FOUNTAIN OF SNOW.
The American Spelean History Association is chartered as a non-profit corporation for the study, dissemination, and interpretation of spelean history and related purposes. All persons who are interested in these goals are cordially invited to become members. Dues of $8 are due January first of each year. Meetings are held in conjunction with the annual convention of the National Speleological Society and sometimes at West Virginia's Old Timer's Reunion.

Front Cover

"Fountain of Snow" in the Cave of Bellamar, Cuba. Cuba with Pen and Pencil, by Samuel Hazard, Hartford Publishing Co., Hartford, CT, 1871.

Officers

President: Dean Snyder
5519 Rt. 873
Neffs, PA 18065

Vice-President: Carolyn E. Cronk
1595 Blueberry Hills Rd
Monument, CO 80132

Secretary-Treasurer: Fred Grady
1202 S. Scott Street #123
Arlington, VA 22204

Trustees

Larry E. Matthews
Marion O. Smith
Gary K. Soule
Jack Speece

The Journal of Spelean History

The Association publishes the Journal of Spelean History on a quarterly basis. Pertinent articles or reprints are welcomed. Please send typed manuscripts to Carolyn E. Cronk at address below. Photos and illustrations will be returned upon request.

Back Issues

Most back issues of the Journal are available. Early issues are photocopied. Indices are also available for Volumes 1-6 and 13. Send your requests to Fred Grady (address given with the officers). All issues of Volumes 1-7:2 are available on microfiche from:

Kraus Reprint Company
Route 100
Millwood, New York 10546

Official Quarterly Publication
AMERICAN SPELEAN HISTORY
ASSOCIATION
History Section
National Speleological Society

Production

Editor: Carolyn E. Cronk
1595 Blueberry Hills Rd
Monument, CO 80132

Proofreading: Robert N. Cronk

Printing: D. C. Grotto
Potomac Speleological Club Press
VISIT TO THE CAVE OF BELLAMAR
MAMMOTH CAVE OF KENTUCKY COMPARED

submitted by Susan Holler
from Cuba With Pen and Pencil
by Samuel Hazard, 1871

Leaving now the town behind us, and passing by some straggling houses, we come out by the side of the bay, whose emerald-green waters wash gently the sandy shore, and from whose blue distance come the cooling ocean breezes of early morning; while across the bay are the verdure-clad hills that over-top the valley of lovely Yumurri; the picture being completed on our right hand by green banks and hills, over-shadowed by the tall and graceful palm, or the fan-like branches of the cocoanut tree. Turning off from the sea-side, and winding up a rugged and stony road, some distance up the hills, upon the top of the plateau, we come to the "Cave House," a large frame building, erected over the entrance to the cave, and containing the visitors' register, as also numerous specimens of the crystal formations of the cave. In the centre of the building is the stairway leading into the entrance of the cave.

I would advise all visitors to the cave to divest themselves of any superfluous clothing in the way of coats, shawls, vests, etc., which they can leave in charge of the attendant at the bar; for the atmosphere inside is quite warm, and with the exercise, gets to be, before coming out, quite oppressive. I would, also, advise the traveler to insist upon a more liberal allowance of lights than those that are furnished, the supply being limited to one large beeswax taper, with double wicks, carried by the guide, and which does not serve to light up the cave as brightly as its most wonderful beauties deserve. There ought to be, at least, a light apiece allowed to visitors (I hope this will reach the eye of the proprietors), in order that their combined effect may serve to illuminate the cave in a larger expanse at a time than a simple cluster, or some one part of a column. I was awfully desirous to set off some blue lights in the cave, as they allowed us to do in the Kentucky Mammoth Cave, which have such weird, wonderful effect; but the guide would not permit it, on the plea that the smoke of too many lights would spoil the crystals.

Well, we pay our dollar each; the muchacho takes his one candle, and following him, we descend the stairs into the cave. After a few paces, we cross a small wooden bridge, and find ourselves in the "Gothic Temple," the accompanying view of which is taken from the bridge, looking towards the entrance. Even in the obscure light (though in this particular place one or two lanterns are hung up) one can see that it is very, very beautiful, with its millions of crystals, its thousand weird forms, and gloomy corners. When the candle is placed behind some of the columns or projecting crystals, their transparency produces a most lovely effect, their colors varying from the purest white to amber and the most tender of rose tints.

This temple, I should think, is quite two hundred feet long, and about seventy wide, and is about one hundred and fifty feet from the entrance of the cave; and while it far surpasses in richness and splendor the temple of the same name in the Mammoth Cave, it does not equal it in size of solemn grandeur, though as far as the ease and comfort with which the cave is seen, it is far ahead of the Kentucky cave, as the proprietor has had enterprise enough to make strong bridges, plank walks, and, when necessary, strong iron-railings for protection from slipping.
The Mammoth Cave leaves upon the mind an impression of solemn, gloomy grandeur, and one peoples it with gnomes and demons. This cave is a dream of fairy-land, with its sprites and lovely fairies keeping gay revel to soft music; and one almost expects to see shooting from the crystal shadows some lovely Undine or beauteous naiad. I am becoming thus dreamy under the influences of the names of some of the most striking places, many of which, the muchacho says, "some call one thing and some another," for every pillar has its great name - as "Columbus' Mantle," and every mass is likened unto the "Guardian Spirit," or more sacred "Altar," while without the "Cloak of the Virgin" it would not be a Cuban cave.

This "Fuente de Nieve" (fountain of snow), was to me one of the loveliest portions and most striking objects in the cave; but it contains attractions enough to bring one here again and again, when he can get the chance. The cave is thus far opened about three miles in extent, and its greatest depth below the surface of the earth, as far as I can ascertain, is five hundred feet. It has been opened about ten years, having been first discovered, in an accidental way, by one of the workmen of Senor Don Manuel Santos Parga, who, while working near by saw his lever sink through the hole which proved to be the entrance to the cave. We occupied about three hours in the cave the first time we went in, coming out by a different passage, which, however, opens into the same Gothic temple, and which is as yet the only part of the cave lit by gas, though the boy said it all would be. "Who has not seen the Caves of Bellamar has not seen Cuba."
THE ANTIQUE CAVE NEAR SALISBURY HAS BEEN IDENTIFIED: TWIN LAKES CAVE, SALISBURY, CONNECTICUT

Dr. S. A. Craven

Thank you very much for publishing my enquiry in your Journal (1997). Two readers took the trouble to write to me. It is nice to know that our efforts to push back the frontiers of ignorance are sometimes successful.

Mr. James Hedges of Big Cave Tannery, Pennsylvania wrote that the geology of the Salisburys Maryland and North Carolina is unlikely to support caves, and offered to pursue the matter in the Library of Congress.

However, it was Mr. Bill Torode of the National Speleological Society library who solved the problem. He checked the original reference and confirmed that it came from Ballou's Monthly Magazine¹. He also sent me two photocopies of modern references to the cave, which has also been known as "Bashful Lady Cave."

The cave was rediscovered in 1935, if not earlier, by Clay Perry², and surveyed in October 1962 by students from Yale University³.


BERLIN SPRING CAVE: THE REST OF THE STORY

by Doug Plemons

While driving back and forth to Lewisburg doing research on Globe Cave, many times I would forsake the interstate in favor of the winding Highway 431, called the Lewisburg Pike, running south from Franklin. Shortly before Lewisburg is encountered, the road takes a brief dip at a crossroads, in a small town called Berlin. On the right side of the road is a small park containing, as its chief feature, a scenic spring cave, known in the Tennessee Cave Survey as Berlin Spring Cave.

Larry E. Matthews' book, "Descriptions of Tennessee Caves," (1971) provides a very short description of the cave, which is marked on the Verona topo. The cave is given in the TCS as being about 150 feet long with its largest dimensions at the entrance, which is 5 feet high and 10 feet wide; Matthews' commentary infers that the cave was not fully explored at the time it was investigated. Just another little cave at the roadside, in the midst of the cedar glades of the Central Basin, not a very significant cave in an area with dozens of similar caves featuring underground streams, it is somewhat of an oddity because there are not that many known Ridley spring resurgence caves known.

But while doing the Globe Cave research I ran across quite a few references to this cave, and it appears that it was a very significant landmark in the early days of Maury and then Marshall County. A whole town grew up around it, flourished and fell back, and there is some history behind it. The cave had nothing to offer settlers other than a considerable and constant source of very cold water (more than enough for most); it was simply a drawing spot around which political history was made, and a major source of recreation during the late 1800s and early 1900s.

This is an attempt to recreate some of the cave's history, without necessarily recording that of the whole town. If the reader is interested in further accounts from the Berlin area, please contact the Marshall County Historical Society, the Lewisburg Public Library or the Tennessee State Archives.

One must begin with the original purchaser of the land around the cave in order to understand its significance. It was part of a 1,200 acre land grant issued to James Watt from Iredell County, North Carolina, as with many similar grants in the Marshall County area. Revolutionary War veterans were offered astronomical parcels of land (according to today's standards!), which were usually sold in sub-parcels to individuals or given to heirs. In 1814, following Watt's death, the land was indeed divided into 190 acre tracts to be held or sold by Watt's heirs.

In the 1810s, families by the names of Hardison, Leggett, Ownby, and others bought into these parcels and settled in the area, at first called Cedar Springs. Several of the Revolutionary War vets actually did come to the land and settle, and by the time Marshall County was created in 1836 the settlement was growing at a steady pace. Goodspeed (1887) indicated that the town actually incorporated prior to the Civil War. It is no longer so today.

Trade quickly sprang up around the cave. Log spring houses, a water power mill and even a "tippling house" were set up at the mouth of the cave at one time or other. The cold water was used for storing perishable items and probably the tippling house utilized the cave's
cold air for temperature enhancement as well as the water itself for use in moonshine distilling and brandy and vinegar making.

At least as late as 1912, cabins stood on either side of the cave entrance for use as storage areas for perishable items. There is a picture of a group of fifteen women in white dresses, standing on a board or log across the front of the entrance and a log cabin can be seen on either side. The photo was included in a "Berlin Community History" compiled for Homecoming '86, from which some of this information was taken. Unfortunately the quality of the reproduced photo is of insufficient quality to be reproduced again.

A general store was erected near the spring, probably by Samuel Ewing, around 1830. This store lasted until the early 1900s, when John Lunn bought it, after which it burned down and was replaced by another building which is still standing and in business today as "Bit" Hardison’s Grocery.

Other businesses such as a tanyard, grist mill, blacksmith shop, woodworking, and a mechanic shop sprang up. Ralph Whitesell, a Marshall County historian and key figure in the early Marshall County Historical Society, claimed that at one time Berlin was a "good business village." Of course, the Civil War trauma and post-war Reconstruction tore away at the foundation of Berlin like so many other former "good business villages" and the growth experienced during the formation days of this area of Marshall County declined.

Aside from the cave spring, there is one other feature of the site which has attracted attention since 1844. In that year, James Finley and Robert Fields placed a large flat rock atop an outcrop a few feet to the south of the cave entrance to be used as a podium for a visit by President James K. Polk, who would address a "large concourse of people." This became "Berlin Rock," and other politicians would utilize the natural podium for their own speeches. Those who addressed crowds here at Berlin Spring Cave were not only Polk, but Andrew Johnson, Governors Robert Love Taylor, Alfred Taylor, Benton McMillan, James B. Frazier and James C. Jones, Senators A. O. P. Nicholson, Edward Carmack, George W. Jones, M. P. Gentry (Both USA and Confederate), James W. Richardson and W. C. Houston. Judges W. M. Polk, Terry H. Cahal, Harvey Watterson, James H. Thomas, Mat Martin, W. M. Martin and Barclay Martin also used the rostrum.

The Rock was transferred to Lewisburg in 1886; Isaac Whitesell "jacked up the large stone under his four mule team wagon and attached it to the cutting pole and running gear by chains" and took it thus to the county seat for use by other politicians in a more opportune location, according to an article in the "Marshall Gazette" dated October 29, 1925.

Life was usually very calm in Berlin at the turn of the century. A secondhand report of the village trends claims that, in 1909, "the Creekites are being much enlivened by listening to the Gramophone over at Ed Morton's. He sets the machine going on his porch at night and the neighbors all enjoy it." The cave spring became the focal point of the town at the turn of the century. It served as a Sunday picnic site, and lover's lane, and travelers from nearby larger towns would come out to the spring (the train ran through nearby South Berlin). Family gatherings and school reunions were held there. There were Independence Day celebrations with such festivities as greasy pole climbers, baseball and greased pig chasers. The fourth Saturday of May each year saw an "Old Folks Day" picnic.

According to Ralph Whitesell, "schoolboys used to go drop apples in the cavern behind Gene Clark's house and then would come running down and watch them flow out of the mouth of the spring." This other cave, probably an insurgence or karst window for the water leaving Berlin Spring Cave has not yet been located by the writer.
Berlin was possibly the home of Bonnie Parker, of "Bonnie and Clyde" fame, for a while during her childhood. There are reports that the Tom Parker family, of which Bonnie Parker was one of two girls and another male sibling, left Berlin and later returned with a "road show." By this time, Bonnie's role in the "show" was that of a dancer and a sharp shooter. This was previous to Bonnie meeting Clyde Barrow in 1930 and their infamous spree of robbery and murder that lasted until 1934 when both were killed in an ambush in Louisiana. Possibly the "road show" was held, as with most other town events, at the cave entrance.

Gradually, as time progressed, nature began to retake the cave entrance area, and it overgrew with poison ivy, briars, and weeds; Ralph Whitesell believed at the time that it probably looked much like it did when it was first encountered over 100 years before.

However, in the mid 1980s, interest in reviving the community with an emphasis on restoring the scenic wonder of Berlin Spring as a place of community gatherings, in conjunction with "Homecoming '86" led to the restoration of the property. In September 1985 groups of people volunteered to remove vines, tree limbs, underbrush and general debris from the entrance area, placed a wooden bridge across the stream below the entrance, and - most significantly - brought the Berlin Rock back to its original resting place for the first time in 99 years. A bronze plaque was placed on the tree next to the Rock. Family and social events were once again held at the cave entrance, with "Yule Log Burning" in December of 1985 and an Easter Egg hunt in April 1986. A new Berlin Fire Hall was built and dedicated in 1986 as a sign of the measure of life restored to the old community.

Today, as you drive by the pleasant little roadside park, you can pull into the parking area which can handle about twenty cars and, after stepping across the cable which blocks the further access of cars beyond the parking area, you can walk down a neatly mowed, picturesque lane to a picnic area, while a family of ducks quietly swims in the cold creek. Electric lights (reportedly functional) are strung up as far as the cave entrance. A few trashcans are scattered about and in December of 1995, a small, scruffy cedar bush had been strung with Christmas lights. The remains of the Homecoming '86 hoopla still remain, and the park is still kept up by someone who obviously cares to have it remain the central attraction to the 180-year-old town of Berlin. A very old (at least 50 years) "trashcan" stands, or rather, leans near the parking area and threatens to fall over at the slightest hint of a breeze. It was comprised of a barrel hoop and wooden slats. There is still trash in it!

After you have read this, you can go and stand atop the Berlin Rock, feel the cold air blowing out of the photogenic cave entrance, and be able to feel a sense of history, instead of merely standing on top of just another karst outcrop in the middle of nowhere. Berlin Spring Cave has earned its place among the landmarks of central Tennessee.

The cave itself is pretty nice; Matthews did not describe the very picturesque dripstone formations that characterize the rear portions of the cave, somewhat of a rarity for a Ridley limestone cave. One must wade through the extremely cold water in a passage which pinches down at about 150 feet in to a six inch airspace with air whipping through. The best part of the cave is off to the left of the low airspace, with actual walking passage possible for a short distance. Not bad for a roadside cave!

---

Journal of Spelean History
Because of the pattern of growth of the National Speleological Society, and also because of
the productivity and influence of Harvard-trained speleologists - not to mention Horace C.
Hovey - American speleology generally is considered to have spread from East to West.
Nevertheless foci of pioneer speleology existed in the western United States long before
the coming of the National Speleological Society. The following little-known 1913 article,
by a well-traveled member of The Mazamas (an outing group of Portland, Oregon) shows
independent development of a high degree of sophistication for its period. Such articles
paved the way for organized speleology a few decades later. It appeared in Volume 4
Number 2 of Mazama, in December 1913: several weeks after a large group from that
club visited a sizeable glacier in lava near Trout Lake, Washington.

submitted by William R. Halliday

CAVES
by C. Barck

Since time immemorial caves have aroused the curiosity and invited the imagination of
mankind. They have found their place in the tales of all nations and of all times. Inhabited
by wild animals, they have more-over been peopled with fabulous monsters. Probably the
best known of such legends is that of the Greek hero Theseus, who entered a large cave in
the Island of Crete, the labyrinth, and there killed the terrible Minotaur. He found his way
back by means of a thread which he had fastened at the entrance. This cord, together with
the respective advice, had been given to him by Ariadne, daughter of the king of Crete.
The old rule still holds good today: Whoever wishes to explore caves or unknown regions
of old ones must take precautions to find his way back. Negligence in this respect has cost
many a life even centuries after Ariadne's reign.

In spite of the role which caves play in fables they have rather been a step-child of the
science of geology. Special treatises on this subject are rare indeed, and a comprehensive
work, to my knowledge, does not exist.

According to Webster there is no difference between a cavern and a cave. He defines both
as "a hollow place in the earth." But I believe that people usually make a distinction
between the two in reference to size, regarding a cavern as a small cave. It would certainly
be wise scientifically to attach different meanings to the two words. Possibly the best
principle for division would be the amount of light that enters. In a cavern there is more or
less light; a cave is absolutely dark. The contents of my remarks will refer mainly to the
latter.

The simplest cause of the formation of a cave is the rending of the rocks by the mountain-
building forces, where the walls on either side of the break - the fault - have been pulled
apart from each other. Such a disturbance produces very deep and long but relatively
narrow fissures. It may of course take place in sedimentary as well as in igneous rocks.
Very large caves attributable to this cause are, however, not known. If we set such cave-
like fissures apart, caves may best be divided into two large groups, according to the
geological formation in which they occur: caves in sedimentary rocks and those in igneous
rocks. These two categories differ according to their mode or origin as well as to their
general aspect and features. This division is therefore also a practical one.
Caves are found in any of the different sedimentary rocks. They are due to erosion, most frequently produced by the mechanical action of water; inland by rain, rivers, etc., on coasts by the waves of the ocean. But the mechanical action works slowly, and therefore the excavations in sandstone and similar rocks are relatively small.

There is, however, one sedimentary rock which makes an exception in so far as it is affected by water not only mechanically but also chemically. This is limestone. Pure water, it is true, does not possess the property of dissolving limestone. But when rain water falls upon decaying vegetation and passes through this bed of oxidizing carbon it gathers carbonic acid (carbon dioxide) into itself. So charged it acquires the power to attack the limestone, because the absorbed gas gives the water a singular capacity for taking into solution a large amount of lime (also some iron and other mineral substances). Therefore if such water comes in contact with limestone it dissolves it slowly or rapidly, as the case may be; afterwards the water proceeds on its way with the mineral burden. By this process a region once level becomes undulating; the surface waters find or make underground channels and finally the region is honeycombed with caverns. At first, while the crevices are narrow, the excavation is done altogether by the dissolving action of the water; but when it has excavated a channel sufficiently large to permit a stream to flow, then the speed of the current increases the mechanical power of the water. The largest and most famous caves of the world are all found in limestone; and as limestone covers a large area of all continents they are lacking nowhere.

The most extensive cave region on the globe is located in our country, in the territory of the lower Ohio River. This river divides the area in such a manner that three-fourths of it lies in Kentucky, while the remaining one-fourth is divided between Indiana and Tennessee. The formation is carboniferous limestone, which has been deposited homogeneously and has remained almost entirely undisturbed. These are two important factors in the creation of very large caves. Where the layers have been upheaved and shaken, so that cracks and fissures are formed, a large number of small grottoes will result, as for instance in the limestone of Virginia.

In the above mentioned cave region in Kentucky we find the largest of all known caves, the famous Mammoth Cave. Long before you approach it you will note a certain peculiarity of the landscape, namely, the absence of all surface streams. For all the rain water that falls is carried down through sinkholes into caverns below. These sinkholes are usually round or oval depressions of every conceivable size and of varying depths; they have no inlet or outlet except through funnels which communicate with subterranean passages. There are thousands and thousands of such sinkholes in the region; they are natural animal traps, and for that reason quite a number of them have been artificially blocked. The water which runs in the subterranean passages is finally collected in a few streams, of which the Green River is the most conspicuous.

The thickness of the limestone in the Mammoth Cave region from the surface to the bottom at the present time is about 400 feet. The Green River emerges as a large stream several miles east and 400 feet below the Mammoth Cave Hotel. Throughout the entire thickness of the rock you find a labyrinth of channels - long winding avenues, small grottoes, domes, large halls measuring up to 150 feet in height and hundreds of feet in length. They are located at different levels, most of them united by steep and intricate passages; a visit of the cave necessitates constant climbing up and down. In the portion which is explored at the time there are more than 200 miles of paths. At the bottom you find the water in the form of rivers, of which, however, portions only are accessible. The largest is the "Echo River," which is partly navigable for a mile or so. In these waters eyeless fish, crayfish
and other aquatic inhabitants are found. Corresponding to the sinkholes on the surface of the earth there are vertical funnels several feet in diameter and more than a hundred feet deep, which are termed "pits," inside the cave. In a number of them waterfalls are encountered, the volume of which varies with the seasons.

The space of this sketch is of course too short to give a more minute description of Mammoth Cave. I will mention only one more feature which we find in this as well as all limestone caves, namely, the formation of stalactites and stalagmites.

We have seen that the water is charged with the limestone, etc., it has dissolved. Suppose there is some water on top of the roof of a cavern which oozes down through narrow interstices drop by drop. Then some of these drops will fall to the floor of the cavern, while others will cling to the roof. From these the water will evaporate and the substances, which have been dissolved in it, will crystallize. In this way a slender pendant-like body begins to form on the ceiling, which grows with varying speed downward. For a rapid process of evaporation a current of air is essential, and therefore we find the largest stalactites at places where there is a constant draught. The drops which fall undergo the same commutation on the floor, and there the firm substances crystallize in a conical heap, which grows upward to meet the corresponding descending cone. The most simple or schematic form of a stalactite and stalagmite would be two cones, which are united at their apices. Such a regular form is of course rarely found; it presupposes that the respective surfaces of ceiling and floor are level, and furthermore that the supply as well as evaporation of water is uniform. Nevertheless one of this type is found in Mammoth Cave. If the water oozes not only through one but through a number of fissures and in varying amounts the most fantastic shapes of stalactites and stalagmites result, which have been named according to their resemblance to different objects, such as "The Armchair," "The Organ," "The Altar," "The Elephant's Head," etc. The finest stalactites of the Kentucky region are found in the "White Cave." This adjoins and is in reality only a portion of Mammoth Cave. But it has a separate entrance, so that the company which owns the property gets a double admission fee from the visitors. Many other features connected with the management of this great natural wonder leave much to be desired, and it is to be hoped that Mammoth Cave will also be made a national park.

As the limestone region is not limited to the Ohio Valley, but extends farther west beyond the Mississippi, we find caves in Indiana, Missouri and Southern Illinois. These, however, are not as large, because the strata of the rock are not as uniform and have undergone subsequent displacements. Of limestone caverns in the mountain regions of the west, let me briefly mention two, which I have visited. The one is situated near Manitou, Colorado, and contains a few beautiful stalactites. The other is in the Grand Canyon of the Colorado River, on the "Grand View" or "Berry's" trail, about 2500 feet below the rim.

In Europe, there is an area very similar to the Kentucky region described. It is located in the southernmost portion of Austria, near Triest, and is called "Krain." The name for sinkholes there is "Dolinen"; they are even more numerous than in the Ohio limestone. Here is found the largest of European caves, that of "Adelsberg." While the extent of the Adelsberg cave is only about one-fourth of the Mammoth cave, it contains more, and amongst them the most beautiful stalactites known.

CAVES IN IGNEOUS ROCKS; LAVA CAVES.

While water is the most efficient agent for cave formation in sedimentary rocks, it plays no role whatever in igneous caves. For these entirely different factors are responsible. Caves in granite and other primary rocks are rare, and we will first dwell upon the numerous lava caves and revert to the former later on.
All lava caves are formed at the time when the lava is still in a molten state, and shortly before it hardens by cooling. In order to comprehend this process, it is necessary to recollect that all lavas contain large amounts of different gases; these are liberated during the process of contraction and their expansive force is a considerable one.

According to their genesis, we may divide lava caves into three groups. Those of the first group are created at the end of an eruption; the semi-liquid magma is prevented from collapsing entirely by the pressure of the mentioned gases, and solidifies in a most irregular manner. A typical example of this kind is the famous "Blue Grotto" on the island of Capri near Naples. It can only be entered by sea and when the latter is perfectly calm, because the rocky arch which forms the entrance is very low. The beautiful and magical color effects are due to the entry of light through a small fissure in the ceiling and its refraction within the grotto.

The other two groups occur in former lava streams. If a lava stream flows down a mountain side the surface cools very rapidly, hardens and becomes solid; while the mass beneath is still in a liquid state. Such a condition may be found anywhere on active volcanoes. Some years ago I stood upon the hardened but still hot roof of a flowing lava stream on the flanks of Mt. Vesuvius. This hardening of the surface progresses until the roof is strong enough to support itself; it may then happen that the lower fluid lava flows on, leaving an arch which spans the cavity it occupied. Thus a long avenue-like cave is formed, the diameter of which may vary between several and as many as 50 feet. The arch in such instances is a more or less crude oval.

The third kind is produced in the following manner: Let us imagine a broad lava stream which has nearly exhausted its force and is in consequence in a viscid (honey-like) state. If it now meets a nearly vertical declivity perpendicular to its course the lava will not flow down vertically, but on account of its sticky condition will flow over it in such a way that there is a hollow space left between the rock and the lava. This will present a steep wall on the one side and half an arch on the other.

It goes without saying that caves of the former group run in the direction of the lava flow, while the latter run perpendicular to it.

Lava caves are found in all volcanic regions. Some of them are several miles in length. Possibly the most famous one is the "Fingal" cavern on the Island Staffa in Scotland, noted for its beautiful hexagonal columns of basalt. It is situated at ocean level, and the water enters it. Caves so situated are often called "wave caves;" and some authors maintain that this cavern, as well as the Blue Grotto, is exclusively due to wave action. This view is hardly tenable, however. Waves alone cannot excavate solid rock; some hollow space must pre-exist, and the waves can only increase and modify it by erosion.

Caves in granite have been formed in all probability in a manner similar to that of lava caves. Their walls are frequently covered with rock crystals, which has given rise to the name "crystal caves."

ICE FORMATION IN CAVES; FREEZING CAVERNS

Let me first make a remark in regard to the terminology. The English word commonly used, "ice cave," as well as the German "eishoehle," conveys an inaccurate conception. If we say limestone or lava caverns it implies that the cavern is in limestone or lava respectively. An ice cave, therefore, literally means a cave in ice. Such cavities of small
size are really found in glaciers, and artificial ones are hewn every summer in Switzerland; you can see them near Grindelwald, Scheidegg and many other places. Here the caves are in the ice; but in the cases under consideration the ice is in the cave. The most appropriate word is found in the French language, namely, "la glaciere," which is frequently used in geology. The English term "freezing caverns," which will be used throughout this article, has been introduced by E. S. Balch, to whom we owe the only exhaustive treatise on this subject; it appeared in 1900.

For twenty years prior to this date Mr. Balch made such caves the object of his researches and personally visited a large number of them in different parts of the world. He gives a list of about 300; but the data of many, being newspaper clippings, are very brief or inaccurate, while others refer to ice in deep wells, in tunnels, or to caves from which strong cold winds emerge. If we exclude these and consider only the more exact reports, from 150 to 200 freezing caverns are known today. Most of them, over 100, exist in Europe; they are found there in every country. The Jura mountain chain contains the relatively largest number of these, while others are found in the Carpathian mountains, Ural, Apennines, Norwegian, English and Scotch mountains. Twelve or such caverns are known in Asia and one in Japan. The number reported in the United States is about 30. Those in the Eastern and Middle states, New York, Vermont, Pennsylvania, Iowa, are relatively small; those in the West are larger. Two are known in northern California, one in Oregon, three in Alaska and one in Washington - the one we visited last summer. Nearly all freezing caverns are found in limestone or in lava; one, however, has been reported in marble. They generally occur in fairly high altitudes. All freezing caverns are situated in the latitude or at an altitude where ice and snow form for part of the year in the surrounding country. None are reported in India or Africa, or in fact in any low-lying places in tropical latitudes. The only freezing cavern found in subtropical climate is "La Cueva de la Nieve," on the Island of Teneriffe; but this is located at an elevation of over ten thousand feet.

In order to understand this natural phenomenon it might be well to recall some familiar phenomena which are related to it. It is a well known fact that in deep gulches on the north side of mountains, where the sun's rays do not penetrate, layers of snow with firn and ice beneath remain throughout the summer. Under big boulders or in deep wells, mines and tunnels the same occurrence exists. One factor, the absence of direct sunlight, is common to all these. According to their position and general aspect Balch divides all freezing caverns into cliff caves and pit caves. In the former the entrance is at the side of a cliff, while in the latter there is an irregular vertical opening in the ground, through which you enter the cave. It is plain that the ones are found in sedimentary rock, the others in lava. The Mt. Adams cavern is a typical example of a pit cave.

The dimensions vary, but they are never very large. A diameter of fifty to a hundred feet seems to be the average size. The largest one known is the cave of "Dobsina," in the Carpathian Mountains with a length of nearly 400 and a breadth of 200 feet.

The chief characteristics of the ice in the caverns are the same everywhere. The deepest part of the cavern is filled with solid ice, and the thickness of this is from a few inches up to several feet. Balch states that in the cave "De L'Haut-D'Aviernoz," in the French Jura, he saw a crevasse, the icy walls of which were more than twenty feet in depth. The surface of the ice is sometimes level, and in portions so smooth that you can skate upon it; while in others it is very rough and hilly, depending, of course, upon the configuration of the bottom. There is a difference in the forms between underground and overground ice. Almost all the lines of underground ice are rounded; the sharp angles and fractures visible on glaciers are absent because the factor of motion is practically wanting. Besides the ice floor, the most striking forms of subterranean ice are the icicles in shape of stalactites and stalagmites, which resemble to a great degree the limestone stalactites. Some of them are
hollow in the center. The most beautiful ones are reported from the Jura caverns; but the ones we have seen in the Mt. Adams cave are a close second. The physical processes which control the formation of ice stalactites are similar to those which have been outlined for the lime stalactites.

All freezing caverns have a relatively large entrance, and the ice is never at a very great distance from it. In a number of the caverns the ice does not last during the entire summer; it is present during the earlier part of it and has disappeared by autumn, reforming again during the next winter. In others, where the mass of ice is larger and thicker, it is perennial, but its volume also decreases with the advancing warm season. Exact observations have been conducted in a number of European and also in a few American caves. They prove that the accumulation of ice is the greatest at the close of winter, in March or April, according to the latitude, and that it is least at the beginning of winter. They show, furthermore, that the temperatures inside of the freezing caverns are higher in summer than in winter. A comparison of the figures recorded proves that from about the first of November to the first of July they are below the freezing point, and that from the first of July to the first of November they are above freezing, and also that the temperatures within the caves vary considerably less than the outer temperatures. As an example let me quote (in condensed form) the temperatures recorded by the Geological Survey in the cave at Decorah, Iowa (temp. in Celsius):

<table>
<thead>
<tr>
<th>Date</th>
<th>Outside</th>
<th>Inside</th>
</tr>
</thead>
<tbody>
<tr>
<td>July, 1897</td>
<td>+33</td>
<td>0</td>
</tr>
<tr>
<td>August</td>
<td>+32</td>
<td>0</td>
</tr>
<tr>
<td>September</td>
<td>+32</td>
<td>+8</td>
</tr>
<tr>
<td>October</td>
<td>+24</td>
<td>+8</td>
</tr>
<tr>
<td>November</td>
<td>+10</td>
<td>+5</td>
</tr>
<tr>
<td>December</td>
<td>-2</td>
<td>-2.1</td>
</tr>
<tr>
<td>January, 1898</td>
<td>-3</td>
<td>-2</td>
</tr>
<tr>
<td>February</td>
<td>0</td>
<td>-5</td>
</tr>
<tr>
<td>March</td>
<td>+5</td>
<td>-2</td>
</tr>
<tr>
<td>April</td>
<td>+20</td>
<td>-1</td>
</tr>
<tr>
<td>May</td>
<td>+17</td>
<td>0</td>
</tr>
</tbody>
</table>

In regard to the causes of subterranean ice various opinions have been advanced. The finds of ice in midsummer have naturally aroused curiosity, and some of the theories are rather far-fetched. Let me mention a few briefly. One of the oldest theories is that the ice in the caverns is a remnant of the glacial period. The simple fact that in many caves the ice disappears at the end of summer disposes of this theory. Another is that the ice is due to the presence of salt in the surrounding rocks. Experience, by letting lumps of the ice melt, give convincing proof that the water is exceedingly pure and sweet, without any saline contents. The natives and peasants in the neighborhood of freezing caverns in Europe, and also occasionally in our country, believe that the ice is formed in summer and melts in winter. This belief, as similar ones, is founded on imperfect observation; in winter they find the temperature warmer in the cave than outside, and in summer the reverse, and draw their erroneous conclusions from that. Furthermore, they rarely visit the caves in winter and make statements not based upon any observation. Other theories, like the one of "waves of heat and cold" or the "compressed air" theory, we may dismiss without further consideration.

After all that has been stated, the solution of the question seems to be a simple one. Two factors are certainly necessary to produce ice - the presence of water and a temperature at or below the freezing point. And these factors are just as essential inside as outside of a cave. Therefore we find no freezing caverns in climates where the temperature never falls below
the freezing point, as stated before. The ice forms in winter. The longer and the colder the winters the thicker the ice will be. The lowering of the temperature inside of the cavern will be helped by a number of factors. Through the opening an amount of snow falls into the cavity; the cold layers of air sink to the bottom, and if they reach the cave by a larger entrance that region will be even colder than the air outside. This explains the fact that the ice is never found very far from the entrance, not any farther than the cold air can reach. The remote portions of a large cave are always warmer than the outside air. With the advancing winter the mass of ice and the stalactites increase, as found by all competent observers. The question is, therefore, not how the ice is formed, for it is formed exactly as anywhere else, but why it does not melt in summer.

In regard to this point we may say that these caverns are natural refrigerators. The paramount factor is, of course, the absolute exclusion of the sun's rays. This is partly achieved by the low level of the ice in reference to the entrance and partly by the sheltering wall of bushes and trees around the entrance, as is frequently the case. The position of the entrance is also of importance. In almost all cases it has a northerly exposure. For all these reasons the summer air, which is warm and light, can only enter the cave with great difficulty. The movements of the air, therefore, determine to a large degree whether and what volume of ice will form and how long it will remain during the warm season. They must act in such a way as to permit the cold air of winter to permeate the cave, and they must be retarded more or less in summer. Still, evaporation has frequently been considered as one of the causes of subterranean ice, and there is considerable dispute on this point even now.

Historically, let me add, the earliest reference to freezing caverns is an account of a visit to the cave "Chaux-les-Passavant" in 1584 by B. Poissenot, a French lawyer. The Mt. Adams cave is known since 1869 and was first described by R. W. Raymond in the Overland Monthly.

Caves in Relation to Animal Life and Anthropology.

Animal life is quite abundant in caverns and caves. Several hundred species of living inhabitants are known, by far the greater part of which belong to the group of articulated animals, insects and crustaceans. It seems that these are forms which by their structure are best suited for the peculiar changes of life underground. Comparing these creatures with their relatives in the outer world, we find that two changes are most manifest. The first is a change in color, namely, a decided tendency of all gaily colored forms to lose their hue in caves and to become of uniform color. The second is an organic change in the organs of sight. It has already been state that in the Mammoth Cave blind fish are found. In these the eyes have entirely disappeared, and there is nothing but a small hollow left to designate the former place of the eyes. In the crustaceans we observe a certain gradation; in some they are still present, but in a more or less rudimentary state. Some species of cavern beetles are very interesting, where the males still possess eyes, while the females have lost them.

The air in caves is very dry and pure because there is almost no decomposing organic matter present. For this reason animal bodies left in the caves fail to decay; they dry up and are to a certain degree mummified. In the European caves an enormous amount of vertebrate fossils have been found, especially of beasts of prey. These differ somewhat from their present day species, and therefore special names, as cave lion, cave hyena, cave bear, have been introduced. Strange to say, in American caves only a relatively small number of bones have been discovered.
Caves were not only the abodes of animals; they were without doubt the very first habitats of primeval man. They were the first homes, built by nature; before man was able to construct abodes they afforded him a natural and in many respects a satisfactory abiding place. The small entrance could be defended to advantage; the recesses, difficult to discover, afforded hiding places of safety. Later on, throughout all history up to the present time, caves have served as places of refuge in time of war as well as during political and religious persecutions. In the old world caverns appear to have been much more commonly occupied as dwelling places than in the new, and even to this day they are used in civilized communities, particularly in southern France. In North America they have been used as dwellings only by the aborigines, to whom the name "Cave Dwellers" has been given. The largest of these, as far as I know, are situated in the lava region of the San Francisco Mountains in Arizona. Several years ago I visited some of them and collected a large amount of pottery. This is very similar to the earthen-ware of the "Cliff Dwellers," and these two races were no doubt closely related.

Within the last decade renewed interest in caves has been taken by anthropologists, because in them the remains of the earliest prehistoric men have been discovered, and also their first crude attempts at drawing, painting and sculpture.