preface (continued from page one)

many scientists, particularly those in government employ, to the increased costs of travel and equipment, and, of course, to the absorption of so many men into the armed forces or related defense activities.

In an attempt to alleviate this situation, several definite steps are being taken. First, the Society is attempting to publicize the diversified but generally unrecognized opportunities for original research that caves offer. Secondly, it provides a ready outlet for reports on completed research projects. Further, it is actively seeking financial support for such investigations. Fellowships and grants-in-aid are solicited to supplement assistance already provided for some projects.

Several grottoes have already carried out or are engaged in hydrologic studies. In use are various types of equipment on loan from the Office of Naval Research, specifically allocated to the National Speleological Society. In this number is the report of one such investigation. A more complete report might have been made except for the transfer of the chief investigator. Reports from other studies will likely appear in future issues. Progress reports are published from time to time in the NEWS.

Readers are requested to give thought to ways in which they personally may help to advance speleological knowledge: through membership in the Society, by making or encouraging worthwhile cave studies, or through giving or seeking financial aid for such investigations.

CHARLES E. MOHR,
President

September 15, 1952
Greenwich, Conn.

Who's Who in Bulletin Fourteen

CARL H. GAUM was born in New York City in 1922. His elementary education was received in the Hamilton Township, New Jersey Schools. In 1942 he entered the U. S. Air Force and served in India and Burma from June 1943 to October 1945. Upon discharge he entered Rutgers University and received a B.S. in Civil Engineering in 1949. He worked for 2½ years in New Jersey for the U. S. Geological Survey, Ground Water Branch as a hydraulic engineer. At present he is working for the Geological Survey on ground water problems of the High Plains of Texas. He was quite active in the Philadelphia grotto, serving as its President before his transfer to Plainview, Texas. His interest in caving began when invited on a trip to Pennsylvania's Schofer cave by his twin brother, Rudolph, and was intensified by association with Jerome M. Ludlow. His main speleological interest is the work of water in relation to caves.

DR. WILLIAM R. HALLIDAY has been active in caving in Virginia and most of the West for about 5 years. He has organized and been chairman of the Southern California, Cascade and Colorado Grottos, and has hopes of adding another to the list in Salt Lake City soon. Having visited 130 caves in 13 states, magnificent Soldier's Cave in Sequoia National Park is his favorite, though Clarke's Cave, Virginia, runs a close second. In this article on lava tubes he introduces a variety of cave which is alien to most members of the NSS. Lava tubes are entirely a western phenomenon, none being known east of Northeastern New Mexico.

JOHN H. D. HOOPER resides at Ashford, Middlesex, England and is connected with the Anglo-Iranian Oil Company. He graduated with honors with a degree in chemistry from London University in 1938. He has explored caves in France, Belgium, Eire and Great Britain in addition to those described in this issue of the BULLETIN. He has taken part in the discovery of several new caves in the Devonshire area of England and is Recorder and Editor of the Devon Speleological Society. Recently he has engaged in large-scale bat banding experiments and has done considerable bat photography, particularly in

attempts to achieve high-speed flash shots of bats in flight. Besides writing a number of technical papers and lighter articles on the habits and movements of cave-dwelling bats and cave exploration in general he has "performed" on TV and radio on the same subjects. He joined the NSS in 1945.

Robert Housley graduated this year from the Roseburg, Oregon, High School where in 1951 he received the science department award, the chemistry award and the Bausch and Lomb science award. This year, in addition to again receiving the Bausch and Lomb science award and the science department award, he also received the mathematics department award and received honorable mention in the annual Westinghouse Science Talent Search. As a member of the National Speleological Society's Committee on Cave Formations and Mineralogy he has spent much of his spare time searching for rare stalactitic minerals. This fall he will enter Reed College at Portland, Oregon, on a scholarship, where he will major in mathematical physics.

Charles J. Kundert, a mining geologist with the California State Division of Mines, was born at Pittsburg, California, October 31, 1925. Graduating from high school at 16 he worked six months as a grocery clerk and then volunteered for the United States Marine Corps in which outfit he shipped overseas on July 1, 1943 and joined the Marine Raiders. Twenty-nine months later he returned to his native state where he enrolled at Pomona College, at Claremont, California, in the fall of 1946, majoring in geology. Shortly after his marriage in the spring of 1950 he obtained a temporary Ranger's position with the National Park Service at Lehman Caves National Monument, Baker, Nevada, where, with the invaluable assistance of his wife he accomplished the field work necessary for the preparation of the article published in this issue of the Bulletin.

Charles E. Mohr, President of the National Speleological Society, was born at Reading, Pa., June 3, 1907. He attended Bucknell University, receiving his A.B. from that Pennsylvania institution in 1930 and his A.M. in 1931. A few months after his first visit to his first cave (Woodward) in 1930 he captured a rare Leib's bat on a return visit. Thus began a study of cave fauna which included 5,000 miles of travel in Pennsylvania alone during his first winter out of college. Among his many contributions to speleology he contributed to Ralph W. Stone's second edition of "Pennsylvania Caves" (1932) by giving locations of 30 new caves and writing a chapter on cave fauna therein. He pioneered with Don Griffin on large scale bat banding projects and has published numerous papers on this subject and on cave fauna in general. He has written cave articles and supplied photographs for numerous publications including LIFE, ILLUSTRATED LONDON NEWS, NATURAL HISTORY, AUDUBON MAGAZINE and others. Mohr's literary contributions are based on a broad and firm basis of extensive exploration and upon keen observation and collecting of underground phenomena in caves throughout the United States and Mexico.

Phil C. Orr, Curator of Anthropology and Geology of the Santa Barbara Museum of Natural History, has been exploring caves and excavating fossils and Indian artifacts for the past 30 years from Mexico to British Columbia. For the last 10 years his attention has been directed toward California caves where he has acted as leader of three other major speleological expeditions sponsored by the Museum, in addition to the one described in this issue of the Bulletin. Besides being a speleologist, Orr specializes in vertebrate paleontology and archaeology and has engaged in cave excavations in Kentucky, Montana, California and British Columbia. Explorations have also been made by him in caves in Tennessee, Illinois, Indiana, Texas, Mexico and Hawaii. In all he has been in approximately 1,500 caves!

Eugenio de Bellard Pietri was born at Maracaibo, Venezuela, Dec. 17, 1927. Most of his early life was spent in study in Jesuit schools in Venezuela from which he received a degree of Bachelor of Philosophy. He also studied medicine for two years and was Professor of Inorganic Chemistry at the Jesuit school in Caracas. He is now studying law at the Universidad Central de Venezuela in that city. In his vocation he is connected with the Ministry of Foreign Affairs of the Venezuelan government. His hobbies are chemistry, speleology, studies on the theory of the evolution of man and philately. He is presently engaged in the preparation of a speleological atlas of Venezuela. He is secretary of the Sociedad Venezolana de Ciencias Naturales.

Lieut. (E.) Trevor Shaw, R.N., was born in 1928 at Exeter, in Devon, England. He was educated in Exeter and joined the Royal Navy as an engineer officer at the end of the war. In the next few years he received his engineering training in Devonport, and also served at sea in the West Indies and the Home Fleet. During 1950 and 1951 he served in a light cruiser in the Mediterranean Fleet, when he visited the Maltese caves herein described. Lieut. Shaw has explored a number of caves in the Mediterranean area and on the mainland of Europe, besides working on those in England. He is a member of the British Speleological Association and has been an Associate member of the National Speleological Society since 1948.

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