BULLETIN EIGHTEEN

OF THE NATIONAL SPELEOLOGICAL SOCIETY
Official Associate of the American Association for the Advancement of Science

IN THIS ISSUE, informative articles on caves, including:

THE HELL HOLE IN THE MUOTA VALLEY

NEW CAVING EQUIPMENT AND TECHNIQUES

BLIND FISHES FOUND IN CAVE POOLS AND STREAMS

PROSPECTING FOR CAVES

THE LEATHER MAN AND HIS CAVES

December 1956

BULLETIN EIGHTEEN

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

IN THIS ISSUE . . . . . . December 1956

Published intermittently, at least once a year; Editor: Roger W. Brucker, 449 W. South College St., Yellow Springs, Ohio. Assistant Editors: George F. Jackson, 104 Lee Ave., Trenton 8, N. J.; William R. Halliday, U. S. Naval Hospital, Oakland, Calif.

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THE NATIONAL SPELEOLOGICAL SOCIETY was organized in 1940. It has members throughout the United States and 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 unlocking the truth 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 the Board of Governors. The Board appoints 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.

LIBRARY: An excellent speleological library is owned by the Society and is being enlarged constantly. Items on hand may be borrowed by NSS members at a nominal charge to defray shipping and upkeep.

FOREWORD

Rain is pounding outside my window as I write, and caves are getting bigger. Cave explorers are going farther too – down, in Utah and Tennessee, out, in Kentucky and West Virginia. As a result the challenges of a few years back, such as Schoolhouse, are shuttled through in routine fashion by increasing numbers of cave explorers. Points of farthest penetration by earlier explorers, as in Floyd Collins Crystal Cave, are merely curiosities, viewed quizzically by novices on a first trip. The climb in and out of Grapevine is not the hair-raiser it used to be for many of our members.

In Switzerland a team is preparing for another lightning attack on sprawling Hölloch Cave as soon as the water recedes from the entrance. In Cuba men are adding new miles to the St. Thomas system, and in Flint Ridge the advance grinds onward. In Virginia patient speleologists change rolls on a barograph, while out West cavers track down rumors of another "long lava cave".

How do we know these things? We take part in them or we read about them in the pages of the *News* and *Bulletin*. By sharing our experiences, findings, and inventions we add immeasurably to our understanding of caves, and the people who care about them. It should not have to be necessary to urge cave explorers to share their findings. But, very frankly, it is. The chief reason you don't receive more *Bulletins* is that articles are difficult to get. Few are submitted voluntarily; most are solicited directly, again and again. The editors, however, can learn of only a small portion of potential material.

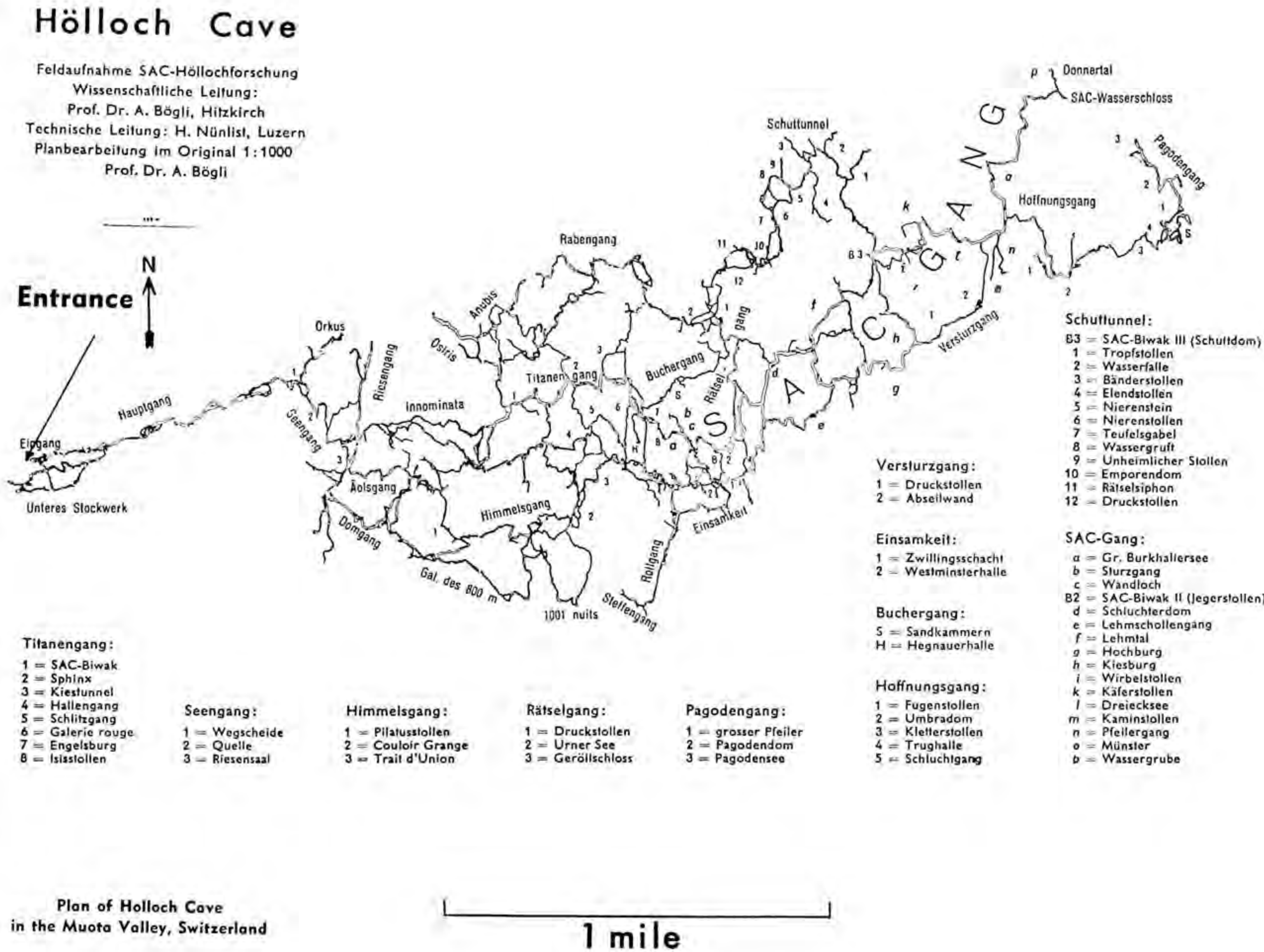
This is an appeal. Read *Bulletin Eighteen* and back issues as well, then see if you can share the information and know-how you have acquired through caving. Well-written trip accounts of more than routine interest do get printed; thorough descriptions of individual or groups of caves are used; readers want to know about new equipment and techniques; scientific reports are one of the main reasons for having a speleological society.

This is an appeal. Read how to prepare manuscripts, inside the back cover of this issue. If you have an idea for an article, write one of the editors, outlining your subject. By writing in advance you may receive suggestions for rounding out your treatment.

Two old friends appear on the masthead. They are Assistant Editors George Jackson and William Halliday, both of whom have been contributors to the *Bulletin* for many years. We welcome them to the publishing side, and thank them for work already accomplished.

* * * * *

What will happen in speleology in 1957? A unified theory of limestone cave development, compatible with observations in many localities, is long overdue. Much of the evidence, both domestic and foreign, is at hand. Level control is evident in caves of the Potomac River valley and in Kentucky. Two speleologists working on a large integrated underground drainage network in Northwest Clare, Ireland, have concluded that deep phreatic solution is not responsible for the major enlargement of passages. Red colloidal clay, an ingredient of one hypothesis, appears to be lacking in caves where it was reported to exist as fill. 1957 is the year for someone to integrate the facts, and thereby launch a new hypothesis.—R.W.B.



Plan of Holloch Cave
in the Muota Valley, Switzerland

The Hell Hole in the Muota Valley

By ALFRED W. H. BÖGLI

SCIENTIFIC DIRECTOR, Swiss Alpine Club - Holloch Research Group

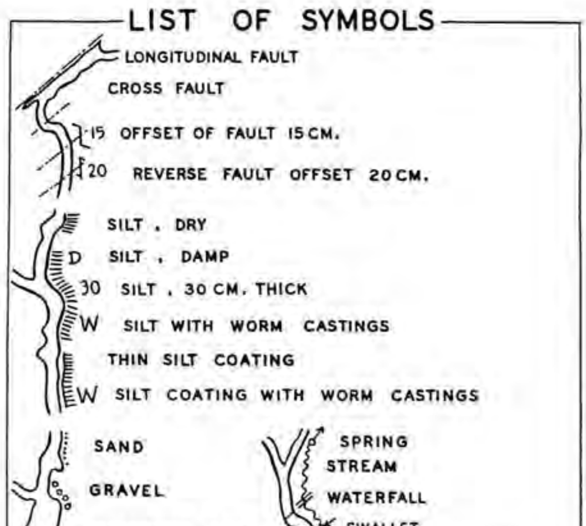
Here is the first authoritative report published in this country about a cave system whose surveyed length now exceeds that of any known cave. Its significance lies partly in the fact that it is the world's largest, but more rightfully, that it is a grand monument to the perseverance of speleologists. Working in a bitter cold 43° F. maze, for continuous periods up to 224 hours in length, the Swiss group has surveyed nearly 38 miles of passageways. Even more remarkable is the fact that the period for safe exploration is limited to the few weeks between December 15 and March 1; before or after those times explorers risk being trapped by high water. The account contains information of real value for those who attempt to study large cave networks.

INTRODUCTION

Hölloch (Hell Hole Cave), in Switzerland, was discovered at the back of a nearly inaccessible gorge in 1875 by Alois Ulrich of the Muota Valley. By 1906 three miles had been surveyed by different explorers and another mile more had been walked through. Then Hölloch Cave was forgotten.

In 1945 the writer placed it on the agenda of a geomorphic study of the Muota Valley and started investigations of the surface above Hölloch; the cavern itself was to be explored later. In 1948 a group of speleologists under André Grobert visited the cave and in 1949 members of the SAC (Swiss Alpine Club) under Hugo Nünlist started independent explorations. The writer joined this group first as scientific advisor, later becoming their scientific leader. The survey technique was improved eliminating sources of error and a geomorphic, geologic, and hydrologic inventory was introduced using a keyed table (Figure 2).

By the end of 1953, 23 miles were surveyed, a year later 29 miles, and by March 1955, 34 miles. By March 1, 1956 the survey had been extended to 37.8 miles. This result is mostly due to teamwork of the Swiss Alpine Club – Hölloch Research Group under the leadership of Bögli and Nünlist. Members of the Swiss Speleological Society (SSS) have achieved good progress in the area of the *Himmelsgang* (Heaven Passage) and have explored about four miles.



The physical inventory form, developed by the author, is included in the map with appropriate symbols for faults, fills, formations, and water.

LOCATION AND GEOLOGY OF HÖLLOCH CAVE

Hölloch Cave is situated at the foot of a great limestone plateau in the heart of Switzerland. The nearby village of Muotatal is reached by traveling 30 miles from Lucerne via Schwyz. Geologically dominant are the Alpine nappes or thrust sheets which were carried far from the south over the crystalline rocks of the Aar Massif. The surface consists of karstic limestone, drained entirely underground and covered with large karrenfields, numerous shafts, pits, sinkholes, and karst valleys. Of the 12 square miles of the valley, eight square miles drain toward Hölloch Cave, and about two billion cubic feet of water drain away each year. The water flows through the cave and reappears at an altitude of 2,095 feet in the Schleichend Springs at the foot of a vertical wall of rock. At flood about 1,000 gallons per second emerge here; at the same time 2,000 gallons per second more flow from the entrance of the cave. The altitude of the surface ranges from 2,095 feet at the springs to 7,590 feet at Silber Peak.

Hölloch Cave lies in the Axen Nappe which is composed here predominately of lower Cretaceous strata. The nappe dips to the north in a series of relatively gentle folds and the rocks are steeply folded downward at the frontal region of the nappe. Numerous faults, some with considerable displacement, cross the region. The Axen Nappe is divided into several thinner sheets by thrust faults: on top is the Thoralp sub-nappe, below are the upper and lower Silbern sub-nappes, the Bachistock sub-nappe, and at the bottom the Axen Nappe in the strict sense.

In the environment of Hölloch Cave, layers of Hauterivian siliceous limestone and Seewer limestone form the sub-nappes. Hölloch Cave is confined to the Schratten limestone (Urgon) which is repeated in each sub-nappe. The limestone has a thickness of about 500 feet, a purity of 95-99 per cent $CaCO_3$, and corresponds in age approximately with the Potomac series of the Atlantic coastal plain of the United States.

In the frontal region the sub-nappes are so reduced in thickness that the layers of Schratten limestone touch each other. In this region Hölloch Cave crosses the upper sub-nappes and extends into the lower Silbern sub-nappe. Therefore in both upper sub-nappes between impermeable rocks there lie thick beds of Schratten limestone. From the level of Hölloch Cave innumerable faults extend upward, but thus far no one has succeeded in ascending through the immense vertical shafts 800 feet into this possible level of the cave. The surface is between 1,000 and 3,000 feet above the cave which is itself between 2,115 and 3,410 feet above sea level.

In spite of the great cover of rock, no increase in temperature of the bedrock has been measured. The temperature is between 5° and 6° C. in all parts of the cave. Neither could any facts be determined about the compression of the rocks by the weight of overlying material as some Austrian speleologists assume for such depths.

Access to the Ravine Passage in the most remote part of the cave. Below men is pit 10 feet deep.

THE EXPLORATION OF HÖLLOCH CAVE

The various periods of exploration of Hölloch Cave are divided chronologically as follows:

1. 1875-1900: Alois Ulrich discovers the cave and advances with friends probably one mile in the main passage.
2. 1900-1904: Speleologists from Switzerland work in Hölloch Cave. Paul Egli, the first scientist, examines it more carefully and surveys three miles.
3. 1904-1906: Famous foreign speleologists visit the Hölloch. Dr. Rahir of Bruselles examines the fauna in particular.
4. 1906-1945: Hölloch Cave is forgotten.
5. 1945: Alfred W. H. Bögli examines the surface systematically during the following years.
6. 1948: André H. Grobet starts a re-survey in Hölloch Cave. He works with a group of the SSS in the region of the *Himmelsgang* where he explores approximately 4 miles (until 1956).
7. 1949: Hugo Nünlist visits the Hölloch Cave with SAC members; finds numerous unknown branches and determines that the map of Dr. Egli (1904) was inaccurate. 1950: Prof. Bögli joined this group as scientific advisor and took over the scientific leadership in 1951.
8. 1952: The SAC Group becomes the SAC Hölloch Research Group (ASACH) and work continues under Bögli and Nünlist. They survey and explore 31 new miles and resurvey 3 miles previously explored.

The Hölloch Cave is accessible only at certain times of the year. From the beginning of the thaw, which starts between the middle of March or the middle of April and continues until July, the advance to the back part of the cavern is closed by a syphon at the cave mouth extending 5,900 feet inward. From August to November every trip into the back parts of the cave is extremely dangerous because of the risk of high flood. Great torrents of thunderstorm runoff water reach the front part of the cave in six hours while smaller floods take sixteen hours. Many miles of passages are totally inundated in a very short time. By the middle of December the danger has largely passed; however, in the middle of December, 1955, a work group of the ASACH was trapped for twelve hours. Normally visits to the back regions are dangerous because of water except for a short period from December 15 to March 1. The warm weather at the end of December 1955, however, brought a new high flood and endangered the winter expedition to such an extent that progress was stopped on December 31, after water had trapped the explorers for four days.

In March and the beginning of April conditions are usually safe; however, a single flood could block the explorers and by that time the four months of high flood might have started. The exploring time, therefore, is very short and comes at a time when members have to earn their living at their jobs. The ASACH has no sources of financial help; thus, the members have to pay their own way unless the two leaders contribute to their expenses. For this reason expeditions of only 10 days at the utmost can be carried out, and only after December 26. Each expedition is therefore assigned an enormous amount of work but achieves results which might be accomplished by a normal, more leisulely, expedition in 20 days.

EQUIPMENT AND OPERATION OF THE EXPEDITIONS

The ASACH possesses only a small stock of equipment: two ropes, one rope ladder of 100 feet, a rubber life raft, a fixed ladder, and measuring tapes. Everything else is provided by the members themselves, such as the personal equipment: lamps, sleeping bags, rubber mattresses, cooking gear and overalls. Single individuals have contributed: 1,300 feet more of rope, rope ladders, four boats, altimeters, carbide, steel measuring tapes, thermometers, hygrometers, cameras, flashlights, and so on.

Communication with the outside world by radio is out of the question because of the great depth under the surface; so are telephones because six miles of wire would not only be very expensive but also the installation would take too much time. Warnings would probably not reach members in time as the return trip is very tiresome. Connection with the outside world is maintained by runners who carry weather reports, forecasts for the next few days, and mail. Runner service begins five days after the start of the large winter expedition.

Each expedition requires great preparation since it is not easy to collect the equipment. First, a preliminary trip is made with an average of 12 men who, with boats, rope ladders, and ropes make the route to Camp II traversable. On a second trip (on which 30 persons went the last time) all the equipment is carried to the back of the cave, including carbide, ropes, rope ladders, boats, camp equipment and rations.

Since 1951 every December 26 sees the 12 men of the main expedition start with their personal equipment on a seven-hour trip to Camp II. There we sleep. The expedition does not use tents although the temperature is only 5-6° C. and the humidity between 95 and 99%. The two leaders appoint four groups of three and delegate the work to the autonomous groups. Side routes are surveyed and the leaders are trained to take inventory of the geologic and morphologic features, wind directions and velocities, and to note all things of interest. All routes entered are surveyed immediately. Advances without surveying are unknown to the ASACH. This means occasionally up to 18 hours of strenuous work during one day. After four such days, a day of rest follows and then the combined advance starts again. This time the uninterrupted advance and return takes up to 40 hours including rests for eating. The carrying along of camp equipment would be too tiring and take too much time. After this "forced march" people sleep in Camp II for as much as 18 hours. Depending on circumstances, all or part of the group then leaves the cave or a new project is started.

The meals are normal and as appetizing as possible because of the great fatigue. After long marches the members still have to cook meals: all members of the expedition take part in the work without benefit of housekeeping support, such as cooks. During the marches chocolate, dried fruit, fresh fruit, bacon and Rye Crisp have proved useful. Res Hanggi and the writer have lived well from a mixture of honey and nuts combined with vitamin-chocolate and Rye Crisp, several times during the longer advances.

The longest stay was endured by four men of the ASACH, including the writer, when they explored for 224 hours under the surface. Large expeditions with 12 men once stayed 216 hours; twice 202 hours; and very often over 100 hours.

Turning back from the Pagoda Passage after a 28 hour march. Picture taken near the end of the cave. Note use of hand held carbide lamps.

Advance in the Main Passage in Holloch Cave. Explorers carry bulging knapsacks containing food and equipment for their long stay underground.

RESULTS OF THE EXPLORATION

Hölloch Cave is the longest integrated cave known in the world to date. Of the original length only the first 2,000 feet are missing because at the original entrance the passage was so near the surface that the ceiling collapsed, creating a gorge containing a natural bridge. So far only one accessible exit is known; no connection from above has been found as Hölloch Cave lies too far under the surface of the earth. The horizontal distance between the numerous surface sinks above the cave and the extremities of surveyed passages is up to two and one-half miles and it is the hope of the ASACH to push forward into this virgin area.

Hölloch Cave is comprised of both a horizontal and a vertical part. The surveyed portion of the cave is horizontal and it underlies a vertical cave, seen from the inside as high chimneys. Unfortunately, they cannot be explored within the present means of the ASACH.

A 100 x 200 inch map on a scale of 1:1000 of the whole surveyed Hölloch Cave was prepared by the writer based on surveys of the ASACH and the reports of the SSS (Figure 5.)

These routes are well studied geomorphically, hydrologically and meterologically. The biological study is not so important because the ice formation during the glacial period almost destroyed animal life. The research activity of the SSS is devoted to problems of physical detail while the ASACH, especially the writer, examines in detail morphologic and chemical questions.

The passages are controlled first by bedding planes and second by joints. The resulting cross-sections have been the subject of extensive study. The uppermost passages which we could not reach must be at least 6,500 feet in altitude; the lowest passages extend to 2,060 feet above sea level. The water continues its work in lower regions and therefore has not had time to make large passage cross-sections. The SAC passage has, however, a cross section 13 feet high and 30 feet wide for over half a mile. The passage shapes nearly always appear very young and have the basic form of an elipse, often for long distances.

The great differences in altitude in the cave causes strong air currents, apparently dependent on outside temperature. In winter, at low temperatures, a strong wind blows into the mountain; in summer, at high temperatures an ice-cold draft blows out of the cave.

Of special interest is the behavior of the water in summer and winter. On three occasions groups were closed in, sometimes only for a few hours, sometimes for several days during which time they observed the behavior of the high water. This knowledge greatly increased the security of subsequent expeditions.

The deposits on the passages of the cave are also of great interest. There is a large amount of silty soil of every kind, loose as well as solid sand and gravel, and breakdown in the cave. Stalactites are present in relatively small numbers due to the great depth, but found in beautiful colors and in nearly transparent forms. There are calcite crystals and other speleothems in innumerable forms. Gypsum crystals as large as a fist are imbedded in the silty soil. Experiments on the origin and formation of varnish-like layers of hydrous iron oxide are in progress.

The Grand Pagoda in the Pagoda Passage. Formations are scarce, but brilliantly colored.

The human being and his behavior in the cave is a little explored field of research. Psychological behavior shows all degrees from a normal type to claustrophobia on one hand and increased vitality on the other. From a health point of view caves prove very good for victims of allergies and asthma; infections are rare and colds and similar sicknesses are lost surprisingly fast.

Dripstone formation called Medusa in the Medusa Dome. Some stalactites within the cave have vivid orange and red hues, resembling carrots.

OUTLOOK

The length of unexplored passages cannot be estimated but it must be many times the length already surveyed. For geomorphic and tectonic reasons one must assume that the exploration has not yet reached the main region of the Silbern sub-nappe and that the surveyed passages approach to within only one mile of this region at the nearest point. From the central region water flows in great streams under the surface towards the known routes. The ASACH is about to advance here on a route 20 feet wide and 25 feet high. Although it is closed by several giant blocks, water runs between them and the wind whistles sharply through the gaps. A by-pass will be tried.

Besides the many explored passages, about 40 small side routes have remained unexplored and will also be attacked in the winter 1956-57. Above the Hölloch Cave are situated two more thrust sheets, the Upper Silbern sub-nappe. The upper Silbern sub-nappe contains a layer of Schratten limestone 500 feet thick which much resembles the layers in which the accessible portions of Hölloch Cave are developed. It is connected by numerous chimneys with the Hölloch Cave above it. It is very possible that a network of passages similar to those of Hölloch exists in the upper region, evidenced by the retardation and retention of rain water.

Two explorers safety a third on a pit traverse deep within Holloch Cave in Switzerland.

Occasionally fragments of stalactite are found in Hölloch Cave whose origin can only be explained by the existence of at least one upper level. The most important task of the ASACH now is to secure the necessary equipment to explore the chimneys from the bottom. In the next season which starts in December 1956 further explorations will be carried out.

New Caving Equipment and Techniques

By DANIEL BLOXSOM, JR.

For more than a year the Cumberland Grotto has been using unusual boat and rope climbing techniques unique to caving and mountaineering. Ingenuity is a requisite in the serious spelunker. Without it, men could only stand in awe at the brink of unplumbed pits, or look longingly at an underground river stretching into darkness. The author includes clear descriptions of the methods for tying prusik knots and bowlines, and discusses a system for ascending and descending a standing rope.

WATER PASSAGE EQUIPMENT

The usual equipment used by caving enthusiasts to pass water barriers is a military rubber raft, of one or two man capacity, blown up by lung power or a compressed gas tank. For heavier duty we have developed a rubber boat called the Goofah. The Goofah is named after a prehistoric boat made from the inflated skins of animals. It was first built about 5000 years ago in the Tigris-Euphrates river valley. The construction is seen in Figure 1. The uses are seen in Figure 2.

This boat will carry four men dry and as many as can get around the edge, wet. The prime reason for the design and construction of this boat was to get additional carrying capacity than was afforded by the usual military rubber raft. There are advantages and disadvantages as compared with the military rubber raft.

ADVANTAGES

(1) lower cost: $7.50 as compared with $25 for the salvage military rubber raft.

(2) heavier construction.

(3) two separate chambers.

(4) you ride *above* the cold water with 12 inches of air insulation.

(5) four man capacity instead of one or two men.

DISADVANTAGES

(1) greater weight – many times that of military one man boat.

(2) greater volume – hard to negotiate in narrow passages.

(3) cannot be blown up by lung power – tractor pump or a bottle of compressed gas must be used.

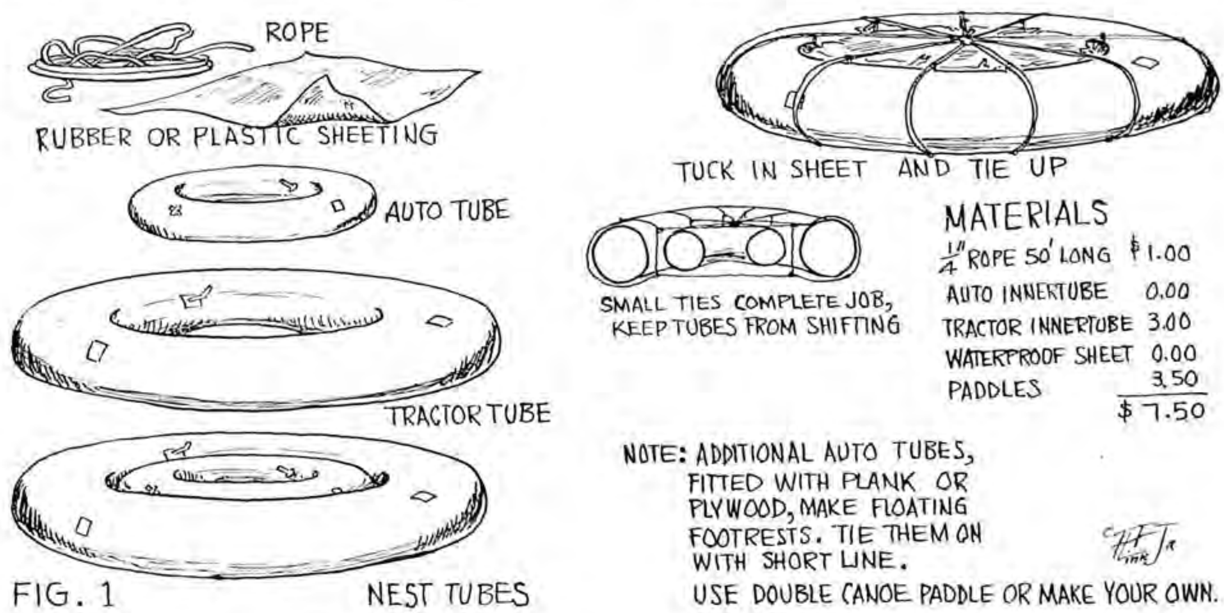


FIG. 1

Figure 2. Goofah can be paddled by two or more. Auto innertube outriggers stabilize craft. Beware when wearing spiked boots. Use double paddles.

This boat was first described in the September 1955 issue of the *Troglodyte,* published by the Cumberland Grotto. A description also appeared in the July 1956 *NSS News.*

This boat has been tested in Shipman's Creek Cave and in Carroll Creek Cave (Middle Tennessee). These trials indicated that short strong paddle strokes are necessary as a long stroke would result in turning the Goofah around.

As an example of the portability of the Goofah, it was carried into the Lost River Room of the Big Room Cave through Tombstone Pass, one of the most difficult known cave passages in Middle Tennessee.

The boat has also been tested in Snail Shell Cave which has an entrance through 2000 feet of deep water. The outer tube was punctured by dropping it onto breakdown deep within the cave; however, it still supported one of the party, unaided, on the small inner tube.

ROPE TECHNIQUES USED IN PIT EXPLORATION

Many times cave explorers have to descend and ascend pits and slopes. Usually this is the most difficult part of the cave explorer's job. The reason for this difficulty is traced to, (a) improper techniques, and (b) lack of training and experience. Those of us who climb mountains know that men have the physical capacity to climb easily many thousands of feet in a day. Some of us have seen the same man who has collapsed at the effort required to climb a 200 foot pit, shoulder the rope after being pulled out and climb a greater distance up the mountain in less than half the time he required to get out of the pit.

Some people try to climb ropes with their arms. Obviously we can exhaust ourselves quickly by this technique. By using the techniques shown in the succeeding Figures 3-7, some of us have gone as much as 800 feet without stopping and without getting tired. By using these prusik knots fitted to ourselves individually, we can use our leg muscles for 80% of the work and our arms for 20%. If one muscle aches with fatigue from being used exclusively to get out of a pit, we know our technique needs improvement. Resting is most important; every muscle should be relaxed and no muscle should be so squeezed that its circulation is cut off.

There is the question of fright to be considered. Fear will cramp a man's whole system; power dissipation of muscle against muscle is enormous. We have seen beads of perspiration break out on the face of a man at the top of a pit, collect and fall off in trickles. We have seen as much as half an inch of movement in his quivering hands. Man cannot be efficient in such a state.

Psychologists have a technical term to denote collapse of all normal behaviour patterns under extreme stress. This is called *panic,* and is characterized by shock, perspiration and over-controlling of muscles. Panic ends in collapse due to exhaustion. The symptoms are due to subconscious reactions against (a) falling, (b) dark. We are not afraid of falling or dark, but our subconscious is, and lets us know about it by

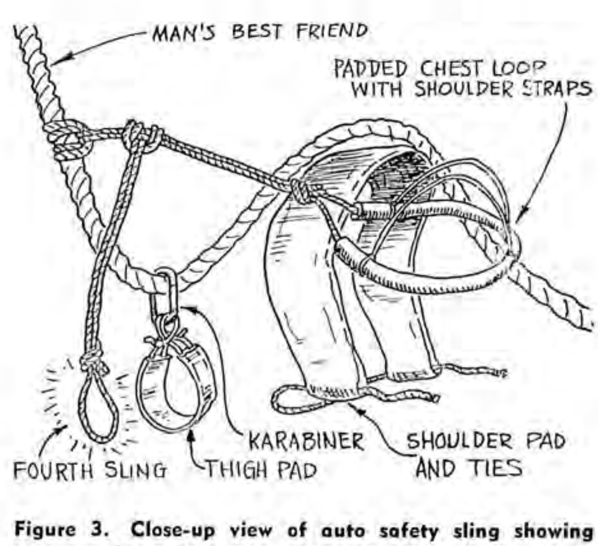


Figure 3. Close-up view of auto safety sling showing padding for chest loop, shoulder, thigh.

FIG. 4 MAKING PRUSSIC KNOT SLINGS

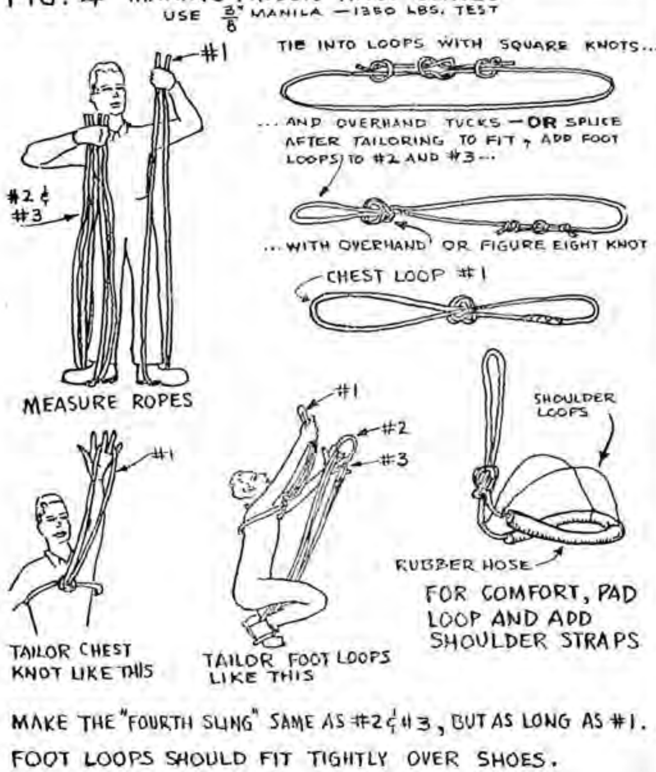


FIG. 5 TYING PRUSSIC KNOTS

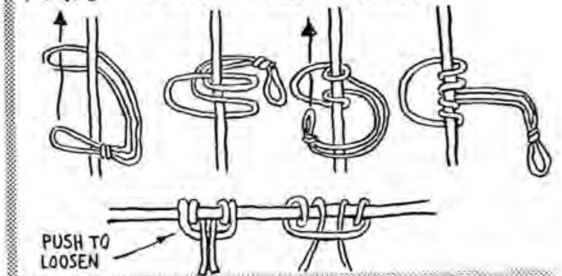


FIG. 6 CLIMBING ON PRUSSIC KNOTS

FIG. 18 TYING THE BOWLINE

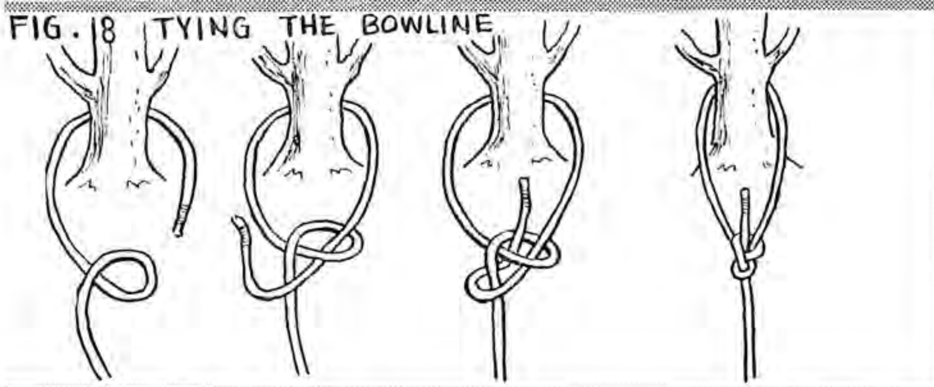
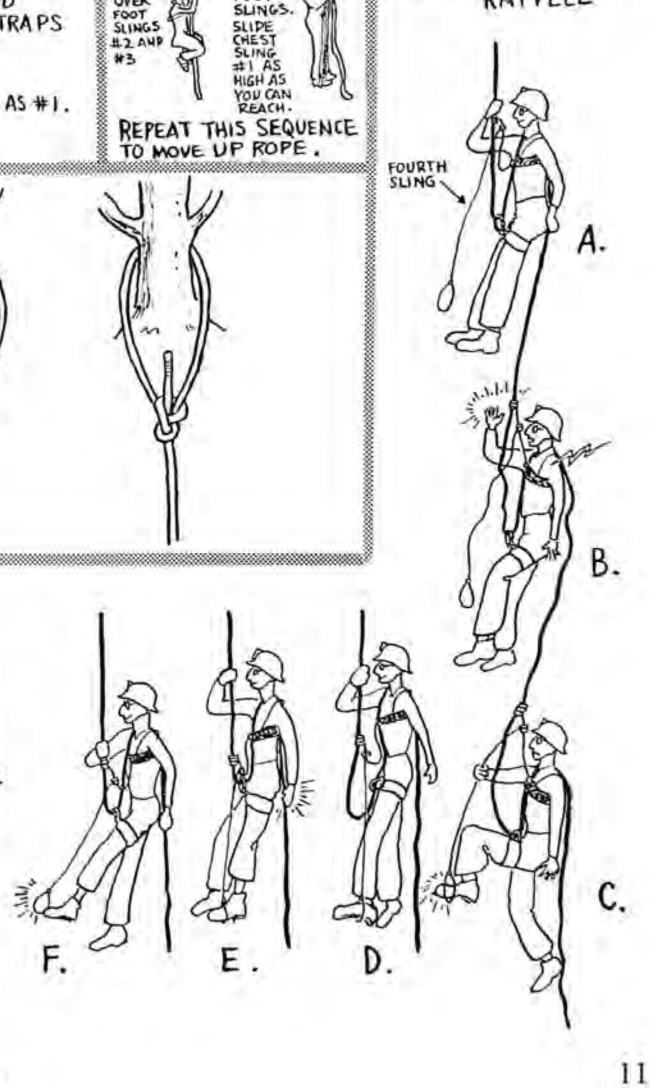


FIG. 7 AUTO-SAFETY RAPPELL



THE USE OF SLING IN FIG. 3 IS SHOWN AT RIGHT. AT A, MAN IS RAPPELLING NORMALLY. AT B HE STOPS, WITH OR WITHOUT SHOCK. AT C HE STEPS INTO THE FOURTH SLING. AT D HE STANDS UP IN THE SLING. AT E, HE RECOVERS THE RAPPELL. AT F, HE HOLDS THE RAPPELL WHILE KICKING OFF ALL WEIGHT FROM THE AUTO-SAFETY. BY TAKING ALL WEIGHT ON THE RAPPELL HE IS IN POSITION A FOR NORMAL DESCENT.

BY ALTERNATING CDE, CDE, HE MOVES UP THE ROPE!

DON'T LET STEP B HAPPEN! USE POSITION D TO REST OR LOOK AROUND.

YOU CAN LEAVE ANOTHER FOURTH SLING AT THE TOP OF PITCHES TO AID CLIMBING PAST LEDGES, PROJECTIONS, ETC.

THE Jr

jamming the subconscious motor circuits. These subconscious behaviour patterns have been conditioned in us when we were young and come out only in moments of such stress. Our purpose here is to make conscious the subconscious, however, and by so doing obtain control over it to a small extent. There are at least two ways of doing this: (a) the military way – condition ourselves to go through the motions mechanically without thinking, then if the subconscious paralyzes us in either war or pit climbing, conditioned reflex action will carry us through; (b) familiarity with the whole pattern – the subconscious slowly gets conditioned to accept pit climbing as the normal state of affairs.

Almost all of the above difficulties, psychic in nature, can be mastered with a little practice. Rig a rope in a tree near your house in such a way that you have 30 or 40 feet of pitch. Go up and down several times every day for two months. The technique will become smooth, like the easy strokes of an expert swimmer. Fear will disappear, since you are conquering ignorance and apprehension. Rope climbing is like swimming in being one of the best all around body developing exercises.

The best and quickest way to descend a pit is with a rappel. With the body or "hot seat" rappel, the rappeller is committed to go to the bottom of the pit no matter how long the rope is. This proves embarrassing when the rope is shorter than the pit. Doubts of this sort lead to fear and apprehension, and in some cases, a bad fall. By using the techniques recommended in this article we are not committed to going any farther into the pit than we want to. At any time we can stop, look around, and by putting on our prusik foot loops, come out of the pit from any point along the rope. The rope can be attached to a firm support by means of the bowline, as seen in Figure 8.

We do not use or recommend a second rope safety, although there are many advocates of this method. We have found that the second rope often fouls the rappel rope. Alternatively, the chest prusik knot provides a good safety. If the rappeller is suddenly incapacitated, the chest safety prusik knot will lock within about six inches of free fall (130 pound rappeller, 3/8-inch manilla on 5/8-inch manila), and he may be pulled out by means of the main rope. **The manila prusik knots should be replaced twice a year since the wear against the main rope is heavy.**

Take care before you go down to see that the rope does not rest against sharp ledges that might cut. On pitches over 50 feet you will sometimes spin. To prevent this, move rapidly up the rope 20 or 30 feet. The easiest way to rest is to sit on one heel with the other two prusik loops loose.

Since so much depends on the main rope, it should be of either 5/8-inch or 1/2-inch high quality *manila*. This gives a safety factor of over 20 for a 130 pound man. In addition to this the main rope should be treated with care, stored in a dry place, and tested frequently. The easiest test method is to inspect it first for obvious defects, then tie it to a tree and have ten people pull *steadily* on it.

One last problem needs to be covered, that of rope friction on the rappelling pads. When the weight of the rope is on the order of 30 pounds or more, rappelling is difficult due to this friction. This permits easy rappelling for a maximum of about 200 feet with 5/8-inch manila and about 400 feet with 1/2-inch manila. We use two ropes, one 5/8-inch, 130 feet long and the other 1/2-inch, 400 feet long. Since the usual pitch is around 100 feet, the 5/8-inch rope gets the greater wear, which it can take. For deeper pits, the 1/2-inch manila is used. Since such pits are uncommon, the 1/2-inch manila gets little use.

This discussion is restricted to rope techniques that any caver can learn. For special applications using nylon rope it should be possible to rig pitches many thousands of feet in depth with greater safety than is now available with winches.

The Leather Man and His Caves

By LeROY W. FOOTE

For nearly a third of a century after the Civil War, residents of Connecticut and New York knew the Leather Man, an itinerant who made his home in caves. Dressed in his special kind of home-made armor, he traveled a circuit of 365 miles in exactly 34 days. Why? Nobody knows. But in spite of his peculiarities he found a place in the hearts of those who fed him, immunity from a tramp law, and a large number of obscure caves in New England which now recall old memories.

The story of the Leather Man in the Society's recent publication, *Celebrated American Caves*[1], tells of a 365 mile chain of caves once occupied by this strange itinerant that encompasses one-half of western Connecticut and a portion of Westchester County, New York. They remain today a silent reminder of a hardy character who can be called Connecticut's pioneer cave man.

The Leather Man supposedly came from Lyons, France and under most unusual circumstances. The son of a wood carver, he fell in love with the daughter of a leather merchant. The difference in social level precluded a match until an agreement was reached whereby the young man was given employment in the leather firm and promised partnership and marriage if he made good. Failure of the firm, charged to the inexperienced boy, wrecked his life. His disappearance matched the subsequent arrival of the Leather Man in America and presented a riddle that baffles explanation.

First notice of the Leather Man came when a man dressed in a patched leather suit appeared at a farmhouse in Harwinton, Connecticut and indicated by signs he wanted food. His reappearance at 34-day intervals started an investigation that has lasted almost 100 years. Even today light is being shed on the Leather Man's story by people who remembered him and by the discovery of his artifacts and pictures.

Chauncey Hotchkiss of Forestville could not overcome his curiosity about the Leather Man's regular reappearances. He drove his carriage over most of the route by following the itinerant, talked with people in the towns through which he traveled and on returning, published the result of his findings.

The Leather Man had regular stopping places where he obtained meals and at night holed up in a cave. He made his trips winter and summer regardless of weather and his arrival at any specified place varied only a few minutes from that of his previous visit.

The Hartford *Globe* on July 12, 1885 published a three-year time table of the Leather Man's arrival at the Forrestville post office and stated:

> For twenty-seven years past he has come and gone over the same route, visiting each place with a regularity and preciseness which would lead one to suppose that he was travelling on an exact schedule of time laid out by him, and from which he must never vary.
>
> Very little is known about him. He is called the "Old Leather Man," a name he seems to accept as all that is necessary by which to designate him, and one evidently very appropriate, because his only visible raiment is of leather.
>
> The Old Leather Man has been an object of curiosity as he passed on his regular trips at intervals of thirty-four days for the past twenty-seven years, and only fragments of his history have been written, but Chauncey L. Hotchkiss of Forestville has for some years been corresponding with persons about the old man's mysterious pilgrimages till he has an account of nearly all his stopping places and many interesting facts concerning his singular life and habits.

Many attempts were made to engage him in conversation to learn his identity but such efforts

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1. Sloane, Howard N. and Mohr, Charles E., eds. *Celebrated American Caves*, Rutgers University Press, New Brunswick, N. J., 1955.

were of no avail. For want of a better designation he was called the "Leather Man" and by others, "Old Leathery." Some thought the leather suit held the secret of his mysterious actions and he felt sensitive about the subject. Others said he clothed himself with the cause of his ruin and was serving penance for some misdeed. Whatever the reason, the leather protected him from inclement weather as well as or better than any material he could have chosen.

The Leather Man's disposition and bearing indicated a man of quiet nature, preferring solitude. If he harbored any wish to be unobtrusive the peculiar leather outfit was a poor choice for it brought him under constant scrutiny. He wore an ill-fitting coat of huge proportions, made by himself of large leather patches held together by wide leather thongs. It hung to his knees. Trousers of the same material and design reached from his chest and fitted into a pair of buckskins. This footwear weighed ten pounds, had thick wooden soles that turned up at the toes. A flat-topped cap of patches had a wide vizor which flapped loosely above shaggy brows. An immense leather bag carrying all his belongings swung from his shoulder, necessitating a stout wooden cane he used for support. Thus arrayed he struck awe to the hearts of all who saw him until they learned to accept him for what he was: a harmless itinerant.

Perhaps the most concrete evidence of the Leather Man today is the string of caves or rock shelters named for him and presumably used by him. Otherwise unnoticed geological upheavals and disfigurements, they ring with a fascinating folklore still fresh in the memory of many.

Hardly a town within the area cannot boast of at least one Leather Man cave. Woodbury, Connecticut has several. So numerous are they in some sections one is bewildered by the pattern of crossing trails. Some report the Leather Man stayed several nights in his so-called "preferred" shelters. This is contradicted by well-authenticated statements that his stops were for one night only. To maintain his established routine of covering the circuit in 34 days there was no alternative but to perform constant foot work.

Proper selection of a suitable cave for overnight lodging was a prerequisite for comfort. Many factors were involved. First of all it must

be along his established route. It must be dry and its location must be away from habitations yet near enough for solicitation of food. Invariably it provided an overhang of rock, faced east, south or west and was near a brook. Of necessity he must be secretive but his efforts were useless. Every cave was found while he inhabited it; some were disturbed and many a location was used as a rendezvous for mischievous boys and as a goal for hikers.

The Black Rock Cave in Watertown is the most impressive and perhaps the best known of his shelters. It is located now within the borders of a state park, and has a wide entrance at the base of a cliff which rises 70 feet perpendicularly. Piles of ashes before the entrance are evidence of visitations by campers who, no doubt, recounted tales of the old Leather Man who preceded them.

Encroachments of civilization and deforestation prompted him to desert certain shelters and to establish new ones. In South Norwalk and Plymouth, reservoir construction ousted him from his secluded retreats. The extension of highways in Westchester County forced him to vacate a cave occupied for decades.

Tories' Den in Burlington, that gave refuge to a band of loyalists in Revolutionary days, was chosen as his northernmost stop. A caprice of nature felled a portion of ledge onto sufficiently high supporting rocks to provide an acceptable room. The location is a mile from the nearest highway. How the Leather Man found it, the only one of its kind in that area, is not known.

Mr. Elbert Barnes of Woodbury kept close watch of the Dug Way Cave when he was a boy. He said the Leather Man once moved his lodging about 75 feet but returned to the previous cave when northeast rains caused him to vacate.

Today it is hard to visualize the cave surroundings as they must have appeared in Leather Man days because trees have grown up. While the caves were occupied the hillsides were being stripped of timber as fuel for household use and for casting shop furnaces. The quenchless demands for firewood exposed numerous caves which today lie hidden in dense forest. In his efforts to find the Good Hill Cave in Woodbury the late Julius Cowles exclaimed, "How the trees have changed in forty years!" Most of the caves must have been in open areas, bright with sunshine, yet cool and refreshing in summer.

One cannot visit a Leather Man cave without seeking answers to the normal questions that arise concerning the unusual behavior of a cave-dwelling man. Why did he isolate himself? What comfort is there in a cave? Without doubt the Leather Man liked his cave-dwelling experience.

People were not inhospitable to him. Actually he had many invitations to sleep in barns, particularly on cold nights, but he refused such offers. Over a long period he had learned how to protect himself from the cold. His fire-making and shelter-improving had reached such perfection the worst New England winters held no fears for him; in his casual yet self-reliant way he secured the necessary warmth with a minimum of effort.

The cave at Jericho Rock was beneath a ledge having a six-foot overhang. He placed poles covered with a thatch of dried leaves against this shelf to make a shelter 15 feet long, 10 feet wide and seven feet high. The location was well protected from storms and the ground diverted the water in a way to make a comfortable lodging. He stored wood in the recesses of the cave, and he piled dry twigs and leaves on the stone hearth in the center of the structure ready to be lit when he made his next visit.

The Leather Man was once a familiar sight along the dusty back roads in the towns of southernern New York and Connecticut. He trudged along at a leisurely gait with his bag full of spare pieces of leather and all his worldly possessions. Friends waved to him but strangers stared in consternation at the queer apparition. Sometimes he chose to rest by the side of the road and once he was seen whittling a pair of new wooden soles with his improvised knife. On other occasions he would read from the old French prayer book which he carried in his pack.

Isolated farm folk looked forward to his coming. The regularity of his visits enabled them to set their clocks by his schedule which was as reliable as the change of seasons. Always approaching from the same direction and pausing for refreshment which was so generously tendered, he went on his solitary way without looking back. He invariably traveled in a clockwise direction.

The meals set out for him would melt the heart of any itinerant. One resident complained that his wife took better care of the Leather Man than of her husband. However unimportant it may seem to feed a common wayfarer, the feeding of the Leather Man carried a distinction that was the envy of many a housewife. It also conveyed a responsibility that was not held lightly for the social standing of his providers was at stake. Woe betide the reputation of the unfortunate housewife if it became public knowledge the Leather Man deserted her doorstep for another.

No itinerant in America could match his popularity. Anti-tramp laws were enacted in Connecticut but exemption was made, it is said, for the old Leather Man. Hundreds of thousands knew him. He was accepted by all as a member of each community he visited. Tucked away in many family albums will be found the photograph of this mysterious man sharing a place of honor as he shared a place in the hearts of his benefactors for so long.

Memory of the Leather Man still lingers in the minds of some of the older residents living in the communities where he made his famous travels. If inquiry is made about Leather Man caves in the lower reaches of the Taconic hills one will hear a strange tale of a cave-dwelling man in a leather suit that has become a choice part of our American folklore.

The St. Michael's Caves, Gibraltar

By T. R. SHAW

There are two St. Michael's Caves in Gibraltar; they lie so close together as to constitute one system, but there is no known connection between the two. One, now called Old St. Michael's Cave, has been known for nearly two thousand years; the other was discovered only in 1942 when it was broken into by military tunnelling.

Many of the travellers who spend a few hours in Gibraltar on their way to the east have seen the apes that roam wild on the upper parts of the Rock. They are the only monkeys to be found in Europe, and closely resemble the Barbary Apes of North Africa. A colorful legend relates that the apes arrived by way of a natural tunnel running underneath the Straits of Gibraltar, and that they used to carry their dead back by the same route. The mouth of this tunnel could be seen by anyone nearly 1000 feet up the Rock, where for many years the uninviting blackness of Old St. Michael's Cave kept people in sufficient awe to prevent their disputing the story. It was popularly said that the monkeys were particularly numerous just round the cave mouth, so what further proof was required?

How and when this legend grew up is not known, but it is still repeated, if somewhat skeptically. To a great extent the story has been the cause of the interest taken in the cave and the many attempts to explore it at a time when caves elsewhere were either ignored or avoided; certainly it is responsible very largely for some of the later tales told of it.

Sir Walter Scott's diary for the year 1831 records the tradition "that an adventurous governor, who puzzled his way to Ceuta and back again, left his gold watch as a prize to him who had the courage to seek it."

Still believed today are stories of previous explorers lost and presumed killed in the cave, but whose bodies have never been discovered. It is recorded that a Colonel Mitchell and his friend Brett lost their lives there some time before 1840. Garrison records appear to prove that they were in fact never seen again; but no bones have been found, and there have been no signs of recent rock falls which could have buried them. Perhaps the two officers wished to leave the Rock, and deliberately led people to believe that they were killed in the cave, so as to avoid pursuit.

Attractive as the legends are, they must be left for the moment, and the more factual history of the cave recorded. It is often difficult to separate the two, for travellers who describe the cave sometimes repeat quite fictitious tales which have been related to them.

The earliest reference to the cave is given by Pomponius Mela, a geographer who, about the year 45 A.D., wrote as follows:

> They are called the Pillers of *Hercules,* and both of them (but Calpe more, and in manner whollie) beare foreward into the Sea. The same being wonderfull hollowe on that part that is toward the Sunne setting, openeth almost his midde side, where into there shutteth a Way, which is almost altogether passageable, as farre as it goeth, and beyond it is a Cave.

The translation is Golding's of 1585.

There are a great many descriptions in the travel literature of the 18th and 19th centuries, many of them very picturesque. It is worth quoting one of these at length, as much to enjoy the style of nearly two centuries ago as for any real information it gives on the cave. In 1771 Lt.-Col. Thomas James published his two-volume history of the Straits of Gibraltar, in which the following account occurs:

> When you descend the slope, the cave widens every way, and the light of torches discovers the mouths of several smaller ones. After you arrive at the foot of the slope, still continue forward due east, by the assistance of your lights to the end of the large cave, which

is two hundred feet in a straight line from the entrance, including the slope, and the width ninety-five. There are many pillars of two feet, and two and a half in diameter, formed by the perpetual droppings of water, that petrified in falling and rising. Several of these pillars are of thirty, forty, and fifty feet in height: and on the top of the cave, between the pillars, arches are formed, so that the whole resembles the inside of a Gothic cathedral church: there are several small niches on the sides of the cave, and many small coved chapels; and from the center of the coves there are rays of petrifaction that shoot so as to cover the top of the above chapels, all of petrified water: and by the assistance of many lights, the spectators are very agreeably surprised with the natural beauties of the gloomy cavern. In most of the cells, the water (which is copiously impregnated with a sparry matter) perpetually drips from the irregular prominences of the roof, and forms an infinite multitude of stalactitae, or stoney icicles of various colours, some white, some grey, and some brown like sugar-candy, and of a vast variety of figures. These stalactitae, stoney icicles, or drop-stones, are all composed of divers coats of crusts, of very little lustre or transparency; and as some of them are no bigger than a goose's quill, others are immensely large, and combining together, form those large columns already mentioned, of the Gothic kind, that seem at present to support the roof of this large cave, as they will, in all likelihood, fill up its whole space in a term of years. The several graduations in the progress of these petrifications, may be easily discovered.

In some places you see small capitals descending from the roof, making their way downwards, while proportionable bases are rising underneath, as the spar concretes that distils through the rock, and drops from above. Towards the south end of this cave, there are passages between the pillars, that lead into other apartments; all are supported by pillars, some standing single, others three or four in a cluster; and the roofs of these apartments have the above petrified rays, which resemble the glories of some Roman Catholic altar. . . .

In the center of one of these chapels is a large deep pit, down which some Englishmen, having lost their way and slipt, were, by the assistance of ropes and men, (let down) happily saved, though much bruised. Down this abyss I descended with others, till at length I arrived at a small hole of eighteen inches diameter, when finding the air too gross, we though it more advisable not to descend any further, having sufficiently satisfied our curiosity: however, before we returned (notwithstanding our torches burned dim, and we fetched our breath much shorter than in the open air) we let down a rope with a weight at the end, through the above hole, fifty feet before it lodged; and whether that was the bottom of the pit, I cannot pretend to say. Our descent to this small hole was four hundred and eighty feet: as we let ourselves down, we found little apartments on either side to rest ourselves; likewise jettees, on which those that fell were stopt from falling lower; this long gallery, (if I may so call it) slopes in some places, on which you put your feet when you lower yourself by the rope, and then you hang

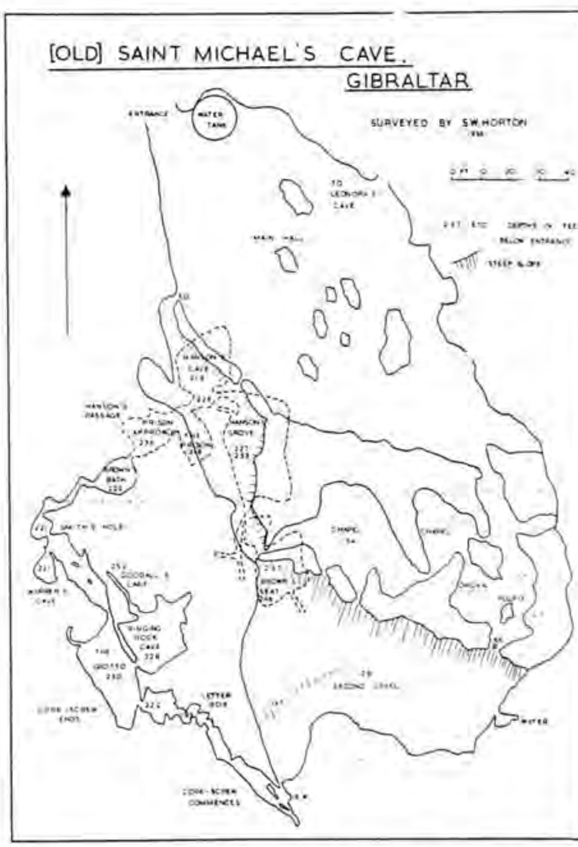

Figure 1. Plan map of Old St. Michael's Cave.

perpendicular for a hundred feet before you can touch the rocks, which are nothing but petrified water, as is likewise the bottom where we stood, which once was open, and, in time, the hole of eighteen inches will be entirely closed. This is a dome, and on the outside we stood. I was very much surprised, as was everyone at the entrance of the abyss, occasioned by the man who went first down, striking his heels against a sheet of petrified water, which hung hollow from the rock; the sound was like a deep-toned bell, but to those above, it was so confused that they knew not well what to make of it. I must observe, that on every jettee, likewise in every apartment or resting place, a man was placed with a torch; which being in a straight line with the entrance of the pit, formed a romantic and horrible scene.

Many other descriptions were published, such as Bigelow's of 1831:

> These spacious caverns are embellished with a profusion of ornaments, which nature, in one of her sportful moods, has most tastefully supplied. . . .

There is not space to quote from many more of these colorful accounts, but the following extract from Bartlett shows just how wild are the exaggerations repeated by the more credulous writers:

> It is the pathway, half beautiful, half horrible, into unfathomable depths below. . . . This chasm bears, moreover, somewhat of a sinister character, and it has been supposed that more than one unfortunate has met with foul play, being enticed within the cave by some assassin, and after being plundered, pushed into this horrible gulf, as a place that would tell no tales. Shortly before our visit, a gentleman who was desirous of exploring the place, caused himself to be lowered with ropes, bearing a light in his hand; but what was his horror, so soon as his foot came into contact with resistance, to find that he was treading upon some substance that yielded to the pressure, while at the same time the pale gleam of his torch fell upon the ghastly features of a murdered man!

To return from fable to fact: it is known that a century ago the more accessible chambers of the cave used to be illuminated on special occasions for the entertainment of members of the garrison and their families. Figure 2 is reproduced from a print published about 1846, and the artist's notes describe the ceremony thus:

> At the time appointed, generally about two or three o'clock in the day, the party assembles on the terrace at the mouth of the Cave; and when the ladies present have attired themselves in their shawls and cloaks, and every apprehension of damp and fear of danger has been allayed by their gallant partners (notice having been given that all the preparations in the interior are completed), they move slowly

(Reproduced by the courtesy of the British Museum)

Figure 2. Old St. Michael's Cave; 19th Century illuminations in the Main Chamber.

> down the tortuous path through the first Cave. While they are descending, a military band of music, stationed in the inner Cave, plays; its sweet tones, rendered doubly impressive by its

invisible position, reverberates through the vaulted cavern, and salutes the ear of the visitors as each enters. As they proceed, the Cave gets darker and darker, only a sufficient number of candles being placed in the way just to indicate the road. The party having groped their way through the first Cave, arrive at the inner; and when all are fairly settled in their respective places, a signal is given to the Artillerymen, when lo! as if by the wave of a magician's hand, from almost total darkness the Cave is instantly and brilliantly illuminated by coloured lights, alternately varied. The imagination, in its most vivid and fanciful dreams, could scarce portray a more appropriate temple for the enchantress.

What may be called the first real speleological exploration took place in 1840, when Captain Webber-Smith made a sketch plan and a factual report on all the passages he visited.

Not long after this, between the years 1857 and 1865, further detailed explorations were carried out. Surveys were made with considerable accuracy, and many hours of painstaking work with hammer and chisel resulted in some small extensions being entered. Lieutenant A. B. Brown in 1865 reached what is still the furthest point in the cave, some 1700 feet from the entrance. For the first time it was established that the true depth from the entrance to the bottom of the cave was only about 265 feet.

Despite the definite figure given by this survey, the depth began to 'grow' again in published accounts, and it is quoted as 620 feet in publications of 1879 and 1915.

Between 1936 and 1938, S. W. Horton spent much time in the cave, surveying it and attempting to reconcile the accounts of previous explorers. His figure of 253 feet for the extreme depth agrees quite closely with Brown's result of 70 years before. It is Horton's plan which is reproduced here from a copy in the Gibraltar Museum, and it is almost identical with a more detailed survey of the lower part of the cave made by the author in 1953. Horton's report was not published at the time, but it has since appeared in Cave Science (1955).

Only the briefest description of the cave itself will be given here. The survey contains most of the relevant information, and reference to more detailed sources is given in the bibliography. First, however, the position of the cave must be mentioned.

The main mass of the Rock of Gibraltar consists of a cave-bearing Jurassic limestone. The entrance to Old St. Michael's Cave lies on the western side at 937 feet, or about two-thirds of the way up the Rock. It is close to St. Michael's Hut, and can be reached via either of the gates leading to the military area of the Upper Rock.

The whole system, of Old and New St. Michael's Caves, is formed within a narrow band parallel to the bedding, dipping west between 50° and 70°. Generally, therefore, the passages are higher than they are broad, and there are several narrow rifts. The influence of the inclined bedding is obvious in many of the passage sections (see Figure 4).

Immediately inside the entrance the cave opens out into a vast chamber some 80 feet wide and 40 or 50 feet high. The floor slopes away gradually and at either side are massive columns of terraced stalagmite, all of them blackened by the soot from the early 'illuminations'. After 160 feet the cave narrows, and between the formations can be seen a steep descent — the 'precipice' of the early travellers. On the right this can be descended easily with a handline, or even without, and leads to the floor of the second large chamber. The roof height is of the order of 70 feet and, if the upper cave is lighted, the formations there can be seen high up in one wall.

Photo copyrighted by T. R. Shaw

Figure 3. Old St. Michael's Cave: Brown's Bath.

Below the second chamber the character of the cave changes altogether. It becomes very constricted and the way down to the lower sections lies through a boulder ruckle – the Corkscrew of Horton's plan. Nowhere is this very tight, but it lives up to its name, descending in twists and turns ledges and slopes, for a depth of 66 feet. At the bottom of it is the Grotto, where many early explorations stopped. The way on lies a little above floor level and directly opposite the entrance to the Grotto, through a series of three squeezes. The first is not tight, though a shallow channel in the floor contains enough water to be uncomfortable, but the second squeeze, Smith's Hole, is still troublesome for all but small people. The third is easier again and leads by a descending passage to Brown's Bath (see Figure 3). This is a shallow pool covering the entire floor of a small chamber, but there is fortunately a calcite ledge on the walls at water level which makes a dry traverse possible.

On the plan the passages are shown dotted from here on, for they lie vertically beneath part of the upper cave.

The Prison is a round chamber whose entrance is almost entirely barred by a grille of short

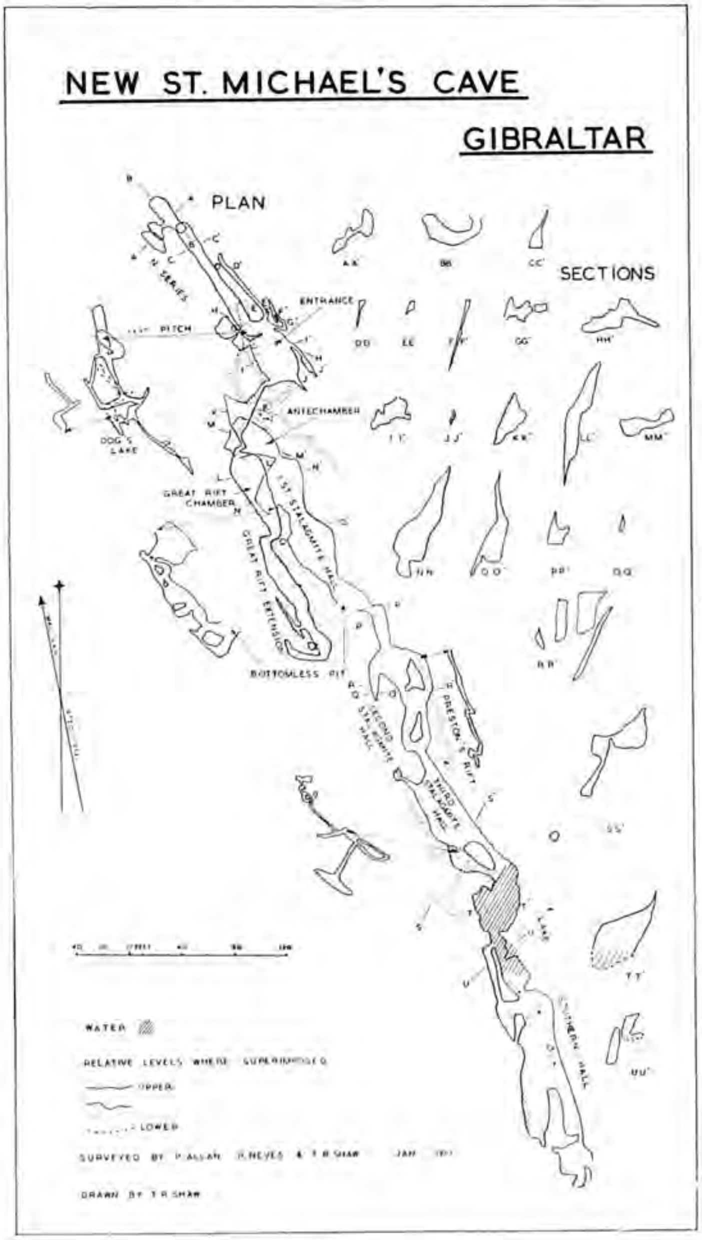

Figure 4.

stout stalagmite columns. The way on lies through an inconspicuous slot on the left hand side and down a slope into Hanson's Passage and Hanson's Grove. The final chamber is roughly rectangular with a single large boulder occupying much of the floor. A slender stalagmite column some 10 feet high joins this boulder to the roof, and the end of the cave is sealed by an irregular calcite flow.

Early in the last war it was decided to utilize the second large chamber, 126 feet below the entrance, for storage purposes. To provide easy access and give a free path for natural air circulation, an adit was driven inwards from the surface of the Rock.

On July 17th, this tunnel broke through into the roof of an unknown cavity, which was explored and found to be part of a new system now called New St. Michael's Cave. This point of penetration is not more than 30 feet from the old cave, and in one place their chambers are probably even closer, though the connection has not been surveyed.

The tunnel is now the most convenient entrance to the lower series of passages in the old cave. The present floor is of concrete laid over loads of rubble, and a structure of wooden beams and corrugated iron has been erected in the centre to protect the stores against rocks and stones falling from the original entrance chamber above. A slot in the southwest corner of the floor has been preserved as the way down to the Corkscrew and the lower passages. The opening in the concrete floor is secure, but the supporting rubble is held back only by heavy timbers. After thirteen years in the damp atmosphere of the cave, these timbers are rapidly becoming rotten, and if they are not soon renewed, the lower passages will become blocked, possibly injuring or trapping men below.

The discovery of New St. Michael's Cave on July 17th, 1942, has been described in a previous paragraph. It was kept a military secret for nearly a year, and the first published reference appeared in the Times of London dated March 23, 1943. A month later illustrations were published and in May a photograph of the Lake appeared as the 'picture of the month' in Life.

A preliminary survey was made by the author in a series of hurried visits to the cave in the spring of 1948. In January 1953 he carried out a more detailed study with a group of Royal Air Force officers, and made the survey reproduced here.

The cave was locked up soon after discovery to prevent vandalism, and conducted visits to the more accessible parts can be arranged with the military authorities. Electric cables have been rigged for lighting, and hand lines are provided in the steeper places, so that visitors may be taken as far as the Lake. The electric system is in bad repair, and in some parts of the cave the lights have been fused for many years.

The artificial tunnel entrance that leads to New St. Michael's Cave is almost immediately below St. Michael's Hut and the entrance to the old cave, being a little less than 900 feet above sea level.

The survey (Figure 4) shows the details of the system, so a brief description must suffice. The plan is somewhat complicated by the fact that the passages at all levels are contained within a narrow band of steeply dipping strata. Some of the lower sections therefore lie vertically beneath the upper ones. The lower passages are shown dotted in their true position on the main plan, and are also drawn out in detail close by, the two being joined by a double-ended arrow.

The point where the entrance tunnel breaks into the natural cave is marked as 'entrance' on the plan, about two hundred feet from the northern end of the cave. A flight of wooden steps leads down from the trap-door into the first chamber where there are several stalagmite columns up to 4 feet in diameter. Many of these show faulting due to earth movement, and some thick broken fragments have fallen to the floor where they are now firmly cemented by flowstone. A small passage in the southwest corner leads down a slope and through another squeeze to the Great Rift Chamber, one of the few places in the cave where bare rock is visible. Directly beneath the point of entry to this chamber lies the way on; a short crawl opens into the Antechamber, and from there is entered the first of the great Stalagmite Halls.

All these Halls are thickly encrusted with orange dripstone, and in the Third Hall immense fluted columns and pillars rise some 30 or 40 feet to the roof (see Figure 5). In the Lake Chamber (Figure 6) there is hardly a square foot of bare limestone to be seen, and the forma-

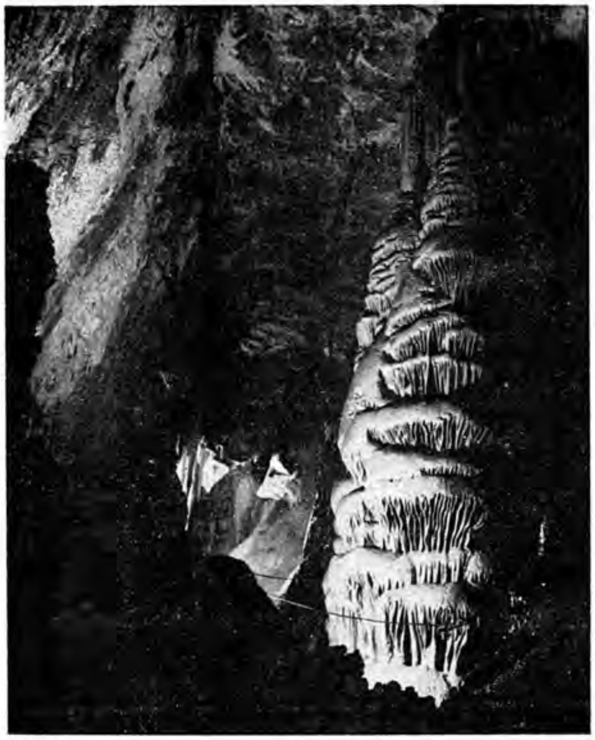

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Figure 5. New St. Michael's Cave; Third Stalagmite Hall.

tions continue even below the present water surface which must therefore be fairly recent. On the walls at water level are narrow ledges of stalagmite like ice fringing a pond; they vary from 1 to 6 inches in width and make it possible to pass the Lake without swimming. On the far side, the Southern Hall (Figure 7) extends 170 feet farther in the same direction. It is possible to climb up the rift at the far end for 40 feet or so, but an extension at high level closes after a few feet.

The Bottomless Pit was so described to the author in 1948 by the Army guide. In fact it is just 54 feet deep and the bottom can be reached by a roundabout route without tackle.

The air in the lower part of Preston's Rift is thought to contain an unusually high proportion of carbon dioxide. No measurements were taken, but the surveyors experienced symptoms of sleepiness, sweating and shortness of breath.

The main level of passages continues on the other side of the entrance chamber as the rather dull Northern Series. Not far along this a slot on the left hand side continues downwards for 53 feet to some attractive little chambers where a former pool has left a number of typical 'underwater' deposits.

There are in the cave four examples of the palette formations described by Kundert in N.S.S. Bulletin 14. Three of these are simple shields with small ribs and curtains hanging beneath. The fourth is shown in Figure 7, high in the roof of the Southern Hall, where it forms the top of a stout stalagmite pillar. It lies in the plane of the bedding, attached to the roof at one corner only, and must be earlier than the immense column which has formed beneath it. The other specimens are not parallel to the bedding or the joint planes, as required by Kundert's theory.

In 1951 a broken stalactite in the entrance chamber was seen to be blowing bubbles! As a drop of water was collecting on the fractured

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Figure 6. New St. Michael's Cave; The Lake.

surface, a gas bubble emerged from the central channel and inflated the drop. Eventually the bubble burst when the drop beneath it became too heavy, and the whole cycle was repeated over and over again, within a period of about a minute. The phenomenon is interesting as a possible example of carbon dioxide, dissolved in the water under pressure in the fissures, coming out of solution. Alternatively there may be some Venturi or capillary effect drawing air into the stem of the stalactite higher up.

The whole of New St. Michael's Cave is notable for the magnificence of its formations, and there are few places where the bare limestone is visible. It is a complete sealing of the fissures by calcite which supports the water of the Lake so far above the water table, although there are dry passages actually running a few feet beneath its bed. This same deposition, however, has sealed off whatever openings may formerly have led to extensions of the cave. It is never safe to predict that further discoveries will not be made, but in this case it can at least be said that they are unlikely without tunnelling such as first revealed the cave.

Gibraltar contains many other caves. All those known at present are smaller than St. Michael's, but many have contained valuable archaeological remains. It is planned to describe these other caves in a later Bulletin.

Figure 7. New St. Michael's Cave; The Southern Hall. Note the palette at the top of the large column on the left.

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Blind Fishes Found in Cave Pools and Streams*

By LOREN P. WOODS

Curator of Fishes, Chicago Natural History Museum

Speleologists visiting Midwestern caves find small blindfish swimming in scattered water bodies something of a mystery. Here is a clear description of the types of fishes encountered, a glimpse into their habits, and observations on their distribution. The author poses a number of questions for further investigation; What is the exact nature of their breeding habits? How can they survive apparently without food for as long as nine months? And is cave integration more widespread than previously thought?

The white blind fishes living in the streams in caves and in other subterranean waters, such as springs and wells, have been the subject of interest and investigation since they first received public attention and description in the early 1840's. What were fishes doing in rivers deep in the earth far from any surface connection? How did they sustain life so far removed from the necessary source of all life, the sun? Why had their eyes degenerated? How did they find their way about from cave to cave and how did they locate food? Some of these questions were readily answered by simple observation. The answers to others are still largely incomplete, chiefly because no sustained investigation has been made of the habits and habitat of blind fishes.

Seventeen kinds of completely blind, exclusively subterranean fishes have been discovered in the underground freshwaters of the world. They belong to eight different families largely composed of normal-eyed fishes with one or two species of each family living in total darkness and without eyes. Most blind fishes are restricted to a fairly small area or to a particular limestone formation or cave system.

In North America two kinds of blind catfishes come from the artesian wells in Texas. Two kinds of blind brotulas are known from the subterranean freshwaters of Cuba and one from Yucatan. These are especially interesting because all other members of the brotula family live in the ocean. Another kind well-known to aquarists is the cave tetra from San Luis Potosi, Mexico. This species reveals a four-step gradation in the degeneration of the eyes from perfectly eyed, normally pigmented, surface-dwelling individuals to totally blind ones with the eye socket covered with tissue and no evident eye structure.

Three kinds of white eyeless fishes, the northern cave fish, Ozark catfish, and the southern cave fish, live in the underground waters of the Mississippi Valley, particularly in the unglaciated parts of Indiana, Kentucky, Tennessee, Missouri, northern Arkansas, and northern Alabama. These fishes are all fairly closely related, belonging to one very distinct family, the Amblyopsidae. The northern cave fish lives only in the Mammoth Cave area and in south-central Indiana. The Ozark cave fish, its nearest relative, lives in southwestern Missouri and northwestern Arkansas. The southern cave fish, widely distributed in Kentucky, Tennessee, Alabama, and south-central Missouri, superficially resembles the other two blind fishes but actually is more closely related to the only eyed members of the cave-fish family — the slightly pigmented springfish (which lives in caves, wells, mouths of springs, or even in surface streams under rocks) and the ricefish (which lives in blackwater swamps and in the shady sluggish parts of streams of the coastal plains from Virginia to south-central Georgia).

Superficially all three of these species of blindfish have the same appearance. When alive, the fishes are translucent white, with a flush of pink around the gills. When dead or preserved, they are pure opaque white. The head is flattened on

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top, snout broadly rounded, and body heavy near the head, tapering to quite thin near the tail. All the fins are broad and rounded (two of the three kinds do not have a set of paired ventral fins). The vent is not in its normal position but has migrated as far forward as it can to a position under the gill openings.

Blind fishes are not the sole habitants of the Mississippi Valley caves. They live in company with several kinds of eyeless invertebrates — crayfish, aquatic sow bugs, scuds, worms, flatworms, and mites. All of these are sources of food for the fishes. These invertebrates with their scavenger habits feed on vegetable debris and organic materials in mud and water when such substances are washed into the underground waters from the surface. Some feed on bat guano. Occasionally surface-dwelling fishes such as sculpins, minnows, catfish, and even sunfish, are found living in underground streams, but they are normally colored and possess eyes comparable to those of their species living in surface waters. Although sometimes found in considerable numbers in underground waters, these surface species of fishes are probably only temporary residents and very likely leave the underground habitat to spawn or feed.

EVIDENTLY FEEL THEIR WAY

Undisturbed blind fishes observed in caves are generally seen just above the bottom of the stream or lake moving about by means of slow oar-like strokes of the pectoral fins. One lazy stroke is followed by a long glide until the momentum is dissipated, and then another stroke follows. They usually come to rest in contact with the stream-bottom or a boulder. When they collide with a boulder or other object it is usually without much force.

Amblyopsis speleus from Spring Mill State Park, Indiana, site of early studies of cave fish.

If a strong flashlight beam is held on the fishes they slowly move away, but they do not pay attention to a weaker diffuse light. Sometimes they are alarmed and retreat to a hiding place if someone wades in the water near them. They

Chologaster agassizi from Union County, Illinois.

are also greatly disturbed by the slow approach of a dipnet and, if closely approached or touched they use their tail fins to dart wildly away toward the surface or under a rock. Occasionally they escape by hiding in a cloud of muddy water. Although they frequently collide with rocks or gravel shoals they seem to know their neighborhood and the collisions may be deliberate — perhaps they ascertain their location by thus "feeling" their way. They do not move incessantly, as does the Mexican blind tetra, but usually remain quietly resting with their tails drooping in order to maintain contact with the bottom. This more or less continuous contact with the solid parts of their home-range must be necessary to prevent their being carried away and "lost". During our cave collecting, if we missed capturing a fish we had only to return to the same locality later — sometimes several days later — and there would be our fish resting against the same rock as when we first observed it.

It has been demonstrated that the skin of blind fishes is sensitive to light and small temperature differences. Head, body, and even the tail fin have many short rows of very sensitive dermal papillae each with a nerve fiber exposed at its tip. The eyed species of this family also are well equipped with these organs and probably rely more on them than on their eyes for information about their surroundings.

Fishes of the eternal dark are blind, but they certainly are not oblivious to their surroundings nor do they fumblingly grope their way about as do blinded surface animals. Their senses of touch, taste, and smell, though perhaps limited to their immediate surroundings, are so highly developed that these fishes do not appear to need sight, the sense on which the Primates are so dependent and for which an additional element, light, is needed.

INSENSITIVE TO SOUND

Blind fishes do not appear to be sensitive to sound, however. We could clatter our equipment or talk in loud voices without disturbing them. Some of these fishes that we kept in an aquarium would start violently if we suddenly rapped hard on the table on which the aquarium rested. This reaction to strong low-frequency vibrations probably was sensed as much by touch as by sound.The auditory apparatus is normally developed in these fishes, and they probably can hear as well as most other fishes but are just indifferent to sound. While some caves are absolutely quiet, others are very noisy from water dripping or small springs pouring from wall or roof. This noise is amplified by being echoed and re-echoed through the cave, and sometimes it was necessary for us to shout in order to carry on conversation above the noise that to us sounded like several people talking at once just around the corner. Such noise loses little intensity on transmission through water or from air to water.

Cave fishes are not gregarious but more or less solitary, and they pay little attention to other fishes as they move about. When several were seen fairly close together, presumably in a good locality for feeding, their position and their movements were independent, never grouped. The one exception was in a lake where we saw an unusually large fish followed by a close school of twelve to fifteen tiny fish, presumably its young.

The most favorable conditions for cave fishes appear to be reaches along the stream comparable to long, deep, quiet pools of surface streams. They were most often found where the water was fairly deep (2 feet or more) and where the bottom was thickly covered with a layer of fine silt. They seemed to congregate around rocks that cropped out through the silt. In a few caves solitary individuals were living in shallow streams with a rocky or gravel bottom and a fair current. In such places the fish took advantage of every sheltering eddy behind rocks and bars and even moved into water an inch or so in depth at the edge of the stream to avoid the current.

The most favorable type of habitat, judging from the hundreds of blind fishes seen in it, was an underground lake, 25 to 75 feet broad, with water 3 to 4 feet deep and a bottom of soft silt 1 to 2 feet in thickness. A stretch 400 yards long of this lake was examined by four slowly stalking men, and more than a thousand fish were seen scattered over the bottom. Also in this place the largest individuals of the southern cave fish were observed to be almost equal in size to average individuals of the northern cave fish.

SEEM TO BE HARDY

All cave fishes we have collected were fat and appeared to be in excellent condition. They store fat between the lengthwise muscle layers along the midline of the back, along the midline of the sides, and also in the tissues surrounding the viscera. Very likely they normally survive fairly long periods of starvation and remain in good condition. We have kept them for three months in an aquarium where they refused all food and were not noticeably thinner at the end of this time. They have been kept for as long as nine months, during which time they never ate. All are known to be carnivorous. The majority of stomachs examined were empty but a few contained crayfish and sow bugs. Although we have observed the fishes for several hours in the caves, we never saw one feeding.

The egg-laying or spawning behavior of the amblyopsids has never been observed but it is known that in one species, the northern cave fish, the eggs are carried in the gill chamber of the female and the newly hatched young are incubated there also. Probably the young stay in the gill chamber until they are able to swim and follow the parent. There are no observations on young re-entering the brooding chamber once they have left it. It has been reported that 60 to 70 eggs are laid by the female into her gill chamber, where they remain for about two months. The opening of the oviduct is located far forward in this group of fishes in a position just under the gill openings.

Fishes with ripe eggs in the ovary or with eggs or larvae being incubated have been taken from Indiana caves during various times from March to November. It is quite likely that they spawn throughout the year. Although only this bare outline of the reproductive habits of the northern cave fish is known, the displacement of the oviduct opening and the enlarged gill chamber with reduced gills also occur in the other species of this family and indicate that they have similar habits of caring for their eggs and young.

Photo by George F. Jackson

Eyeless fish are not abundant in easily visited caves. At the base of a breakdown in a large room the author and Robert Inger search a stream.

The cave environment offers one of the most secure ways of life there is, provided animals can adjust to the absence of light. Dangers from predators are probably at a minimum. Sculpins are found in caves more frequently than are cave fishes, possibly because they are more easily seen since they are larger, darker, and not so shy as cave fishes. Sculpins are carnivorous and often two or three times the size of cave fishes. Although several stomachs of sculpins from caves have been examined and only invertebrate remains found, the sculpin is a possible predator.

In most caves we find raccoon tracks in the muddy banks along the stream. The raccoons enter the caves to catch crayfish and they may take an occasional fish, but again we know of no evidence that they ever do. Another possible mammal predator is the mink. Its appetite for fish is proverbial and there is certainly no reason that a mink could not enter caves and capture fish, but here also the evidence is lacking.

We frequently hear reports in cave regions that cave fishes are washed out of caves in time of flood, a phenomenon that we have never observed. If the reports are true, then cave fishes feeling their way along a stream to re-enter a spring or cave are exposed to the same dangers from birds and other fishes as small surface-stream fishes. However, under such circumstances they are very likely somewhat protected by the turbid condition of the floodwaters.

SUBTERRANEAN TEMPERATURE CONSTANT

In addition to constant darkness, the underground habitat usually has a nearly constant temperature. This temperature in our midwestern subterranean waters is from around 52 to 58 degrees F. depending on the latitude, since this temperature generally reflects the mean annual temperature of the locality. The air temperature in Mammoth Cave, for example, varies from 52 to 56 degrees F. but the water temperature varies scarcely one degree in the course of a year or from year to year.

Other conditions of the cave waters vary considerably. A short time after heavy surface rains the underground streams begin to rise, and quiet confined brooks become raging torrents. Some cave streams may rise only slightly with but a small increase in current, and some may exhibit little or no change. Heavy rains, washing life-sustaining silt and nutriment into the caves, usually cause the underground streams to become turbid, and they may remain so for many days after a rain.

Subterranean streams vary in their conditions as much as surface streams in size, current, bottom, and bank. They may cut through solid rock or be broken into many rivulets among large boulders; they may form waterfalls or rapids or in their sluggish meanders form broad sandbars or mudflats; they may be damned and form a broad deep lake. In some places floods leave isolated backwater pools, or the stream that is a rushing torrent in time of high water may at low water be fragmented by mudbanks and boulders into a disconnected series of ponds. The streams may wander in broad meanders in rooms of great width entering and leaving a particular cave. Springs appear to be numerous in groundwater streams but tributaries few.

Photo by George F. Jackson

Robert Inger checks the river in Wildcat Cave, Indiana, looking for the extremely rare Typhlichthys Wyandotte, identified by Eigenmann in 1897.

Throughout the range of the Mississippi Valley blind fishes there are vast untilted limestone formations lying beneath the surface. Frequently an outcrop occurs at the surface, usually along valleys of large rivers. These formations, which are very thick, were deposited on the beds of ancient continental seas. During the long period of time that they have been under dry land they have become honeycombed with anastomosing tubes of varying size by the dissolving action of ground-water. Some of the tubes are now filled completely or partly with clay, some with water, and some are dry with only occasional springs or clay banks. The drainage of regions underlaid with a network of solution channels is often largely underground, with only a few large surface streams and some of these may originate as a large spring or disappear underground as a "lost river."

During the 19th century and the early part of the 20th only a few widely separated caves were known to contain fishes. The underlying rock strata of the intervening areas were not well known and it was assumed that each cave system contained an isolated population of animals. It was believed that cave fishes only rarely made their way from cave to cave through surface streams or that they were accidentally dispersed in times of flood by being washed from their caves and carried downstream, subsequently entering and establishing themselves in new caves.

APPARENTLY NOT ISOLATED

Underground dispersal does not appear to be more difficult for subterranean fishes than surface dispersal is for surface fishes. The difficulty in demonstrating this belief lies in the lack of ability of collectors to penetrate into underground waters in enough localities to prove that the populations seen are not geographically isolated. It is known that the solution channel networks cross under large river beds and also under the ridges forming divides between surface drainage systems. The dispersal of aquatic cave animals would seem to be limited by the extent of particular limestone formations carrying suitable streams and the degree of dissection of these formations by surface erosion. Another factor that would bring about isolation or prevent occupation would be for the cave-bearing strata to be buried deeply under rocks of later periods or under glacial drift.

The arrival of a glacier tying up the groundwater under it and shutting off all food, finally burying the habitat under a thick layer of drift, would exterminate any subterranean vertebrates.

No cave fishes are known to live in the glaciated part of the Mississippi Valley. If they were once living farther north than now, they have for some reason not returned since the retreat of the glacier. There are two or three vague reports of amblyopsids in northern Ohio, northern Indiana, and southern Michigan, and it is not impossible that some may eventually be found in these areas.

EXPLORATION IS RIGOROUS

Cave exploration is strenuous work and usually not very rewarding. During the past three years Dr. Robert F. Inger, Curator of Amphibians and Reptiles, and the writer have searched the waters of more than fifty caves and springs finding cave fishes in only twelve or fifteen of them. The great majority of caves investigated contained fair-sized streams but not enough headroom, so that we covered as much distance in the caves by crawling or wading as we did by walking. The water ranged from knee-deep to as deep as it was possible to wade, and sometimes the ceiling would be so close to the water that it would be difficult to keep the light from being extinguished. It was necessary to maintain a grip on the lamp and dipnet while climbing, wriggling, or wading along, alternately watching the water for fishes and the ceiling for projecting rocks.

Because of conditions in these low wet caves, equipment was kept to a minimum. For light we used miners' acetylene lamps with 8-inch reflectors. These lamps, which were much more satisfactory than flashlights or gasoline lanterns, could be dropped, submerged, or pushed ahead as we crawled, and they would still function, giving a strong, diffuse light. Fish were collected in large wire strainers lashed to a 3-to-4-foot handle. Cloth dipnets could not stand cave conditions and moved too slowly through the water, warning the fish of their approach. Eight-ounce jars with formalin were used to preserve the fish and a two-quart tin pail was satisfactory as a temporary container for living fishes. Even this small amount of impedimenta on occasion seemed almost too much to be dragging along.

Cave fishes may be reduced in numbers in some readily accessible caves, but they will never be exterminated by collectors. However, they are in grave danger of extermination in many areas of their range because of various engineering activities of man. The impoundment of large streams for purposes of hydroelectric power, navigation, or recreation raises the ground-water level, flooding the caves completely, ponding the streams that feed them, and no doubt rendering many of the cave-fish habitats sterile and unfit places to live because the food is washed into higher caves or deposited on the bottom of the newly formed lakes.

This may cause temporary dislocation, but it is not nearly so serious a threat as the development of many oil fields, particularly through the Ohio River Valley. The salt water and oil from numerous wells go down into the underground water and pollute widespread areas. Another important source of pollution in some regions lies in extensive mining and quarrying operations. Silt from stamping and washing operations and sludge from the mines render the nearby waters uninhabitable. A few caves have been utilized as natural sewers by industries or population centers.

Fortunately the best areas for caves and cave animals are not yet polluted because they lie in wild or sparsely populated regions. But certainly large sections of their former range are no longer available to these inhabitants of the underworld.

Prospecting for Caves

By CORD H. LINK, JR.

Topographic maps are useful adjuncts to field work when they are studied for clues to caves. The techniques discussed are useful for interpreting surface features in the hunt for limestone caves in areas of gentle dip. At best, however, a topographic map serves to isolate those areas which can prove most worthy of careful search. Topographic maps can be obtained for twenty cents each from the U. S. Geological Survey, Washington 25, D. C. or from your state department of geology. State index maps are free on request.

Elsewhere the writer has urged more extensive use of topographic maps in the search for caves. The development of underground drainage systems often produces subtle or profound changes in the surface features. When these changes are recognized, or when the results of such changes are large enough to be mapped, organized search parties are likely to be more efficient at cave finding by making use of the mapped clues.

Without doubt, the method of search-by-map is most applicable in regions similar to the Cumberland Plateau in south central Tennessee, a region of essentially flat limestone beds. In these circumstances, a given combination of map clue and cavern discovery in a particular small area can be expected to recur elsewhere in the surrounding area. Extrapolation is possible here where it is quite likely to be invalid in areas of large and variable dip, or where faulting exists. In any case, map prospecting relies for success upon knowledge or what to expect in the way of erosional features, and this means that the cave prospector must observe a lot of country of the kind that he is prospecting in by map.

The maps used by the writer are 7½ minute quadrangles purchased from the Tennessee Valley Authority which performed the photogrammetric mapping of the Tennessee Valley in conjunction with the Geological Survey. The majority of these maps are less than 15 years old, and new ones are still being compiled.

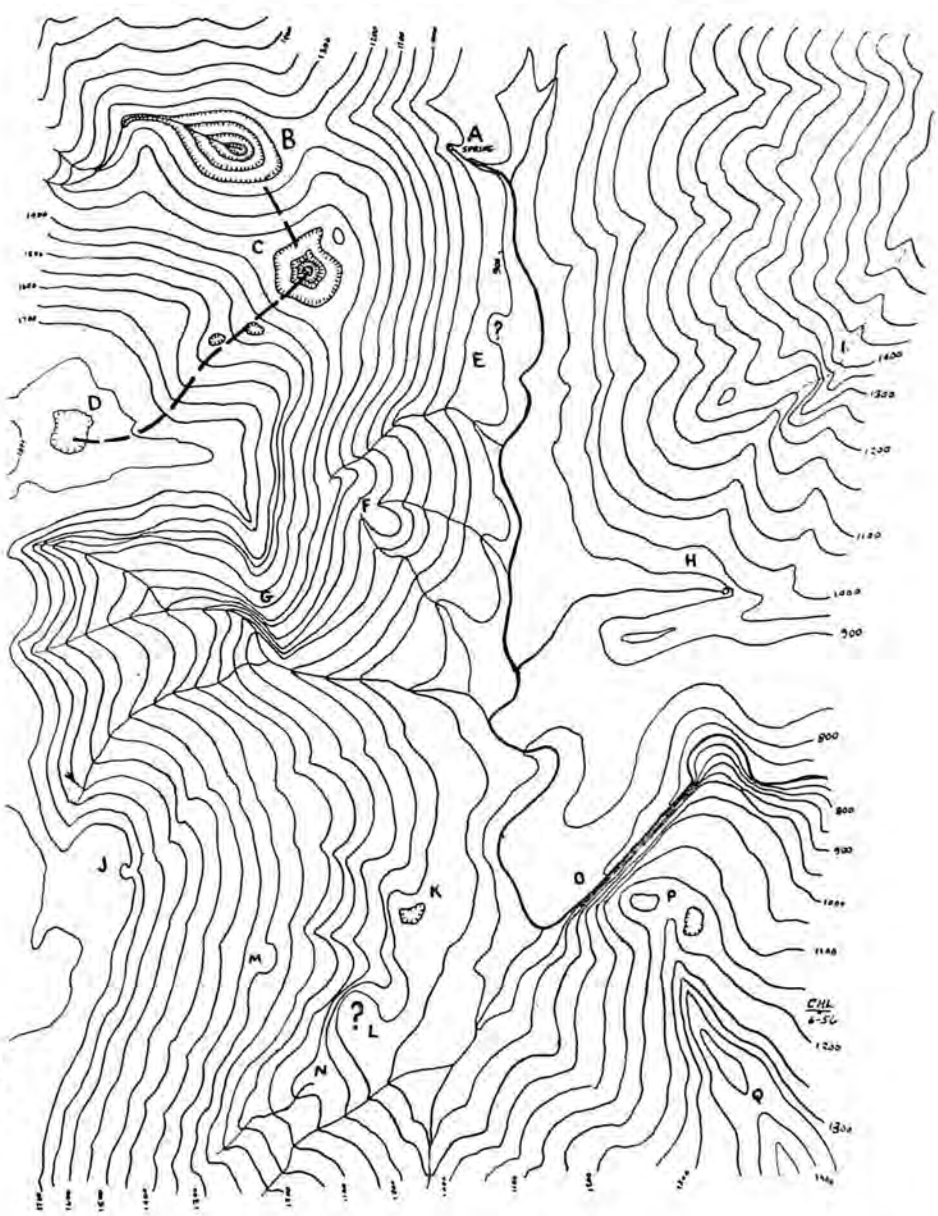
It is essential to know what the maps will and will not show. Any feature normally represented by contour lines which happens to have a vertical dimension less than the contour interval can conceivably be lost if it falls between contour lines. When the horizontal dimensions are less than about fifty feet, the feature may not be contoured. In wooded areas features obscured by trees when the aerial photographs were made may be lost, since the usual procedure is to subtract a fixed correction height from treetop contours. Cliffs may not be mapped since the trees grow tall at the bottom and short at the top of the cliff, reducing the apparent relief. Caves are mapped ordinarily only when they have extensive mouths which may be contoured or when they are discovered by the field-check survey teams who fill in place names. A well-known small cave may be mapped while a larger, less famous cave may be ignored. Most springs are noted but a common failing is to show a blue line stream for a wash that runs only after a cloudburst. Any errors which one may find on such a map are completely outweighed by the very existence of the map itself.

The purpose here is to point out those features of a topographic map which may be clues to cavern development. The accompanying map is fictional, but the density of clues is by no means exceptional for the coves of the Cumberland Plateau in Middle Tennessee. By a change of scale, this map might also be representative of the Highland Rim of the Nashville Basin in the valleys of the Duck and Elk Rivers. The contours are spaced 50 feet apart in elevation. We can assume that we are looking at one or two square miles — a fraction of the area shown on a 7½ minute quadrangle.

Some of the clues are obvious, and are clearly indicated on the map. These include large sinkholes and springs. The less obvious ones are noticed as exceptions to normal contours. Normal contours are convex, bowed away from the slope, and they have sharp concavities at streams and washes. Any unusual reversal of normal contours, especially if accompanied by steep grades, is worth looking at. At the same time, isolated knobs and ridges, seen as circular closure or near-closure of contour lines, can pay off with a pit. Valley streams such as shown here will normally meander about; abnormal behavior near a cliff is always interesting. We shall examine the map in some detail.

We are looking down into a small valley or cove, with a stream in the bottom, and high land on either side. The stream is fed by springs. Where do they get their water? At A, a spring is identified. Nearby is a dry wash. Moving up the wash we find a ridge with large sinkhole development. At B we have a lost stream, one that vanishes at the bottom of the sink. This kind of country is best exemplified perhaps by the chain of lost coves named Cave, Farmer, Wolf and Sinking Cove, each of which is a large sink at the bottom, and each cove has a supply of caves. One of the largest lost coves is Grassy Cove which drains through some seven or eight miles of cave at the head of the Sequatchie Valley.

At C there is another large sink. Tons of earth



Simulated topographic map of an area suspected of containing caves. Letters refer to text discussion.

have been transported downward and away through some sort of underground channels. Along the line C to D are shallow depressions in what may have been an ancient stream bed. The whole area from the spring at A to the upper depression at D should be examined. Usually there will be several other features too small to be mapped in areas with this many clues.

At E is found an indication of an old sunken area, or one too small to be mapped, or not near a contour elevation. Since sinkhole C is nearby, the slopes between E and C just might produce something of interest.

If we happen to get near the little bulge at F, we might look for a pit. It seems that pits are very efficient at taking away groundwater after rains, and the good inner drainage keeps the soil and rocks fairly dry so that normal erosion is retarded. The eroding forces operate inside the pit rather than on the surface outside. The net rate of removal of material may be the same, but the hillock is worn away from inside out, and the area around the pit does not wear down as fast as the nearby slopes, thus producing a small outlying knob.

At G we find strong relief, a bluff face over a wash. These cliffs often show remnants of cave formations if they do not actually contain caverns. An old cave or a phreatic open joint has perhaps first captured the surface stream, and then quarried away the stream bed from beneath so that the stream runs in the bare bones of the cave.

Across the valley at H is another spring. There seems to be an old wash or stream bed nearby, with its contours rounded by long inactivity. But three or four hundred feet farther up the hill the contours are sharp in the stream bed, so that it may be active in the upper reaches on the surface and plunge underground half way down to the spring level. We look now at I.

Back across the valley, high on the rim, we notice an odd notch at J. From it there appears to run as a dry wash. Perhaps a stream spilled over here in a 50 to 100 foot falls before its supply of water was pirated by a branch of the wash at G. It we happen to get near it we might take a look.

Down at the valley floor we find a shallow sink at K, such as may have been found at E. But at K results are likely to be better since K can be larger than E and K seems to be associated with some washes on the slope. K might have an open bottom. At L there is another odd concavity in the contours with a steep side. This is some kind of collapse area whether due to a cave chamber falling in or the remains of an old sink hole. Nearby, at N, a small stream vanishes. Up the hill at M is a small outstanding bench similar to F where we might have a pit. We can hope to get into cave somewhere around K, L and N and such cave may run as far as G – if we can get in.

At O the valley stream makes a strange pass along the steep bluff. This may be a condition similar to that at G. We may find that the stream vanishes under the bluff, to come out around the hill. Sometimes bypass channels are found here, where flood waters take a short cut. The presence of a sunken spot at P further indicates some cavernous conditions.

The ridge at Q is likely to contain a series of pits along or near its crest. As suggested at F, the resistance of the ridge is enhanced by the existence of the pits, often developed along a common joint running the length of the ridge and serving to keep the soil so well drained that normal karstification does not take place – or takes place at a reduced rate.

We have now fairly well covered the valley, as far as map reading is concerned. A few minutes have sufficed to outline enough work to keep field crews busy for several weekends. However, the field crews will enter the valley with definite objectives and can afford to neglect many hundred acres of hillside as not likely to yield caves.

Of course, just off to the right of the map, down the valley, there are farms and farmers. Stop off before beginning the search and chat a while. They may be able to confirm or deny your interpretation of the clues. At times they will not know – and you may surprise them – and vice-versa.

Next Friday, read your maps, and get out there Saturday and find those caves. In this way you may contribute to the contents (or the obsolescence) of the various state cave surveys. And you may have that greatest thrill of all in caving – you may find virgin cave.

Discovery at the Fontana Chistaina

By JOHN HOOPER

The author's light-hearted account portrays the thrill of discovery in what the expert thought was a small cave. Herein is the ancient lesson that a thoroughly explored cave can yield new secrets when examined by those unfamiliar with it — those who apply keen observation, meticulous exploration. Folklore, associated with many European caves, is interwoven through the story.

The Fontana Chistaina — the Ebbing and Flowing well — is a spring high up on the slopes of the Piz S-chalambert, a mountain in Eastern Switzerland, only a few miles from the triple junction of the Swiss, Austrian and Italian frontiers. The entrance, which is marked on the district maps, and has in fact been known at least since 1500, lies 6035 feet above sea level and is situated in the Val d'Assa, a tributary valley which feeds into the River Inn (En), about 5 miles to the N.E. of the picturesque old village of Schuls (Scuol).

In August 1953, my wife and I, while on a holiday in Switzerland, visited Schuls to meet Herr T. F. Anker, a Zurich editor and keen speleologist who had invited us to join him for a few days caving in that district. When we arrived in the Engadine, he suggested that for our first cave, we should visit the Fontana Chistaina. He told us that it was only a small cave and that he had already visited it and surveyed it a few days previously. The entrance is a narrow fissure from which a waterfall gushes, this fall taking the overflow from a small lake just inside and which is fed by a submerged tunnel. The level of this lake (and hence the flow of water) rises and falls daily, and Anker told us of the delightful legend behind this occurrence.

Once upon a time — in the approved fashion of all legends — a certain Lord, who lived in a castle near Schuls, fell in love with a fairy who lived at the cave, and each day he left his castle and went up the mountain to pay her a visit. This went on for a long time, until the wife, growing suspicious of her husband's daily excursions, followed him and on discovering his guilty secret, made him promise never to visit the cave and the fairy again. The fairy, of course, was a little annoyed about this, and told the unfortunate man that if he deserted her, his noble line would come to an end. The Lord however kept his promise to his wife and the fairy's threat was soon fulfilled. He was killed in battle, and on the very same day, within the short space of one hour his three sons all died from the plague. The legend then relates that the fairy, lonely for her lover, returned to the cave, where she still weeps copiously each day, both at the time when he had been accustomed to meet her and again at the time when he used to leave, — so that twice a day, once at 9 a. m. and once at 6 p.m., the waters rise as the valley is flooded with her tears. So the legend goes, but measurements made within the last 100 years show only one daily rise and fall, although various observers differ over the precise time of the occurrence.

Herr Anker then gently broke it to us that we should have to make an early start, as the climb to the cave would take two and a half hours. The actual distance was small, but there was a little matter of 2400 feet difference in altitude to be overcome! So Win and I, who were camping near Schuls, reluctantly crawled out of our tent at 6:00 a.m. the next morning and went down to have breakfast with Anker at the farm where he was staying. Afterwards, we somehow managed to fit the three of us and our rucksacks into our aged but faithful car, and then we drove on down the Inn valley, following a narrow, corrugated apology for a road, with a treacherous, dusty surface. Below us, on our right, steep slopes fell away to the twisting, gleaming waters of the Inn, and beyond the river, equally steep but wooded slopes soared up for thousands of feet, before merging into the barren, snow-flecked crags of the great mountains, 10,000 feet high, which formed the Southern wall of the valley. About five miles from Schuls, we passed the little village of Ramosch, and after numerous unpremeditated skids, we left the main road — intentionally, this time! — to follow a zigzag track that took us down to river level. We crossed the river by a massive wooden bridge, completely roofed in, and parked the car in a field just beyond. Then we shouldered our rucksacks and set off, Win and myself rather conscious of the fact that a week of car travel was not the best of practice for mountain climbing. An hour or so later, this fact became even more obvious. However, at first, everything was easy. We crossed a meadow and ambled up a gentle slope where wild strawberries, sweet and ripe, tempted us to linger. Then we entered the woods, and immediately life became much more real and earnest — a long, hard grind straight up the line of the slope, which continued with uncompromising steepness for as far as we could see. Eventually Anker bore off to the left and as we followed him through the trees, we caught a brief glimpse of several deer flashing uphill with an ease that we wished we could emulate.

For a while we were able to look over into the precipitous wooded ravine where the waters of the Val d'Assa took their final steep plunge down into the main valley, and then we turned onto a goat track that zigzagged up through the crags at an angle that was always discouraging and at times disconcerting. As we gained height so the view below us grew in magnificence, and the sight of the distant river and the tiny wooden bridge that we had crossed emphasized to us that we really were making good progress. After climbing for roughly a thousand feet, we reached a rough track used for bringing felled timber down to the head of a cable transporter, and for a while we were able to travel along an almost level path — a welcome relief, as the sun was now very hot indeed. We crossed a clearing, colorful with wild flowers and in particular with tall purple spikes of Monkshood, and then we came to a broad fan of stones, littered with twisted, splintered trees. This chaotic mess was the remains of an avalanche and as we traversed down across the stones and boulders to stream level, we saw that they merely formed a loose covering to a thick bank of frozen snow beneath. After Anker had hurled a few of the larger rocks into the fast-flowing torrent to act as stepping stones, we crossed to the far bank, and plodded on upwards again. At an altitude of 1680 metres (5250′), the valley forked. We took the right fork, crossing the stream once again, and for the next 20 minutes endured the worst part of the climb — a hard, steep ascent over loose stones under the full heat of the mid-day sun. However, by 12 noon, two and a half hours after leaving the car, we reached our destination — the Fontana Chistaina. This name covered two entrances, the most obvious being marked by a waterfall which cascaded out from a dark fissure in the left hand wall of a rocky bay on the right side of the valley. The second entrance was in the cliff forming the wall of the valley itself: it was a small hole in the cliff a hundred feet or so to the North (i.e., downstream) of the water outlet, and was roughly at the same level, being reached by a steep scramble up a bank of loose earth and scree. Anker wished to survey this second cave, but decided to give us first a brief 'show' trip in the wet one. However, an even more prominent item on the agenda was the question of lunch, and we scrambled up over a platform of snow some five feet thick to a shelving terrace near the foot of the waterfall. We were all in need of a drink, and this was supplied in good measure from a shower of drips outside the cave, although the water was almost too cold for internal comfort. Anker told us that the snow bank up which we had climbed had, ten days previously, formed a deep platform right across the little ravine in which we were sitting. We gathered, in fact, that because of the snow, the cave entrance is normally only accessible between July or August and the beginning of October.

After a decent interval, we put on our boiler suits and went down to tackle the waterfall that pours out of the Fontana Chistaina. At its base, this fall fanned out down a series of cascades which could be avoided by climbing up over green and slippery, algae-covered ledges on the left. However, after about 9 feet, the ledges ended and one had to reach up to the right and wriggle hopefully into the narrow fissure itself, immediately above the water. (N.B. The hope was that one would remain 'immediately above' the water). A crudely assembled collection of poles just here had been installed by some unknown philanthropist and served as a ladder of uncertain vintage and negligible stability: it was however, more of a hindrance than a help, but in spite of the lack of friction offered by the damp and slimy rocks we all managed to scramble up over the forceful jet of water at the cost of little more than a wet boot. Once in the rift,

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Entering the Fontana Chistaina on the occasion of the "discovery" trip in August of 1953.

we found that we could traverse along a narrow ledge on the right hand wall, a foot or so above the water. About 25 feet from the daylight, the stream section ended, the water emerging through a tunnel beneath our feet from a 'Lake' chamber on the right. This 'Lake', which we could look down into through a second and more convenient archway, was a shallow pool, six to eight feet in diameter, and was fed by a submerged channel in the opposite wall. Anker told us that by about midnight, the water level in this lake would have risen by eight cm. The water almost certainly came from a glacier three thousand feet higher up the mountain, the increase in flow being due to the additional ice which was melted during the hours of sunlight. It was not known however just how long it took this water to reach the Fontana Chistaina. It could only be 12 hours, or on the other hand, it might be 36 hours – in other words, the increase in flow which would start from the glacier in the morning, might perhaps reach the Fontana the same night, or it might not get there until the following night – an intriguing problem still to be solved.

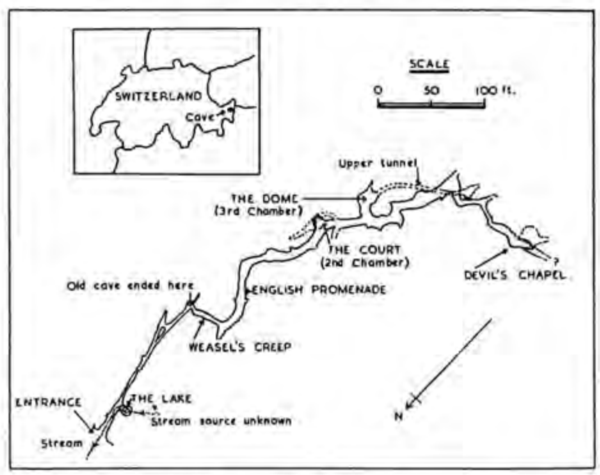
Leaving the lake, we continued up the rift, whose damp, cold walls were barely a body's width apart. The rock, which in places had a rather drab, flowstone coating, was a yellow Triassic limestone. About 60 feet beyond the lake, the walls widened slightly, and we came to a Y-junction. To the right, the rift continued, offering routes both at high and low levels – which we followed according to our individual choice – but which both ended in a small chamber with a sandy floor, about 140 feet from the entrance. In fact the whole cave ended here, apart from a tight-fitting tube which, Anker told us, only went in a short distance, and having inspected it, we were quite prepared to take his word on this point.

On the floor, there was a small amount of bat dung and we sat down so as to be able to examine this more closely. Since the cave temperature was only 39°F, the effect was closely equivalent to that of sitting on a pile of snow, and I hastily got up again. Win however, remained sitting and this was to have unexpected consequences. It should be mentioned at this stage that since we had only expected to be in the cave for a few minutes, Win and I had not bothered very much about clothing and had merely slipped boiler suits on over shorts. Perhaps because of this lack of clothing, Win rapidly became aware of the fact that an icy draft was coming up through the sandy, but apparently solid floor. Now drafts in caves, whether icy or not, have to come from somewhere, and so she and Anker did a little tentative excavation. To their surprise, a hole was revealed almost immediately and further enlargement of this – albeit with fingers numbed by the cold sand and the cold drafts – proved unexpectedly easy. Unfortunately, I missed all the excitement of this, for – to save time, as I thought – I had gone back to the Y-junction to take a photograph and had been much too busy wrestling with my camera and tripod in the confines of the narrow rift to pay much heed to the activity at the end of the passage. In fact by the time I was ready to take the picture, the hole was looking very promising indeed, and a minute later, while Anker was long-sufferingly providing a little 'human interest' for my photograph, there was a triumphant shout from Win that her "hips were through". Thereafter, there was a prolonged silence and it was soon obvious not only that the rest of her body had duly followed her hips, but also that she was completely out of hearing range. Presently an excited voice from the depths encouraged us to join it, adding – as a slight inducement – that there was a passage 'big enough to drive a car through'.

Anker therefore climbed back into the little chamber and tried to negotiate the hole, only to find that there was not enough room for the simultaneous passage of his body and the rather bulky cylinder (worn at his belt) which supplied acetylene to his head-light. He carried out a strategic retreat so that he could sort out his affairs in more comfort and in so doing uncorked the hole and released a sudden gale which almost blew me out of the cave. As Anker seemed a little preoccupied with his various encumbrances, I tentatively inserted my feet into the squeeze, and managed to insinuate myself under a flake of rock without too much difficulty, emerging into a level tunnel, 18 inches to two feet high, with a sandy floor. A minute or so later, when Anker had finally got himself, his helmet and his gas cylinder through the hole, we crawled on, and after about 35 feet, entered a surprisingly capacious tunnel. Win's statement that one could drive a car through it was certainly true, though I would not recommend it for a vehicle on which one set any great value! To the right, the rocky floor sloped downhill to end in a small chamber, but to the left, there was a broad passage – 10 to 15 feet wide – going on into the darkness, and with this in front of us, we plunged on into virgin territory. There were relatively few stalactites, apart from a small group of little helictites and soda straws on the left. But the continuation of the passage itself was our main anxiety for the moment, and after rounding a corner to the left 20 feet farther on, we were relieved to see that the corridor, as large as ever, continued for at least another 70 feet. Hurrying on – everyone anxious to be in the lead! – we rounded another corner, this time to the right, and soon entered a rocky chamber, littered with giant boulders.

We had been surprised to find bat dung in this new section – not in big patches – but in a thin and fairly uniform sprinkling all over the floor. Since our own point of entry had been completely sealed, it was obvious that there must be at least one route to the outside world which was, at any rate, negotiable by bats.

At first glance, we feared that there was no way on from the boulder chamber which we had entered, but a scramble over a large fallen block led into a narrow tunnel, which was only four feet high. The way ahead was now clear again and we crawled on hopefully. Presently the roof height increased once more, and 70 feet from the boulder, we emerged through an archway into



Outline plan of the Fontana Chistaina, Lower Engadine, Switzerland. Entrance elevation 6035 feet.

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Herr Anker adjusts a depth recorder, set up in 1954 to measure the rise and fall of the water level in the "lake." A float inside the lower tube moves a pen which draws a line on chart fastened on the clock-work driven drum.

what, for ease of reference in this account, may be called 'The Second Chamber'. This was complex in shape, with high-level sections at both ends. For the moment however, we did not worry about these as a roomy passage ahead still beckoned us on, and after marking the entrance to the chamber with an arrow, we continued our triumphant advance. We were now in a tunnel almost 15 feet wide: once again, although small stalactites were plentiful, there were few formations of note, and as in the previous passages, the floor was well sprinkled with bat dung. Fifty feet on, we came to a Y-junction. An archway to the left opened into a high, circular chamber (temporary name — 'The Third Chamber'), but the main route appeared to lie along the right hand branch, so we went to the right and after scrambling over many scattered boulders well coated with soft clay, we found that we had to crawl through a low section, only a foot or so high, of which the least uncomfortable portion appeared to be a mud bank on the right. I was leading at the time and was a little perturbed to find that this apparently solid bank consisted merely of a thin layer of clay cunningly masking a boulder ruckle beneath, with the result that almost every time I rested a hand on the mud, it broke through and shot down into a void beneath, and I was prevented from following it through only by the buffer action of my face on firmer ground ahead. Several horizontal, leaf-like flakes, about half an inch thick, protruded from the walls of this section: they looked solid enough, but they were really mud with a wafer-thin veneer of stalagmite on top. Sometimes the mud acted as a matrix for a thin band of pebbles on the underside, but it was the stalagmite glaze on top which held the brittle structure together. Some of these flakes were reminiscent of grotesque fungi growing from the trunk of a large tree, and one particularly good specimen, which we were able to crawl past without damaging, was about 12 to 18 inches deep and some two feet long.

After a few yards, we were able to get to our feet again, and to walk along a drab passage whose floor was an intimate mixture of boulders and mud, the latter often of treacherous stability in that it was not always so solid as it looked. A small stream was noticeable on the floor and Anker now raised a moment's alarm by wondering if and when the water from the glacier was due to arrive. However, after studying the mud deposits and the bat dung on the floor, we convinced ourselves that water did not normally flow in quantity through the tunnel. Thus reassured, we continued on our way. Seventy feet beyond the mud crawl, we came to a corner where there was an impressively high aven (dome) going straight up above the passage roof, and a few feet on we noticed that about ten feet up the left-hand wall was a terrace which looked as if it might lead to some upper-level passages. For the moment however, we still had an easy tunnel ahead — a fine rift, 12 feet high and more, which soon bore sharply to the right. For a short while we had to crawl over a clay floor, covered with a thin layer of stalagmite, whose uncertain strength added a certain piquancy to our progress, as one never knew — until too late — when a knee or a hand was likely to break through into the soft, wet morass beneath. Ahead we could hear dripping water and we soon saw that this came from a number of stalactites to the left of a small chamber — little more than an enlargement of the passage — which, to our sorrow, now ended in a choke, roughly 700 feet from the point where we had first crawled into it. A few feet before the choke, the passage narrowed to a fissure with some colorful formations on the walls; particularly noticeable was a delicate curtain, almost orange in color, and nearby was a clean white boss of gleaming stalagmite.

About eight feet above the floor on the right, there was a muddy terrace, and straight ahead at the same level, there was a further terrace, also muddy, which appeared to continue for several yards. I managed to climb up to this second ledge, and was encouraged to find a rocky pipe continuing upwards at the end. This was none too large, but the mud lining lubricated my progress as I wriggled upwards, following a rather spiral course. Other, smaller tubes branched off at intervals, and one at least must have connected back to the main passage below, for at the place where the diminishing cross-section of the tunnel put an end to my advance I could hear the voices of the other two distinctly. Reversing downhill again, I tried to estimate the extent of this small addition to the cave, and decided that it was equivalent to five 'body-lengths'. Regaining the terrace, I found that there was still one more possibility — a sloping mud bank on the left at the top of a five feet wall. The mud was slippery and such hand-holds as there were held only to my hand and not to the cave each time I put any strain on them. So I had to call on Anker's moral support, not to mention a shoulder or so beneath my wildly waving posterior before I could make any impression on the slippery chute above. This in turn made an impression on Anker beneath, as large chunks of cave came away beneath my grasping

Emerging from the "Weasels Creep." This is the hole excavated with bare hands to give access to the new system. Picture taken in 1954 after hole had been enlarged.

hands and thudded down all round him, but after tottering in unstable equilibrium for several pregnant seconds, I managed to scramble over the lip of mud above only to find that all these diverting acrobatics had been in vain. There were two small chambers, a hole in the floor dropping back to the main passage, and impressive quantities of mud, but by no stretch of imagination was there a way on. So I descended the slope again, a process that was only too easy as all that one could do was to slide and hope for the best — a rapid and exhilarating backward dive that ended in a muddy bounce and a neat piece of fielding by Anker, who prevented me from continuing the downward movement into the main passage below.

When Anker and I had rejoined Win, I attempted a photograph of some straw stalactites, with a triumphant trio of discoverers firmly anchored in deep mud beneath. When the smoke cleared, we took it in turns to get a drink from one of the dripping stalactites, these being nicely spaced so that as one stood with upturned face and open mouth beneath one stream of icy water, other streams simultaneously cooled the neck and washed the hair. Thus refreshed, we started the return journey, carrying out a rough survey as we went.

While Win and Anker surveyed back towards the mud crawl, I went on ahead to examine the 'third chamber'. This was a dark and sombre, rocky vault, devoid of formations and only 12 to 15 feet in diameter, but was impressive because of its height, the jagged walls curving up to a shadowy dome, 30 feet above the floor. In the centre of this dome there was the mouth of a black chimney which went on higher still. On the far wall a rocky slope led up to an ascending fissure which looked as if it might go on, and near the entrance to this fissure there was a curious bank of pebbles, several feet high. These pebbles, although not apparently bonded together in any way, had settled into a surprisingly firm mass and were neatly graded with the smallest stones at the top. To the right of the chamber, a narrow rift gave access to a ledge about eight feet higher up, with what appeared to be a passage beyond. On climbing up, I found that the floor of this passage was a steep pile of wedged boulders, largely held together by faith, and on the left, there was another bank of tightly packed pebbles. Above the boulder pile, a tunnel mouth, three to four feet in diameter, offered an inviting way on. The tunnel behind was an almost straight and level tube of the same size and its floor was paved with soft and rather sandy mud, creamy-white in color, which in drying had cracked into large irregular flakes. Crawling over this mud I was once again struck by the extreme coldness of the cave, the chilly dampness of the floor beneath my hands numbing them almost as much as snow would have done. This tunnel also was strewn with bat dung.

After 60 or 70 feet of easy crawling in this rocky pipe, which remained remarkably constant in cross-section, I reached a small, rift-like chamber with a pool in the floor, a few feet below on the right. This chamber formed a short cul-de-sac to the right, but on the left, a hole through some boulders led down into a muddy passage that continued on into hopeful blackness. So I went back to fetch the others and in due course we found that this left-hand passage ended abruptly at the edge of what at first appeared to be a pit, with undercut walls and a floor about 12 feet below. Beyond the pit there was a muddy tunnel continuing at our present level. It was only a short stride across, but the way on beyond ended after a few yards with a view down into another dark hole. We soon established that these two holes both opened into the roof of a lower level passage from the opposite sides of a sharp corner. The passage below was lofty, and obviously continued, and we could no doubt have got down into it, but we doubted our ability to climb out again without a rope. However, when we later plotted out the survey, we regretfully came to the conclusion that we had been looking down into the main passage of the cave system at a point about 80 to 100 feet from the terminal chamber. This connection was in fact confirmed on a subsequent visit. An upward sloping pipe began a few feet above the shelf on which we were standing but we left that for another day and continued the survey back to the 'Second Chamber'.

In side elevation this chamber would appear in shape like a distorted and very much flattened figure '8': the lower half of the chamber comprised the main passage, here slightly enlarged, while the upper portion of the '8' consisted of two diametrically opposed lobes, at slightly different levels which lay, however, in the same general line as the passage below. The inner lobe (the one farthest from the entrance) sloped sharply upwards, but the other, about five feet up from the passage floor, was about 12 feet across and 15 feet deep, ending in a low crawl that seemed to go on indefinitely. As time was getting on, we did not attempt to explore this crawl, but with great devotion to duty concentrated on the survey of the main passage. This survey, when completed, showed that our discovery had added fully 950 feet to the known length of the cave, with the possibility of much more to come.

Triumphantly, we returned to the daylight, and although we got very wet slithering down through the waterfall in the entrance, this by no means damped off our high spirits. We knew that, thanks to the draft which Win had sat on, we had turned the Fontana Chistaina into the largest cave in the Engadine. Win and I would not let Anker forget that he had only been going to take us for 'an easy trip in a *little* cave, less than 50 metres long,' and he in turn was intrigued by the novel method of discovery of the new system. Before we left Switzerland, he presented us with a map showing the location of the cave, and on which he had written:

"With thanks and compliments to the co-discoverers of the cave system of the Fontana Chistaina in the Val d'Assa, 15th August 1953. Long Live the Inadequate Underwear."

In August 1954 my wife and I returned to the Engadine and to Schuls, and with Herr Anker once again trudged up the long climb of the Val d'Assa to the Fontana Chistaina. This time the trip was made a little less tedious by the fact that we were able to use as an 'advanced base' a hunter's cabin, only about one hour distant from the cave.

We spent several hours investigating the tunnels that we had left unexplored in 1953, but although we added a few yards here and there, we made no fresh discoveries of any major size. In particular we were disappointed to find that the promising-looking pipe that sloped upwards at the inner end of the high level tunnel (that I discovered on our way out) merely curved up to a small chamber, with no way on beyond. Similarly the low crawl that appeared 'to go on indefinitely' from the Second Chamber was also regrettably shown to come to a finite end after a tight squeeze over a slab of rock some 20 feet along it. Anker took the opportunity to carry on with the survey which we rather hurriedly made in 1953, and this survey was subsequently completed by Anker and his associates in the Société Suisse de Spéléologie. Definite names were given

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Winifred Hooper in the "Devil's Chapel" at the end of the Fontana Chistaina.

to the main features of the cave, and English translations of these are shown on the rough outline plan which accompanies this account. This plan is a crude simplification of Anker's accurate and large scale survey, and I gratefully acknowledge the information which I derived from the latter in drawing out the simple map now illustrated. It will be seen that the part which my wife and I played on the discovery trip is commemorated in the 'English Promenade' (local name 'Promenada Inglaisa')!

Eagle Lake Lava Caves

By ROBERT GIVEN

Tracking down caves which persist in local legends can be rewarding work . . . IF you find the caves. The author set out to find one cave, spurred on only by the name of an obscure lake on a California map. His search led to three caves, each an interesting link in the growing chain of known lava caves which dot the speleological map of the Far West. Eagle Lake lies about 70 miles south southwest of Lava Beds National Monument in northern California.

Eagle Lake Ice Cave appears on many road maps of northern California. However, in pinpointing the cave and actually finding it, little or no information can be found locally. Many apparent caves in the lava flows near the lake are actually only fissures and cracks. From them come many tales and stories. Most of them have been carefully and painfully followed up by the author, usually with no result other than sore feet. Lava beds are the world's worst places for hikes!

Finally, one of the very old residents of the Eagle Lake region offered a vague bit of information and a few hazy directions to the apparently mythical and certainly elusive Eagle Lake Ice Cave, and to another cave to the north. After more meticulous searching and more defeats than I care to remember, a group of five students from the Chico State Biological Field School at Eagle Lake Resort found the ice cave in July, 1955.

The terrain immediately surrounding Eagle Lake consists mostly of an extensively logged pine forest with much underbrush of sage and mountain mahogany. There are many exposed areas of shallow cap lava and lava beds, which are of recent enough Quaternary origin to be still quite prominent and not severely eroded. The typical shrinking and cracking patterns of these shallow flows accounts for many cracks and fissures, some of which hold winter ice all year long. These fissures are generally mistaken for "ice caves", since they give the general appearance of a cave due to collapse of walls and covering of certain areas by debris.

In some of the thicker pahoehoe basalt caps, however, conditions are similar to those of Lava Beds National Monument, where there are many sizes and lengths of lava tubes, all following the same basic horizontal pattern with later modifications, largely due to collapse. On most maps of the Eagle Lake area, there is a "lava bed" shown, but it is actually only a small part of the vast lava field which covers the greater part of the area surrounding the lake.

It is difficult to give specific directions and names to roads and locations in this area because it is still being logged. Logging roads are constantly being changed and landmarks removed. The best way to find the most likely areas for cave discovery is to arrange for a personal escort by someone who has been to the cave, or have a good knowledge of the visible features of a lava flow which indicate the presence of tubes. Many of the flows are too shallow to have any tubes of major size, and knowledge of the characteristic formation of gullies by complete collapse of tubes saves many hours of fruitless searching in sterile areas. Lava caves are generally inconspicuous, and a whole new concept of search is needed by one accustomed to limestone caves.

At present, two distinct caves are known west of Eagle Lake and they are so aligned that it is entirely possible that they may be remnants of one continuous lava tube. Farther to the north lies another cave, called Indian Cave. Ceilings of these tubes are characteristically very thin and collapse is usually evident. Complete line collapse leaves a characteristic gully or trench, and partial collapse often cuts the tube or locally constricts the passage to a crawlway.

It is most probable that the larger of these two caves is Eagle Lake Ice Cave which has been placed, probably through hearsay, on many Forest Service and road maps. It corresponds to the directions and description given by older natives, even though lost for a time due to the ever-changing logging roads and landmarks of the area. The two adjacent caves are found approximately 250 and 430 feet west of the main Paul Bunyan logging road in the northwest portion of section 27, R10E, T32N, on the map of the Susan River District of Lassen National Forest in Lassen County, California. This is 3.4 miles from Stafford's Eagle Lake Resort. The first cave, presumed to be Eagle Lake Ice Cave, contained ice even in September, 1955. Approximately 180 feet farther west another larger opening, which is probably part of the same original tube, leads to a much smaller cave known as Pack Rat Cave.

In our searches we naturally found the cave closer to the road before finding the other. At first, and even second glance, it seemed a small and uninteresting grotto, and seemingly led to nothing. Due to the peculiar lighting conditions, we failed to see the small crawlhole which leads to the large lava tube glaciere. It was thus not until a later exploration that it was really discovered.

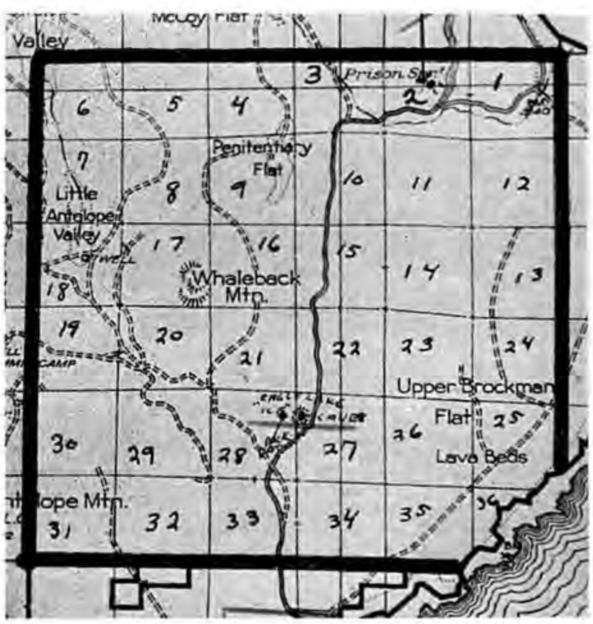

Photo by W. R. Halliday

Map of Eagle Lake area, California.

We continued up the slope and found the other, larger sink. Here we encountered and mapped a small two-room cave containing no ice. It was apparently inhabited by a few spiders and pack or wood rats; we dubbed it Pack Rat Cave. The experience of missing an important turn and thereby a whole cave in a seemingly insignificant hole emphasizes the importance of searching every nook and cranny in lava tubes.

The entrance to Eagle Lake Ice Cave is a small antechamber, about 20 by 20 feet and 8 feet high, with a broken floor and ceiling covered by a large quantity of dirt which has sifted in. At

Entrance to Eagle Lake Ice Cave, Lassen County, California.

one end of this room is a skylight. The lighting through this hole obscures the opening leading to the rest of the cave, and the whole room appears insignificant. At the rear wall, however, there is an inconspicuous pile of rock, completely ignored by us during the first examination of the cave. Behind the rock pile lies the entrance to the 156 foot length of Eagle Lake Ice Cave.

The first 75 feet is all rough crawling. The sharp and unyielding lava rock, the sharp drip stalactites, and low ceiling make progress slow, forcing one's head to remain almost on the floor. There is a small quantity of ice on the floor at the end of the crawlway, and even a small ice slide. This opens into the cave's only real room, a chamber about 50 feet long by 13 feet wide, 15 feet high. At the end a small crawlway leads to a tiny cubicle where a wall of lava blocks progress. In the middle of the floor of this last small crawlway stands the only distinct ice speleothem in the cave, a pinnacle of ice about 10 inches high. The average thickness of ice in September, 1955, was five to six inches, but there is evidence that this perennial ice is added to by the plentiful moisture on the walls and floor during winter and spring. The remainder of the cave's floor is wet, even muddy where dirt has sifted in. This mav have been a seasonal effect, however. Halfway down the tube a side passage proved to be a difficult dead end crawlway.

The entrance of the Pack Rat Cave is at the lower end of a lava sink probably formed through tube collapse. The opening is about four by six feet, and a cool draft emerges from it. A 15 foot crawl begins almost at once, leading to a long narrow room. Beyond is a tight 10 foot crawl to a larger chamber, about 45 feet long and 12 feet high. It terminates as a dirt slope suggesting sectional collapse of the lava tube.

Small ice slide found in Eagle Lake Ice Cave.

The walls and ceiling of the cave are festooned with typical "melted lava drip" stalactites. These differ from the familiar sedimentary speleothems found in limestone caves, and are actually formed during cooling of molten rock. Some show carbonate precipitation at their tips, due to subsequent deposition, but the main body of the actual projections are hard, sharp lava.

Earth, fungus and sprouting grass were found in crevices along the floor; animal droppings were plentiful. These were tentatively identified as those of pack or wood rats, which suggested a name for the cave. A few roots protrude through the ceiling, and sifting dirt indicates a thin roof.

Indian Cave is fairly well known in the locality. It is located about 200 yards left of the main Paul Bunyan logging road, approximately 30 miles from Susanville, California, and about six miles from the Eagle Lake Resort. It is the largest cave now known in the area. The name is attributed to a legend that 200 Indians hid in the cave during the last of the white man's massacres. Despite local reports, it is not a glaciere, but appears to hold seasonal ice. The entrance is located on the side of a large lava sink, largely filled with rock and debris probably originating from ceiling collapse. A much larger entrance in the same sink goes back only about 20 feet. The large pit could have housed 200 Indians, but the present cave would not have been practical for shelter. Spurred on by stories of buried Indian bones and relics, the entire 302 feet of the tube were searched minutely, but nothing was found. The ceiling, however, shows evidence of recent rockfall, and relics could be covered by large boulders. The only evidence of habitation is that left by porcupines and marmots.

The actual entrance of Indian Cave is a small hole from which a 20 foot crawlway leads to a chamber of moderate size containing washed-in dirt and animal debris. Beyond, the cave is quite typical of lava tubes: long, horizontal and of fairly uniform diameter, averaging about six feet in height and ten feet in width, except where wall or ceiling collapse has caused constriction.

End of the only "room" found in Eagle Lake Ice Cave.

Within the cave are "molten lava drip" stalactites and other decorations. They are generally of a uniform reddish-brown to grey color. The beauty of the lava cave lies in its unique formation from liquid rock by the agency of huge bubbles of volcanic gas.

A Cave Description from the Middle of the 17th Century

By CHARLES E. WEBER

Accounts of the terrors awaiting those who venture underground apparently have early beginnings. Here is a compendium of information heard frequently today with regard to caves, generally in popular magazines and from "eye-witnesses". Apparently cave reporting of an exaggerated nature knows no national boundries, or time boundries. Before we judge Herr Zeiller too hastily, we ought to examine our own versions of cave stories. So long as speleologists remain skeptical, caves will be studied regardless of obstacles both imaginary and real.

Toward the middle of the Seventeenth Century, during the last years of the Thirty Years' War, there commenced to appear a series of books so remarkable that they were in demand and continued to be printed for many subsequent decades. Indeed, they may be termed one of the most successful publishing ventures of all times. This series of books owed its success largely to its illustrations, which were made from copper etchings and which set a new standard of excellence for landscape portrayal in book illustrations. The copper etchings were made by the publisher of the books, Matthaeus Merian, and his heirs. Another reason for the success of the *Topographiae* lies, perhaps, in the spirit of the age in which they appeared. People of the baroque age liked to travel and find out what other places were like; they had a predilection for the exotic and the bizarre. In any event, the *Topographiae* can furnish a highly vivid impression of Europe in the middle of the Seventeenth Century; even the modern reader is fascinated by these volumes. The texts of the volumes are by Martin Zeiller, who lived from 1589 to 1661.

In the volume on the Duchies of Brunswig and Lueneburg, which appeared in Frankfurt am Main in 1654, there is found a description of Baumann's Cave[1]. This description throws interesting light on attitudes toward caves and their exploration in previous centuries. Baumann's Cave was discovered in 1536 by a miner by the name of Friederich Baumann while he was prospecting for iron deposits[2]. It is located on the Bode River in a district near the Harz Mountains known as the Rübeland ("rough land") and is one of the most important caves in Germany. Unfortunately, we do not have access to it nowadays because it is just within the western boundary of the "German Democratic Republic," about 20 miles to the east and slightly south of the historical old mining town of Goslar, which is today a famous tourist attraction. In 1777 Goethe, the great German poet, visited Baumann's Cave and was fascinated by it.

But now let us return to Zeiller's description[3], which can speak for itself:

"If we go from this locality [the Rosstrap] toward the west to the iron-works on the Rübeland, located between Blankenburg and Elbingrode, there is to be seen another work of nature in the County of Blankenburg called Baumann's Cave that is so marvellous that it may be truly said of it:

Ludit in humanis divinia potentia rebus.[4] This cave, sometimes called Baumann's Cave from its discoverer, is right near the Rübeland on a rather high hill, and has been fashioned by nature itself into a hard rock cliff. Its entrance is round and so narrow that anyone who wants to go into it must slide or crawl for several fathoms. Soon after that, passages of such size open up that whole houses could stand within them, some toward the west, some toward the north. Like the others (about which more below) these are in such solid stone that one might assume that they had been carved out in the form of an arch with the expenditure of great labor. Beyond these cavities or arches there are more and more cavities toward the west and north, although one must often crawl through narrow holes in order to get from one into the other. If one has walked and crawled along for many hundreds of paces in the cave, he comes upon a sharp stone between two cliffs called the "Horse," over which one must slide and then even lower himself with ropes at times. It is not until then that one gets into the passages in which the bones (more about these later) have been found and large piles or columns of nothing but drip-stone are encountered.

By the very nature of things no daylight can get into this subterranean place, as is the case with all such caves, it is constantly filled with mists and fogs and in addition water is always dripping down from above. To top it all off, this place is quite renowned because of the ghosts that are to be found in it. Thus, there are usually a good many people who want to see the place. They provide themselves with a number of torches or lights, as well as one or two tinderboxes, so that when the lights are extinguished by the thick mists or ghosts they can be lighted again. When they do not have a guide who knows the caverns well, these people also use the device learned by Theseus from Ariadne and used in the Labyrinth. They tie a cord to the place where they walk or crawl in, so that they can find their way out again; notably when their way is lost in one of the innumerable passages and it is impossible to find the way out. Examples of this difficulty are to be found in the case of the dead bodies or skeletons that have been found there. People thus lost would have to remain in there, die and decay.

There is no person, however, who could say that he knew an end to these innumerable, eerie passages, although there have been many people (some of whom were local people with a knowledge of mining) who spent several days in them and offered a number of proofs that they nearly reached, under the earth, the vicinity of the Free Imperial City of Goslar, which is four long German miles [about 20 miles] from the entrance of this cave.

Copper engravings accompanying the description of Baumann's Cave in Merian's "Topographia" (1654). Above: locale of cave. Buildings labeled A are the iron-works. Cave entrance is marked C. Brocken, highest mountain in central Germany, is marked F. Original size is 347 x 231 mm.

Some people who have gone quite a way into this cave report that they have heard a very large stream roaring as if a big river were falling from a high cliff. Many also claim that they were chased around by various ghosts for a long time and finally came across strong, locked iron chests of unbelievable size that were guarded by fierce dogs. We shall have to take all of these claims with a grain of salt, however, no matter what their intent, because these things are illusions of the Evil One.

This much is certain and can be attested by reliable people: About 65 years ago a young, strong cowboy from the Harz region dared to go in alone, and because he lost his way and his lights went out, spent all of eight days there with great terror and anxiety until he finally got out by God's special, palpable providence. Thereafter he lived to a ripe old age, but during that time he became as pale as ice and was terrorized beyond all measure by the ghosts, inasmuch as he was seized by a few of them, accused of being a thief, condemned to the gallows, led to them and a noose placed around his neck. Scarcely had he eluded these when he fell into the hands of another party of them, by whom he was condemned to death as a murderer, and so on by many others and in many ways was tormented and terrorized to the extreme.[5].

Above: The entrance to Braumann's Cave overlooking the Bode River. The cut below shows several men exploring the cave with torches. One of the two men shown in the background is sliding over the "Horse." Original size: 173 x 135 and 171 x 139 mm.

Besides the marvelous structure of this amazing cave, for which nobody has yet been able to offer a plausible explanation, there are a number of other remarkable things in it. There is, notably, a small spring with very clear water right in the first passage. This water is used daily, not without effect, by many people for the pains of kidney stones. If this water is kept in a glass, it keeps for one or more years free of all corruptions, and not the slightest amount of foul matter is to be found in it. Furthermore, as already mentioned, the water in the cave is constantly falling down from above in drops. Thus such drops hang on the stones like icicles. These long, thin stones are of an entirely white color and, being prized, are brought out in large quantity, sold, pulverized and strewn into the wounds of injured cattle with great effect. In addition, a great quantity of all sorts of bones and bonelets, often nearly decayed, and from unknown animals, is found beyond the "Horse" in nearly all passages. These are offered to the common people as unicorn [bones]. Among such bones, teeth are often found of an incredible size, such as three that were brought out some years ago, of which one was more than three times as big as a horse's tooth. From this we may easily assume that huge animals used such teeth. Likewise, a complete skeleton of a human being of unbelievable size was found some years ago."

LITERATURE CITED AND NOTES

1Pp. 31-33.

2Anton Lübke: "*Geheimnisse des Unterirdischen.*" Bonn, 1953. P. 183. In passing we may note that this recent general work on speleology covers almost every phase of the science. It has over 130 valuable illustrations and is a good source of information about caves not only in Europe, but in other parts of the world.

3Translation mine.

4Approximately: Divine power plays a role in human affairs.

5Of course, all of this would not have happened to him if he had been following the basic safety rules of the N.S.S. and not have gone in alone!

Seven Principles of Effective Expedition Organization

By PHILIP M. SMITH

From other fields of exploration—mountain climbing, undersea research, polar expeditions — we can learn organizational techniques directly applicable to speleological exploration. Cooperative leadership with a simplified organizational structure is recommended. Versatile men and equipment should be employed. Communications need refining, as well as personal standards of excellence in technique and comfort. The principles are a firm foundation for planning large or small trips underground.

WHAT DO WE DO NEXT?

We were seven miles from the historic entrance of Floyd Collins Crystal Cave. The trip was primarily a sight-seeing excursion. Many discoveries had been made during the year I had been in north Greenland, and I wanted to see some of the new features of the Flint Ridge System in south central Kentucky.

With me were Jim Dyer, also interested in seeing new vistas, and our guide Jack Lehrberger. As we walked along a main avenue, Jack suggested we divert our trip into an inviting side passage which left the main corridor, then rejoined it a few hundred yards ahead. Jack had recalled an unexplored lead in the cut-around.

On reaching the unexplored lead we stopped. Neither Jim nor I had explored much in the past year so we welcomed the rest. Jack, always in top physical condition, decided to explore for a few minutes in the new lead. He left. No arrangements were made as to whether we should follow.

Twenty minutes later Jim and I wrote a note stating we were going into the unexplored passage, then we plunged into the hole through which Jack had disappeared. It was simple to follow Jack's footprints until the passage forked; Jack's footprints went both ways! I followed the footprints leading to the right through a crawlway to a point where progress was blocked by a gravel fill.

Jim followed Jack's tracks to the left, to a point where fill came close to the ceiling, but where Jack had pushed on. Jim reported this, and as minutes passed we decided to return to the place where we had left the note. We felt Jack might well be there, since only an hour earlier all three of us had crawled through an unexplored lead and found ourselves back in the main passage.

Jack had not returned. What were we to do next? We knew Jack did not expect to be alone for long, nor was he prepared; we were not individually equipped for big cave exploration, although among us we had carbide for 36 hours and food. But Jack had no extra carbide. Both Jim and I knew Jack to be one of the most competent cavers we had ever met, but how long should we wait in one place for him? Should Jim and I divide forces?

As we were speculating, Jack emerged, to our relief. He reported a complex new series of pits and domes . . . a discovery of real significance.

PLANNING BASED ON LESSONS

This personal incident is worthy of mention not because of its uniqueness, but because of its universality in exploration carried out by spelunkers and speleologists everywhere. It is illustrative of the problems of trip organization, problems which are ever-present, yet rarely written about or discussed.

American speleology has made rapid advances within the last decade. Few of these advances have resulted from improving the *method* of exploring caves. The organization of cave trips is important for many reasons, some obvious, some more subtle. Overall effectiveness of the time spent in a cave is highly dependent on planning. Cave exploration is costly both in time and money. In several sections of the country the limits of the unknown have been pushed back to the point where major efforts are necessary for new discovery. Effective planning can make the individual hours within a cave more useful, reduce the time spent in support of a trip, yield more new discoveries or scientific data per dollar spent, and enable exploration teams to push farther into the large cave systems.

Organization problems are similar in every cave trip, be it a major expedition or a Saturday afternoon jaunt to a nearby mud crawl. Problems include the definition of the mission of the trip, the selections or recruiting of personnel, the selections of leaders, and a decision on the length of stay in the cave. Equipment, sometimes elaborate, is needed in caves. Food is necessary as an emergency ration or as regularly scheduled meals if the stay underground is long. Telephone or communications systems may be a valuable asset in conveying ideas and plans in a clear, concise way. Finally, all of the gasoline used in driving to the cave, the new rope and pitons for the unexplored lead at the top of the waterfall, the flash bulbs shot off on the photo survey, and the carbide in lamps must be paid for.

Such organizational considerations naturally are not limited to exploration underground. High-peak mountain climbing, undersea research, polar expeditions, and jungle exploration are all activities in which the success of the trip can be dependent on the effectiveness of the planning. In all fields of exploration there are many accounts of trips experiencing incomplete success because of improper organizational structure. Others have failed because equipment did not survive severe environmental conditions. Diet alone has been the downfall of expeditions, especially on the seas and in polar regions.

Much applicable to speleology can be learned from the successes and failures of others. The ship frozen in the polar sea is not like the geological party camped well within a cave, but the actions, experiences, and equipment of the floating "laboratory" can contribute suggestions for better management of scientific cave study. Nor is the climbing team within a few feet of a cloud-shrouded summit like a group of spelunkers making an assault on a network of unexplored passages, but the assault program of the climbers can yield new ideas useful in the methodical exploration of the underground.

Truth is stranger than fiction, but not all reported as truth is true. When read critically, however, the writings of explorers can contribute generalizations pertinent to speleological expeditions.

Ideas on organizational structure can come from our own cave exploring activities, from people in other fields, such as the military, or those in the field of educational theory. We frequently lose sight of the ideas around us, however, in our myriad work in grotto or chapter committees, regional organizations, and Society functions.

SEVEN PRINCIPLES

The writer has abstracted some of those principles which stand the test of exploration organization, in caving, and in other areas. None of them are new, but they are food for thought.

1. PERSONNEL ORGANIZATION, LEADERSHIP, AND COMMAND SHOULD BE COOPERATIVE, AND SHOULD RESULT FROM, RATHER THAN BE IMPOSED UPON, THE MISSION OF THE EXPEDITION. In speleology, little has been written on *how* the command structure should be evolved. In many cases organizational planning starts at the wrong time and place. A roster is made up, an arbitrary organizational structure is blueprinted, and people on the roster are "given jobs" according to the rigid plan. Their functions really may not be needed in the cave.

It is far better to analyze completely the goals sought within the cave, then plan accordingly. The adoption of a single pattern such as a military "chain of command" with leader, executive officer, and a multitude of "platoons" is rigid and not suited to most tasks underground. A cave master controlling the entry and exit of parties may be a person wasting a day. The logistics officer on a large trip may conceivably be a "fifth-wheel" without a full-time job. The best organizational structure is one that frees surface personnel for relatively more important underground work. Experimentation in organizational structure should be encouraged. The thinking of a year or a trip may not be adequate for another, slightly different situation.

The activity of speleology is self-imposed. Few are active in speleology who do not want to be active cave explorers. Likewise, direction of exploration should for the most part be self-imposed. The leader should be a resource person rather than a commander. His judgment is better devoted to decision making than administration. Most trips of any worth have their major decisions underground; an expedition leader tied to surface responsibilities is not making the major decisions of the trip.

Parties should rely on the trip leader for coordination and advice, not for specific direction. The minute-by-minute, foot-by-foot decisions of cave exploration are best arrived at through cooperative decisions involving the entire party.

2. Simplicity in all phases of trip organization is a goal to be sought after. Complexity in organization and equipment is a virtue only as it becomes necessary to the task at hand. Complexity and bigness themselves are indicative of no equal amount of effectiveness, and, too frequently success is judged by size instead of actual acomplishment. To report that 20 people entered a cave or that two miles of passages were "covered" are themselves no statements of accomplishment.

When planning a cave trip more critical evaluation of all aspects of the endeavor is possible when simplicity is used as a standard of measurement. It demands careful consideration of the real number of people needed, the employment of the best possible equipment, and the paring off of execesses which compound in logarithmic fashion to hinder maximum accomplishment within a cave.

3. Multi-purpose equipment is more desirable than specialized equipment where choice is possible. To reduce support problems, use equipment which accomplishes several ends. Camp management can be streamlined to the point that many more man-hours are available underground. Rigging devices, especially, can be reduced when equipment purchased or made can serve several functions in cave rigging.

Unfortunately, little multi-purpose equipment is available for speleological work. A great opportunity exists for individuals and chapters to invent and design such gear. Cave exploration needs better topside camping and messing equipment. Erector Set type rigging is entirely possible; made in modules, it could be used for climbing domes, crossing pits, and rigging drops. Better transport devices for cameras, food, carbide, water, and other supplies would facilitate underground travel.

4. Personnel skilled in several aspects of speleological work are greater assets than those capable of performing one or two jobs only. As multi-purpose equipment promotes effectiveness, the selection of versatile personnel is even more important. The explorer who can survey, calculate latitudes and departures, take documentary photographs, and make geological and biological observations is far more valuable than the person whose forte is exploring and little less.

In rapid exploration, such as is often done in areal surveys, a single party of persons skilled in several disciplines can accomplish more than separate exploration, surveying, and photo parties. Since there are no formal schools of speleology, the initiative is squarely on the explorer to develop skills and knowledge useful in underground work.

5. Effective communication is imperative in a successful exploration program. Nothing reduces total accomplishment, wastes more hours, confuses individual parties, and increases the potential seriousness of any accident, than poor communication. As the size or complexity of a cave increases, the difficulty in maintaining communication with the surface and other parties and individuals increases. The writer's recent experience, cited earlier, shows that even when a party is thoroughly acquainted with the problem of communication, it still may arrange ambiguous meeting places and times. We still fail to communicate with other parties, and what's worse, we may confuse other parties through unclear messages.

Improvement of communications comes through telephone systems, signal systems, written logs, notes and diaries. The greatest responsibility lies with the individual. Joe Lawrence, Jr., in discussing communications problems summarizes 10 rules which must be observed by explorers if effective communications are to exist.[1]

1. Write specific notes.
2. Identify yourself on notes and in phone calls.
3. Date all notes and include the time.
4. Name landmarks, such as passages and distinctive formations.
5. Summarize phone calls clearly in a log book.
6. Tell others in detail what you saw.

7. Make schematic maps to refresh your memory and to help others understand a new or unfamiliar area.

8. Share your thoughts, ideas, and problems with others; don't keep them to yourself.

9. Write a trip report or tape record one. Both are better than one.

10. Talk about the trip with others to share ideas and learn lessons.

6. THOROUGHNESS AND EXCELLENCE OF PERFORMANCE INCREASE THE TOTAL SUCCESS OF ANY EXPEDITION. Since speleology is an avocation we seldom consider it in terms of the greatest individual effort possible. On major expeditions, state or areal cave surveys, and any serious underground trip, high standards of performance are necessary. The crawlway pushed to its end leaves no doubt of large caves beyond. To turn around in such a crawl before the end is reached because one doesn't like to crawl does not typify the performance needed in serious exploration.

The ability to explore at a rapid pace with a minimum amount of rest, a desirable attribute, can be obtained only through self-training with a gradual increase of one's own physical endurance. A retentive mind which logs details that later form a comprehensive report does not become retentive without practice. Experience is necessary if a keen judgment or ability to size-up the better of several alternatives is to be developed. Like the acquisition of many speleological skills, the development of high standards of excellence is largely a matter of individual training and initiative.

7. PERSONAL COMFORT IS POSSIBLE WITHOUT SACRIFICING INDIVIDUAL PERFORMANCE AND THE ACCOMPLISHMENT OF THE TRIP'S MISSION. Generally, the greater the individual comfort, the greater the individual's ability to withstand environmental conditions that cause fatigue, hunger, and demoralization. The present age is one of technical exploration. There is little of the heroic or dramatic in withstanding hardships endured because of an "expedition" or "exploratory" attitude. Ascetic or philosophical experiences which might arise out of such heroics seem alien to the real nature of intelligent speleology. Any technique, garment, or equipment that makes the explorer's life easier should be employed so long as it does not increase organizational or logistical problems. Comfort does not mean that the explorer must be arrayed with gadgets. Comfort comes through the use of well-fitted clothing that retains heat, but is not too warm for strenuous activity; it comes through the choice of flashlights and water bottles that allow ease of movement in tight places; it comes through use of rations that are appetizing, yet produce more energy than the carrying of them consumes.

1. Joe Lawrence, Jr., "Some New Approaches to Speleology", a paper presented jointly by Joe Lawrence, Jr., Roger W. Brucker, Philip M. Smith and David B. Jones at the April 16, 1955 NSS Annual Meeting. Complete text available from NSS Library.

THINK ABOUT HOW YOU PLAN

These seven principles by no means exhaust the planning ideas applicable to speleological exploration. Principals such as these should, though, be the basis for planning both large and small cave trips. By using them, organizational problems, such as the approach to the assault on the unknown, time to be spent underground, the mission, selection of leaders—all can be simplified. The probable result is greater group harmony, greater group efficiency.

We need to think about how we go caving, then write down what we thought, what we did, and how the plans worked. References on planning are infrequent in speleological literature. Equipment study on a local and national level should be increased rapidly and in many directions. No satisfactory diet for the man underground has come to this writer's attention.

Research on food would produce a notable addition to present studies of organization and equipment. Such thinking and activity is needed if we are to survey thoroughly the unknown existing today. Research, experimentation, and planning need not reduce the pleasures obtained from spelunking and speleology, nor will more effectively organized trips become dull and business-like.

Consideration of these problems and the discovery of useful solutions should make for greater enjoyment of the weekend cave trip, the routine of the state cave survey, and the major expedition.

"After-Glow" of Cave Calcite

By **BRIAN J. O'BRIEN**

Photographers of cave formations swear by it, others who visit caves may have detected it. The manifestation is "after-glow", here examined by the author in a short treatment. While pure calcite does not emit after-glow, impurities present in cave calcite may well cause a red or blue light emission after a light is extinguished. Reports of after-glow have appeared in the NEWS *on several occasions and in various grotto publications.*

For some years, cave photographers have come forth from their activities bringing tales of crystal formations which glowed brightly for several seconds after irradiation from a flash-bulb or powder (1). Doubt has often been expressed that this effect is anything but an after-effect of the bright flash on the retina of the observer.

A number of calcite samples were procured by the author from various parts of Jenolan and Cliefden Caves in Australia. These were inspected under ultra-violet lights, and the existence of an "after-glow" established beyond doubt for several specimens.

The crystals were scanned by a shuttered photomultiplier (R.C.A. type 1P21) which was used to trigger a Tektronix oscilloscope. The decay of the light pulse when irradiation ceased was then clearly seen on the oscilloscope screen, and found to drop to one-third of its initial strength in one-quarter of a second. The logarithmic response of the human eye results in the glow being clearly visible for two to five seconds.

The luminescence under 2537 A° irradiation was generally blue-green, but one sample glowed orange-red. The strength of the after-glow varied greatly from specimen to specimen, and two samples from the Temple of Baal at Jenolan gave no visually detectable glow. The strongest glow came from a single clear crystal of about 20 cc. which was found at Cliefden.

A spectroscopic analysis of this crystal was made to a sensitivity of better than one part per million, and the result was rather overwhelming. Traces of the following elements were found: manganese, iron, silver, copper, aluminum, strontium, barium, magnesium, potassium, sodium and silicon, with a faint trace of lithium. The manganese was present in appreciable quantities, but no quantitative measurements have been made as yet.

THE LUMINESCENT PROCESS AND "AFTER-GLOW"

If one follows the conventional concept of an atom as a central nucleus surrounded by orbital or planetary electrons, one may see that an electron may accept the energy of an ultra-violet photon and jump into another orbit. Then, after a certain time, it will return to its initial orbit, giving out a flash of "visible" light as it does so. The electron may take some time to make the second jump, and thus one sees an "after-glow" made up of myriad flashes from the millions of electrons involved. The quality of the two energy transfers depends on the atomic lattice and set-up of the substance, and in some cases it is necessary for an extraneous atom (an impurity) to be present before the jumps can take place.

It has been shown (2) that pure calcite shows no luminescence. However, the judicious addition of certain impurities—lead, thallium, cerium and manganese have been reported—to the pre-crystalline solution to the order of a fraction of a per cent concentration, results in luminescence upon radiation by 2537 A° ultra-violet (3). (In cave deposits, such addition can take place as the ground-water wends its way downwards.) It appears that the addition of manganese alone will not result in a strongly luminescent crystal, and a second or even a third impurity is necessary.

CONCLUSION

Small concentrations of manganese, in association with one or more of the listed elements, will result in phosphorescent calcite crystals. The luminescence may be blue or red, and an "after-glow" will be visible, in general, for a few seconds after irradiation ceases. The requisite impurities are far from rare in natural deposits, and the "after-glow" phenomenon is perhaps not so rare as formerly thought, but it may be of greatly varying intensity.

ACKNOWLEDGMENT

The author desires to acknowledge the assistance of Mr. Chris Wallace in a portion of the above investigation.

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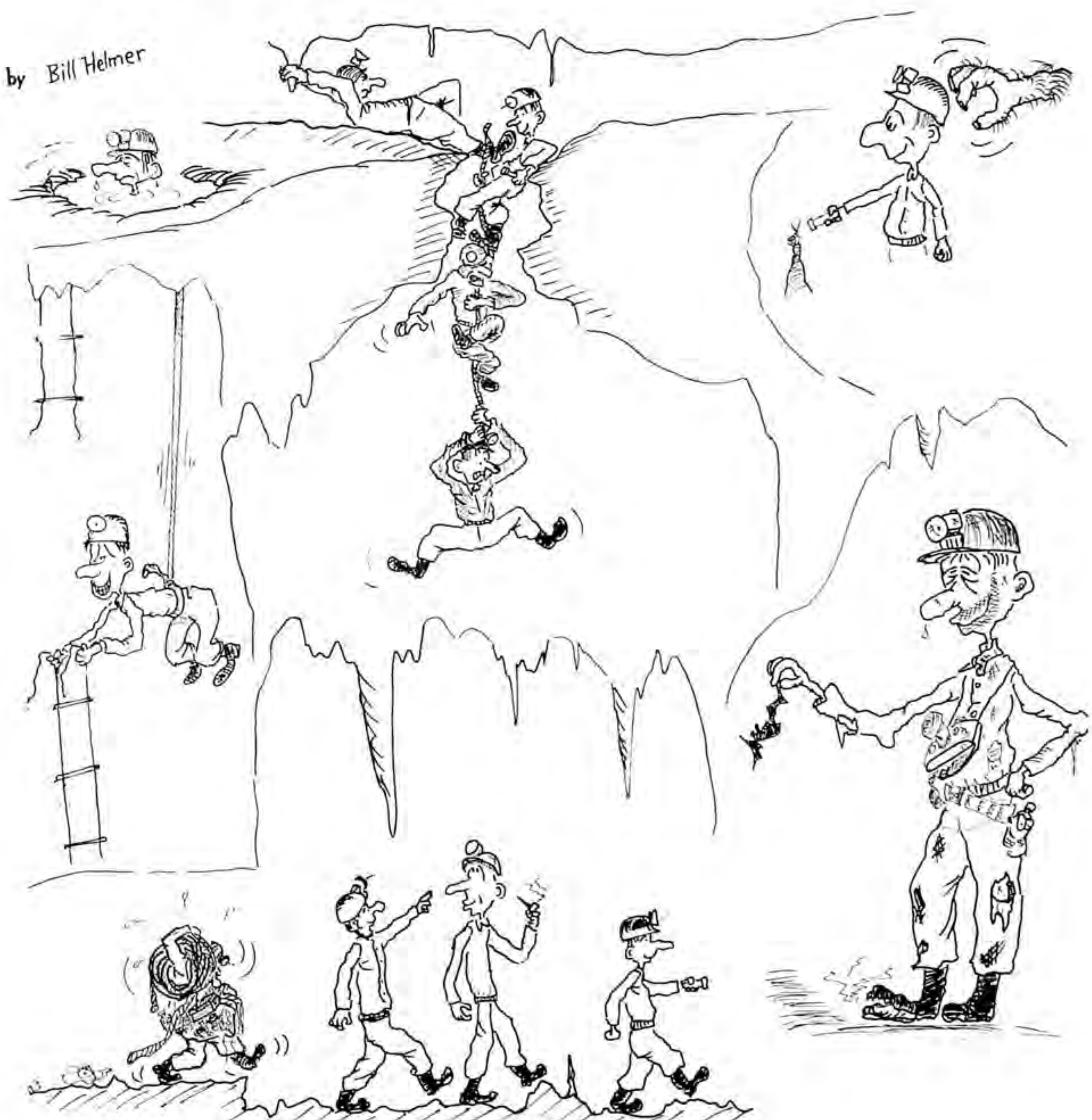
[2]H. Leverenz: "*Luminescence of Solids*", p. 340 (1950). Wiley & Sons, N. Y.

[3]J. H. Schulman et al. Jour. Appl. Phys. *18*, p. 732 (1947).

Underground Man



SPELEOLOGICAL SOCIETIES OUTSIDE THE UNITED STATES

Compiled by BURTON S. FAUST

This compilation is the result of the expenditure of much time and energy, over a period of four years. Every available source of information was used in its preparation – foreign speleological publications; personal correspondence with friends in many far-flung sections of the world, some of whom furnished complete lists of societies in their native lands; and much personally communicated information from other sources. The master list is being maintained in a card file and corrections are kept as current as possible. While an effort has been made to produce a correct and complete directory, it is inevitable that errors appear because of the time lag in receiving information from far places. Errors or omissions should be brought to the attention of the compiler.

AFRICA

1. South African Speleological Association, Cape Section,
P.O. Box 3538, Cape Town,
Stuart Macpherson, Secretary.
2. South African Speleological Association, Transvaal Section,
P.O. Box 413, Springs, Transvaal,
David Crabtree, Secretary.

AUSTRALIA

3. Sydney University Speleological Society,
Box 35, The Union, Sydney University, Sydney,
H. Fairlie-Cunninghame, President.

AUSTRIA

4. Verband Osterreichischer Hohlenforscher,
39, Neulinggasse, Vienna III,
Hans Salzer, President.
5. Landesverein fur Hohlenkunde, Ausserland,
20, Fischerndorf, Altaussee, Steirmark,
John Gaisberger, President.
6. Landesverein fur Hohlenkunde, Ebensee, Upper Austria.
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7. Landesverein fur Hohlenkunde, Hallstatt,
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10. Spelaeologoisches Institut, Bundesdenkmalamt, Schweitzerhof,
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11. Landesverein fur Hohlenkunde, Salzburg,
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Gustav Abel, President.
12. Landesverein fur Hohlenkunde, Sierning,
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13. Landesverein fur Hohlenkunde, Styria,
26, Lagergasse, Graz, Steirmark,
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14. Landesverein fur Hohlenkunde, Tirol,
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15. Landesverein fur Hohlenkunde, Trofaich,
Trofaich, Gasthaus, Schnuderl, Steirmark,
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16. Landesverein fur Hohlenkunde, Ober Osterreich,
17, Hopfengasse, Linz,
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Hans Siegl, President,
(6A Goethestrasse).
17. Landesverein fur Hohlenkunde, Weil,
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BELGIUM

18. Ajistes "Cavernicoles",
Maison des Jeunes,
14, Rue de la Paille, Brussels,
A. G. Monmart, Secretary.
19. Cercle Speleologique des Etudiants Gembloutois,
7, Rue Ernotte, Namur,
Michel Drion, Secretary.
20. "Les Lombrics" de Bruxelles,
99, Rue Vonck, Schaerbeek-Brussels,
Roger Dethoor, Secretary.
21. Cercle de Speleologie de L'Ecole, Abbatiale de Maredsous,
Ecole Abbatiale de Maredsous, par Maredret,
Guy de Bethune, Secretary.
22. Cercle de Speleologie de l'Universite de Bruxelles,
68, Avenue de la Toison d'Or, Brussels,
Jean-Pierre Genon, Secretary.
23. Equipe Speleologique "Colonel la Pantoufle".
20, Boulevard Montefiore, Liege,
R. Daumery, Secretary.
24. Equipe Speleologique "Norbert Castaret",
380, Rue St. Gilles, Liege,
Maurice Paquay, Secretary.
25. Federation Speleologique de Belgique,
Belgique, Abbaye de Maredsous, Par Maredvet, Belgique.
37, Rue Darchis, Liege,
M. P. G. Liegeois, President.
26. Les "Nutons" de Soignies,
127, Chaussee de Neufville, Soignies,
O. Tart, Secretary.
27. Les "Cyclopes" de Seraing,
13, Rue Papillon, Seraing,
Gur Danel, Secretary.
28. Groupe Speleologique de Charleroi,
7, Chaussee de Philippeville, Loverval,
Mme. Y. Brixhe, President.
29. Les Amis de le Nature, Section de Verviers,
40, Rue de la Nouvelle Montagne, Verviers,
H. Courtois, Leader.
30. Les Naturalistes Belges, Section de Nivilles,
6, Rue de Fontaine l'Eveque, Loupoigne par Genappe.
31. Speleo-Club de l'Olifant, a Bruxelles,
74, Rue de Rotterdam, Brussels,
Edgard Clotuche, President.
32. Societe anonyme des Grottoes de Han et de Rochefort,
Chateau de et a Denee,
Jules de Montpellier, President and Director.
33. Societe de Reserches et d'Exploitations souterraines de Dinant,
Joseph Deloge, Explosifs, Merlemont.
34. Societe "Les Naturalistes Verviétois",
49, Rue P. Limbourg, Verviers,
L. Renard, Secretary.

35. Section Speleologique des Boy-Scouts et Girl-Guides de Belgique, 106, Rue A. Lambiotte, Schaerbeek, Brussels,
A. Slagmolen, Secretary.

36. Centre de Recherches de la Region Condruzienne,
82, Rue de l'Enseignement, Brussels,
Roger Guldentops, Secretary.

37. Club Scientifique de Liege,
26, Rue V. Lallemand, Grivignee,
Marcel Hotterbex, Secretary.

38. Societe "Ardenne et Gaume",
28, Avenue de la Tenderie, Boitsfort, Brussels,
R. Mayne, President.

39. Societe des Naturalistes Namur-Luxembourg, College N.D. de la Paix,
59, Rue de Bruxelles, Namur,
Robert Dendal, Secretary.

40. Societe Royale d'Etudes geologiques et archeologiques, "Les Chercheurs de la Wallonie",
14, Place J. Willem, Chene, Liege,
J. Fraipont, Secretary.

41. Societe Speleologique de Namur,
10, Rue des Carrieres, Namur,
Marcel Collignon, Secretary.

42. Speleo-Club de Belgique, a Bruxelles,
31, Avenue Maurice, Brussels,
Didier de Bournoville, Secretary.

43. Societe Speleologique de Belgique,
Abbaye de Maredsous,

CUBA

44. Sociedad Espeleologica de Cuba,
28 No 308, Vedado, Havana,
Kenneth A. Symington, President.

CZECHOSLOVAKIA

45. Ceskoslovenske Spolecnosti Zemepisne,
Albertov 6, Prague II.

EQUADOR

46. Sociedad Espeleologica Nacional,
Cuenca,
J. Alfonso Silve A. Director.

ENGLAND

47. Axbridge Caving Group and Archeological Society,
Apple Garth, Rickford, Burrington near Bristol,
W. W. Ashworth, Secretary.

48. Beecham Cliff Speleological Society,
4 Kensington View, Upper East Hayes, Bath, Somerset.

49. Birmingham Cave and Crag Club,
37 Queenswood Road, Mosley,
Birmingham 13,
J. L. Williams, Secretary.

50. Bradford Pot-Hole Club,
12 Granville Street, Clayton,
Bradford, Yorks,
B. Hainsworth, Secretary.

51. Bradford Technical College Caving Group,
Technical College, Bradford, Yorks,
D. Newell, Secretary.

52. Bristol Exploration Club,
51 Ponsford Road, Knoele,
Bristol 4,
R. J. Bagshaw, Secretary.

53. British Speleological Association,
Duke Street, Settle, Yorkshire,
E. Simpson, Recorder.

54. Burnley Caving Club,
222 Manchester Road, Burnley,
Lancaster,
R. Morris, Chairman.

55. Cambridge University Caving Club,
Trinity College, Cambridge,
F. Dyson, Secretary.

56. Cave and Crag Club,
29 Beacon Road, Wylde Green,
Sutton Coldfield, Warwichshire.

57. Cave Diving Group,
6 Temple Gardens, London
N.W. 11,
G. Balcome, Secretary.

58. Cave Diving Group, South Wales,
97 Park Road, Staple Hill, Bristol.

59. Cave Diving Group, Geology Section, University College,
Leicester,
T. D. Ford, Director.

59A. Cave Diving Group (Derbyshire Group),
19 Adelaide Road, Sheffield 7,

59B. Cave Diving Group (Somerset),
Leigh House, Nemphett,
Chew Stoke, Near Bristol,
J. W. Ifold, Secretary.

60. Cave Preservation Society,
Sutcliffe House, Giggleswick,
Yorkshire,
R. D. Leakey, Secretary.

61. Cave Research Group of Great Britain,
Seaton House, Scrublands Road,
Burkhamsted, Hertfordshire,
E. A. Glennie, Secretary.

62. City Museum,
Director, City Museum,
Queens Road, Bristol 8.

63. Craven Pot-Hole Club,
19, Castle Road, Keighley,
Yorkshire,
L. Crunden, Secretary.

64. Derbyshire Pennine Club,
427, Whirlowale Road,
Sheffield 11,
J. R. Hastings, Secretary.

65. Derbyshire Speleological Group,
43 Wilstrop Road, Sheffield 9,
Miss T. Rains, Secretary.

66. Devon Speleological Society,
Torrels, 9 Oakland Road, Meber,
Newton Abbot, Devonshire.

67. Hereford Caving Club,
44 Chandon Street, Hereford,
L. A. Taylor, Secretary.

68. Durham Cave Club,
Y.H.A. Hostel, St. John's Hall,
Wolsingham, Co. Durham,
R. T. Hyalton, Secretary.

69. University of London,
The Secretary, Institute of Archeology,
Inner Circle, Regents Park,
London N.W. 1.

70. Lancashire Caving and Climbing Club,
82, Red Lane, Breightmet,
Bolton, Lancashire.

71. Leicester University Speleological Society,
University College, Leicester,
D. M. Fidler, Secretary.

72. Liverpool Caving Club,
Borrowdale Road, Liverpool 15,
A. C. Sanderson, President.

73. London Speleological Group,
4, Gladwell Road, N.8.

74. Martel Caving Club,
122 Relford Road, Sheffield 9,
A. L. Pill, Secretary.

75. Matlock Bath Speleological Group,
The Bungalow, High Tor, Matlock, Derbyshire,
J. Roberts, Secretary.

76. Mendip Caving Club,
88, Cawdor Crescent, Boston Manor, London W.7,
M. Cotter, Secretary.

77. Mendip Nature Research Committee,
Apple Garth, Rickford, Burrington near Bristol,
H. H. W. Ashworth, Secretary.

78. Moorland Ramblers Club,
28, Melville Road, Kearsley,
Farnworth, Lancaster,
J. Shevelan, Secretary.

79. Morecambe Rock Climbers and Potholing Club,
Back Lodge, Hawksheads,
Bolton-le-Sands,
Carnsforth, Lancaster.

80. Northern Pennine Club,
Crow Nest Cottege, Austwick via Lancaster,
R. Ashworth, Secretary.

81. The Northern Speleological Group,
Malharm Tarn Field Center,
Malham, Yorkshire,
F. Whalley, Secretary.

82. Nottingham University, Mountaineering Club,
Nottingham University, Nottinghamshire.

83. Odin Exploration Club,
26, Anthony Drive, Alverston,
Derbyshire.

84. Operation Mole Speleological Society,
Hawthorne Villas, Monk Street, Tutbury, Staffordshire,
D. A. Nash, Secretary.

85. Orpheus Caving Club,
32, Chapel Street, Borrowash, Derbyshire,
J. E. Plows, Secretary.

86. Peakland Archeological Society,
2, Avondale Road, Edgeley, Stockport, Cheshire.
N. Davenport, Secretary.

87. Peakland Speleological Society,
Department of Geography,
341 Bristol Road,
Birmingham 5,
G. T. Warwick, Secretary.

88. Red Rose Cave and Potholing Club,
7, Prinects Avenue, Ashton Road, Lancaster,
W. Taylor, Secretary.

89. Red Rose Pothole Club,
9, Summersgill Road, Lancaster,
R. A. Bliss, Secretary.

90. Royal Air Force College Society, Pot-Holing Section.
R.A.F. College, Cranwell, Lincolnshire.

91. Rushop Explorers Club.
4, Brooklyn Ave., Manchester 16,
D. D. Hilton, Secretary.

92. Sheffield University Mountaineering Club, Caving Section,
The Union, The University, Sheffield 3.

93. Shepton Mallet Cave Club,
18, Brown's Close, Evercreech, Somerset,
R. C. Cave, Secretary.

94. Sidcot Speleological Society,
Sidcot School, Winscombe, North Bristol.

95. The South Town Caving Club,
Clifton College, Bristol 8.

96. South Wales Caving Club,
157, Commercial Road, Newport, Monmouth, South Wales,
P. I. W. Harvey, Secretary.

97. The Speleological Society,
University College, University Road, Leicester.
D. M. Fidler, Secretary.

98. Stockport Pot-Holers and Climbers Club,
8, Palmer View, Alpine Road, Stockport, Cheshire,
B. Chandler, Secretary.

99. Stoke-on-Trent Pot-Hole Club,
Chase Lane, Tittensor, Stoke-on-Trent,
A. B. Malkin, Secretary.

100. University of Bristol Speleological Society,
University of Bristol, Queens Road, Bristol 8,
D. A. S. Robertson, Secretary.

101. Wessex Cave Club,
22, Wolseley Road, Bishopton, Bristol 8,
Frank Frost, Secretary.

102. Wessex Cave Club, London Group,
92, Station Crescent, Ashford, Middlesex,
Winifred Hooper, Secretary.

103. Westminster Speleological Group,
392, Victoria Road, Ruislip, Middlesex,
N. Brooks, Secretary.

104. Yorkshire Ramblers Club,
42, York Place, Leeds 1,
F. S. Booth, Secretary.

FRANCE

105. Association des Excursionnistes Provencaux, Siege,
52, Cours Mirebeau, Aix-en-Provence,
M. Jean Hartmann, Leader.

106. Association Speleologique de l'Est.
Rue du Moulin, des Pres a Vesoul, Haute-Saone,
M. Pelletier, President.

107. Du Centre de Recherches Speleologiques,
6 allee Claude Dumond, Caluire, Rhone,
M. Corbel, General Secretary.

108. Club Alpine Francais, Commission de Speleologie,
7 Rue de la Boitie, Paris 8e,

109. Comite Scientifique de Club Alpin Francaise,
7 Rue de la Boitie, Paris 8e,

110. Commission de Speleologie de l'Association des excursionnistes provencaux,
30, Rue des Cordeliers, Aix en Provence, Bouches-du-Rhone,
M. Bruni, President.

111. Comite National de Speleologie,
44, Rue de Chateaudun,
Paris 9eme,
Guy de Lavaur, Secretary.

112. Groupe Cevenol de Speleologie, de la Societe Speleologique de France,
8, Rue Magnol, Montpellier, Herault,
M.du Cailar, President.

113. Groupe de le Section des Causses et Cevennes du Club Alpin Francais,
7 bis Rue de Strasbourg,
Millau, Aveyron,
M. Rouire, President.

114. Groupe Prehistorique de la Haute-Saone,
14, Place de la Republique, Vesoul,
M. Humbert, President.

115. Groupe Speleologique d'Art,
Ecole Municipale,
Boulevard Pelletier, Apt., Vaucluse,
M. Fady, President.

116. Du Groupe Speleologique de Bourg,
10, Rue Charls Robin, Bourg,
M. Chantelat, President.

117. Du Speleo-Club de Dijon,
56, Rue Varmarie, Cote-d'Or, Dijon,
M. Beuillot, President.

118. Groupe Speleologique de Langeais, Ganges, Herault.

119. Groupe Speleologique de Roquecourbe,
Roquecourbe, Tarn,
M. Magne, President.

120 Groupe Speleologique de Valance,
23, Rue de Mulhouse, Valance, Drome,
M. Ageron, President.

121. Societe Speleologique de France,
69, Rue de la Victoire, Paris 9e,
R. DeJoly, President.

122. Groupe Speleologique des Ardennes,
26, Rue Baue, Montey-St.-Pierre, Ardennes,
Jacques Tisserant, Secretary.

123. Laboratoire d'Hydrologie,
Faculte des Sciences,
1, Rue Victor Cousin, Paris 50,
M. Bardet, Director.

124. Section des Causses du Club Cevenol,
2, Rue de Laumiere, Rodez, Aveyron,
M. Balsan, President.

125. La Societe Meridionale de Speleologie et de Prehistoire,
Toulouse, Haute-Garonne,
M. Meroc, Prof. de Prehistorie, Faculte des Lettres, President.

126. La Societe Speleologique d'Avignon,
18, Rue d'Amphoux, Avignon, Vaucluse,
M. Lenain, President.

127. Speleo–Club de Perigeux,
102, Rue Louis Blanc, Perigeus, Dordogne.

128. Speleo–Club de Touraine,
49, Rue Louis Braille, Tours.

129. Union Francaise de Speleologie,
1, Rue des Feuillants, 1e, Marseille,
M. S. Dujardin-Weber, President.

GERMANY

130. Deutsche Gesells fur Karstforschung,
13a, Nurnburg, Gewerbemusumplatz 4, U. S. zone.

GREECE

131. Hellenic Alpine Club—Athens Section,
2a, Botassi Street, Athens,
Peter Brussalis, President.

132. Societe Speleologique de Grece,
27r, Tsakalos, Athens,
G. Grafios, Secretary.

ITALY

133. Circolo Speleologico Campano, Via Macedonia Melloni 94, Napoli, Alfonso Piciocchi, President.

134. Circolo Speleologico Romano, Via Ulisse Aldrovandi N. 18, Rome, Aldo G. Segre, Secretary.

135. Club Alpino Italiano, Genoa.

136. Club Martel, Groupe Speleologique Societe Speleologique de France, de la Cote d'Azur, Lycee de Garcons, Avenue Felix Faure, Nice, M. Vigeron, President.

137. Gruppo Grotte Milano, Via Fabio Filzi 45, Milan, A. Cigna, President.

138. Gruppo Speleologico Ligure "Arturo Issel", Museo Civico di Storia Naturale "G. Doria", Via Grigata Liguria 9, Genoa, Ing. E. E. Codde, President.

139. Gruppo Speleologico Marchigiano, Via Marsala 12, Ancona, C. Pegorari, Secretary.

140. Ricerche sulla Morfologia e Idregrafia Carsica, Centro di Studi per la Geografia Fisica, Istituto di Geografia, L'Universita di Studi, Bologna.

141. Servizio Geologico d'Italia, Largo S. Susanna 13, Rome.

142. Societa Alpina delle Giulie, Via Milano 3, Trieste, Stelio Quarantotto, Librarian.

143. Del Touring Club Italiano, Corso Italia 10, Milan.

MARTINIQUE

144. Groupe Speleologique de Antilles, Fort de France.

MOROCCO

145. Societe Speleologique de Maroc, c/o de l'Aviation Francais, Casablanca.

NEW ZEALAND

146. New Zealand Speleological Society, 38 Harlston Road, Mt. Albert S.W. 2, Auckland, Henry G. Lambert, President.

PERU

147. Sociedad Espeleologica del Peru, Cuzco, Miguel Sumar Pacha, Director.

PORTUGAL

148. Do grupo espeloelogico de Associacao dos Estudantes, da Faculdada de Ciencias de Lisbon, Ave. Duque de Loule 50-10, Lisbon, Jaime Martins Ferreira, Leader.

ROMANIA

149. Institute de Speleologie, University din Cluj, Casuta Postala Nu. 158, 501 Cluj, P. Chappuis, President.

SPAIN

150. Grupo d'Exploraciones Subterraneas del Club Montanes Barcelones, Sociedad de Ciencias Naturales, Plaze Real 3 - 1°, Barcelona, Antonio Fite Fissas, Secretary.

151. Instituto de Geologia, Facultad de Ciencias, Universidad de Oviedo, Oviedo, N. Llopis Llado, Secretary.

SWITZERLAND

152. Societe Suisse de Speleologie, Comite Central, Sion.

153. Societe Suisse de Speleologie, Geneva Section, 14 Rue de l'Arquebuse, Geneva.

TASMANIA

154. Tasmanian Caverneering Club, 18 Elizabeth Street, Hobart, K. S. Iredale, Secretary.

VENEZUELA

155. Speleological Section of the Venzuelan Society of Natural Sciences. Caracas.

YUGOSLAVIA

156. Institut za Raxiskovanje Krasa, S.A.Z.U., Postojna.

WHO'S WHO IN BULLETIN EIGHTEEN . . .

BRIAN J. O'BRIEN has caved for six of his 22 years in his native Australia. After receiving his B.S. from the University of Sidney in 1953, he began working for his Ph.D. in nuclear physics at the same institution. He has explored caves in New South Wales, especially in the Yarrangobilly mountain region. One of his studies was on the occurrence of "foul air" and its effect on speleologists in the caves at Bungonia, N.S.W. He has also investigated the subject of radio transmission in caves. He is a past president of the Sydney University Speleological Society, and is currently editor of their *Journal*. He organized the initial meeting of the Australian Speleological Federation at Christmastime, 1956. Other interests are poetry and music, and his main hobby is "going bush".

DANIEL BLOXSOM, JR., an engineer, became interested in speleology in 1952 when he moved to Tullahoma, Tennessee, in the heart of the middle Tennessee cave region. He was a charter member of the Cumberland Grotto, serving as secretary and editor of the "Troglodyte" in the group's first year. He was born in 1929 in Houston, Texas, and received his B.A. degree in physics from Rice Institute in that city. On graduating, he joined the Arnold Engineering Development Center at Tullahoma as an engineer. He has contributed articles on cave subjects to the NSS News frequently, and has lectured at several annual meetings of the Society. He married Ann Deming of Houston in 1951. His primary interests in speleology center around exploration of new caverns and developing the techniques for efficient exploration and mapping.

ALFRED W. H. BÖGLI, of Hitzkirch, Luzerne, Switzerland, was born in 1912, and has published widely on speleological subjects in continental journals. A geomorphologist by training, he is an instructor in geography in the Hitzkirch Teachers College. Under his leadership various work groups have been established to further the scientific study of Höloch Cave. He is co-founder of the Swiss Geomorphological Society. He is an accomplished photographer in both black and white and color, as well as an experienced, all-around cave explorer. Dr. Bögli has a warm feeling for the growing exchange of speleological information internationally; his article marks his first publication in English. Having been trapped by high water inside Höloch Cave, he knows well the dangers involved in large-cave exploration, as well as the satisfaction that comes with mapping a cave larger than any other now known.

LEROY W. FOOTE, Middlebury, Connecticut, resents the fact that New England was short-changed in caves, since he is an ardent spelunker. He joined the NSS in 1942, becoming the Society's second treasurer. One of the earliest Life Members of the Society, he was instrumental in establishing the Endowment and Reserve Funds, and, with Clay Perry, reorganized the New England Grotto in 1946. His wife and three children share his enthusiasm for the underground. He is a banker and an amateur mineralogist. From his home in the heart of the Leatherman country he has ranged out to interview old residents who remember this colorful figure, and has visited many of the itinerant's caves. His slide lectures have made him a widely recognized authority on the Leatherman in Connecticut and nearby states.

ROBERT GIVEN, born in 1932 in Los Angeles, received his A.B. in Biological Sciences from Chico State College in California in 1953, one year before he joined the NSS. His first interest in caving came when he and two others visited the Modoc Lava Beds of northern California in search of an extremely rare ice-dwelling insect, the *Grylloblattid*. The lure of lava caves has since drawn him back many times. His present plans call for entering the University of California at Los Angeles to complete a M.S. in Zoology. In addition to cave exploring, he has been spearfishing and aqua-lung diving for several years; he takes movies underwater. He looks forward to more search in the Eagle Lake area, the setting of his current article.

WILLIAM J. (BILL) HELMER is vice-chairman of the University of Texas Speleological Society and a grotto representative to the Texas region of the NSS. He has been caving with the UT Grotto for three years, with primary interests in photography and mapping. He is a native of Iowa City, where he was born in 1936, but soon moved to Olympia, Washington. He became a Texan in 1945; his present home is in the town of Donna, on the Mexican border. At the University of Texas he is a junior majoring in physics, and after classes he is employed as a photographer by the Defense Research Laboratory. He is a "ham" radio operator (W5AJR), and, logically enough, a cartoonist for the "Texas Caver".

JOHN H. D. HOOPER, like Trevor Shaw, is no stranger to these pages, having authored "The Kuh-I-Shuh Caves" in NSS *Bulletin Fourteen*. A native of England, he lives in Ashford, Middlesex, and is with the Anglo-Iranian Oil Company. He received his education from London University, graduating with honors in 1938, after majoring in oil chemistry. His cave exploring has taken him to many caves on the continent, as well as Eire, Great Britain, and Iran. In the Devonshire area he has helped to discover new caves; both he and his wife are active in the Devon Speleological Society. Late in 1956 the pair became a trio as daughter Alison arrived. They have high hopes she will carry on the family tradition.

CORD H. LINK, JR. was born in Chattanooga, Tennessee in 1923. He was educated at the University of Chattanooga where he obtained his B.S. in physics in 1950. He went on to do graduate work at Johns Hopkins University. He is employed as a staff engineer at the Arnold Engineering Development Center, Tullahoma, Tennessee. He has served variously as chairman, secretary, and treasurer of the Cumberland Grotto, and as editor and contributor to the "Troglodyte". In close association with Daniel Bloxsom, he explores Tennessee caves. Cord Link is an artist in his own right, as the drawings accompanying Daniel Bloxsom's article indicate. In a future *Bulletin* his methods of prospecting for caves will be illustrated in an article dealing with caves in the area of Payne's Cove, Tennessee.

TREVOR SHAW, a Lieutenant in the Royal Navy, 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. He received further engineering training in Devonport, with sea duty in the West Indies and the Home Fleet. From 1950 to 1951 and from 1953 to 1954 he served on cruisers of the Mediterranean Fleet, where he explored caves in Malta and in Europe. The work on Gibraltar caves, described in his article, was done when he headed a special seven-man expedition flown out from England for the purpose. Lieut. Shaw has also done original work in England and Ireland. He is a member of the British Speleological Association, the Cave Research Group of Great Britain, and The NSS since 1948. His article "Caves of Malta" appeared in NSS *Bulletin Fourteen*.

PHILIP M. SMITH comes from Springfield, Ohio, where he was born in 1932. At Ohio State University he obtained his Bachelor and Master degrees in education. In 1952, with Roger McClure, he organized the Central Ohio Grotto and initiated the Ohio Cave Survey in conjunction with the Ohio Geological Survey. In the NSS he served as a member of the Board of Governors in 1955 and 1956, and was for three years chairman of the Conservation Committee. He was active in the Society's Crystal Cave expedition and in its Flint Ridge Project. From July 1955 to August 1956 he was a member of the Army's Transportation Arctic Group in north Greenland, working on oversnow transport, polar navigation, and crevasse detection. He logged some 2000 miles on the ice cap. At present he is on temporary duty with the Navy's Task Force 43, Deep Freeze II in the Antarctic. There he is navigator for a party establishing a tractor route from Little America II to Byrd Station, 600 miles inland.

CHARLES E. WEBER, a native of Cincinnati, was born in 1922. He was first introduced to caves by his father who took him, in a vintage 1929 car, to Mammoth Cave, a trip he vividly recalls today. His interest in caves lay dormant for many years until he took a teaching position at the University of Missouri. There he was urged by students to take part in cave trips, and soon became an active cave explorer in some of Missouri's best caves. He received his Ph.D. from the University of Cincinnati in 1954, writing his dissertation on the incumbula of the German language. From 1953 until this year he taught at the University of Missouri, and is now Assistant Professor of Modern Languages at the University of Tulsa, not too far from his beloved Ozark caves. He believes that much work needs to be done in the investigation of cave lore from previous centuries.

LOREN P. WOODS, Curator of Fishes, Chicago Museum of Natural History, was born in Poseyville, Indiana in 1913. He graduated from Earlham College in 1936 and took graduate work in Zoology at Northwestern University. He has spent summers as a naturalist for the Roosevelt Wildlife Foundation and as an assistant at the Friday Harbor Marine Laboratory, Washington. He married in 1937, and the following year joined the Chicago Natural History Museum staff as a Guide-lecturer, moving to Assistant Curator of Fishes in 1941. War interrupted, and he served as a Navy officer. From 1946 to 1948 he wrote a descriptive catalog of fishes collected by the Crossroads operation at Bikini for the U. S. National Museum. In 1947 he was appointed to his present position. He has taken part in four expeditions, two of them in Mexican waters. His chief interest is in fishes of tropical oceans, and his hobbies include gardening and the study of cave fish.

PREPARATION OF MANUSCRIPTS FOR PUBLICATION IN THE NSS BULLETIN

These suggestions are presented in order to minimize revisions and editorial corrections. Many points may seem arbitrary, but they are essential to uniformity in style and format. By cooperating in preparing your article you enable the editors to publish the greatest number of papers with the limited funds available.

STYLE. Review recent issues of the *Bulletin* to become familiar with its general style. Manuscripts should be neatly typewritten on 8½ x 11 inch paper with wide margins throughout. Double space every line, including titles, footnotes, quotations, tables, literature cited, and legends. Number pages consecutively. Type extensive quotations with slightly wider margins. Words and numbers to appear in italics should be underlined in the typed copy.

Allow a three-inch margin at the top of the first page above the title. Type the title in capital letters. Scientific names of organims in the title should be underlined. Author's name should be typed in capital letters below the title, followed by mailing address.

Main headings are to be typed in capital letters, centered and not followed by a period. Subheadings may be centered or located at the beginning of a paragraph. When a sub-heading apears at the beginning of a paragraph it may be numbered, and is followed by a period. Text should begin below the author's name; do not use a separate title page.

TABLES. Type tables double-spaced on separate sheets of paper, one table per page, numbered consecutively, and place them in a group at the back of the manuscript. The reason for this is that tables are usually set by hand, and are separated from the text by the printer. Keep the number of tables to a minimum; avoid numerous small tables. Use a double horizontal line immediately below the title of the table and a single horizontal line below the column headings and at the bottom of the table. Do not use horizontal or vertical lines in the interior of the table.

Footnotes to tables should be noted by asterisks, daggers, or other signs to avoid confusion with numerals in the table and with numbered footnotes elsewhere.

The position of the tables in the text should be indicated in the manuscript. Refer to tables in the text as "table 1" or "(table 1)".

ILLUSTRATIONS. All illustrations are referred to as "figures" and should be numbered consecutively. They may be photographs or line drawings in black India ink. Each figure or group of figures in a plate should be identified along the bottom edge with *author's name, address, figure number,* and *title of manuscript.* If you use illustrations not original with you, you must credit the source and show permission for use by the originator. As many as possible of the illustrations should be grouped and mounted on heavy white cardboard for reproduction as a single engraving. Eliminate excessive white space.

Line drawings, especially cave maps, are often made too large for reproduction. As a general rule, drawings should be no larger than 16 x 20 inches. If they are drawn carefully, they need be no more than twice as large as the desired size of the figure in print. Submit original drawings, not copies or tracings. Make lettering large enough to be legible after reduction.

Draw a scale on all maps which will automatically indicate the size of the original regardless of reduction.

Captions or explanations for single figures should be typed, double spaced, on a separate sheet of paper. Do not attach them to pictures or drawings.

Figures are referred to in the text as "figure 1" or "(fig. 1)."

FOOTNOTES. Try to avoid text footnotes if possible. Reference to the literature is not permitted as a footnote but must be placed in the section on *References* or *Literature Cited.* Acknowledgements are included in the regular text at the end of the *Summary,* if any, just before *Literature Cited.*

If you must use footnotes, they should be typed, double-spaced, in sequence on a separate sheet of paper. Refer to footnotes by subscript numerals.

REFERENCES or LITERATURE CITED. Accumulate all references in a list arranged alphabetically by author's last name, typed double-spaced, on a separate sheet of paper. The page should bear the heading REFERENCES or LITERATURE CITED typed in capital letters and centered. References are referred to in the text as Wilson (1939) or (Wilson, 1939). Standard form for reference listing is as follows: (Note punctuation particularly.)

journals or magazines

WENTWORTH, C. K. (1921) Russel Fork fault of southwest Virginia, Jour. Geol., vol. 29, no. 4, pp. 351-369.

books

BAILEY, G. S. (1836) Great caverns of Kentucky, 64 pp., Church Pub. Co., Chicago.

BIOGRAPHY. With each manuscript submit an up-to-date short biography of the author, typed, double-spaced, on a separate sheet of paper. Length of biography should not be more than one page.

GENERAL. Keep a carbon copy of the manuscript for your own reference. Photographs and drawings will be returned, but original manuscripts may bear editing marks. Authors receive an extra copy of the *Bulletin* in which their stories appear. Because of limited funds, reprints of articles may be obtained only when requested in advance, and at author's expense.