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OF THE

NATIONAL SPELEOLOGICAL SOCIETY

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JANUARY 1959

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THE SOCIETY is a non-profit organization of men and women interested in the study of caves, karst and allied phenomena. It is chartered under the law of the District of Columbia.

THE SOCIETY serves as a central agency for the collection, preservation, and dissemination of information relating to speleology. It also seeks the preservation of the fauna, minerals, and natural beauty of all caverns through proper conservation practices.

THE AFFAIRS of the Society are controlled by an elected Board of Governors. The Board appoints national officers. Technical affairs of the Society are administered by a Research Committee of recognized specialists in professional fields.

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Speleology in Australia

by BRIAN J. O'BRIEN

The major cavern areas in Australia are the Nullabor Plain of South Australia, the Paleozoic limestone areas of the Eastern States, tht Yarrangobilly Plateau of New South Wales, and the Silurian limestone areas of Tasmania. In the Burdekin River area of Queensland there are some lava tubes. Australian caves have yielded remains of Pleistocene giant marsupials; prehistoric cave paintings are in the caves of the Kimberley area and the Nullabor Plains. Australian speleology is organized primarily in eleven local societies affiliated with the Australian Speleological Federation.

Before writing of Australian caves, it is necessary to bring matters into perspective by the statement – even though it may sound like a cliche–"Australia's a big place". The resultant distances involved in Australian speleological activities are indicated by the following: the site for the Inaugural Meeting of the Australian Speleological Federation, held in December 1956, was chosen as Adelaide in South Australia partly because Adelaide is so centrally situated*. Even so, the average distance travelled by Australian speleologists attending the two-day conference was over 2000 miles. Those speleos who felt inclined and able to go on the associated Nullarbor Plains cave-expedition–they were sixty in number–logged a further 2,500 miles before returning home.

As a result of these large distances, caving centres in Australia generally are concentrated around the cities and regions of denser population. One exception to this is the Nullarbor Plains area, but, as will be seen later, one becomes used to this region as an exception. Consequently, when writing of Australian caves, more attention will be paid to the better-known systems, but it does not follow necessarily that these are the "best" or most interesting caves. Figure 1 shows the major caving areas of Australia, with the Kimberley and Katherine regions included more for the sake of completeness since little speleological work has been done there.

* The second National Conference was held in Hobart, Tasmania, December, 1958. After the conference several weeks were spent in exploring Tasmanian caves.

Although there are many limestone outcrops in Australia which have unknown caving potential, the limestone caves of Australia may be divided into two characteristic types, one epitomised by the Nullarbor Caves in unfolded Tertiary limestone, the other by the caves of the eastern states, which occur predominantly in the extensively folded Devonian and Silurian deposits. These two types are dealt with in the following sections, and some mention is made also of other Australian caverniferous deposits which are of interest.

The Nullarbor Caves

The Nullarbor Plain limestone was laid down during the late Cretaceous and Tertiary periods when large portions of southern Australia were invaded by the sea, reaching in about 200 miles from the present coast line (David 1915, Laseron 1953). Subsequent uplifts have left the level plain about 500 feet above sea-level, with the limestone 300 to 500 feet thick, covering an area of about 30,000 square miles and extending right down to the coast. The upper Tertiary deposits are silicified forming a protective capping on the purer limestone below.

The low rainfall of the region and the porous nature of the limestone have resulted in a complete lack of surface river- or drainage-courses. A sudden thunderstorm may render the surface inpassible to vehicles, and yet in a day or so the quick drainage and high day-time temperatures (often above

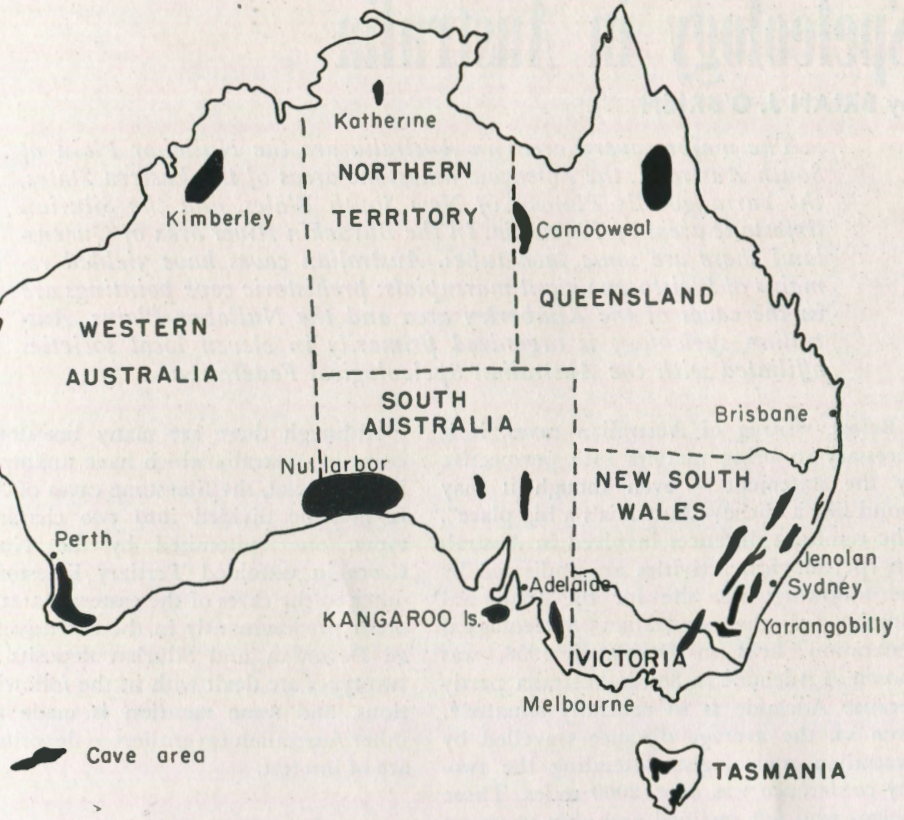

Figure 1

Principal areas of caverniferous limestones in Australia.

100° F) will dry the ground and permit further travel.

Under the surface of the usually barren Nullarbor (nul = no, and arbor = tree) are many caverns, ranging from small shallow caves to huge impressive chambers several hundred feet below the surface, occasionally containing large underground lakes. About one hundred caves are known, but since they have been found only where a roof collapse has yielded some surface opening, it is likely that many more lie unknown below the surface of the Plain. The abundance of the caves is indicated by the feat of Captain Maitland Thomson (1947), who in 1939 in two and a half hours flying, located forty-two new caves in an area just north of the Great Australian Bight.

Although the Australian aborigines have an intense fear of the blackness of the Nullarbor caves, their presence lingers on in the wondrous names of the caves—Weebubbie, Abrakurrie, Murrawijinie and Koomooloobooka. The aborigines believed that Jeedara, the spirit serpent, dwelt in the caves and his lashings caused the fierce dust-storms of the plains (a number of the caves with small entrances are of the blow-hole variety, with strong winds blowing in or out). However, in Murrawijinie or the Caves of the Bloody Hand are examples of aboriginal hand-painting, similar to those left by the Aurignacians in French caves, all being white on a background of red ochre. It is fascinating to speculate on the linkage of the desolate Nullarbor with the grand Pyrenees through the mysterious minds of "primitive" men.

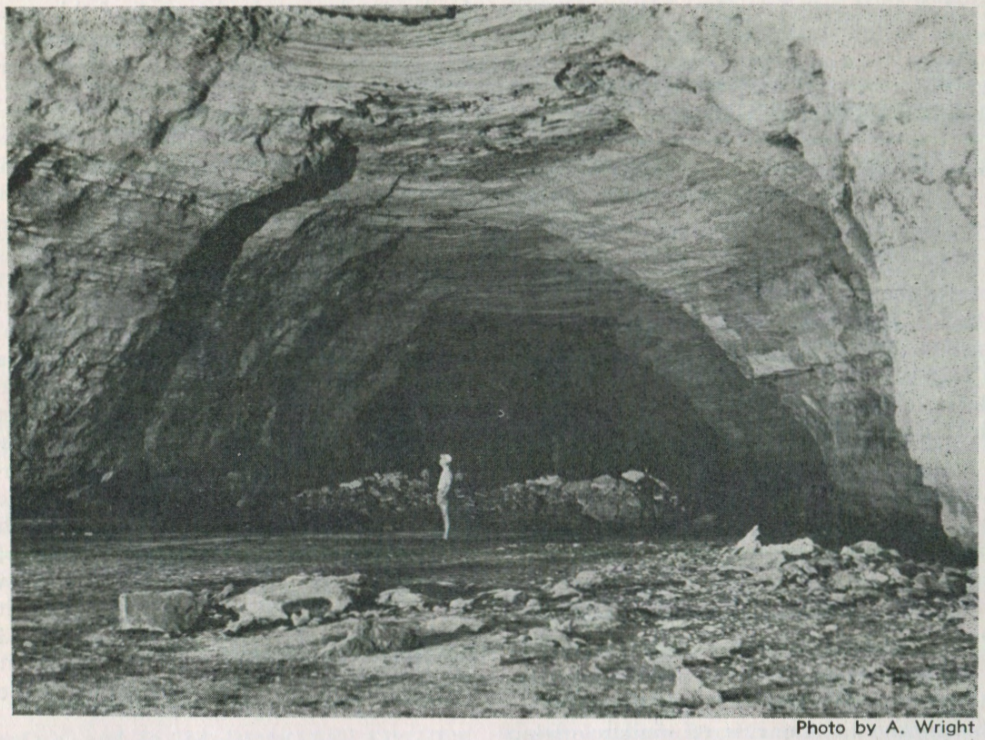

Photo by A. Wright

Figure 2

Abrakurrie Cave on the Nullarbor Plains. Tunnel extends for over 400 yards with level floor.

Before Christmas 1956, it was thought that the Australian aborigines had never regarded caves as being other than mysterious places to be avoided by a wise person, but in the recent Nullarbor Plains Expedition comprising members of the newly formed Australian Speleological Federation a number of exciting discoveries were made (The Advertiser 1957) which will lead to drastic modification of this idea.

The President of the Anthropological Society of Victoria (Dr. Gallus) discovered an old aboriginal fireplace about 200 ft. below the surface in the Koonalda Cave. He found charcoal and stone implements (chippers, scrapers and axes) and his digging revealed five levels of aboriginal activity; the lowest level dates at least 8000 years old and older levels are probably below this as the excavations have not reached bedrock. Members of the expedition also found hand-prints in red ochre at the Abrakurrie Cave, similar to those at Murrawijinie. Wall drawings, 200 feet further in than the limit of daylight penetration, have yet to be evaluated.

Since the oldest dated relic of human occupation in Australia is only 10,000 years old, the recent Nullarbor discoveries are of great general interest. They will alter the Australian speleo's whole attitude to anthropological investigations in caves, changing them from a rather hopeless task to a work of great potentialities.

The entrances to the Nullarbor caves, as may be expected, are a variety of sizes, from the ones which provide a snug fit for the slim speleologist to an unnamed hole 1000 feet wide, and to the well-known Koonalda cave, 240 feet in diameter and 80 feet deep. The caves themselves provide as great a range. The mighty cavern of the Abrakurrie

cave is 1200 feet long, and has an average width of 160 feet and height of 150 feet (Figure 2). The Weebubbie, Koonalda and Warbla caves contain large lakes about 300 feet below the surface. One of the several lakes in the Koonalda cave is 540 feet long with an average width of 50 feet and depth of 5 feet, while that in Weebubbie is 1300 feet long and 100 feet deep in the centre.

The Nullarbor is a very arid region, but one of the few settlers has been able to draw the brackish waters up from the Koonalda cave to provide for his sheep. He performed a mighty feat in transporting about 200 feet below the surface an old Ford engine to drive a pump.

Perhaps because of the frequent interbedding of siliceous limestones with the purer limestone, and also because of the infrequent rain, extremely few of the Nullarbor caves are ornamented with the secondary speleans growths familiar to all cave explorers.

By contrast, in the south-west of Western Australia and the east of South Australia, although the limestone is of similar origin, many beautiful crystal growths are to be found which are comparable to the beauties of the older limestone caves of the eastern states.

The Caves of the Eastern States

A few miles from the coast of Queensland there extends at the present time a coral reef about 1000 miles long known as the Great Barrier Reef. Running in a similar North-South direction down the inland of eastern Australia are intermittent beds of Silurian and Devonian limestone, and within these outcrops are the caves which provided spots of interest and adventure to the speleologists of the eastern states.

In New South Wales alone there are about 300 separate limestone outcrops (Carne and Jones 1919), and about 40 localities are reported to contain caves. About 30 of the locations have been given at least some examination by the speleologist. The concentration of speleological activities in N.S.W. as contrasted with the other eastern mainland states has made the caves of this state fairly well known; the caving potential of Victoria, Queensland and the Northern Territory is still largely speculative.

In the caving areas in N.S.W. are examples of caves at various stages of formation and development. At Moore Creek near Tamworth the meandering river has removed most of the limestone, leaving only some small vestiges on the sides of the valley walls. But at Bungonia the caves are left isolated on the tableland while the local creek streams 1000 feet below through a narrow limestone gorge. No cave is known at Bungonia which is more than 400 feet deep. At Jenolan, the best-known of all Australian caves, the main stream drops underground about two miles upstream from the tourist or commercial caves, passes through several wild caves, pours through some of the tourist caves and resurges in a junction with another stream (Figure 3). At least, it does this when it is its normal, well-behaved self. When heavy rains swell its volume, it comes downstream both above and below the

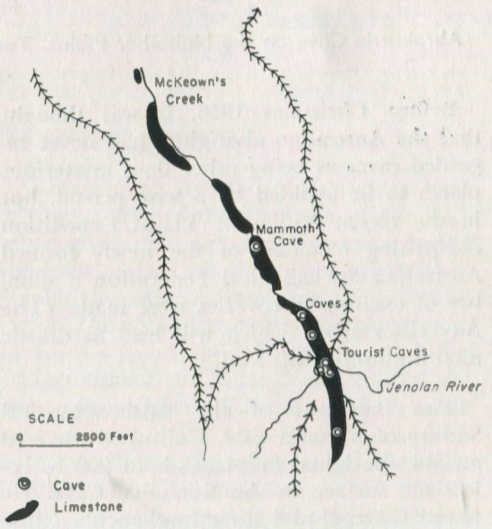

Figure 3

McKeowns Creek area, Jenolan, N. S. W. Drainage is primarily subterranean in the limestone area (after O. Trickett).

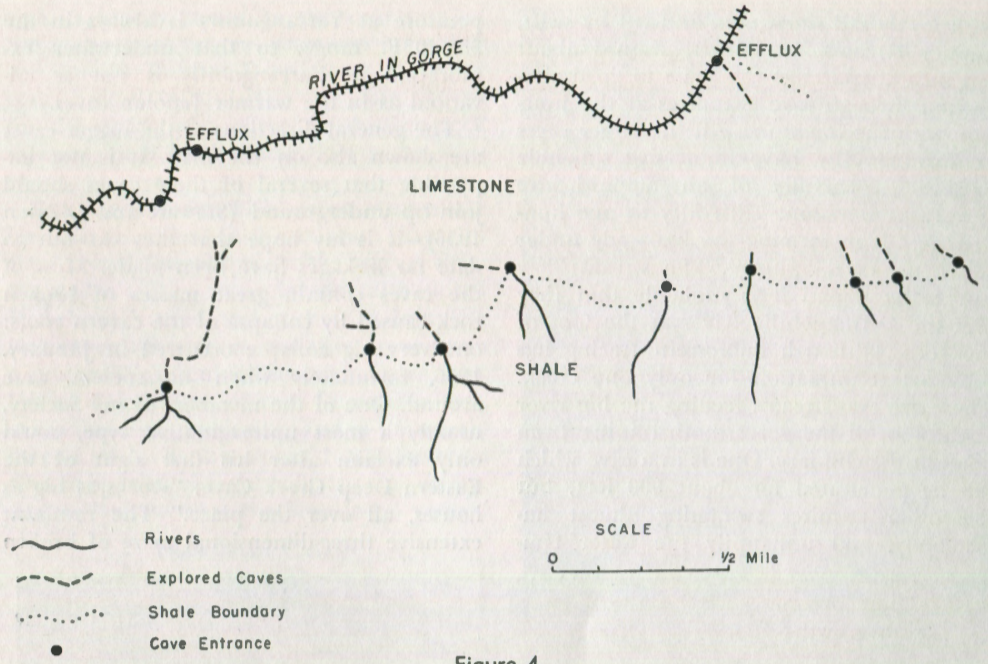

Figure 4

Limestone plateau at Yarrangobilly, N. S. W. showing the relation of drainage and caves.

surface, and in the largest wild cave, the Mammoth, the underground river is no longer 200 feet below the entrance but about 50 feet, and the rest of the cave is flooded. On one occasion the writer entered a cave about ¾ mile upstream from the tourist caves with the McKeown's Creek sinking into the ground opposite the cave entrance. On his emerging from the cave a few hours later, he found the surface creek had retreated several hundred yards upstream.

A somewhat similar erratic river exists near Camooweal in Western Queensland (Benson 1955). In that area rivers are dry until the monsoon brings the "Wet," when they become flooded—there is no intermediate state. I might mention here that there are only two seasons in the North Australian year—the Wet and the Dry—rather like U.S. cities in the prohibition eras around 1930.

Near Camooweal is a river-bed which is generally dry. During the annual flood the river pours along and disappears completely through loose boulders at one particular location. It continues in this manner for two days, and then, having filled whatever massive cavities it has entered, it continues an uneventful course along the surface. The Mt. Isa speleologists have explored caves in the vicinity, but have not solved as yet the mystery of the disappearing waters.

Yarrangobilly

On a spur of the Snowy Mountains in southern N.S.W. lies the Yarrangobilly Plateau, consisting of a limestone belt over 4 miles long and about one mile wide, with a thickness of 400-500 feet. Because of the size, ruggedness and unknown nature of the caves in this plateau, and because of the extraordinarily beautiful formations they contain, Yarrangobilly has provided me with most of my finest hours of caving.

The Yarrangobilly plateau is bounded on the western and southern sides by a gorge about 500 feet deep, which was cut out by the fast-flowing Yarrangobilly River (Figure 4). The rest of the plateau is bordered by shale, and the whole area is densely timbered

limestone outcrops, and almost none of the extensive New Guinea regions, have been visited by cavers, the Australian speleologist may look forward to many years of cave exploration and new discoveries in the future.

Non-limestone Caves

Most speleologists regard caves occurring other than in limestone as something in the nature of poor relations, and little investigation has been made in Australia of cavities such as lava-tubes, rock-shelters or sea-excavated caves. However, there are examples of all of these in Australia, and extensive anthropological investigations have been made in some of the rock-shelters (Tindale and Heard 1927).

West of the Burdekin River in Queensland lie deep pits in an old lava flow, and these pits reputedly link up with passages below. There are large numbers of wind-worn sandstone rock-shelters in the Centre of Australia, and although these are generally small, they provided durable canvasses for the aboriginal artists of long ago. A few holes in sea-cliffs have been found, but none is known to the writer which is more than a few hundred feet long, or which offers promising fields for speleologists. The temperate climate and lack of high mountains preclude the posibility of permanent ice-caves in Australia, although the writer has found ice formations–stalactites, stalagmites and shawls–about one hundred feet inside several Yarrangobilly caves, but these only lasted for one winter (O'Brien and Stewart 1955).

Palaeontology

The opportunities for the archeologist in Australia are rather limited, but palaeontologists have had some remarkable successes in excavations in caves, notably at Wellington in N.S.W. (Anderson 1926, Mitchell 1831, Owen 1877), Buchan in Victoria, and in several South and West Australian caves.

Bones of the giant marsupials, the Diprotodont, from the Pleistocene are among the most interesting finds in caves. Other excavations have been successful in determining the time relationships of other Australian fauna, of extinct and present-day species.

As mentioned earlier, the aborigines regard caves as evil places, and very rarely will they enter even as far as the twilight zones. One exception was a black "bush-ranger" round 1900 up in the Kimberley region, who used some of the limestone caves as camps and a means of escape from the police forces sent after him. Indeed, bushrangers have deserved praise for their efforts in several Australian caves, the most famous being one gentleman called McKeown, who was directly responsible for the discovery of Jenolan caves, as he fled there with some stolen cattle when his pursuers were close behind. The ungrateful authorities subsequently hanged him.

Aborigines have left hand-paintings in at least two Nullarbor caves, but there are paintings of a more vivid nature in the rock-shelters in the Kimberleys of northwestern Australia, and in the sandstone hills in the Centre of Australia.

The Kimberley paintings, depicting creatures with heads surrounded by a type of halo, remain a mystery, although some rather unconvincing attempts have been made to link them with Malay raiding-parties on the Australian coast several hundred years ago. Somewhat less unique, but no less interesting, are the drawings and paintings in the Centre of Australia, where the typical scenes of primitive artists are reproduced–scenes with special significance in hunting or magic or fertility rites, and drawings of mythical creatures from the Dreamtime. A further intriguing link with other primitive races is the X-ray drawing or carving, where the subject, be it turtle, fish, bird or other creature, is drawn in a skeletal style, analogous to a modern X-ray.

The recent discoveries in some of the Nullarbor caves, as mentioned earlier, will result in a complete revaluation of the association of the aborigines of long ago with Australian caves.

Caving in Australia

Speleological groups in Australia organised for caving per se, date only from the formation in 1946 of the Tasmanian Caverneering Club. In 1948 the Sydney University Speleological Society was formed, but then for a few years these two groups were

alone in Australian speleology. However, about 1953 a number of interested people in several areas commenced small caving groups and some of these became constituted societies.

This growth was accentuated and also typified by the formation of the Australian Speleological Federation at Christmas 1956 in South Australia. The writer played a part in the preliminary negotiations that preceded this formation and since he was made Chairman and President he feels he is in a position to generalise about caving in Australia.

The Federation, or the A.S.F., has currently eleven fully-constituted member societies. These societies remain completely autonomous, and the functions of the Federation are to act as a central coordinator of research and exploration, to aid individual societies wherever possible *eg.* by calling on known experience, and, if necessary, the Federation acts as a National body in promulgating some conservation or public-relations policy. Decisions effecting the Federation are made by the officers subject to ratification by the committee, consisting of a representative from each member society.

There are some activities, such as nation-wide bat banding and associated studies, which are ideally-suited for their assistance by the A.S.F. Again, there are the national conferences and subsequent joint expeditions, which are sources of delight and very real value. The A.S.F. is also actively compiling a central reference bureau which will do much to place Australian caving on a more permanent footing.

Australian Speleological Federation

Members of Executive:

President–B. J. O'Brien, Antarctic Division, Dept. of External Affairs, 417 Church St., Richmond, Victoria.

Secretary–E. Hamilton-Smith, c/o Brotherhood of St. Laurence, 67 Brunswick Street, Fitzroy, N.6. Victoria.

Treasurer–B. S. Nurse, 3 Glenwood Avenue, Coogee, N.S.W.

Librarian–F. Anderson, 1 Bay Parade, Malabar, N.S.W.

A.S.F. Sub-Committees:

Terminology–J. N. Jennings, Department of Geography, Australian National University, Canberra, A.C.T.

Safety–G. D. Lyons, P.O. Box 82, Scottsdale, Tasmania.

Constitutions–A. L. Hill, Box 485D, G.P.O., Adelaide, South Australia.

Ethics–K. W. Lynn, c/o Cave Exploration Group (South Australia). P. K. MacGregor, 5 Deakin St., West Ryde, N.S.W.

Bat Research–J. Mahoney, Dept. of Geology, University of Sydney, N.S.W.

Publications–E. Hamilton-Smith, address above.

Member Societies:

Canberra Speleological Society, P.O. Box 35, Canberra, A.C.T.

Cave Exploration Group (South Australia), c/o South Australia Museum, North Terrace, Adelaide, South Australia.

Cooranbong Speleological Association, Australian Missionary College, Cooranbong, N.S.W.

Jenolan Speleological Society, c/o Jenolan Caves, N.S.W.

Newcastle Technical and University Colleges Speleological Society, c/o 15 Livingstone St., Merewether 2N, N.S.W.

Orange Speleological Society, c/o 15 Moresby St., Orange, N.S.W.

Sydney Speleological Society, P.O. Box 198, Broadway, N.S.W.

Sydney University Speleological Society, Box 35, The Union, University of Sydney, Sydney, N.S.W.

Tasmanian Caverneering Club, c/o 15 Harrington St., Battery Point, Hobart, Tasmania.

Victorian Cave Exploration Society, c/o 15 Riverside Rd., Ivanhoe, N21, Victoria.

Wagga Wagga Speleological Society, c/o P.O. Box 39, Wagga Wagga, N.S.W.

Membership pending:

New South Wales University of Technology Speleological Society, University of Technology Union, Harris St., Broadway, N.S.W.

Western Australia Caving Group, c/o 3 Baker Ave., Perth, Western Australia.

Wollongong Speleological Society, c/o 1A Marlo St., Towradgi, N.S.W.

Speleological information is published by various member societies of the ASF. Currently these are:

Australian Speleological Federation:
Newsletter (Mimeograph) Nos. 1-4 published 1956 –

Sydney University Speleological Society:
SUSS (Mimeograph) Vol. 1, 1-3, Vol. II, 1-2, Vol. III, 1-2, Vol. IV, 1-2, 1950 –

Sydney Speleological Society:
Communications (Mimeograph) Vols. I-II. 1956 –

Cooranbong Speleological Association:
C.S.A. Reports (Mimeograph) Vol. I 1957 –

Victorian Cave Exploration Society:
Occasional Papers (Mimeograph) No. 1 1957 –

Tasmanian Caverneering Club:
Handbook (Mimeograph) 71 pp. Hobart 1953.

The personalities in Australian caving are as eccentric as those of most countries. Australian caving contains, perhaps, a much higher proportion of younger sporting types than do the older caving groups in England or the U.S. Yet time will solve this problem, and result in Australia having the necessary percentage of mature cavers to contribute particularly to its scientific status.

Secretary of the A.S.F. is Elery Hamilton-Smith, a bearded, pipe-smoking member of the Brotherhood of St. Lawrence. Elery led the very successful Nullabor Expedition of January 1957, and has a keen personal interest in research coordination and the bat-banding programme.

Ben Nurse is Treasurer of the A.S.F. and President of the Sydney Speleological Society. His activities have led him underwater, and he was one of the principals in two successful acqua-lung attempts on siphons in the Jenolan area.

Frank Brown is doyen of Australian caving, having nursed Tasmanian caving from its birth. Frank is a very keen on the exploratory side of caving, and has led many successful exploratory trips.

Brian O'Brien is President of the A.S.F., member of Cave Research Group of Great Britain and Hon. Life Member of two Australian caving groups. He has B.S. with 1st Class Honours in Physics and in 1957 completed Ph.D. in Physics. Now physicist with Antarctic Division in Melbourne. Scientific caving includes foul air studies, walkie-talkies in caves, after-glow of calcite (O'-Brien 1956).

Miss J. Marlow of Adelaide, has been carrying out some studies on the structure of spelian formation, especially oolites and helictites.

Dr. Gallus is Victorian anthropologist who found under the Nullarbor artifacts from some of the oldest Australians.

Joe Jennings, President of Canberra Speleological Society, is currently Reader in Geomorphology at Australian National University and is working on geomorphology of limestone terranes. He represented A.S.F. at International Speleological Conference in Italy in 1958.

Alan Hill, the Secretary of the Cave Exploration Group of S.A. is a model of efficiency who has done much to coordinate S.A. caving. Hill along with R. T. Sexton, has been working on survey techniques and instruments.

Adrian Hunt is another black-bearded speleologist, who is President of S.U.S.S. He is chiefly known for his determination in remodelling and refitting a vintage T-model Ford.

Since Australian caving is scattered over very wide fields, there is little direct competition between societies. Only in Sydney, which has two speleological societies, is there much give and take, but it is probably no accident that the same two societies are among the strongest in Australia.

Commercial caves in Australia are primarily run by the Tourist Departments of each state, which have spent considerable sums of money modifying the caves and the areas around the caves as well as providing access roads.

Relationships between cavers and the Tourist Departments are good. In 1956 the South Australia Department provided a cottage alongside one of the larger cave systems for use by cavers. This cottage forms the nucleus of the Naracoorte Research Centre. In other states cooperation is mutually extended also. For example, when a new Ranger was appointed to the Yarrangobilly Reserve we were asked to show him through the Eastern Eagles' Nest—2500 feet of fairly tough cave. At one stage, very tired and cold, Jim, the ranger, fell thigh-deep into a pool of water at 36°F. When we got out again, he issued an invitation to visit the commercial caves—"where we haven't any puddles for a bloke to fall in."

Most of the cave systems in Australia are on private property, and speleos generally enjoy the utmost assistance and hospitality from the land owners, even when the caves themselves are not so pleasant. For instance, a few years ago three of us were out in the sheep country several hundred miles from Sydney tracking down little-known caving systems. We came to a farm house on a great, flat expanse of land, and chatted with an ancient inhabitant. "Yes," he drawled, "there's a cave over in that paddock there. Last year we lost a few sheep in the dip, and we threw 'em down the hole. About seventy head there were. Ain't seen 'em since, so I reckon it's a pretty big cave underneath." Sure enough, it was a pretty big cave, but after a fifty-foot climb down a chimney which had very dead sheep all around, I came out and we abandoned the cave to the sheep.

The comparative youth of our caving members and the consequent scarcity of speleos with high academic qualifications have been a hindrance in our obtaining financial and other support from Universities and the like. However, this situation shows signs of alteration, and in the Australian bat-banding programme we are obtaining a great deal of valuable help.

Australian caving parties range in size from only two or three members up to about sixty. It is generally felt that three is the minimum desirable number, and of course, in the event of an expedition having sixty members, these are rapidly divided into many smaller groups each of which act as an independent party, with knowledge of what other parties are doing.

Speleos mostly favour cover-all boiler suits suitably modified with padding or stitched-up pockets. Fibre helmets are in general use, some with electric or acetylene headlamps. However, the most common form of lighting is the cheap and solid acetylene hand lamp.

The survey standards conform in general to those of the Cave Research Group of Great Britain, but subcommittees of the A.S.F. are at present considering both this matter and that of caving terminology, and these are expected to modify existing systems and adapt them to suit Australian conditions.

Cave photography in Australia seems to be in a very sound position, and it has enthusiasts ranging from the professional photographer who caves with two Leicas and much assorted equipment to the young novice with a box camera and a length of magnesium ribbon. Perhaps it is best if I tell you about the "Diprotodon." The Diprotodon proper was an animal which ranged Australia about 750,000 years ago. But the name has now come to be associated by Australian speleos with a fabulous and rather fiendish device used in lighting of big caverns for photographic purposes. The Diprotodon was devised by South Australian cavers as a solution to the difficulty of adequately lighting the vast Nullarbor caves when photographing them in them in their entirety. Subsequently, modifications were made by some Sydney speleos. Basically, the Diprotodon consists of an air reservoir, which is used to blow magnesium powder past a methylated-spirits flame. The simplest air reservoir is one or more balloons, and the quantity of magnesium powder used can range from one ounce to a devastating one pound. For the photographers I might mention that the guide number for Kodachrome and a "medium" charge of powder is about one thousand.

Of course such a device is suitable only for very big caverns, and indeed one is soon driven from the largest caverns by the smoke which is produced. One of the sights of the Nullarbor expedition was surface view of the giant sink-holes when the photographers where at work below. In the night, a sink-hole a hundred feet in diameter would be a deeper blackness in the surrounding dark. Then would come a great fiery flash lasting

several seconds, so that a tongue of light leapt from the cavern mouth. Then a greater darkness would descend, but softly and silently a dense white cloud would creep out of the darkness and blend with the night.

All varieties of stories and legends are accumulating about the Diprotodon, most of them from the early experimental days. For example, one of the boys tested a prototype in his garage. Not only did his father stagger back in alarm before the six-feet long flame, but he also had to repaint the scorched garage doors.

Underwater exploration of Australian caves has developed in the last four years from an exceedingly dangerous sport with amateurish equipment to a highly organised technique with the latest diving equipment. Most activity has been from Sydney, where a Cave Diving Group is being set up, but the speleologists in Victoria are now following suit, and diving with aqua lungs, good communication and other devices.

Other equipment in Australian caving is similar to equipment elsewhere. Strong wire-and-dural ladders are fairly common; there are several scaling poles, and so on. Most of this equipment has been built almost on a trial-and-error basis, but very happily there have not been any serious accidents in Australian speleology.

One may summarize Australian caving by comparing it with Australia herself. They are both young but intensely enthusiastic. They both suffer from the sparseness of population, but they are growing rapidly, they have immense potential and they aren't afraid of the future.

ACKNOWLEDGEMENTS

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Bear Bones from a Boone County Cave

by PATRICK H. WELLS

Native bear population of Missouri became extinct during the 1800's and the bears now in the Ozarks were introduced about 15 years ago. A fissure cave in Boone County recently excavated by William Elder, Professor of Zoology, University of Missouri, has yielded many late Quaternary bones. Among them are the skeletons of six bears. The bears were black bears but their skeletons show they were much larger than modern black bears. Teeth were strikingly oversized in keeping with the other skeletal parts that were proportionally heavy.

Its been a long time since Daniel Boone hiked the trails through the county in Missouri which bears his name. Boone was a crack shot, they say, who accounted for many bears in the course of his colorful career. Bears were important animals in those days, as we may judge by the old settlers' tales of warm bearskin robes and feasts of juicy bear steak. Potentially dangerous, too, for the hunter who didn't shoot dead straight.

The settlers who followed after Boone also were good shots, and they lived a hundred years or so before we became very conscious of our *conservation responsibilities.* It wasn't very long after Boone's death that the last native Missouri bear joined him in the happy hunting grounds. Indeed, all this happened so far in the past that we have little scientific information about the original bears of the region. The few bears now living in the Missouri Ozarks are not directly descended from native stock, for the state had no bears from the late 1800s until the 1940s, when a few reentered from an unknown source.

As the result of a most interesting cave discovery, it has recently been possible to obtain skeletal material of bears undoubtedly native to the region. While studying bat populations in Boone County, Dr. William Elder, Professor of Zoology at University of Missouri, chanced to enter an unusual vertical cave (geologists call it a solution fissure). Unlike the sink-hole type caves common to the area, this pit is on the side of a hill rather than in a depression. The opening is about four feet long and two feet at its greatest width. Although it is possible to climb a few feet down the hole to a substantial ledge, the passage soon starts to enlarge in the shape of an inverted funnel. A rope is necessary in making the full descent. The bottom of the pit is perhaps fifteen by twenty feet, and is a full forty feet straight down from the surface of the ground. Any animal which enters this cave beyond the level of the ledge is either killed by the fall or trapped, so the cave floor is rich in skeletal material.

Under Professor Elder's direction an organized excavation of the cave floor was undertaken, with mammalogy students and zoology staff members of University of Missouri participating. Bones of pigs, rabbits, squirrels and other rodents, and turtles were found in abundance. In one corner, all but buried in the clay, the lower jaw of a bear could be seen.

The careful excavations of the floor of the animal trap cave are still incomplete. So far it has yielded skeletons of six bears, as well as bones of many smaller animals of scientific interest. One incomplete skull has features resembling a grizzly bear. The shapes of the other skulls and bones, however, tells us that most of the animals were black bears. They were strikingly larger than present day black bears. The massive jawbones are more than an inch longer than those of large modern black bears. The teeth are over-sized, too, and other skeletal parts are proportionately heavy.

Figure 1

A student mammalogist prepares to make the forty foot descent into the Boone County bone cave. A few feet below the surface this cave enlarges in the shape of an inverted funnel.

Figure 2

Walls of the cave show interesting formations and the cave floor is rich in skeletal material from animals which have been caught in the trap. These workers, silhouetted by light from their lantern, are recovering the skeleton of a large bear.

At the present time it is difficult to say just how old the Boone County bear bones may be. They are in an excellent state of preservation and were not deeply buried in the clay. Some of them, however, were firmly imbedded in the "dripstone" which very slowly forms on the sides of caves such as this. Perhaps the bears lived at the time of Daniel Boone himself, but they could not have been much more recent than that. Probably some of them are very much older, having entered the pit hundreds or even thousands of years ago. Exact aging of the remains must await detailed study of the bones and of the clay in which they were buried.

Meanwhile the Boone County discovery may remind us that caves are among the best potential "historical vaults" provided by nature. Every speleologist may add to the excitement of his explorations by keeping this in mind. We may learn a conservation lesson, too, from the needless extermination of these interesting large mammals, and resolve to preserve the esthetic values of nature (including caves and cave life) which still remain to us.

Figure 3

Some of the bones, such as this bear femur, were firmly imbedded in the "dripstone" which has slowly formed in this limestone cave.

Holocrystalline Speleothems

by WILLIAM R. HALLIDAY

Dripstone speleothems which display characteristics of a single crystal have been found in several caves in Texas and California. Two forms, externally holocrystalline and internally holocrystalline, exist. The former are generally tubular in form; the latter are sometimes solid lacking an open central canal. The internally holocrystalline forms fracture obliquely across the stalactite on a single face. Internally holocrystalline speleothems possibly are formed by internal flow and recrystallization.

In the past few years, there has been considerable interest in the western United States in the occurrence of "dripstone" speleothems which display the characteristics of a single crystal either externally or upon fracture. Most of these speleothems are stalactites, but one and perhaps two externally holocrystalline stalagmites have been reported. Many vermiform helictites of the type studied by Moore (1954) possess more or less defined crystalline surface – "In general the features are bounded by relatively flat surfaces. . . The cross-section near the tip is usually triangular" (Moore 1954). Other helictites have cross-sections with as many as four well-defined faces, and additional rudimentary ones. Even an externally multicrystalline helictite from "Secret Cave", Texas, is largely triangular in cross-section. I have found fragments of internally holocrystalline helictites with rounded exteriors in California and Texas.

A preliminary paper (Halliday 1953) mentioned the existence of a hexagonal stalagmite taken from a California cave, and James F. Quinlan (personal communication) has recently noted a tapered, externally holocrystalline stalagmitic speleothem eight inches tall, in "Secret Cave", Texas (Figure 1). Its cross-section is that of a parallelogram with sides about one inch wide at the base and one-eighth inch wide at the apex. A central canal 1/16 inch in diameter is present.

Holocrystalline stalactites occur in two forms. Externally holocrystalline stalactites are hexagonal tubular forms found in Virginia (Snyder 1951), Texas, and California (Halliday 1953). Other types also occur. Several broken specimens found in "Secret Cave", Texas, by James F. Quinlan, have a rectangular cross-section and oblique planar fracture surfaces. One of these has a triangular tip (Figure 2). Unfortunately, these specimens have a secondary surface coating which prevents discernment of additional, poorly developed surfaces which may be present. All externally holocrystalline stalactites which I have examined are also internally holocrystalline, with one possible exception mentioned below.

Three types of externally holocrystalline stalactites have been reported previously (Snyder 1951, Halliday 1953). All were basically hexagonal "soda-straw" stalactites although one type, reported by Edward A. Danehy (Halliday 1953), had a thicker wall and was somewhat tapered. Another rare type noted by Danehy consists of a pointed, facetted tip on an otherwise "normal" stalactite (Figure 3). The form that is entirely holocrystalline reaches a length of more than two feet in one California cave (Danehy, personal communication). The crystal faces on all of these three types are continuous throughout their length.

A broken specimen found in "Secret Cave", Texas during the summer of 1957, appears to be another distinct type of externally holocrystalline stalactite. It is 9½ inches long and averages about ½ inch in diameter (Figure 4). Its lower third main-

Photo by James F. Quinlan

Figure 1

"Secret Cave", Texas. Externally holocrystalline stalagmite.

Figure 2

From left to right: fragment of internally holocrystalline stalactite showing oblique fractures; tip of quadrilateral stalactite with triangular end; end view of hexagonal stalactite with three major and three minor crystal faces.

tains this diameter quite evenly, but the upper part of the specimen enlarges from a width of ¼ inch, which is hardly more than that of a "soda-straw" stalactite, to a width of one inch in its mid-portion. Because of this variation in diameter, the crystal faces on this externally holocrystalline stalactite do not maintain unbroken continuity.

A "stalactite-type" central canal, 2 to 4 mm in diameter, extends to a point about ½ inch from the tip of this stalactite (Figure 5). The course and size of the canal shows through the fairly clear wall of the stalactite. With transillumination, the canal appears as a wide tube except in two areas. A moderate narrowing of the channel occurs at the widest part of the stalactite, and marked narrowing is prominent just above the point where the uniform distal portion of the specimen begins.

On the surface of this stalactite, there are several small side-growths of crystal. A single growth is located at the thickest point of the stalactite. A growth consisting of a small group of crystals is located at a point coinciding with the maximum narrowing of the central canal. The largest group of crystalline side-growths is about ¾ inch from the tip, nearly coincident with the end of the central canal (Figure 6). As the remainder of the stalactite is free of these excrescences, their grouping in association with the narrowings of the canal indicates a probable relation to the occlusion of the canal.

The mineralogy of this and other bizarre crystalline speleothems of "Secret Cave" is far from clear. There is a possibility that this type of externally holocrystalline stalactite is the result of secondary subaqueous deposition on a tubular stalactite. The correlation between the crystalline excrescences on its surface and the strictures of the canal, however, suggests strongly that this stalactite is a product of authigenic rather than of subsequent external deposition. Its origin is probably quite similar to that of other hexagonal stalactites.

One fragment of hexagonal stalactite from Sebolts Cave, Virginia, has a poorly developed seventh side, and Quinlan reports (personal communication) that another stalactite

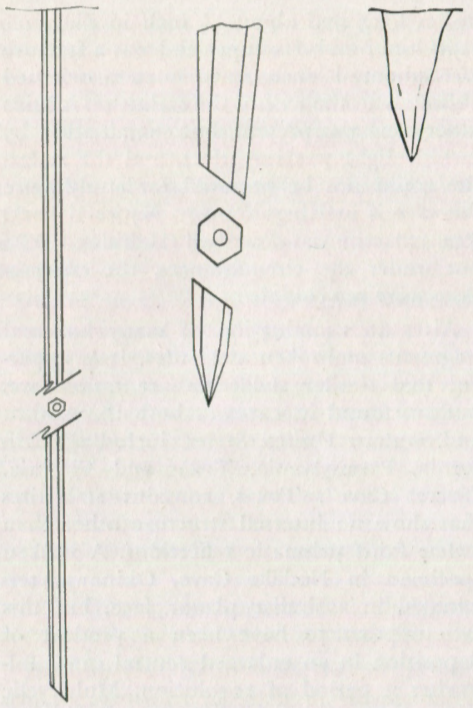

Figure 3

Three types of externally holocrystalline stalactites (after Danehy).

from that cave has an eighth side, indicating that this form is subject to other modifications. In a hexagonal stalactite from Sebolts Cave, the central canal is narrowed to a diameter of only 1.5 to 2 mm, in contrast with the large central tube in the large specimen from "Secret Cave" just described; the external diameter of the specimen from Sebolts Cave is 9 by 12 mm, which is more than that of a simple tubular stalactite.

Another type of hexagonal tubular stalactite is represented by a single 3 cm fragment, also sent to me by James F. Quinlan. It has three faces about 7 mm wide, and three narrower faces about 3 mm wide, so that at first glance it appears to have a triangular cross section. This specimen has a central canal 4 mm in diameter and a wall 2 to 4 mm thick.

Internally holocrystalline speleothems are characterized by a weakness to fracture along a single plane which is oblique to the axis of the speleothem (Figure 7). In all but one stalactite examined these fracture faces are about 45 degrees to the central axis. In one internally holocrystalline stalactite found by Quinlan, the stalactite is fractured along two such planes with fracture faces at right angles to each other (Figure 2). In the case of other fractured specimens with two planar fracture surfaces, the two surfaces are parallel, or in the case of helictites, they are nearly parallel being modified slightly by the shifting axis of the helictite. In the unique specimen of Quinlan's, faint concentric rings are present.

Internally holocrystalline stalactites first came to my attention in 1949, in Lilburn Cave, California. This cave contains relatively few speleothems, but those that are present are notable for their pristine whiteness, translucency and homogeneity. In this cave, in a passage that is rarely visited, I observed a broken stalactite about three

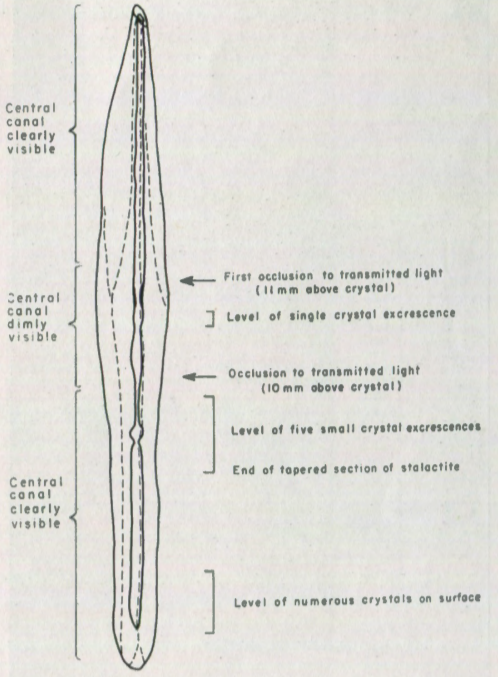

Figure 4

Longitudinal section of an externally holocrystalline stalactite from "Secret Cave", Texas showing occlusions in central canal.

Figure 5

Holocrystalline stalactite showing a "shadow" remnant of a central canal.

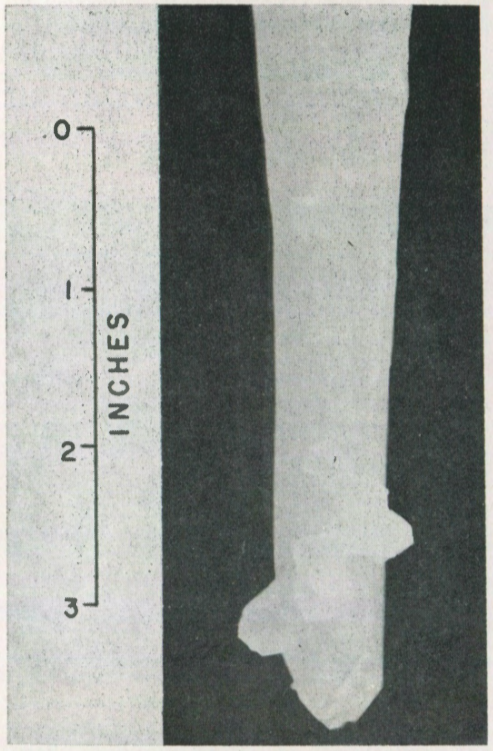

Figure 6

Crystal growths on a holocrystalline stalactite.

inches long and about ½ inch in diameter at its lower end. Its upper end was a fracture face about 1 inch in diameter, oriented obliquely to the axis of the stalactite. A faint inner zone was present, but examination by carbide light was imperfect, and the stalactite could not be removed for study since the cave is in Kings Canyon National Park. The stalactite was described (Halliday 1953), but under the circumstances, the observations were not complete.

After an examination of many hundred fragments of broken stalactites, it is apparent that similar stalactites are quite rare, but are found in caves in both the eastern and western United States, including California, Pennsylvania, Texas and Virginia. "Secret Cave", Texas, contains stalactites that show no internal structure other than a few faint prismatic reflections. A broken specimen in Nodake Cave, Okinawa, terminated in a similar planar face, but this face appears to have been a product of deposition in an enlarged central canal following a period of re-solution. Multicyclic speleothems are common in Okinawa caves.

Examination of other broken specimens has also resulted in discovery of fragments of two holocrystalline stalactites in a little-known cave in the central Sierra Nevada of California which will not be named for reasons of conservation. They differ from all other internally holocrystalline stalactites known to the writer because the fracture surface is interrupted by a six-pointed star apparently consisting of differently-oriented crystals. Like most holocrystalline speleothems, these two stalactites are so translucent that many internal features can be observed through the side when properly illuminated.

The stars are aligned so that the narrowest part of the faces are traversed by one set of arms of the star (Figure 8). In the center of the face of each stalactite is a small, roughly circular area about ¼ inch in diameter. It reflects light at a different angle from the rest of the face. Upon transillumination of the stalactites, this central area can be seen to continue down the length of the stalactites as a solid, axial structure. It appears to consist of a multitude of tiny lines radiating downward and outward from the

center. These lines may represent either tiny openings or inclusions. In one of the stalactites, this axial structure is asymmetrical and the cross-section of the stalactite shows slight flattening toward a triangular cross-section. The surfaces of both stalactites have a number of small, rounded, oblique ribs arranged in parallel groups; this has been noted in other internally holocrystalline stalactites.

One of the stalactites is probably modified from its original form by the presence of a bulbous protrusion near its lower end. It terminates in a flat, obliquely oriented tip at the end of the axial structure; in this specimen the axial structure is asymmetrical. The edge of this flat terminal plate is interrupted by the end of a central canal about ½ mm in diameter. This canal begins near the level of the bulbous protrusion. The location of this short canal and that of the bulbous protrusion suggest that they are interrelated phenomena of internal flow.

The other stalactite ends in an almost planar face which parallels the upper face, but lacks its stellate pattern. While it appears to be a fracture face, it may be a natural termination. At its center is a barely visible central opening with an attached triangular crystalline wedge. Surrounding these is a partially demarcated clear zone. This zone appears to be continuous with the central axial structure. Transillumination reveals that the central opening extends about 1 cm upward from the lower end of the specimen, but it lacks the sharp demarcation of the tube of the other specimen. The entire central zone has the appearance of the channel of a tubular stalactite which has been filled by mineral deposited through internal flow. It is not sharply demarcated from the surrounding part of the stalactite, however, and crystal faces on the upper surfaces appear to be continuous across the transition zone.

The origin of internally holocrystalline stalactites is a perplexing question. If they originate as tubular (soda-straw) stalactites, and are later converted to their ultimate form through subsequent deposition, marked internal reorganization must occur no matter whether the deposition is a product of in-

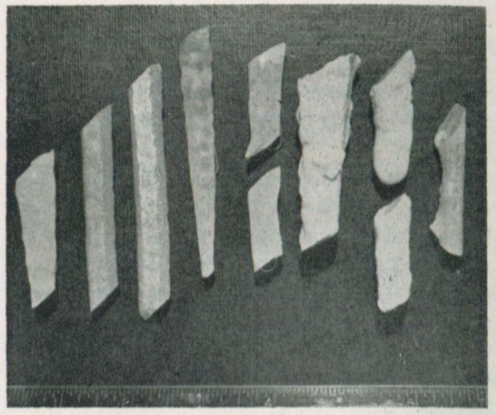

Figure 7

From left to right: "stellate" stalactite fragment; hexagonal stalactite fragment (2 specimens); holocrystalline stalactite without visible internal structure; two fragments of an internally holocrystalline stalactite; fragments of quadrilateral externally holocrystalline stalactite; fragments of two internally holocrystalline stalactites with secondary coating; fragment of internally holocrystalline stalactite with two oblique fracture faces.

Figure 8

Internally holocrystalline stalactite showing a stellar shaped central "canal" area.

ternal or external flow. Only the faintest suggestions of a parent tubular stalactite are present in the stellate specimens. Others vary from those with a distinct central zone to those which show no trace of such a structure.

It is difficult to believe that these stalactites had no central tube and were formed by external deposition alone since this would require complete evaporation without formation of a drip ring and without change in conditions of deposition. Internally holocrystalline stalactites have a number of resemblances to the type of helictite recently studied by Moore (1954) and may prove to have been formed under closely related conditions. Since internal flow to and through the bulge of a bulbous stalactite has been observed experimentally (Moore 1953), it appears that internal flow is present in some or all of these specimens. It is possible that phenomena of internal flow and internal recrystallization, about which little is known, are largely responsible for the features of holocrystalline speleothems.

In closing, it should be urged that no search be made for unbroken internally holocrystalline stalactites. It is doubtful that they can be distinguished before they are broken, and they are so-exceedingly rare that breaking stalactites in search of them is totally unjustified. In keeping with the pressing need for conservation those who wish to find additional examples should limit their search to the innumerable fragments of speleothems which litter the floor of all too many American caves. All specimens mentioned in this report were found in this way.

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The Exploration of Cass Cave, W. Va.

by HUNTLEY INGALLS

Cass Cave was first investigated in 1947. In 1949 the systematic explora- of the cave was begun in earnest and carried on until 1957. The entrance to the cave is via a small passage 800 feet long, 170 feet of which is a crawlway. Beyond this is a drop of 180 feet to the floor of the large room which is 830 feet long, 180 feet high and 75 feet wide. The cave leading from the Big Room is over 5000 feet long, consisting of passages of all types from wet crawlways to large rooms and domepits.

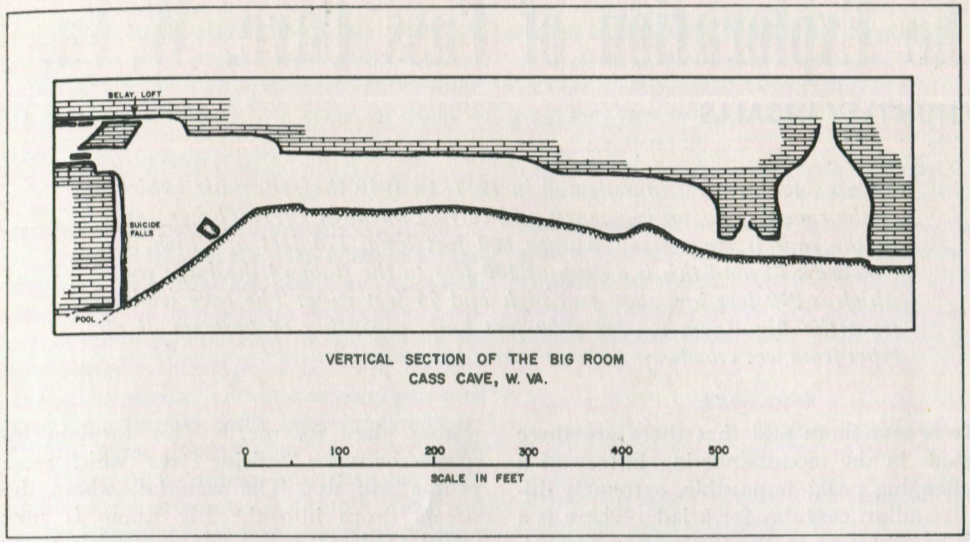
It is sometimes said that there are three periods in the mountaineering history of a challenging peak: impossible, extremely difficult and an easy day for a lady. There is a similar evolution in the exploration of challenging caves. Stories and memories of the first two stages in the history of an outstanding cave form a feeling for its character which stimulate and influence us even in the third stage. Most of the people who participated in the early exploration of Cass Cave spent many of their more exciting and inspiring as well as unpleasant subterranean hours there.

Cass Cave is located in the Allegheny Front near the company town of Cass, Pocahontas Co., W. Va. In May, 1947, a party of cavers led by Mr. J. S. Petrie made a reconnaissance of the cave on the way home from a weekend trip. Members of his party got through a 170 foot crawlway, 800 feet from the entrance, and came upon a huge chasm into which the stream they had been following disappeared. They learned that many of the natives had been in the cave as far as the chasm, and that a party of CCC boys had once lowered a member of their group 100 feet over the waterfall without reaching bottom. They were also told that a migrant from North Carolina disappeared from the town of Cass in the 1930's. One week later his brother showed up bearing a letter stating that his body would be found in the cave where he had evidently shot himself. He was found just inside the entrance. Apparently he had suffered from poor health and thought that the cave would be a "good resting place for me."* This incident inspired the name "Suicide Cave" which some people still use. The waterfall where the stream drops into the Big Room is now called "Suicide Falls". Since Petrie's party had neither the time or the equipment for entering the Chasm they made no further explorations.

In the next two years no serious attempt was made to enter the chasm but in July, 1949 Petrie returned with Ray Moore, Bob Handley and several others. Dressed in an immersion suit, Ray made the first descent over the waterfall and found himself in an enormous room. Since communication with the top was very poor he returned without exploring beyond the area at the foot of the waterfall. On the way up water poured into the neck of the immersion suit and Ray gained considerable weight before he reached the top. Bob made the next descent and climbed to the top of a breakdown slope where he saw the room open to even greater dimensions. Meanwhile some of the men climbed into a fissure in the ceiling near the waterfall and found a small room about 30 feet up. The room ended in a second fissure which dropped into the Big Room. Since the drop from the fissure was observed to be at least 20 feet clear of the waterfall, Ray decided to construct and hang a permanent ladder there for further exploration.

The ladder was made from steel wire and cypress rungs. The rungs were made 10

* This story is from a report by Mr. Petrie.

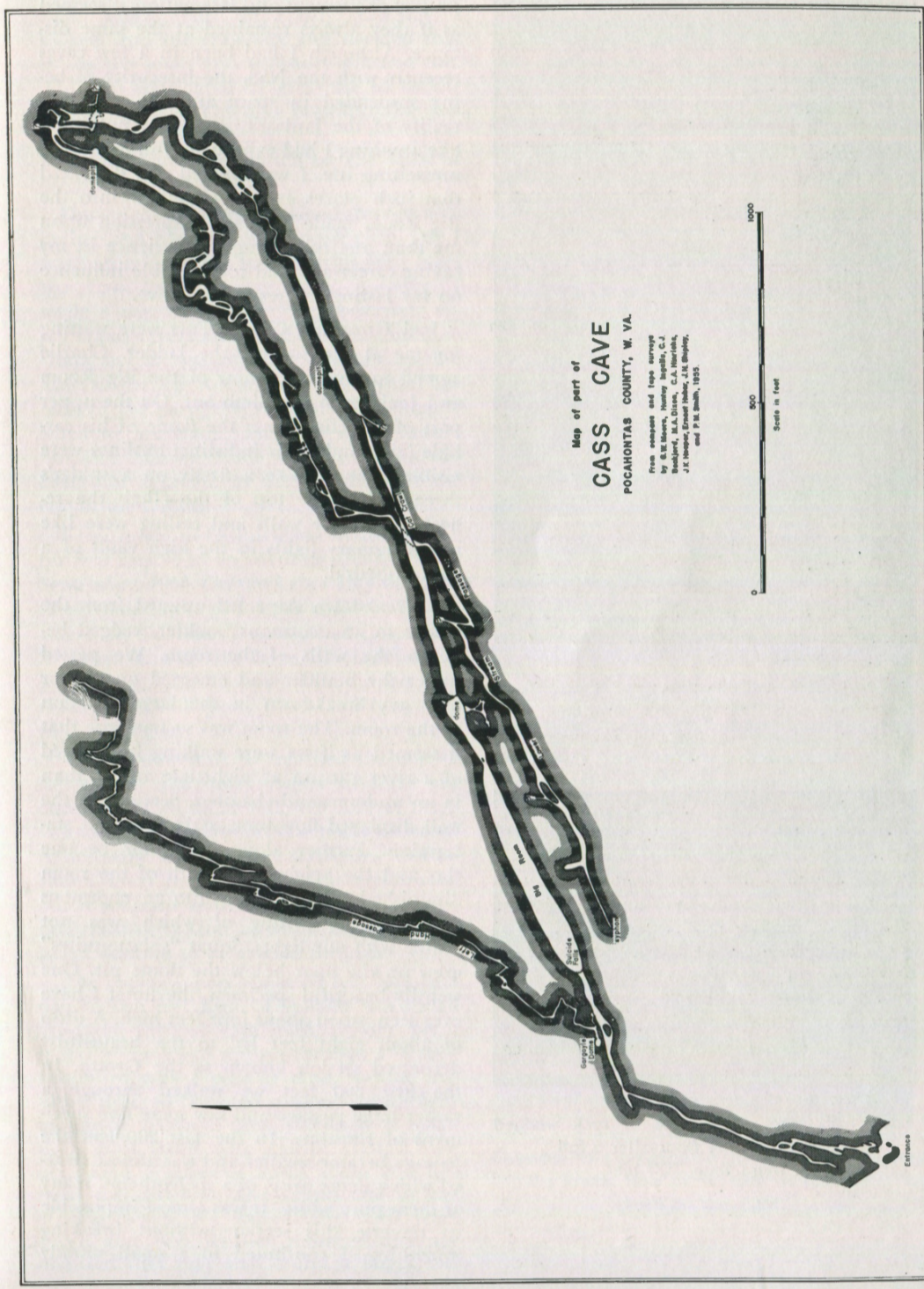


VERTICAL SECTION OF THE BIG ROOM
CASS CAVE, W. VA.

inches long and spaced 14 inches apart. The whole ladder was 180 feet long, weighed about 60 pounds and required about 100 man-hours to construct. The difficult task of setting it up in the cave was accomplished on New Year's eve 1949. At the Crawlway it was unrolled and, with several men at intervals along its length, was laboriously worked through the Crawlway, up the fissure to the small room now known as the Belay Loft, and fed into the Big Room. On New Year's day several people made the descent. The ladder reached bottom with five feet to spare. They explored the Big Room, 830 feet long with a maximum height of 180 feet and a maximum width of 75 feet, and found it to be one of the largest yet discovered in West Virginia. At the east end of the room they found a beautiful 500 foot passage, parts of which were decorated with a forest of formations. With these discoveries Cass became one of the most spectacular known caves in West Virginia.

I made my first trip into this cave in September, 1951, when I was a novice. Petrie led our party of five. From the double entrance we descended a breakdown slope to a fissure passage which led to the stream feeding Suicide Falls. At this season the stream was reduced to a series of pools and potholes in a bare rock floor. The Crawlway was fairly dry, but its pavement of angular rocks made progress unpleasant. One hundred fifty feet past the Crawlway the stream disappeared into an abyss which immediately merged into the Big Room. After a muddy climb in a ceiling fissure near the falls we arrived at the Belay Loft and belayed three men down the ladder.

A dreary three hours of waiting passed before they returned for the ascent. By this time I had little desire to see any more of the cave, but Petrie insisted that I should go below. The first 10 feet was a narrow rough-walled mud-coated fissure. The ladder was jammed edgewise in a wide crack at one end of the fissure, which made climbing awkward. A few feet farther down the climbing became less uncomfortable, but I wondered if there was anything really worth seeing. Thirty feet down I came to a ledge where the fissure ended and the Big Room began. I backed off the ledge and looked down in awe. From the lip of the ledge the ladder hung free and plunged into an appalling void where it converged toward two distant lights and faded into the blackness. Suicide Falls, 30 feet to my left and nearly dry, trickled into the abyss with a rushing sound and drifted downward until it reached the distant floor with a remote splattering roar. I descended toward the lights. In my high



From the bottom up, the 180 foot ladder in the Big Room.

The Chockstone, 1000 tons of rock wedged 15 feet from the floor after a fall of more than 100 feet.

state of excitement and fascination it seemed as if they always remained at the same distance. Although I had been in a few caves recently with the NSS, the insecurity of being suspended in space and the near unreality of the fantastic scene was not quite like anything I had experienced in my rather unexciting life. I was amazed and delighted that such places exist. This climb into the Big Room made a greater impression upon me than any other single experience in my caving career and had considerable influence on my lasting interest in the cave.

Joel Gross and Charlie Fort were waiting for me at the foot of the ladder. Charlie agreed to give me a tour of the Big Room and Joel began the climb out. On the upper part of the climb only the flame of his carbide lamp and a few indistinct outlines were visible. He was like a firefly on a spider's thread. Near the top of the climb the reflections on the walls and ceiling were like half-imaginary lights in the high vault of a dark cathedral.

A breakdown slope led upward from the ladder to an enormous boulder wedged between the walls of the room. We passed under the boulder and emerged on a floor of heavy breakdown in the largest section of the room. The room was so immense that it seemed as if we were walking in the bed of a river canyon at nighttime rather than in an underground chamber. Sections of the wall displayed flowstone, stalactites and stalagmites. Farther along, the floor became clay and the height and width of the room diminished, then opened into an enormous dome-pit, the ceiling of which was not visible with our lights. Squat "splattermites" grew on the floor below the dome pit. One weirdly beautiful specimen, the finest I have ever seen, stood about four feet high. A drop of about eight feet led to the beautifully decorated section known as the Grotto. In the first 300 feet we walked through a rather large passage and saw some fine specimens of rimstone. In the last 200 feet the passage became smaller and was almost choked with a dense array of a speleothems, many of them pure white. It was almost impossible to traverse this section without breaking something. I continued to a small muddy

room which ended in a tiny crawlway. I looked into the crawlway and decided that it was too small and probably pinched out. This was considered by everyone to be the end of the cave. The only possibility for further exploration seemed to be a few openings which had been noted on the walls of the Big Room.

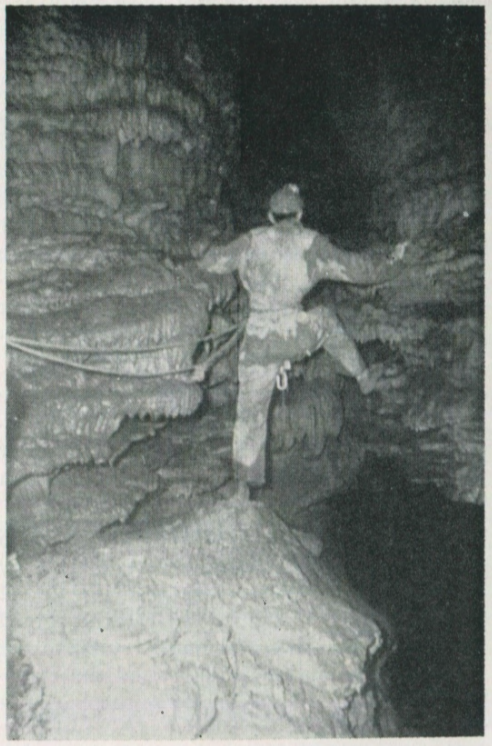
During the next year I gained considerable caving and rock climbing experience, but I was hardly qualified to lead trips into caves like Cass. In November, 1952, however, I made a trip there with five moderately experienced cavers and climbers. We hoped to climb up to one of the openings on the walls of the Big Room, near the Grotto, but most of the party was tired and discouraged when we got there. The trip was a failure but Bill Youden made the interesting discovery of a breeze in the Crawlway at the end of the Grotto. . .

I continued to be intrigued by the breeze, but was unable to do anything about it until September, 1953. On the Labor Day weekend Chuck Standard and I drove to Davis, W. Va. where an old timer's reunion of cavers was in progress, with the hope of organizing a party there. We shopped about a bit and managed to talk Jerry Bloch and his group into joining us.

After a slow start we reached the end of the Grotto and Jerry began to force the crawlway. Two other followed him at intervals to relay messages. At one point he found it necessary to break out stalactites to continue. Then the messages became confused, but it sounded as though Jerry was through the crawlway. After a while Chuck and I heard nothing so we started through.

The crawlway was about 50 feet long and one to two feet high. The floor was rough flowstone covered with mud. At one point it was necessary to squirm through a depression filled with a pool of mud. Beyond this filthy tube we entered a small beautifully decorated passage, then traversed a small deep pool lined with calcite crystals. We descended a series of levels about 300 feet from the crawlway and found one of the missing cavers. We waited here until Jerry Bloch and Bob Richter returned and announced that they had found a larger sec-

Speleothems at the end of the Big Room.



Entrance to a passage on the north wall of the Big Room; floor of the room is 150 feet down on the right.

tion of rooms and passages farther ahead. They believed that they had explored everything but recommended that we look at it.

Chuck and I crossed a small pit and entered a large room over 300 feet long and up to 50 feet wide and 40 feet high. In one section flowstone and columns up to 20 feet high decorated the walls. A beautifully symmetrical circular dome-pit pierced a flat, level ceiling and dripped into an equally circular pit in the floor. We found the skeleton of a small mammal which was so old that it was impregnated with gypsum crystals and hardly recognizable. At the end of the room we entered a fissure passage which ended in a short crawlway leading to a tiny room. I noticed a small irregular opening, now known as the Keyhole, and wriggled into it. A crawlway about three feet high led on. Jerry and Bob had not been here! We were now rather far separated from the main party, but we had to see if this led to anything. One hundred thirty feet of crawling from the Keyhole took us to a room with a breakdown ceiling. A wide, low passage led on over large, flat slabs of breakdown. We walked and crawled for about 400 more feet. The passage continued, but with our very low supply of carbide and our distance from the main party, we were already overextended. We were forced to turn back, but I was determined to return as soon as possible.

In the following week I met Ray Moore and Tony Solar who were immediately interested when they heard about the new discoveries. Bill Youden and Gerry Morgan were also eager for another go at Cass.

Early in October we were at the cave. To save time Tony, Bill and I were lowered by rope, like feed sacks, into the Big Room. Ray and Gerry made the sacrifice and agreed to remain on the surface and return to the ladder 12 hours later. We passed the crawlway at the end of the Grotto in the excellent time of two hours from the surface and were going strong when we reached the point where Chuck and I had turned back.

The passage developed into several levels, interconnected with a confused set of crawlways, rooms and fissures. We followed the general trend of the levels and probed about in holes, crawls, and fissures for something interesting. We finally stumbled upon a vertical slot which led to a lower level crawlway which took us to a stream passage. We walked downstream until we were blocked by bad breakdown 60 feet from our point of entry. We then worked our way upstream along an easy passage. About 700 feet from the junction we found an old tin can in the stream! Then we found several shiny ones! Since it had been necessary to break speleothems to get into the sections beyond the Grotto, we knew that no one had ever entered this part of the cave by way of the Big Room. We felt certain that there must be another entrance and that the cans had probably been washed in from a dump near it. We passed through several hundred feet of low dreary sewer passage and entered a large pleasant hall. More tin cans. We were walking at a rapid, comfortable pace. Soon we would be out in a beautiful autumn afternoon. About 3000 feet from the junction the stream became a deep pool which flooded the passage from wall to wall. Our hopes began to fade. Since I was the wettest I was elected to see if we could get through. I waded for about 150 feet and came to a hopeless syphon. There was nothing that could be done except turn back. We were delighted that we had discovered so much new cave, but we did not look forward to the trip back to the surface. This place was named Disappointment Syphon. We met Ray and Gerry at the ladder and returned to the surface after 15 hours of continuous activity underground.

I made no more trips to Cass until the summer of 1954. In June a party composed of Ed Riggin, Lou Kibbee, Bob Hinshaw and myself was eager to make further explorations in the sections beyond the Cat Hole—the name, borrowed from the English cavers' term for a small tubular crawlway, which we had given the crawl at the end of the Grotto. Ike Nicholson led the support party.

The cave was wetter than I had ever known it. The Cat Hole was so wet we hesitated to go on, but we did not want to change our plans after so much preparation. With much violent comment we wriggled

through, each man pushing a wave of mud and water along with his chest and shoulders. With our coating of liquid mud it was necessary to move constantly to stay warm; whenever we stopped for even a few minutes we would become chilled by our wet sagging clothes. We reached a confused area near the junction with the stream and had a quick lunch break, part of which was spent jumping up and down to keep warm. No one felt much like going any farther, but we were determined to look about a bit before giving up. We entered a small rectangular passage which made a number of right angle turns and ended in a low crawlway. This crawlway was only about 15 feet long, but we were forced to squirm through thick plastic mud, which did not add to our appearance or comfort. This led to a small fissure passage which Lou explored for about 100 feet and reported not worth further effort. We returned to the lunch room, scraping gobs of mud from our clothes, and continued on to the stream. It was too swollen to be worth any effort we could make in the time remaining at our disposal.

By the time we had returned through the Cat Hole we were completely disenchanted. Our morale was gone and we could think of nothing but getting out. We stripped off our mud saturated coveralls and threw them away. Ed remarked "This has been quite an experience, but I will never come here again. In fact I am not sure that I will do anymore caving." Everyone agreed. Nothing seemed worth the extended miserable discomfort we were experiencing. It was about one half hour before the time when the support party had agreed to pull us out. Lou poked about futilely, looking for some driftwood dry enough to burn. Ed, Bob and I just waited, depressed and dismally chilled. Then we had a strange experience which is familiar to many cavers. All of us heard voices and thought that the support party had arrived. Words were not distinct, but it seemed as if they would be if we listened more closely. When the voices continued at a constant distance and tone we realized that they were erratic sounds and overtones in the general roar of Suicide Falls. Small caving parties, when they are not making distracting sounds,

Rimstone dams in the intermediate level of the cave.

often notice this phenomenon in caves where there is running or dripping water. It has probably been responsible for many "hairy" stories of underworld beings. The next set of voices we heard really was the support party.

Lou began the climb out while the rest of us gathered up the gear. As Ed and I approached the foot of the ladder we heard desperate shouting from above. We could not tell what was happening but it sounded bad. For several minutes we waited in a resigned, depressed mood, expecting a serious accident. We learned later that an old telephone line, left by a previous party, had become entangled with the ladder and safety rope. Lou spent all his strength struggling to climb in this mess and had a very hard time of it. The last members of the advance party finally emerged in a beautiful clear morning 18 hours after they had entered the cave. Everyone believed that he would never return to this place again.

Almost everyone in both the advance and support parties did return. As the days and weeks passed one found himself thinking with more and more fascination and nostalgia of another trip to this cave. Eventually he no longer thought of mud, cold, and fatigue, but of unexplored regions, awesome black voids and the strange beauty of underworld formations. Furthermore Cass was now a challenge; not the challenge of danger, which is stupid and morbid, but of difficulty. Although danger is sometimes stimulating, those who pursue it for its own sake have

an excellent chance of attaining an unresponsive condition in which its thrills are not appreciated. I decided to begin a project to explore, map and photograph the cave systematically. This was partially accomplished in a series of ten trips in the period between September 1954 and March 1956.

The greatest problem was always with personnel. Few people were attracted to a project which involved so much time, effort, and discomfort. Many cavers who were competent enough to be useful were not interested in more than one trip. It was often so difficult to organize a party that I was forced to postpone a trip weekend after weekend. In desperation I sometimes accepted people who did not belong in the cave. They were usually more trouble than help. Some showed such little knowledge of basic techniques and safety rules that I was greatly relieved to get through a trip without an accident. I decided that it would be better to abandon the project than to make any more trips with this kind of risk. Probably the work we accomplished could have been done in half as may trips if all the parties had been as competent as some of the later ones.

Although some trips were little better than a waste of time, a circle of excellent cavers was gradually formed and much good work was accomplished. Most of our trips were made on two day weekends. We would usually enter the cave in mid-morning on Saturday and emerge in the early daylight hours Sunday, often spending more than 20 hours in continuous activity underground. We never camped in the cave since too much time would be consumed in sleeping, and struggling with equipment, to allow us to accomplish anything and still make the last part of the 450 mile round trip to Washington, D. C., where most of us lived. Large parties were never more than partially successful unless they were divided into subgroups which worked independently in different parts of the cave. With these large parties such an appalling amount of time and energy was spent in the mere movement of people and equipment that nothing more than a tour could be accomplished. On one occasion I waited at the foot of the ladder in the Big Room for five hours while people struggled to climb out. Some parties have spent nearly ten hours just climbing out of the Big Room. Much of this dreary and exhausting business was avoided by the smaller parties. The most successful trips were made by parties of three to five highly experienced cavers. The greatest technical problem was, of course, the climb in and out of the Big Room. After we were forced to cut Ray Moore's badly deteriorated ladder we used our own light, but very uncomfortable cable ladders. It would have been more efficient to use a single 200 foot rope and rappel in and prussic out. Of course it would help if a support party set up a ladder for the climb out, although some people spend more time climbing a 200 foot ladder than the 30 minutes required for a good caver to prussic up the same length of rope. In the period when these trips were made all but a very few cavers considered rappeling and "prussicing" for such distances to be an extremely radical procedure. Later we did have trips where no one was left above to belay us out, but in all the parties I led, Bill Cuddington and I were the only cavers who negotiated the drop from the Belay Loft by rappel and prussic knot.

Earlier trips were often ordeals of discomfort and exhaustion. Sometimes we would be strained to the limit of our endurance. Some cavers would not recover from the effects of a trip for a week, sometimes developing a secondary illness through their weakened condition. Later when we had developed greater endurance and better techniques we made trips in which we were continuously active for periods of more than twenty hours without becoming seriously fatigued or overextended. It was important to keep warm and dry on trips of this length. We always carried a change of clothes in a rubber bag when we crawled through the liquid mud in the Cat hole. Sometimes when we were forced to wait we would cover up with a plastic table cloth, with one or two carbide lamps in the arch formed by our knees. The warmth from the lamp would soon form a bubble of warm air under the covering. The most important thing of all was the spirit of the party. A gay compatible group of highly experienced cavers, with an intense interest in their work, hardly noticed discomfort and fatigue.

In all these trips I attempted to make a photographic record of the cave and our activities. I was determined to get as authentic a record as possible and very ofter carried my Leica ready for action in even the most awkward places. I became accustomed to operating a Leica while walking, crawling and climbing. The most difficult shots were the ones of the ladder pitch at Suicide Falls. They were made by firing from 4 to 20 G.E. No. 50 bulbs simultaneously with a battery and using aluminum foil spread on a slope as a reflector. In the course of these operations I had to have the grit cleaned out of one Leica twice and another was smashed in a 150 foot fall.

The most important task was to make a map of the cave. This was supervised by George Moore, who also made geological studies and gave the Cass project such strong support that he probably prevented it from being abandoned.

In May 1955, a party composed of two groups was organized for mapping and for exploring certain leads on the walls of the Big Room. The first thing the climbing party wanted to investigate was the ledge at the bottom of the fissure which drops into the Big Room from the Belay Loft. Tony Solar had traversed it for about 80 feet in 1952 and reported that it might be a new route into the Big Room or even lead to an extension of the passage in which the Belay Loft is located. I traversed as far as Tony's lead and set a few expansion bolts for protection, but no one seemed interested in joining me so I returned to the Belay Loft. Three cavers were missing – Al Webb, Bob Hinshaw and Ike Nicholson. We had no idea where they were. After quite a long wait, during which we became a bit irritated they returned and announced that they had discovered a long virgin passage. They had done a bit of climbing on a wall about 50 feet from the climb to the Belay Loft while they were waiting for equipment to be hauled above. Al discovered an opening about 30 feet up and they could not resist the urge to explore it. About 50 feet of narrow fissure passage led to a double dome-pit, one of which was unlike anything we had ever seen. It was about 15 feet in diameter and perhaps 40 feet high, and its walls were covered with weird fungoid excrescences which projected as much as two feet. We named this unusual place the Gargoyle Dome. The origin of these formations is not clear, but the adjacent dome-pit has considerable showers of water and clean walls which suggests that the Gargoyle Dome is no longer an active dome-pit constantly eroding its walls. Projections caused by complex erosion or differential solubility are often noticed in ordinary dome-pits. Perhaps the gargoyles are such projections with a coating of cave coral and flowstone. A narrow, very tortuous passage with a small stream led from the dome-pits. Most of the passage displayed small gypsum crystals. In a few places shelves were covered with gypsum snow. This passage continued for about 2300 feet to a pinchout, maintaining almost constant dimensions and character. Every party which had ever been through the first crawlway in the cave passed within a few feet of the entrance to this section.

The next day we returned for more mapping and climbing. George Moore's group decided to map the new discovery and my group returned to the Solar Ledge. Most of the ledge was actually a half disintegrated passage in the roof of the Big Room. At one point it was almost blocked by rubble. We pushed it off into the Big Room with such terrific and delightful roaring and crashing that I felt sorry for mature people who cannot allow themselves such fun. The ledge ended hopelessly in about 20 more feet. This was very disappointing, but this part of the ledge was probably less than 100 feet above the floor of the Big Room and might be a good place for a fast party to hang a rope. The mapping party was very successful and surveyed about 4000 feet of cave.

In September 1955, we made another two-group trip for more mapping and climbing. We were interested in several leads near the end of the Big Room. One was high on the south wall and the lower 20 feet was smooth wet flowstone. Borrowing an idea from the French cavers, we cut a

pole about 25 feet long with the intention of attaching a ladder to one end and propping it against the flow-stone wall. After much trouble, labor and lost time we got the cumbersome object to the end of the Big Room, but first we checked the less difficult leads.

All the leads on the north wall were disappointingly short, but we did see some beautiful speleothems. We were surprised to find several skeletons of small carnivorous mammals on clay shelves about 50 feet above the floor. It seems impossible that they came over Suicide Falls or through the Cat Hole and climbed up there. In some cases it is possible that they came through a small entrance, now closed, to these upper shelves and passages, but it also seems possible that they came in through the regular entrance when the Big Room was nearly filled with clay.

We then set up the pole on the south wall and Jim Shipley and Mike Nicholson zoomed up the ladder and over the rocks above the flowstone to an entrance about 60 feet above the floor before I could get to the pole. After much shouting and swearing about cave ethics they lowered a rope for me. Again we found a skeleton of a small mammal. We explored several small passages. totaling about 150 feet in length. One had a beautiful clear pool and a curtain of strange bulbous stalactites. The view from the entrance was rather impressive. It was barely possible to see the other wall of the Big Room. It was like standing on the edge of a cliff on a dark night.

A lead in the floor of the Big Room amounted to nothing. In the meantime the mapping party surveyed 700 feet of the sections beyond the Cat Hole.

We made no further trips for exploration, because we considered it more important to complete the mapping, photographing, and geological work first. Most of these trips were routine with respect to achievement, although there was always something of human interest such as: George Moore attempting to geologize behind Suicide Falls while struggling to stay dry under a plastic table cloth; the people who gagged with exhaustion and swore they would never return, but did; the time the cave rats chewed up our spare clothes near the entrance; the night we tried to reach the cave by a new route and wandered about the woods in the snow and moonlight looking for it.

In October, 1955, a light party consisting of George Moore, Mark Dixon and myself, and supported by Tom Ford and Gay Michone, set out to complete the map as far as Disappointment Syphon. This trip was an excellent example of what an efficient party of experienced cavers in good condition and high spirits can accomplish. We spent 25½ hours of continuous activity underground without becoming heavily fatigued. This included the 175 foot climb up a free swinging cable ladder after more than 23 hours of underground activity. None of us experienced the prolonged dull depression and dismal discomfort of some of the earlier trips. We completed the 3000 feet of mapping necessary to reach the syphon and spent some time probing about in various leads. When we emerged it was a beautiful autumn morning. The light walls of the entrance room were soft yellow from the glow of sunlight transmitted through a golden maple tree near the entrance. The rest of the trip was spent enjoying the bright tranquil beauty of autumn in the clear, soft light of a perfect day.

When the survey notes were compiled we were disappointed to find that the syphon is only about 150 feet from the pool at the foot of Suicide Falls. We had believed that there were two independent streams in the cave. Obviously the water from the falls passes through a submerged passage and appears at the syphon. The tin cans found in 1953 were either washed over the falls from the rubbish left by the earliest parties or carried in from the main entrance by floods. There is evidence of floods which inundate the section of the Big Room about Suicide Falls in 40 feet of water. Floods of this magnitude are probably rare, however. No large flood occurred in the period from October, 1953 to October, 1955 since foot prints left by the first party on banks in the Lower Stream Passage were undisturbed. High water, of course, is common and often prevents parties from entering the cave. When

the map of the cave was superimposed on a topographic map of the area, no correlation was noticed between surface and subsurface physiography, except that dome-pits were located where streams or gullies crossed a passage. This indicates that they are relatively recent features, of completely vadose origin, in the development of the cave. At first glance it seems probable that the Big Room was formed by the erosive and solvent action of Suicide Falls. At a point little more than 100 feet from the waterfall, however, the room suddenly widens from 20 feet to 75 feet in width and no longer has the character of a huge fissure. It is evident that this trench carved by the falls is merely a supplementary feature of the Big Room. The main part of the Big Room was probably formed by phreatic waters. Later a series of changes in the erosion level of the Greenbrier River probably occurred which lowered the water table in the cave. Further phreatic action, and collapse between levels, probably enlarged the room. A surface stream, which now feeds Suicide Falls, has been captured by the main upper passage. The back end of the Big Room has been enlarged by an enormous dome-pit. Another striking feature in this section of the cave is that part of the main upper passage, the Big Room, the Grotto, and the passages between the Cat Hole and the Key Hole have been developed along a single joint over 2200 feet long. At least five major levels and an undetermined number of minor levels have been developed. All levels show evidence of past earth fills. Alternating beds of clay and gravel in the Lower Stream Passage indicate that cavern fills are not necessarily deposited in entirely phreatic conditions as Bretz has suggested.

On a trip in February, 1956 we found high water at the cave, but we entered anyway since we thought it would be interesting to see Cass in this condition. It was, indeed, spectacular. We had a merry time negotiating the partially flooded crawlway and wading up to our waists on the other side. A beautiful, noisy waterfall cascaded out of the passage leading to the Gargoyle Dome. The whole cave presented such an exciting spectacle that we were hardly aware of dis-

Solution rills in a small passage high on the wall of the Big Room.

Surveying near the siphon at the end of the lower stream passage.

comfort. The view of Suicide Falls from the ladder was marvelous. As it fell into the Big Room it broke against the walls and became a wild white cascade about 20 feet wide plunging downward into blackness. It was one of the most infernal sights I have ever seen in a cave. The lower 20 feet of the ladder was in the edge of the cascade, but I was determined to go to the bottom and have a look. With difficulty I untied, got a plastic table cloth over my head and shoulders, and walked up the slope in a swirl, of spray, wind and noise. I hesitated to let the party continue, but I knew that no one would want to miss this. There was so much noise that we could not communicate even by shouting in code and I could not see more than 20 feet in the mist which enveloped the slope. As I attempted to approach the ladder to see if our packs had been lowered, a gust of spray tore off my plastic table cloth and put out my lamp. Everything was so saturated by the driving spray that I was unable to obtain another light. In total darkness I managed to feel my way to the ladder without difficulty, but by now I was so numb from the ice cold water that it would have been folly to continue the trip. Holding on to the ladder, I groped about under the water fall for the safety rope and found it, with all the packs, just as I was ready to give up and climb without it. I attempted to climb with the packs, but I had become so weakened from the cold water that after I had climbed only ten feet, I was forced to abandon everything, except one small pack containingy my photographic equipment. I was now so numbed and cramped that I could hardly hold myself on the ladder. After a slow exhausting climb I reached the Solar Ledge and attempted to feel my way up the fissure to the Belay Loft. I became jammed in a narrow part of the fissure and tore off my pack. It landed on my feet, but when I attempted to recover it I could no longer feel it and then I heard a dull distant boom below me. The pack, with my Leica and photographic accessories, was smashed on the floor of the Big Room. The rest of the party had been unable to hear any of my signals while I was below and had feared the worst. The only contact they had had with me was through the movements they felt in the safety rope. It was a bad experience. I believe Cass could be entered safely during high water if everyone in the party was equipped with an immersion suit and an electric head lamp. It would be well worth the effort.

I made only one more trip to Cass before I moved to Colorado. The project has not been completed and much remains to be done. The most promising place for further exploration is the complex area near the down stream end of the Lower Stream Passage. It is quite possible that a way can be found around the breakdown which prevents further exploration along the stream. A study of the surface topography shows that the nearest possible resurgence of the stream is about 2000 feet from this area. A large spring which has been located in Latherbark Canyon is the probable point of resurgence. Many leads have been noted in other parts of the regions between the Cat Hole and Disappointment Syphon. One very difficult lead remains on the south wall of the Big Room. The discoverey of the Gargoyle Dome and the Left Hand Passage indicates that even the unpromising leads are well worth investigating. There is also more geological work to be done to complete the studies which George Moore began.

It is becoming less and less a feat to tour or explore Cass Cave. I hope that the tourists will refrain from marring it by leaving rubbish, broken speleothems, and walls covered with names and comments which impress no one. The exploration of such a cave was a wonderful and exciting experience for all who helped pioneer it. I hope that I, and everyone who shared in this endeavor, will be so fortunate as to explore many other such challenging and interesting caverns.

For the Record

by T. R. SHAW

. . The depth and lengths of caves are controversial subjects. To date the greatest known depth is 3680 feet at Gouffre Berger in France. Fourteen other European Caves are over 1400 feet deep. In America the deepest cave is Neff Canyon Cave, 1186 feet, followed closely by Carlsbad Cavern, 1070 feet. The longest mapped cave is Hölloch in Switzerland, 37.6 miles. Mammoth Cave in the United States has 33 miles mapped and has a total passage length in the order of 100 miles. Crystal Cave, Kentucky, has about 23 miles mapped and is a rival to Mammoth in size.

Many sports are plagued by record-seeking. In some, such as athletics or motor-racing, it is inherent in their very nature and an essential part of their being. In others record-making and record-breaking, though mainly incidental, are often over-rated.

Mountain climbing and cave exploring are comparatively free from this, but whenever an important record is surpassed it is seized upon by the press and an imaginative public, and its importance is magnified beyond all bounds. A man who has explored a cave deeper than any known before is undeniably and justifiably proud of his achievement, but it is not the prospect of attacking the previous record which inspired him to make the descent in the first place. We explore because we enjoy it, and we find satisfaction in discovering new ground and new facts. The attraction of breaking records is a subsidiary one with cavers as it is with mountaineers. As "news value", however, it ranks second only to accidents, so the public is led to believe that we are a race of glory-seekers, who are prepared to take any risk to achieve "fame".

Dissociated from popular hysteria, records of depth and length are important facts for the speleologist. They are constantly changing, and to become even moderately up-to-date involves sifting fact from a mass of printing errors, exaggerations, misquotations and reprints of obsolete figures.

A pleasant and amusing time can be spent studying some of the more remarkable errors that have been published. Today the press is sometimes guilty, but the most picturesque exaggerations can be found in books of last century and before.

In this article, therefore, I will try to give the latest available data on records of depth, length, etc., as well as mentioning some of the more notorious exaggerations.

Of all the leading dimensions of caves, it is depth which appeals most to the imagination and the spirit of competition; and the measurement of depth is always the most subject to error, and to subsequent revisions and corrections by other expeditions.

Depth is usually determined by one of two methods – by surveying or by altimeter readings. The surveys on really deep descents –at the present limit of world exploration– are often hasty and made by men near the limit of endurance. In steeply-descending potholes, too, there is rarely a chance for the surveyors to close their traverses, and any errors must remain undetected. Altimeter readings are even less reliable. Even if allowance is made for changes in barometric pressure at the surface while exploration is in progress, there may still be unknown pressure drops across constrictions in the cave; the very presence of a draught indicates that there is a pressure difference between the air in two parts of the cave.

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THE WORLD'S 15 DEEPEST CAVES

	Depth in feet	Name	Location
1	3680	Gouffre Berger	France; nr. Grenoble.
2	2389	Gouffre de la Pierre St. Martin	France; close to Spanish frontier of Basses-Pyrenées.
3	1980	Trou de Glaz & associated systems	France; nr. Grenoble.
4	1949	Spluga della Preta	Italy; nr. Verona.
5	1835?	Antro di Corchia	Italy; in Tuscany.
6	1768	Anou Boussouil	Algeria; the Djurdjura.
7	1700	Abisso di Verco (or Iasbaun)	Jugoslavia.
8	1700	Geldloch (or Oetscherhöhle)	Austria.
9	1697	Tonionschacht (or Fledermaushöhle)	Austria; Styria.
10	1653	Gouffre de Chevrier	Switzerland
11	1599	Gouffre de Caladaire	France; Basses-Alpes.
12	1519	Grotta della Piaggia Bella (or Voragine del Colle del Pas)	Italy; Cuneo.
13	1482	Grotta Guglielmo	Italy; Como.
14	1477	Abisso Bertarelli (or Zankajna Jama)	Jugoslavia; Istria.
15	1463	Gouffre de la Hennenmorte	France; Haute-Garonne.

Men of the type who make such descents will undoubtedly resist any temptation to falsify the depth deliberately, but there may be a tendency to give it the benefit of any doubt. Nearly all modern surveys have shown that their predecessors err on the deep side.

In the table I have listed what I believe to be the most recent depth figures for the 15 deepest caves in the world. Each exploration of one of the major pot-holes seems to bring a revision of the published depth (1) * The table given in Casteret's book (16) is already wrong in several particulars.

The deepest cave known at present is the Gouffre Berger near Grenoble in France.

The cave was discovered in 1953 and was first famous in 1954 when it became the deepest known cave in the world. On September 11th of that year the explorers had reached 2425 feet and so passed the 2389 foot record which the Gouffre de la Pierre St.-Martin had enjoyed for over a year. Then on the 24th of the same month they continued downwards to 2959 feet or well over half a mile.

The story up till then has been told in a most readable book by Jean Cadoux and three of his colleagues (2). Not much has yet been published on the 1955 and 1956 expeditions (3). For 1956 I have seen only two references in the British press (4) (5), both of which give a wrong depth. They confuse the subject still more by having a bogus translation of the name of the cave: it was in fact called after its discoverer, M. Berger, and is not the Shepherd Pit at all. The principal French caving journals are always slow in publishing but the Italians did have two short notes on the 1955 expedition (6) (7). An account in a Swiss journal (8) described both 1955 and 1956, and Bob Powell of the Craven Pothole Club has written about this experiences with the international group of 1956 (9) (15).

There was a preliminary expedition in July, 1956 when two tons of equipment were taken down to form a depot at 2100 feet. The French Army was assisting with wireless communications and Electricité de France had lent a helicopter to transport the 5 tons of food and equipment to the cave mouth. Besides the French cavers who have been forcing the cave a little further every year since 1953, there were invited representatives of nine other countries.

* Numbers in brackets denote items in the list of references at the end of the article.

The main descent began on August 2nd. The explorers were usually divided into two groups so that tackle could be rigged by one while the next was still carrying equipment forward in relays. Five underground camps were set up altogether, the deepest at 3280 feet. The weather was bad, delaying progress, and all the gear including sleeping bags and "dry" clothes was drenched between Camps III and IV. After eight days the main party was at Camp V and from there the bottom of the cave was reached. There is a sump about 25 feet in diameter at more or less the same level as the terminal sump in the resurgence cave (the Cuves de Sassenage). The explorers were still below 3000 feet on August 16th when a very violent storm broke on the plateau above and they were cut off for 70 hours. Those who were in camp at 3081 feet found that the wind from the roaring waterfall 50 yards away was strong enough to blow out their acetylene lamps.

The Gouffre Berger is therefore almost half as deep again as any other known cave in the world.

Pierre St. Martin's 2389 feet is probably correct, as both the altimeter reading and the surveyed depth agree to within a few feet. Often quoted, however, is 2152 feet, which was the surveyors' first announced figure in 1953, before they corrected a mistake in their calculations. When the descent of the entrance shaft (1135 feet) was first made in 1951, the Manchester Guardian (10) had a little paragraph referring to "M. Lepineux, the discoverer of the internal precipice."!

The Trou de Glaz system of the Dent du Crolles in the French Alps has suffered a set-back in recent years. The depth of 2157 feet given in Chevalier's book "Subterranean Climbers" was based in part on an old survey and Jean Noir's more accurate figure is 1980 feet.

The Spluga della Preta in northern Italy was famous for many years as the deepest cave in the world. From the exploration of 1927, right through the war years to 1947, it occupied the place of honour. The depth of this first descent was corrected in 1954 from 2090 feet to 1861 feet, but the same expedition continued downwards as far as 1949 feet. The press in 1954 published variations on the theme: the Daily Telegraph of 13th August gives the depth attained as 2507 feet and claims a world record; The Times of the same day repeats the old figure of 2100 feet and is supported by the Daily Express.

For the Antro di Corchia I have seen published figures of 1750, 1773. 1835, and 1862 feet, but I do not know which is correct.

The Anou Boussouil in North Africa is often quoted as 1689 feet deep, but the cave continues upwards for another 79 feet above the entrance, giving a total of 1768 feet.

The Geldloch or Oetscherhöle was descended to 1421 feet in 1953; with the 279 feet above the level of the entrance, this gives a total vertical extent of 1700 feet. An expedition in 1923 claimed to have reached 1418 feet, but the latest survey shows this point at only 1154 feet.

Successive expeditions have penetrated deeper in the Fledermaushöhle or Tonionschacht in 1929, 1936 and 1953. Each has made a survey which reduced their predecessor's figure, and showing their own progress beyond the previous limit. At present the depth stands at 1697 feet.

The Gouffre de Chevrier (11) in Switzerland was explored to a depth of 1653 feet in February 1955. This makes it the deepest cave so far known in Switzerland and the tenth deepest in the world.

In Caladaire the depth of the 1948 descent, measured as 1808 feet, was corrected to 1580 feet by another party the following year, but they in turn reached 1599 feet.

Close to the Franco-Italian border is a very interesting system comprising the Piaggia Bella (1519 feet), the Raymond Gaché pothole (1371 feet) and the Dupega Caves. These three are separate caves but they form part of the same system and it is thought likely that a link-up will eventually be achieved.

Piaggia Bella is a deep cave in its own right – the 12th deepest in the world. There

have been expeditions every year from 1952 to 1955 and several conflicting depth figures have been published. The 1952 expedition was described in The Times (12) and, although this does not give the latest news of the cave, it provides the only detailed account of it in English. The depth attained, quoted there as 1300 feet, was stated more reliably (13) to have been estimated as 1263 feet. In 1953 another French expedition reached a sump which has still not been passed. The depth they claimed as 1656 feet (1), but in the next year a further French expedition corrected this to either 1522 feet (13) or 1499 feet (7) (14). In 1955 an Italian expedition reached the same place again and their survey gave a figure of 1519 feet (14).

Casteret (16) quotes a depth of 1739 feet but he does not give his source, so it is safer to take 1519 feet as the established figure until more information comes to hand.

Further up the same mountain lies the entrance to the Raymond Gaché pothole, at more than 8000 feet above sea level. It was discovered in 1954 and explored at first to a depth of 1150 feet. Attout (17), writing in 1954, says: "It's link-up with the Piaggia Bella cave is almost certain, but the late hour of its discovery made this impossible to effect. That will be undertaken in 1955." In 1955, however, it was not effected; Renault (7) writes of the 1955 French expedition: ". . . and in four days reached an estimated depth of 1371 feet", but mentions no break-through. The difference of level between the entrance of the Raymond Gaché and the bottom of the Piaggia Bella cave is of the order of 2788 feet (17) so if the two figures are anything like accurate the two caves must be very near joining or have "missed" each other.

The Dupega Caves are risings in the Italian valley of that name and if a connection can be forced between them and Piaggia Bella, a total depth of 4,400 feet will result, which certainly would beat existing records. It must be this system which is meant in the Guinness Book of Records (18) which contains the intriguing statement that an Italian cave will become the world's deepest when it is explored!

What is the deepest cave in the United States? There seem to have been fewer accurate surveys here as yet so the answer is very uncertain.

Neff Canyon Cave has been explored to a depth of 1186 feet (19). Carlsbad Cavern in Texas is a close second and according to Folsom (20), "at least one geologist thinks it likely that one or more levels exist below the eleven-hundred foot depth that has been reached." Gibbons and Hale (21) quote 1070 feet for Carlsbad. The next deepest in U.S.A. is Bull Cave at 796 feet (21).

I have heard (22) a recent American figure of 3000 feet for the depth of Ophir Cave in Montana, based on altimeter readings. The exploration was said then to be still in hand, but I have heard nothing since.

Fantastic and often picturesque exaggerations of depth are common in early writings. Almost everyone has met examples of simple shafts being magnified into bottomless pits by credulous writers or local people.

Some of the most spectacular cases concern Eldon Hole in Derbyshire (England), the true depth of whose entrance shaft is at present 200 feet (23).

Joan Parkes (24) in "Travels in England in the 17th Century" says: "Young Edward Brown describes Eldon Hole as 'a pit of vast depth, that the greatest ingines and the boldest fellows that could bee found to goe down never find any bottome.' "

In 1678 Thomas Hobs (25) mentions a depth of 200 ells (750 feet), and then in 1681 Charles Cotton (25) writes as follows in "The Wonders of the Peak":

> "But I myself, with half the Peake surrounded,
> Eight hundred, four score and four yards have sounded;
> And though of these fourscore returned back wet,
> The plummet drew, and found no bottom yet;"

Dr. Charles Leigh (26) in 1700 misquotes Cotton's figure in fathoms instead of yards, bringing it to 5304 feet. A Dr. Short (1734) (27) (quoted by Martel) reduced this to 422 yards. Thomas Amory (28), writing about 1755, repeats the figure of 422 yards, but carefully points out that "how deep the water is cannot be known". Yet another extreme depth was claimed by Alexander Catcott (1768) (25) (29) who plumbed a depth of 993 yards without meeting bottom.

Some wild accounts are given of St. Michael's Cave in Gibraltar. Bigelow (1831) (30) writes: "The love of marvel, peculiar to the vulgar, has originated the notion that this passage extends under the Straits, though fathomless, quite across to the opposite continent." It is by this natural tunnel that the Gibraltar apes are popularly supposed to have arrived from North Africa.

Drinkwater (31) in 1786 gives the depth as about 500 feet; and Bartlett (32) describes one of the passages as "the pathway, half beautiful, half horrible, into unfathomable depths below." His credulity has also given us the following attractive account of the place:

> "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!".

According to Horton's survey of 1938 (33), the real depth is 253 feet below the entrance (which is at 937 feet). As far back as 1865 (34) an army officer had measured it as 265 feet, but that did not deter his successor from allowing it to 'grow' again. In 1879 Major Willoughby Verner (36), who later discovered the Spanish painted cave of La Pileta, "measured the depths" and found the lowest point to be at 620 feet. This is quoted again in 1915 (35), and as late as 1936 an Army guide gave the depth as 600 feet (36).

The nearby Gibraltar cave, known as New St. Michael's Cave, affords a recent example of a legend growing up. The cave was discovered in 1942, and six years later a certain shaft inside the cave was pointed out to me as bottomless. In fact it is just 54 feet deep and the bottom can be reached by a roundabout route without tackle.

Another notable exaggeration concerns the Deutschmann Cave (1) in British Columbia, for which a depth of 1970 feet was published in 1905.

The exaggeration record of all time must surely go to Norway for the following note which appeared in 1903 in The New Popular Encyclopoedia (37): "Some [caves] are of great depths as that of Frederikshall in Frederikshall in Norway which is calculated to be 11,000 feet in depth." This is enough to have more than a quarter of the cave below sea level if the entrance were at the very top of the highest mountain in the country. I think I have the answer now, which shows that the editor of the encyclopoedia had gained an extra nought in his figure. In Norway is Larshullet, the deepest cave in northern Europe, which is just about 1100 feet in depth. Noir (1) gives a figure of 1180 feet but later (38) he revises it to "somewhere between 1070 and 1100 feet according to the datum chosen on the surface." Lewis Railton (39) (40) was the first to reach this depth and a Cambridge University expedition last summer achieved it again (41).

The accurate measurement of the length of a cave is less difficult than that of depth, but the establishment of a length record presents problems of its own.

The total passage length of a cave often gives a misleading idea of its extent. Some caves, including many of those containing active streamways, are straightforward. In others, such as Gaping Gill, it is easy to visualise where all the length comes from. In other types of cave, notably in phreatic networks, a labyrinth of passages covering quite a small area may contain an unexpectedly great length of surveyed passages. For example Bakers Pit Cave (42), in Devon (England), is only about 800 feet in a

straight line from entrance to extremity, but the survey shows a total passage length of almost a mile.

The world record for length is still in doubt. It is claimed by Mammoth Cave in Kentucky, but the very various distances quoted leave it open to suspicion. It is said that the proprietors will never allow a complete and accurate survey to be published, for fear a neighbouring land-owner should be able to make a subsidiary entrance and so break their tourist monopoly. Be that as it may, no reliable figure is known. Many of the early accounts mention 150 or 200 miles. Even the present brochure issued by the National Park Service contains the following oddly worded phrase: "Mammoth Cave has over 150 miles of explored corridors literally filled with spectacular features . . ." If 'literally filled' they can hardly be counted towards the total. Some plans had been made by the time of Martel's visit in 1912, and his considered opinion was that 62 miles could be taken as a minimum. In fact Mammoth Cave contains about 28 miles of mapped passages.*

Also in America, a length of 34 miles is claimed for Carlsbad Cavern (43). Other lengths claimed for it include 23 miles and 37 miles, but the true figure appears to be about 8 miles.

For long caves America is fast re-establishing its claim to the greatest, on a firm basis. Exploration in the Floyd Collins Crystal Cave (44) is continuing almost every weekend and the latest figure I have is from Brother G. Nicholas (45) who mentions 23 miles of surveyed passages. He says (46) that there is "perhaps twice that number still to be mapped". In August 1956 it was announced (47) that a new entrance had been made into a remote part of the system so that new areas are now within reasonable reach for work. It is even possible that a connection may eventually be found with Mammoth Cave beneath the next ridge (48).

Another American cave which is reputedly very large is Colossal Cave in Arizona. It is said (48) that a plan made in 1922 showed 39 miles of passages surveyed without the end of the cave being reached. This map has apparently been destroyed since the death of the geologist who made it.

Although Mammoth Cave and Crystal Cave in America have perhaps the greatest potential length, the longest cave survey made to date is in Europe, in the Hölloch (Hell-Hole) of Switzerland. The latest figure (49) I have is 37.6 miles after the spring expedition of 1956 and Grobet (50) says that still "it goes".

Until 1953, Eisriesenwelt (The Realm of the Ice Giants) was the longest cave in Europe, with about 25 miles of passages. It can still claim world supremacy among ice caves.

Tantalhöhle, also in Austria, contains some 22 miles of passages.

Another European cave famous for its length is Postojna in Jugoslavia (formerly known as Adelsberg and then as Postumia) where the section open to tourists contains an underground post office and railway. It is commonly said to comprise 14 miles of natural tunnel but Serko and Ivan (51) show this to be an exaggeration. They give 12.3 miles for the total passage length of the cave, but this too is utterly misleading for it includes the 4880 metres of the Malograjska Cave, which has no passable connection with the main cave. A better figure for Postojna would therefore be 9.3 miles.

Aggtelek Cave in Hungary is another long European cave, with 13 miles of passages (52).

In France the Dent de Crolles system (Trou de Glaz etc.) holds the national length record at 11 miles, besides being the third deepest cave in the world.

A visit to some of these European caves would be salutary for the American writer (53) who said a few years ago: "There are more good caves in the U.S.A. than in the whole of Europe."

* Editors Note: Precise instrument surveys of Mammoth Cave were made from 1935 to 1942 by members of the U.S. Geological Survey and the Civilian Conservation Corps. Since 1942 a small amount of surveys for engineering purposes have been made. 28 miles of passage have been plotted from these surveys and 4 to 5 more miles are in notes not yet plotted. The surveys cover all the major passages and important side passages; in all about a quarter of the cave has been surveyed.

Tales exaggerating the lengths of particular caves are legion. We have all met the rustic who tells us that our cave goes to Little Piddlemarsh church, miles away, because years ago a dog went through and came out without any hair. Such a story is told of Pixies' Hole at Chudleigh (England), and it is a refreshing change to read Risdon's simple account in his Survey of Devon (1605-30): "There is a cave hereabouts that creepeth far under the ground, about which many marvellous matters are spoken."

"The largest underground chamber in the world" has attracted several claimants, but the outcome is still in dispute; the difficulty is to define exactly what is meant by a chamber or room.

Carlsbad Cavern's famous Big Room (54) is usually accepted as the winner, being 4270 feet long (more than ¾ mile), 656 feet broad at the widest point, and with a maximum height of 328 feet. But the survey (55) shows that, although these measurements are undoubtedly correct, the Room consists of a number of wide bays on either side of the centre line. Thus about midway along its length the width is only 60 feet, and at another point the roof height is a little as 75 feet on the centre line.

The Big Room of Carlsbad was photographed in colour not many years ago, and I quote a paragraph (56) which revels in all the record-claiming possibilities of such a shot: "Carlsbad Cavern's famous Big Room has been photographed in color – the biggest flash photo ever made! A spectacular double-page spread in 'The American Weekly', November 9 (1952), presents the awe-inspiring masterpiece." Altogether 2400 flashbulbs were used, with 3 miles of wire connecting them; afterwards it took 6 hours to gather up spent flash bulbs and to disconnect the wiring.

In Europe we cannot claim maximum dimensions of such a size, but the caverns in question are single cavities undivided in any way. For many years the Grotta Gigante (57), near Trieste, was supreme, being 786 feet long by 432 feet wide and 452 feet high. It is said that the whole of St. Paul's cathedral in London could be contained in it. In 1951 the Elizabeth Casteret Chamber was discovered in Pierre St. Martin (57), and this, although not so high, possessed a bigger floor area. Present measurements give it as 1300 feet by 500 feet, with a roof height estimated at between 150 feet and 300 feet.

When I first read Attout's book (58) on Pierre St. Martin I thought the record for the world's largest underground chamber had changed. He writes, of the Salle Chevalier in that cave: "A single cry of admiration came from all three. A vast, amazing cave, surpassing in size and splendour all that they had so far seen, larger than the Casteret and Loubens caves combined, more imposing than the Quéffelec and its annex the Adèlie, lay before them like a great vessel of stone plunging forward in the waves." However, a glance at the section drawn in Casteret's book (59), together with the text, shows than the Salle Chevalier is in fact smaller than either the Salle Elizabeth Casteret ('the Casteret Cave') or the Grotta Gigante at Trieste.

Now that cave diving has become an established part of exploration, records may well be sought for the deepest underground pools or the deepest descents into them. I have not very much information on these, but it seems likely that the present record for both is held at the Fontaine de Vaucluse (France). A descent made in 1946 (60) passed 150 feet; the depth gauge read 46 metres, but was known to be reading low by an unknown amount. In 1955 another expedition (61) (62) was more successful. The explorers followed downwards along the roof of the sloping passage until at a depth of 212 feet (61) or 210 feet (62) it turned upwards again and opened into a submerged chamber said to be 150 feet wide and 100 feet high.

Yet another figure for Vaucluse is found as a passing newspaper reference (63) and cannot be taken too seriously. It occurs in an account of the diving on the wreck of the Italian ship Andrea Doria in the Atlantic: ". . . the cameraman, Malle, has filmed 270 feet down in the Mountain of Vaucluse". Perhaps this is a misprint for 210 feet.

Some years ago a curious fraud was practised at Vaucluse (64). In 1936 a Señor Ne-

gri, a Marseilles salvage diver, went down and as he descended he broadcast his impressions into a microphone fixed inside his helmet. He claimed to have reached 120 feet, but nothing that he described fitted what Cousteau found ten years later. Negri must have descended just out of sight of the surface and then broadcast an imaginary account of his explorations!

Another deep dive has taken place in the Fontaine de Chartreux, the rising which supplies Cahors with drinking water, and in 1947 de Lavaur and his colleagues reached 197 feet (60) (65).

Modern expeditions find it necessary to spend longer and longer periods underground, and subterranean camping has become a normal part of an important exploration.

The world record for exploration underground is held by members of the 1956 Berger expedition (3). The advance party descended on August 2nd and on August 16th they were still below 3000 feet; altogether some of the party spent 17 days below ground.

Casteret's stay in Pierre St. Martin in 1953 amounted to about 232 hours (from about 10 a.m. on 7th August to after 2 a.m. on the 17th). In Caladaire in 1949, the 13 members of the expedition, including one woman, remained below for between 222 and 231 hours (about 9½ days). In 1951 the Tantalhöhle expedition spent 209 hours underground.

In U.S.A., I am told (22) the longest time spent underground on exploration is 7½ days, by Roy Charlton during the 1954 Crystal Cave expedition.*

Two physiological experiments have been carried out in Mammoth Cave involving long periods spent underground. Not long ago (66) Dr. Kleitman and Bruce Richardson used this cave to live in while they found out whether human beings could adjust themselves to a "day" of other than 24 hours. They planned their life on a 28 hour cycle, unaffected by any alternation of day and night, and continued the experiment for five weeks, living in the cave the whole time. Richardson had no difficulty in adjusting to the new routine but the older man found himself less easily adaptable.

In 1843, a Dr. Croghan (67) believed that the pure, dust-free air of Mammoth Cave would be good for tuberculosis patients. He had buildings erected in some of the chambers and kept his patients there for more than five months (22). Every one of them became worse because of the damp and lack of sunlight, and one, or probably two, of them died as a result.

All kinds of other records are often claimed and discussed, but less on the international scale than over glasses after strenuous week-ends.

The terrors of the most severe cave are magnified as the evening progresses. What does constitute a severe cave? Are caves compared under standard weather conditions – in flood so many caves are impassable that there is no point in claiming that distinction – and with a low stream they are not severe at all. Technical difficulty alone does not make a cave severe unless it demands endurance as well. In many cases the label "dangerous" or "severe" has persisted for no very good reason, and the hole retains it like a dog with a bad name.

More measurable is the tightest squeeze, although even there the shape of the cross-section is often of more importance than its least dimension, and the presence of a bend may make a passage of tolerably large size quite impassable.

The extreme squeeze can probably be claimed by English cavers, though not inside their caves. One of the clubs possesses a 'squeeze machine' which is brought into use after such occasions as annual dinners and special parties. The distance between two stout wooden beams can be adjusted by nuts, and the 'machine' can be mounted anywhere on the floor or on a strong table. The owner-club record stands at 5¾ inches at present but a neighbouring society borrowed the machine recently and their secretary achieved a nominal 5⅝ inches. In both these cases, perhaps ⅛ or even ¼ inch was achieved by literal squeezing, bowing the beams and bruising the body.

Having spent so many pages finding mistakes in other people's record claims, I cannot hope that my own figures are altogether correct. Some will be revised later by more accurate surveys, or there may be some recent corrections as yet unpublished. In general reviews of contestants for a particular record, some may well have been overlooked, and I should welcome correction by any reader of the Bulletin. Standards of tightness, difficulty, etc., are all partly subjective, and even one man's views may well vary from day to day according to the jaundicity of his outlook.

It will be noticed that this article is provided with a very full list of references. Being separate from the text, it can be ignored if desired, but in so contorversial a subject as cave records it is essential that every statement be properly supported. Apart from this the references are necessary to anyone who wishes to follow any particular aspect of the subject or to find out more details of a particular exploration.

* Editors Note: Luther Miller is credited with spending 8 days underground on the same expedition.

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C^{14} Dating of Cave Formations

W. S. BROECKER and E. Z. OLSON

Recent studies of Calcium Carbonate deposition in caves indicate that C^{14} dating may be applicable to dating of cave formations. CO_2 in solution, derived from surface materials, interacting to dissolve limestone or the possibility that some $CaCO_3$ deposited in the formation may be derived from material in the near surface ground-water system would form the basis of dating. Accuracy of 2,000 years in 30,000 may be possible.

The possibility of applying the radiocarbon method of age determination to cave formations has usually been cast aside with the comment that such formations are always deposited with little or no C^{14} and hence would yield very old C^{14} dates regardless of their true age. The reasoning is as follows: Cave formations result largely from the redeposition of old limestone deposits which are essentially free of C^{14}; thus newly deposited cave formations should also be essentially free of C^{14}.

This reasoning is not necessarily valid however. First of all, the old statement that it takes CO_2 to dissolve $CaCO_3$ is very important to this problem. Every molecule of $CaCO_3$ dissolved by the water must be matched by a molecule of CO_2 gas. This CO_2 will, in general, come from decaying organic material in soils and will hence have an almost normal contemporary C^{14} concentration. While in solution, the HCO^3 ions formed from the CO_2 will completely mix with those from the $CaCO_3$. Thus, on redeposition of the $CaCO_3$ from the water, the C^{14} concentration will be at least half that in a tree growing outside the cave.

The second possibility is that the $CaCO_3$ in cave formations does not arise wholly from the solution of limestone within the cave but represents $CaCO_3$ in the water before it left the near-surface ground-water system. Measurements by the Lamont and the Heidelberg laboratories on ground-water samples show C^{14} concentrations from 65 to 90 per cent of those in contemporary wood. From these arguments it seems reasonable that newly formed cave deposits have more than 50 per cent of the C^{14} concentration present in the carbon of modern wood.

In order to check this revised reasoning, two recently formed cave materials have been measured. The first was the surface millimeter of material scraped from an active stalagmite collected by R. Gurnee in New River Cave, Virginia. The C^{14} concentration in this material was 71 percent that in modern wood. The second was a crust of $CaCO_3$ formed on a piece of wood in Crystal Palace Cave, California, and collected by R. deSaussure. In this case a C^{14} concentration within 15 per cent that in modern wood was obtained. Although more measurements are needed to confirm this conclusion, it seems safe to say that most cave formations are deposited with 70 ± 20 per cent of the C^{14} concentration in modern wood. If this stands up, it will be possible to date cave formations with an accuracy of $\pm$ 2,000 years back to 30,000 years.

On this basis, two measurements on materials from below the surface cave formations suggest very slow growth rates. Material bored from the center of the 4 inch diameter stalagmite from New River Cave yielded a result of more than 20,000 years in age. Material from .2 to 1.0 inches below the surface of a flowstone layer in Schoharie Caverns yielded an apparent age of greater than 32,000 years. Unfortunately no currently forming material was obtained from this locality.

If further measurements back up the data in hand, the radiocarbon method ought to prove extremely useful in solving the age-old problem of how long it takes for cave formations to grow.

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