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OF THE

NATIONAL SPELEOLOGICAL SOCIETY

VOLUME 28 NUMBER 1

JUBILEE ISSUE

Commemorating the 25th Anniversary of the Society

JANUARY 1966

Information for Contributors To the Bulletin

Papers in any discipline of speleology are considered for publication in the BULLETIN. The upper limit for length is about 10,000 words or approximately 40 pages of manuscript, typed double-spaced. At least one copy but preferably two copies of the manuscript (typed, double-spaced) should be submitted to the Editor, Jerry D. Vineyard, Missouri Geological Survey, Box 250, Rolla, Missouri 65401. Photographs and line drawings, if required, should be submitted with the manuscript. In general, prints and line drawings will be photo-reduced to the size necessary for use in the BULLETIN.

The upper limit for length may be waived where a paper has unusual merit. In case of doubt, write directly to the Editor. In like manner, number, type and size of illustrations may vary within limits, and in case of doubt, write to the Editor.

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COMMEMORATING THE 25TH ANNIVERSARY OF THE SOCIETY

GEORGE W. MOORE, GUEST EDITOR

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DISCUSSION of papers published in the the BULLETIN is invited. Discussions should be 2000 words or less in length with not more than 3 illustrations. Discussions of papers in this issue should be forwarded to the editor by April 15, 1966.

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THE NATIONAL SPELEOLOGICAL SOCIETY is a non-profit organization devoted to the study of caves, karst and allied phenomena. It was founded in 1941 and is chartered under the law of the District of Columbia. The Society is associated with the American Association for the Advancement of Science.

THE SOCIETY serves as a central agency for the collection, preservation, and publication of information relating to speleology. It also seeks the preservation of the fauna, minerals, and natural beauty of 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 specialists in the fields that relate to speleology.

PUBLICATIONS of the Society include the BULLETIN published quarterly, the NEWS appearing monthly, and the OCCASIONAL PAPERS. All members receive the BULLETIN and NEWS.

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Frontispiece.

Discovery on the Society's 1964 Expedition to the Rio Camuy, Puerto Rico. Photo by Roy Davis.

The Earth Sciences and Speleology*

By William E. Davies

Early Work

The beginning of intellectual interest in caves goes back as far as classical Greek time; but myths, religious implications, and little factual information are contained in these records from ancient Greece. In the writings of Aristotle, Homer, and Plutarch, caves are often mentioned and some speculations made as to their origin, but few detailed descriptions or other observations are recorded. Similarly the Romans – Vergil, Seneca, Pliny and others – had something to write of caves but like their predecessors their writings were not very descriptive or scientific. Tacitus, the historian, did step beyond the role of mythologist when he wrote of Emperor Tiberius' use of a cave as a cool summer abode, terminated by a sudden collapse of rock that killed his servant.

Descriptive writings on caves which eventually led to geological and archeological studies did not appear until the 16th century. Diego de Landa, a Spanish priest who traveled extensively in Yucatan and other parts of Mexico, wrote of his travels in 1566. His manuscript, now on deposit at the Franciscan Convent at Merida, Mexico, contains several references to caves and limestone springs and is the first to cite caves in the Americas. Another early manuscript, by Antonio Vazquez de Espinosa, completed in 1629 is on file at the Seville Archives of the Indies, Spain. This work contains descriptions of karstic ebb-and-flow springs near Chiapas, Mexico. In Amsterdam in 1655, Athanasius Kircher published the first part (publication of other parts continued to 1678) of his encyclopaedic compilation *Mundus Subterraneus*. This work primarily covered legends and myths of Italy and southern Europe, but a few descriptions and other observations were included. A decade after Kircher's work was completed, Baron de Valvasor (1689) published the first observations on water in limestone terrain. Shortly afterward, in 1748, the first detailed investigation of a specific cave was completed by Nagel. He had been commissioned by the Emperor of Austria to undertake the study of caves in Moravia, and his beautifully illustrated manuscript now resides in the Court Library in Vienna.

During the 18th Century most speleological references treated caves as curiosities of nature to be mentioned briefly as to their existence along with the host of other natural history phenomena. Typical of this approach were the narratives of early voyages to the West Indies which contain references to caves on Jamaica and Barbados.

As the 18th century drew to a close, interest in caves as objects of study developed. Jonathan Carver in 1778 published his observations on the cave that bears his name in Minnesota. Carver had explored this cave in November 1766 during his journey to the region of the upper Mississippi River. His description, although confined to the front part of the cave, was full of detail and is the first mention of a large cave in the United States. The first geologic studies of caves in both Europe and America started at the end of the 1700's. Thomas Jefferson, in his *Notes on the State of Virginia*, published first in Paris in 1782, produced a map of Madison Cave, Virginia; this map is the oldest known map of an American cave. Jefferson's

*Publication authorized by the Director, U.S. Geological Survey

interest in caves continued beyond merely describing caves, for the finding of a skeleton of a Pleistocene ground sloth by saltpeter miners in a cave in Virginia in 1796 attracted his attention, and he published the first of several papers on the bone deposit in 1799. In spite of the detail contained in the paleontological portions of the papers, Jefferson failed to specify the cave from which the bones came. However, from the published information, it appears that the locale was Organ Cave in the area that later became the State of West Virginia.

Paleontology and Archaeology

Throughout the 19th century and well into the 20th century, earth science speleology centered around paleontology and archaeology. In 1806, Benjamin Barton discovered Pleistocene bones in a cave in eastern Kentucky. Other caves in that state yielded additional finds, but the discovery in 1870 of the Port Kennedy Bone Cave in eastern Pennsylvania (Cope, 1899) opened a vast storehouse of Pleistocene paleontological material (table 1). This cave, as with many other bone caves, was encountered in a limestone quarry. A second but smaller cave was excavated for bones in the same quarry in 1895. Since 1870 nine major limestone caves have been excavated in the United States, and the paleontological material obtained from them constitutes the bulk of vertebrate remains so far recovered from the Pleistocene. One of the later discoveries, the Cumberland Cave, was opened in 1912 when the Western Maryland Railway was being constructed and a steam shovel cut into the deposit (Gidley and Gazin, 1938). Fortunately, the foreman of the construction crew realized the value of the bones and took steps to insure preservation of the deposit until the U.S. National Museum could excavate the cave. Again in 1952 the railway went out of its way to aid further excavation of remote parts of the cave by Bro. G. Nicholas (1953).

The excavation of bone caves was also the first manifestation of scientific interest in caves in Europe. Caves in southern Germany and Hungary had long been known to contain fossil bones, and in the late Middle Ages these bones, supposedly supplied by the mythical unicorn, were obtained to meet medical needs. Caves in the Franconian section of southern Germany were systematically excavated by Esper in 1774, Rosenmuller in 1804, and Goldfuss in 1810 (Dawkins, 1874).

In France, excavations were made as early as 1800, and during the first half of the 19th century a large yield of Pleistocene animal remains was recovered. Baron George Cuvier published a summary of these early discoveries in his *Ossemens Fossiles* in 1821-1823. In the latter part of the 19th century the excavation of bone caves in France yielded positive evidence of the use of caves as homes by ancient man. V. Edouard Lartet in 1860 recovered remains of animals and early man from a cave at Aurignac in southern France and published an account of his work in a large two-volume report *Reliquae Aquitanicae.* Three years later, in the Perigord area of southern France, he obtained the bones of Cro-Magnon man from a shallow cave. Since then the Perigord – Dordogne section of France has yielded evidence of ancient man in many caves.

Remains of fossil men and fossil animals from Belgium and Germany were found in caves similar to those in France and included the controversial remains of Neanderthal man discovered in 1857 by Fuhlroth.

The pioneer workers in bone caves in England include Joseph Whidbey and William Buckland. In 1816, Whidbey, an engineer, was in charge of quarrying limestone for the breakwater at Plymouth. The quarry intersected Oreston Cave, and Whidbey found his interests diverted from engineering to paleontology. Buckland, Professor of Mineralogy and Geology at Oxford, following his experience in excavating Gailenruth Cave in Germany, began the excavation of bone caves in Great Britain in 1821. Kirkdale Cave and Hemsley Cave, along with others, yielded data that formed the basis of Buckland's *Reliquae Diluvianae* (1822), a work that established a high standard in early speleological literature. In the succeeding years (1825-41) Kents Hole was explored and its bones were excavated by J. McEnery and studied by the British Association for the Advancement of Science in 1865. Later excavations by William Pengelly at Brixham established the relation between ancient men and Pleistocene animals in England. W. Boyd Dawkin's excavations in 1859 at Wookey Hole, as well as his experiences elsewhere, culminated in his book *Cave Hunting* (1874), which summarized the finds made in bone caves in Europe in the first part of the 19th century.

At the Mediterranean fringe of Europe early work on bone caves was done in Gibraltar, Malta, and Sicily. In Sicily Pleistocene bones from caves were used as early as 1829 in sugar refining, but it was not until 1859 that Falconer examined the caves for paleontological material.

In the 20th century, while caves in Europe and America were producing large numbers of fossil animals, several ancient caves near Pretoria, South Africa, yielded the oldest man-ape bones so far recovered. Four caves in lime quarries in the Sterkfontein area were excavated by Robert Broom of the Transvaal Museum during 1936 to 1939 and 1946 to 1952. The fossils were in a consolidated breccia fill. A similar cave in a lime quarry at Makapan was excavated for bones in 1925 and 1947 to 1955. During the latter period man-ape remains were recovered. The fossils are dated as early Pleistocene (Brain, 1958).

In any review of bone caves it is fitting to cite Benno Wolf's encyclopaedic bibliographic check list and index *Fauna Fossiles Cavernarum* published 1938 to 1941. The coverage of the work is worldwide, and its 608 pages record over 1500 cavern citations.

In America, archaeological work in caves developed in the latter part of the 19th century. In 1875, F.W. Putnam in conjunction with the Peabody Museum of American Archaeology and Ethnology worked in Salt Cave, Kentucky. At about the same time William H. Dall worked on the caves of the Aleutian Islands. In the 1890's, Henry C. Mercer of the University of Pennsylvania studied the archaeology of Appalachian caves and later extended his work to the caves of Yucatan. Work in the Cave of Loltun, Yucatan by Ed-

Table 1.
Major Bone Caves of the United States

Cave	Date of Excavation	Number of Pleistocene Species
Port Kennedy Cave, Pennsylvania	1870, 1895	51
Potter Creek Cave, California	1902	46
Hawver Cave, California	1907-09	24
Conard Fissure, Arkansas	1904	50
Samwel Cave, California	1903-05	34
Frankstown Cave, Pennsylvania	1907	40
Cumberland Cave, Maryland	1912-15; 1950-53	50
Durham Cave, Pennsylvania	1893	21
Friesenhahn Cave, Texas	1949-51	—
Burnet Cave, New Mexico	1930-33	62
Conkling Cave, New Mexico	1928-29	—
Brewery Cave, Missouri	1946	10
New Paris Sink, Pennsylvania	1948-50; 1956-63	100
Bushey Cavern, Maryland	1908	25
Hartman Cave, Pennsylvania	1880	28

ward H. Thompson, and in the Caverns of Copan, Honduras, by George B. Gordon, was also done near the end of the 19th century.

These explorations and excavations, plus those in the Appalachians and Ozarks in the early part of the 20th century by Charles Peabody of Phillips Academy, and Gerard Fowke, U.S. Bureau of American Ethnology, yielded considerable data on pre-Columbian Indians, but traces of truly ancient men in American caves were not found until later. Some of the bone caves – Potter Creek Cave, Hawver Cave, and Samwel Cave – contained material related to prehistoric man, but a real understanding of ancient man in America was not attained until the late 1920's and 1930's.

Most of the caves containing evidence of ancient man in Nevada, Arizona, New Mexico, Utah, and Oregon are small or are rock shelters. Typical of such sites is Sandia Cave in New Mexico. One Sunday in 1936 a student from the University of New Mexico was exploring caves near Albuquerque for the purpose of collecting archaeological tidbits which in themselves were of little significance. The fact that they came from a cave, however, interested Frank C. Hibben, Professor of Archaeology at the University of New Mexico, who led a small scientific party to the cave (Hibben, 1941). In the back part of the 200-yard passage forming the cave, the bones of a Pleistocene giant ground sloth proved to be a real find and justified excavation on the possibility that human and Pleistocene animal remains might be contemporaneous in the cave. Excavations extending over four seasons brought to light America's first cave man. The oldest culture recovered from the cave dated back to 10,445 years ago which still leaves America's cave man far younger than those in Europe. About 20 other caves in Utah, New Mexico, Arizona, Nevada, and Oregon were excavated for archaeological purposes in the next 20 years. Material from these caves, including a number along the edge of ancient Lakes Bonneville and Lahontan, dates from 7,000 to 10,000 years ago.

Many shelter caves in Texas were excavated in the 1930's by Frank M. Seltzer and others working with the Texas Archaeological and Paleontological Society and the Sul Ross State Teachers College. The evidence of human habitation recovered from these caves, however, was younger than the other caves cited in the Southwest.

In the eastern United States, the Russell Cave, Alabama deposit is significant in that it is the first trace of "cave men" of great antiquity in eastern North America. The cave was excavated by Carl F. Miller (1958) of the Smithsonian Institution in cooperation with the National Geographic Society. The oldest trace of man's occupation of the cave dates from about 9,020±350 years ago. Another shelter in Alabama excavated by D.L. De Jarnette a few years later (1962) yielded evidence of occupation at about the same time and Graham Cave, Missouri, also contained archaeological material of about the same age.

The most precious speleological material is the cave art in France and Spain. Paleolithic man, when occupying caves depicted his surroundings with an artistic expression of a high degree of sophistication. Paleolithic cave art in France was noticed as far back as 1575 and was cited by Francois de Belleforest in a brief description of Rouffignac Cave, Perigord. This cave was mapped in 1759 and the pictures were again noted, but their significance was not understood, and for another 200 years the cave was open to exploration but the drawings attracted little attention. It was not until 1956 that L.R. Nougier, Professor of Archaeology at Toulouse University, demonstrated the authenticity and significance of the art in this cave (Nougier and Robert, 1958). Altamira Cave in northern Spain is an example of a cave with Paleolithic art that was under a cloud of suspicion for many years after its discovery. The first to enter the cave was a hunter who dug open the entrance in 1868 to retrieve his dog after it had crawled through a small opening. The cave was forgotten until 1879 when the owner, Marcelino de Sautuola, visited an exhibit of ancient artifacts. His curiosity was aroused and he began excavating his cave. His own finds were of little importance but those of his young daughter, who played in the cave while her father was digging, surpassed all imagination for one day she came across a series of highly colored frescos on the walls of the cave. The academic world greeted the announcement of the discovery with skepticism and most authorities disclaimed any great antiquity to the paintings, ascribing them to some cave visitor after the opening of the cave in 1868. So strong was the skepticism that the International Congress of Archaeologists, meeting in Lisbon in 1880, refused to pay an official visit to the cave. However, in 1902, Abbe Henri Breuil, who was at the beginning of a long career that was to earn him the title of the Father of Prehistory, and Emile Cartailhac, studied the cave frescos and produced evidence as to their authenticity (Brodrick, 1963). From then on discoveries of Paleolithic art in caves were numerous and about 145 sites are now known in southern France and the Cantabrian Mountains in Spain (Trombe, 1952). Included in these sites is the well-known Lascaux Cave (Bataille, 1955). Its discovery in 1940, following the pattern set earlier, centered around the loss of a dog in a small hole. Five boys rescued the dog by enlarging the hole and in doing so they also unearthed a cave, the walls of which were crowded with colorful Paleolithic drawings. Abbe Breuil studied the cave immediately after its discovery, and at the end of World War II the French government opened the cave for public inspection. Unfortunately, deterioration of the paintings set in and in the early 1960's the cave was closed in hopes of halting the destruction.

Descriptive Speleology

With the development of speleological studies in paleontology and archaeology in the early part of the 19th century, there was also a rapid increase in the exploration of caves for sport as well as for science. Cave descriptions in popular as well as in scientific magazines increased in number and in quality. In 1815, the first small monograph on a single American cave, Wiers Cave (Grand Caverns), Virginia, by Calvin Jones was published. By 1840, Mammoth Cave, Kentucky had become such a tourist attraction that several detailed discriptive guidebooks had been published. However, it was not until 1850 that a report on caves within a region was published. The first such study was a 30-page compilation by George D. Gibb in the Geologists Magazine (London) describing 30 Canadian caves.

The state geological surveys that blossomed in the United States in the last half of the 19th century produced a large quantity of descriptive data on caves. This approach to speleology reached a high point in 1896 when W. Blatchley, Director of the Indiana Geological Department, published *Indiana Caves and their Fauna* which was the forerunner of numerous state reports a half century later.

In 1878, a young man with a background in divinity, the Reverend Horace C. Hovey, made his appearance on the American speleological scene. For the next 35 years Hovey's name was dominant in American caving, and his contributions in descriptive speleology earned him on his death in 1912 a memorial biography by the Geological Society of America such as is seldom gained by those outside the geologic profession.

Hovey's work centered on Mammoth Cave, Kentucky, but also covered all major caves in the Midwest. His *Celebrated American Caverns* is still one of the few sound summaries of America's major caves, and his guidebook to Mammoth Cave, co-authored with Richard E. Call, which went through seven editions, is without equal.

Descriptive speleology in Europe during the 19th century kept pace with and, in some areas, exceeded that in America. Toward the close of the century and for a time afterwards, extremely detailed studies of specific caves resulted in large tomes, with the one on Grimaldi Cave, Monaco, based on work from 1895 to 1902, and published in 1906 in two large quarto volumes of 69 pages (de Villeneuve, C.L. *et al.* 1906) setting a record that has not been exceeded.

In the decade following World War II systematic regional cave reports were a dominant feature of American speleology. The stimulus for such reports was the supposed need for protective shelters in a nuclear war along with a need to deal with the large volume of speleological data that had accumulated from the establishment of organized speleology in 1939. In 1949 an engineering study prepared by Guy Panero and Company for the Corps of Engineers, U.S. Army set the stage for considering underground facilities as places of refuge in case of war. While caves themselves were concluded to have little value as shelters, the attendant publicity given the pros and cons of their use placed the fascination of caves before the public. The search for data by Panero and his associates focused attention on the lack of published speleological data and many of the state geological surveys were made conscious of this lack when inquiries were addressed to them.

Up to World War II, only two extensive and detailed regional reports had been issued after the publication of Blatchley's study on Indiana caves in 1896. During the First World War, T.L. Bailey (1918) examined 109 caves and shelters in east-central Tennessee for nitrate deposits and the results, including descriptions of caves, was published by the Tennessee Geologic Survey. The second regional study was by Ralph W. Stone (1932) in Pennsylvania, published in 1930 with a second edition in 1932. The first edition covered 29 caves and the second, 88.

In 1948, the West Virginia Geological Survey instituted a survey of all of the caves of the State. William E. Davies, assisted by Thomas W. Richards, undertook the survey during the summer of 1948 (Davies, 1950). Data covering about 100 caves of West Virginia were on file with the National Speleological Society and served as a guide for the fieldwork. With the conclusion of the field season in the Autumn, information on over 400 caves had been gained. The report, published in 1950, was sold out within a few years and a second and enlarged edition describing over 500 caves was published in 1958. By 1964 this edition was exhausted and a third edition is now in press. Data for the second and third editions were obtained from members of the National Speleological Society who had pushed into practically every accessible nook and corner of subterranean West Virginia.

Other regional studies came about in several ways (table 2). In a few cases they were private efforts directed by one or two individuals with publication by state geological surveys or privately. In other cases projects were directly financed by a state geological survey. Several regional studies were also prepared and published by the National Speleological Society.

The present trend in regional cavern surveys is toward projects involving special statewide organizations of speleologists working, at times, in cooperation with state geological surveys. The Missouri Speleological Survey has been operating in this manner for nearly ten years and is producing very detailed data on the caves of Missouri. Similar approaches to regional studies are now carried on in Florida, Arkansas, Alabama, and several of the western states.

Systematic regional studies of caves in areas outside of North America have been limited to Italy, Spain, France, Norway, and Belgium. In the latter country E. Van den Broeck, E.A. Martel, and E. Rahir (1910) produced an extremely detailed report of over 1,700 pages in two volumes. Field observations for this work were begun in 1898. Systematic regional descriptions in Italy and France are carried on by individuals or groups of speleologists with publication in regular speleological journals. In Spain a catalogue of speleological features is now underway in the Province of Barcelona as a cooperative project between the government and the speleological group of the Barcelona Mountain Club. The first part of the catalogue was published in 1961.

Norway, while little-known for its caverns, produced detailed speleological studies of its main cavern regions in 1914 and 1947. Work was done by John Oxaal (1914), and Gunnar Horn (1947), both members of the Norges Geologische Undersokelse. The caves in Norway are of special interest for they are relatively large caves existing in an area that was covered by continental ice sheets during the Pleistocene Epoch.

The Tennessee Valley Authroity has been deeply involved in speleological research since its inception in 1933. With many of its dams and reservoirs located on limestone, T.V.A. has faced cavern problems ranging from foundation leaking to lateral flow of impounded water through caves. As a result of its engineering studies for Kentucky Dam, solution cavities to a depth of 223 feet were revealed beneath the river bed (T.V.A., 1949). Speleology benefited greatly from the various papers on caves and karst published by T.V.A. geologists Edwin Eckel and Berlin C. Moneymaker as a byproduct of their engineering observations. In the long run, limestone caused one defeat

Table 2.
Regional Cave Surveys of the United States

State	Author	Sponsor	Publisher	Date	Number of Caves Described
West Virginia	Davies	W. Va. G. S.	W. Va. G. S.	1950/58/65	626
Maryland	Davies	Private	Md. G. S.	1950/52/61	55
Connecticut	Huntington (editor)	NSS (chapter)	NSS (chapter)	1963	68
Pennsylvania	Stone (editor)	NSS	NSS	1953	261
Virginia	Douglas	NSS	Private	1964	1790
Tennessee	Barr	Tenn. G. S.	Tenn. G. S.	1961	700
Indiana	Powell	Ind. G. S.	Ind. G. S.	1961	398
Illinois	Bretz and Harris	Ill. G. S.	Ill. G. S.	1961	62
Missouri	Bretz	Mo. G. S.	Mo. G. S.	1956	437
Missouri	Vineyard	Mo. G. S. & Private	Mo. G. S. & Private	1957/61/64	1402
California	Halliday	Private	Private	1962	538
Washington	Halliday	Private	Wash. G. S.	1963	110
Michigan	Davies	Private	NSS	1955	10
Vermont	Scott	Private	Private	1959	68
Alabama	Tarkington & Varnedoe	NSS	Private	1965	617

for T.V.A. Hales Bar Dam near Chattanooga, which T.V.A. inherited from pervious owners, defied all attempts to seal leaks through channels in the limestone foundation, and T.V.A. is now at work on Nickajack Dam which will replace Hales Bar.

It would be difficult to determine when the first mass assault was made on a cave for purposes of exploration and scientific research. In America, in 1924, the National Geographic Society dispatched an expedition to Carlsbad Caverns. Included in this expedition was a U.S. Geological Survey geologist, Willis T. Lee (1925), who made some early studies on fills and on the geology of the caverns. The expeditions in January and May 1925 by the Explorers Club and the American Museum of Natural History to Endless Caverns, Virginia, were among the first to be widely publicized. The eight members of the expedition included a geologist and, though scientific results were meager, a popular report on underground streams did result (Reeds, 1928). In February 1954 members of the National Speleological Society mounted a large expedition for an all out push on Floyd Collins Crystal Cave, Kentucky (Lawrence and Brucker, 1955). The direct scientific results, as far as the earth sciences go, were limited, but the subsequent interest in the geology of the caves in the Mammoth Cave area fully justified the undertaking. The National Park Service in cooperation with the U.S. Geological Survey undertook a hydrologic and geologic study of Mammoth Cave in 1959. The geologic phase centered on cave fill with emphasis on stratigraphy, mineralogy, and physical properties (Davies and Chao, 1959). Surface studies of the karstland adjacent to Mammoth Cave showed the relation of surficial mineral occurrences to the cave deposits, and also revealed the first occurrence of the mineral rhodochrosite in lacustrine sediment. Research in mineralogy also was continued by members of the Cave Research Foundation and involved the occurrence and origin of sulfate minerals in the caves of the Mammoth Cave area.

CAVE ORIGIN

The basic data collected as cave descriptions during the 1800's were the foundations upon which the geologic aspects of speleology evolved into a science. Curiosity as to the origin of caves brought forth numerous speculations, but it was not until the 1890's that critical attention was devoted to the question. The leaders in establishing speleology as a part of the earth sciences were primarily Austrian. The Austrian Society for Cave Study (*Verein für Höhlenkunde*), founded in 1879, the Geological Survey of Austria, working in the karst lands of Bosnia and Hercegovina, and the University of Vienna, formed a nucleus of students of karst hydrography. Jovan Cvijic, Professor of Geography, Hochschule zu Belgrad, in 1893 published his *Das Karstphänomen*, a monograph of 112 pages, which along with his later paper on *Hydrographie Souterraine et Evolution Morphologique du Karst* (1918), proposed a karst base theory of solution. In this Cvijic postulated that solution activity and hence cavern development is concentrated along the base of the limestone at its contact with other rocks or at a contact with an insoluble stratum included within the limestone. Above the karst base, the older caves and solution tubes are intermittently filled with water for considerable periods of time. Immediately below the ground surface is a zone of caves and tubes that act as conduits for water but are not flooded. Cvijic's work also covered the classification and origin of sinkholes, polyas, karren and other surface karst features, tying them into a development in the zone of air-filled tubes and caves near t.e surface.

In contrast to Cvijic, Alfred Grund, a professor at the Deutschen Universitat Prag, in his *Karsthydrographie* published in 1903 and his later work on the morphology of the Dinaric Mountains in Yugoslavia (1910), presented a theory on karst and cave development that envisioned a level of saturation in limestone below which all openings are filled with water, with circulation of water confined to that descending from the surface of the ground and to lateral flow in the zone of saturation. Cavern development was believed to take place in the zone of saturation with later modification by descending water.

Friedrich Katzer, geologist for the Province of Bosnia and Hercegovina, took strong exception to Grund's ideas in 1909 in his publication *Karst und Karsthydrographie.* Katzer proposed that subterranean water circulated continuously regardless of depth, and any irregularities were a result of siphons which formed temporary, isolated areas of solution development. Katzer presented his ideas with strong feelings giving rise to a scientific controversy that still has adherents on each side. To a great extent Katzer's position was reflected by the French geologists, geographers, and cave explorers led by E.A. Martel.

The controversy concerning karst hydrography was reopened 40 years later in America in the writings of William Morris Davis who expanded on Grund's ideas, and by Gardner, Swinnerton and Malott reflecting combinations of Katzer's and Cvijic's approaches. Until the 1930's most Americans who speculated on the subject generally felt that caves developed near the surface from water descending from the surface to the level of ground water. James M. Weller (1927), however, after a study of the geology of Edmonson County, Kentucky, an area which includes Mammoth Cave, concluded that the initial development of caves took place below the water table. This was followed in 1930 by the extensive paper by William Morris Davis, then the dean of American geomorphologists. Davis at the time he wrote his paper was an old man, and active participation in speleological exploration was not possible for him. His paper was therefore based on published observations of others plus a large amount of inductive thinking. Davis cited a number of important features that could only be accounted for if caves were initially developed below the water table and were later elevated and modified in a zone of aeration above the water table. This, to a great extent, reflected the theory previously proposed by Grund.

Two years after Davis' publication, A.C. Swinnerton (1932), of Antioch College, published a paper on the origin of caves that predicated the initial development in a zone near the water table that was alternately aerated and flooded. In taking exception to Davis' ideas Swinnerton precipitated a controversy that continued for over a decade. James H. Gardner, a prominent petroleum geologist, contributed a paper in 1935 propounding ideas similar to those put forth earlier by Cvijic. Clyde A. Malott (1938), who spent many years studying the Indiana karstlands, outlined an "invasion" theory in 1938 in which the mature development of cave passages is by captured surface streams

diverted underground. Strong support from field observations for Davis' ideas was supplied by Harlen Bretz (1942), Professor of Geology at the University of Chicago. In addition, Bretz called attention to the significance of cave sediment in the developmental history of caves.

In Europe, Otto Lehmann, in re-examining Grund's and Katzer's theories of karst hydrography, introduced quantitative data in support of Katzer's position in 1932. A. Bourgin followed this in 1945 with studies in the Alps that modified Cvijic's ideas by removing the concept of the karst base control for solution but retaining the three distinct hydrologic zones porposed by Cvijic.

The speleological data accumulated after World War II indicated that certain cavern features were not adequately accounted for by any of the theories. The development of horizontal passages across inclined rock strata and parallel to the strike as well as the presence of large quantities of clastic material in cave fills were in need of explanation. In England, Margaret M. Sweeting (1950) after a study of the Ingleborough District, concluded that cavern levels are closely related to erosion levels. In the United States William E. Davies (1960), drawing on his observations in the Appalachians, concluded that caves are closely related to river terraces and other erosion surfaces, and the horizontal development of passages in folded rock is a result of maximum solution in a small zone directly beneath the water table during periods when the water table is relatively stable. In 1960, at a symposium at the American Association for the Advancement of Science in Chicago, theories of controlled solution level in the development of caves were expounded by Davies, William B. White, and George Deike. Since 1960 Ryszard Gradzinski (1962) in Poland and Camille Ek (1961) in Belguim have lent support to the shallow-phreatic theory of development of caves by citing evidence in caves of their countries. Alfred Bögli's (1962) recent study of the additional dissolving capacity obtained by mixing two waters, both saturated with limestone but having different CO_2 partial pressures, ties into the shallow-phreatic theory and gives it additional support.

Cave Mineralogy

Work on mineralogy in caves and on speleothems in general has been carried on by individual scientists in both Europe and America. W. Prinz's (1908) treatise on the speoeothems of Belguim is still the most complete work available on the subject. In America, George P. Merrill (1894), of the U.S. National Museum, produced a short paper on stalactites and gypsum incrustations in Luray Caverns, Virginia, and Mammoth Cave, Kentucky. In 1929 Frank L. Hess, also of the U.S. National Museum, described the mineralogy of cave pearls obtained from Carlsbad Caverns by W.T. Lee in 1925. Another long gap in time ensued until George W. Moore (1954) published his observations on the role of the changing directions of crystal axes in development of helictites, and followed in 1956 with the significance of calcite-aragonite relations as indicators of paleotemperature.

Glacières (freezing caves) were the subject for three long books and papers published between 1861 and 1900. G.F. Brown's *Ice Caves of France and Switzerland* in 1865, and M. Thury's *Glacières Naturelles* in 1861, were primarily descriptive works. Edwin S. Balch's *Glacières or Freezing Caverns* published in 1900 was an exhaustive descriptive summary of known ice caves and contained an analysis of the origin of *glacières* with the conclusion that the ice in most freezing caves was formed by the trapping of cold air that entered the caves in winter.

In 1932 E. Dudich published a short but significant paper on microbiological activity observed on limestone in Baradia Cave, Hungary. While "moonmilk" had been known from surface deposits in mountain areas, it had not been previously described in detail or analyzed in cave deposits. Similar studies were made later by Paul Madgeburg (1933) in Germany and O.A. Hoeg (1946) in Norway. During the last decade, both in America and Europe, abortive attempts were made to study the mineralogical effects of microorganisms in caves, but it was not until the 1960's that French and Hungarian scientists succeeded in putting such studies on a laboratory basis. T. Pobequin, J. Ponchon, and V. Caumartin of France, E. Dudich of Hungary, and M. Molnar and A.M. Williams of England, are among those who are now engaged in such studies. The future in this field of speleology is bright and may eventually bring about a realization of the significance of bacteria in rock and mineral alteration.

Karst

Since World War II karst landscpaes have again received a large amount of attention. Jean Corbel (1957), Univerity of Lyon (France), has examined the cold climate karst features in northeast Europe, Greenland and Canada and concluded that temperature is the controlling factor in karst development. In contrast, Margaret M. Sweeting (1964), Oxford University, after studying karst in Jamaica and Great Britain, cites production of carbon dioxide as the main factor in the solutional development of terrain. Work on karstland in Jamaica dates back to 1914 when J.V. Danes of Hungary studied the "cockpit" country and described its unique topography formed of modified hums. Verners A. Zans, for 12 years Director of Geological Surveys in Jamaica, was also a student of Jamaica in the 1950's and related the development of bauxites in Jamaica to karstification (Zans, 1959). Herbert Lehmann of Germany, also a student of tropical karst, produced several papers in the last decade on karst form and genesis in the Caribbean area and the East Indies.

In the last 25 years a large school of karst geologists has developed in the U.S.S.R. Among the leaders in this field are D. V. Ryzhinkov (1954) and G.A. Maximovich (1963) who have published extensively on karst and produced standard texts on the subject. Soviet karst studies have mainly involved developing a terminology and classification of karstlands and karst features.

In America very little work has been done on karst features. During the early days of the Soil Conservation Service, U.S. Department of Agriculture, S.N. Dicken and H. B. Brown, Jr. (1938), studied the physiographic expressions of areas in central Kentucky underlain by soluble limestone and their relation to soil erosion. Dicken and Brown also set up a classification of karst forms and types applicable to limestone of the interior plains of the United States.

At the 18th International Geographical Congress in Rio de Janeiro in 1956, steps were taken to establish a Commission on Karst Phenomena. The commission at its meeting in Vienna in October 1959 accepted as one of its major efforts the production of an *International Atlas of Karst Phenomena.* The champion of the atlas is the chairman of the commission, Herbert Lehmann, of Frankfurt, Germany. To date three atlas sheets have been published covering areas in Cuba, Italy, and Puerto Rico. Each atlas has a large-scale topographic map depicting a selected area of karst, a sheet of photographs along with a small geologic map, and an explanatory text in three languages.

Within the present generation of speleologists a small but important group is developing a quantitative approach to cave studies. Arthur L. Lange (1959), Cave Research Associates, for example, has written extensively on the geometry of cavern features. Rane L. Curl (1958) University of Michigan, introduced statistical analysis to determining the possible number and size of undiscovered caves. Other mathematical studies, primarily of an engineering nature, have concerned breakdown within caves (Davies, 1951).

Another aspect of quantitative research that has been applied in caves and karstland are the techniques of geophysics. In 1929, J. W. Joyce (1931) investigated the electromagnetic properties of the rocks overlying Manmoth Cave, Kentucky, by experimenting with radio transmission. Since then studies have been made in applying electrical resistivity, gravimetric, seismic, and magnetic methods (Roeschlein, 1960) to detect cavern openings. All the methods have given promising results.

Limestone Hydrology

Basic research for all speleological studies involves hydrology with emphasis on quantitative observations, but it is surprising how little work of this nature has been done. The surge of qualitative hydrologic studies of limestone terrains at the end of the 19th and beginning of the 20th centuries ended rather abruptly, and only of late has there been a renewed interest.

In 1941, J.F. Smith, Jr. and C.C. Albritton, Jr., published a paper showing the rate of solution in limestone as a function of slope. Their studies were made in western Texas and applied primarily to the development of microkarst features in a desert area. Seven years later Richard B. Hohlt's (1948) study on the development of porosity in limestone appeared. Hohlt's study centered on petrofabric analysis of carbonate rocks and showed a direct relation between solution and the orientation of mineral grains. A later study by R.C. Murray (1960) of the Shell Development Company provided further evidence on the relation of solution to original microstructures within the rock. Clifford Kaye (1957) demonstrated the effect of solvent motion on limestone. His laboratory experiments showed that the rate of solution was a direct function of the degree of motion of the solvent.

H.D. Holland (1964), Princeton University, working with several others on the chemical evolution of water in a cave, concluded that water passes through three stages in carbonate rocks. In an upper zone carbonation occurs in the soil; beneath this solution of carbonate minerals takes place; and at the base is a zone in which the water approaches equilibrium with cave air. In the study it was observed that the concentration of carbonate material in solution was greatly in excess of that which would be expected from the solubility product calculated for limestone (or dolomite) and that all water within the cave itself was supersaturated with limestone.

The equilibrium constants for carbonates in relation to temperature and pressure were calculated by R.M. Garrels and R.H. Dreyer in 1952. Laboratory work relating temperature and pressure to solvent action on carbonate rocks is now being done by Robert F. Sippel and E.D. Glover of the Socony Mobil Oil Company.

In the last few years distinct interest has been shown in the hydrology of the limestone terrains of Florida. R.H. Jordan (1950) described solution action to depths of 3,700 feet in artesian zones. These zones in thick limestone beds are not confined by impervious strata, and in many areas the water moves up dip across the layers of rock. William Back (1963) expanded on Jordan's observation, and his work on the departure from saturation with calcite of ground water in Florida has reopened the question of deep solution. Back's data indicate that at depths of hundreds of feet under-saturated water moves through the limestone.

Conclusions

In looking back on a century of history of the earth sciences in speleology, it is quite noticeable that progress has varied greatly with periods of one or two decades highlighted by important achievements, separated by long periods of relative inactivity. High points include two decades from 1890 to 1910 when most of the basic concepts of karst hydrology were laid down; the 12-year period, 1930-1942, which saw the crystallization of most of the theories concerning the origin of caves; and the post-war decade, which in America was an era of regional studies. Today the earth sciences in speleology appear to be building up to another boom, based on quantitative hydrologic studies of limestone terrain.

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Evolution of Cave Biology In the United States, 1822-1965

By Thomas C. Barr, Jr.

The first biologist seriously to concern himself with the fauna of caves in the United States was Constantin Rafinesque, naturalist and professor at Transylvania University, in Lexington, Kentucky. His writings include a 4-page article entitled "The Caves of Kentucky" (Rafinesque, 1832a), in which he mentions the presence of bats, salamanders, and other more conspicuous animals in Mammoth Cave and caves near Lexington. It is to Rafinesque that we owe the first description of the cave salamander, *Eurycea lucifuga,* which he collected in caves around Lexington (Rafinesque, 1822, 1832b).

Troglobites were first described from Mammoth Cave, Kentucky. James DeKay (1842), in a footnote in his *Zoology of New York,* diagnosed the genus *Amblyopsis,* based on the blind cavefish, *A. spelaea,* from Echo River. Theodor Tellkampf (1844a, 1844b) described several invertebrates, including beetles and crayfishes, from Mammoth Cave. The great naturalist Louis Agassiz (1851) made some observations on cavefishes, and the famous Russian coleopterist, T. Victor von Motschulsky (1854, 1862) visited the cave to collect and describe blind beetles. With these beginnings – all more or less isolated studies – cave biology in North America was off to a slow but auspicious start.

In order briefly to trace the development of cave biology in the United States from its beginnings to the present, and set it in its proper perspective to the establishment and growth of the National Speleological Society (1941-1965), I have found it useful to think in historical terms of an "Early Period" (1871-1909), a "Middle Period" (1930-1955), and a "Modern Period" (1956-1965). The Early Period, characterized by the Neolamarckian revolt against Darwin's theory of natural selection, was followed by a sharp cessation of biospeleological activity for about 20 years. No such break appears between the Middle and Modern Periods. They are distinguished principally by a sudden acceleration of interest and publication at the beginning of the Modern Period.

EARLY PERIOD

The first active period began in 1871 with the visit of Alpheus Spring Packard, Jr., to Mammoth Cave (Packard, 1871). Packard dominated the period until his death in 1905, writing at length on the faunas of Mammoth, Wyandotte, Nickajack, Carter, and other caves. The most important of his contributions were included in his monograph, *The Cave Fauna of North America,* which appeared in 1888. Other students of American cave faunas in the last half of the 19th century included W.S. Blatchley (1896, on Indiana cave fauna), R.E. Call (1897, on Mammoth Cave), E.D. Cope (1872, on Wyandotte Cave; Cope and Packard, 1881, on Nickajack Cave), J.H. Emerton (1875, on spiders), S. Garman (1889, on Missouri caves), W.P. Hay (1893, 1903a, 1903b, on crustaceans), H.G. Hubbard (1880, on Mammoth Cave insects), and F.W. Putnam (1872, 1875, on Mammoth Cave). This Early Period closed with a flourish with the publication of A.M. Banta's (1907) detailed study of a single Indiana cave and Carl H. Eigenmann's magnificent monograph, *Cave Vertebrates of America* (1909).

Following the Early Period, interest in cave biology stagnated in the United States for nearly 20 years – the same two decades during which the studies and writings of E.G. Racovitza and René Jeannel sparked the spectacular rise of modern biospeleology in Europe. In 1931, in the preface to a series of papers on U.S. cave faunas, so little had been done in this country that two Europeans, Bolívar and Jeannel, could complain that

> ....American naturalists have undertaken no serious study of the fauna of the im-

mense subterranean domain available for their investigations. One would look in vain in the collections of the museums for a single cavernicole whose capture dates from the 20th century!

Middle Period

The next 25 years (1930 – 1955) represent what might be called the Middle Period in the study of cave biology in the United States. Following – and possibly stimulated by – the appearance of Bolívar and Jeannel's *Campagne Spéologique dans l'Amérique du Nord en 1928* (published 1931), there ensued an era of slow but steady description of the major elements of the rich cave faunas of the eastern United States. Most of the work was taxonomic. The descriptions were far more accurate than the hastily and often superficially prepared descriptions of the Early Period, and the availability of transportation by automobile made it possible for cave biologists to sample a wide variety of caves in broad geographic areas. Cave surveys were almost non-existent, and biologists had to locate and partially explore the caves themselves, so progress was slow.

Between 1931 and 1952, J. Manson Valentine produced six papers on trechine beetles of Virginia, West Virginia, Kentucky, Tennessee, and Alabama. The trechines – predaceous beetles of the family Carabidae – have more species of troglobites than any other group of animals inhabiting the caves of the eastern states. With Walter B. Jones, then State Geologist of Alabama and Director of the Alabama Museum of Natural History, Valentine initiated the first of the broad scale collecting programs which have so greatly expanded our knowledge of cave faunas of the United States. Just as accurate descriptions and maps of the caves of a region must precede the more sophisticated investigations of karst development and speleogenesis, so a faunal survey is prerequisite to advanced studies in cave ecology, evolution of troglobites, and physiology of cavernicolous animals. Working primarily in caves of Alabama, but with occasional forays into Tennessee and Kentucky, Jones and Valentine collected not only trechine beetles but many other groups of invertebrates, which were made available to appropriate specialists for identification and, if new species were included, for description. Meanwhile Leslie Hubricht, who published a pioneer series of papers on cave amphipods (1943), isopods, and snails, extended general cave-fauna collecting into parts of Missouri, Arkansas, Illinois, Virginia, and eventually Kentucky and Tennessee. Kenneth Dearolf (1937a, 1937b, 1941) made an important series of collections in Pennsylvania and West Virginia.

Other biological studies of the Middle Period included (a) the beginning of bat banding by Charles E. Mohr, Donald R. Griffin, and others; (b) a comprehensive monograph on cave crickets of the genus *Ceuthophilus* by T.H. Hubbell (1936); (c) the beginning of a long series of descriptions of troblobitic flatworms by Libbie H. Hyman (1937, 1939, 1945, 1954, 1956); (d) the discovery and description of troglobitic crustaceans and salamanders in northern Florida (*e.g.* Carr, 1939, Hobbs, 1941); (e) the publication (in French) of a major paper on cave beetles of eastern United States, based primarily on collections made in 1946 by Henri Henrot (Jeannel and Henrot, 1949); (f) the beginning of an important series of papers on American cave pselaphid beetles by Orlando Park (1951, 1956, 1958, 1960); and (g) descriptions of several cave millipedes by H.F. Loomis (1939, 1943).

The establishment of the National Speleological Society in 1941 thus found American cave biology in the Middle Period – a time of steady but not rapid growth. The Middle Period was interrupted but not otherwise adversely affected by World War II. In retrospect it can be said that, for the first 15 years of its existence, the Society had little effect on cave biology. Most active cave biologists were Society members, but participated only to a minor degree in the organization and operation of the Society. A Cave Biology Committee, under the chairmanship of James A. Fowler, attempted to coordinate biological studies, but the effort was probably premature. Biologists interested in caves were too few and far between, and one of the early goals of the Society, that spelunkers would assist professional geologists and biologists, had not at the time been achieved.

Modern Period

During the Modern Period (1956-1965), the National Speleological Society has done much more to generate interest in cave biology and facilitate its serious study. This has been a decade of exponential increase of biological studies in caves. Not only have systematic studies proliferated considerably, but ecological and physiological investigations are now being made (see Poulson, 1964 for physiology review).

Faunal surveys have continued, with the result that the known cave fauna of the United States will have quadrupled in numbers of species over a period of about 10 years, when material already collected has been described. The most active cave collectors during the past 10 years have been T.C. Barr in Tennessee and Kentucky, J.R. Holsinger in Virginia and West Virginia, and J.R. Reddell in Texas. Among actively publishing taxonomists currently handling this material are Leslie Hubricht (snails); W.B. Muchmore (pseudoscorpions); H.H. Hobbs, Jr. (crayfishes); J.R. Holsinger (amphipods); H.R. Steeves, III (asellid isopods); Nell B. Causey (millipedes); Kenneth Christiansen (Collembolans); T.C. Barr and C.H. Krekeler (carabid beetles); Orlando Park (pselaphid beetles); Ronald Brandon, Robert Mitchell, and J.R. Reddell (salamanders). Some major studies in progress are those of W. J. Gertsch on North American cave spiders; A. Vandel (University of Toulouse, France) on North American cave trichoniscid isopods; B. Condé (University of Nancy, France) on cave campodeids (Ins., Diplura); and T.H. Hubbell on a revision of cave crickets of the genus *Hadenoecus*.

The ecological investigation of whole caves and cave systems is dependent to a large measure on the percentage of the fauna which has been adequately described and has a valid taxonomic name. It is thus no accident that Brother G. Nicholas chose a small cave in Mammoth Cave National Park to study trophic dynamics, or that T.C. Barr and R.A. Kuehne chose the Mammoth Cave system in which to conduct a general ecological study. Mammoth Cave has been studied longer and more often by biologists than any other North American cave, and most of its inhabitants are described and named. Kenneth Christiansen has limited his ecological studies to the Collembola, a group of insects in which he is a highly competent systematist. Other ecologists have made intensive studies of the ecology of single species or a small number of species – T.C. Jegla on the crayfish *Orconectes inermis testii;* T.L. Poulson (1963) on the cavefishes of the family Amblyopsidae, the taxonomy of which has been recently stabilized by Woods and Inger (1957); Robert Mitchell on the life history of the carabid beetle *Rhadine subterranea;* and David Reichel, John Palmer and Orlando Park (1965) on the cave cricket *Hadenoecus subterraneus.*

Modern studies of cave-inhabiting bats are largely ecological in approach, and like the work of Poulson and Jegla, frequently combine physiology with ecology. Comparative ecology of cave bats has been studied in recent years by Wayne Davis (1959), Davis and Harold B. Hitchcock (1965), J.W. Twente (1955), E.L. Cockrum (1956), James Cope, Bryan P. Glass (1958, 1959), and Robert Henshaw.

Some species of cave bats have been the subject of special life history studies. Among investigations recently completed or in progress are those of John Hall (1962) on *Myotis sodalis;* Wayne Davis on *Pipistrellus subflavus* and *Eptesicus fuscus;* Richard Myers on *Myotis grisescens;* and R.B. Davis, C. F. Hereid, III, and H.L. Short (1962) on *Tadarida brasiliensis.*

Cave bats as vectors of rabies have been studied by Denny G. Constantine and many other investigators. Finally, no summary of bat research in the United States, however brief, would be complete without mention of the classic studies of D.R. Griffin on echolocation.

The role of the Society in advancing cave biology during the past 10 years has differed considerably from the nebulous role of 1940-1955. First, there has been increasingly active participation by biologists in Society affairs. Second, many cave biologists have come to realize that they share with the layman caver a common interest (a) in location, descriptions, and maps of caves; (b) in cave conservation and cave-owner relations; and (c) in caving techniques and safety. Although still very few in number, some lay members of the Society have become excellent biological collectors, collaborating with one or more taxonomists. Third, the Society has begun to serve as an important medium of communication for biologists interested in cave-oriented research, both those within and without its membership.

During the past 10 years there have been five biospeleological symposia at national meetings co-sponsored by the National Speleological Society: Indianapolis (AAAS, 1957), Chicago (AAAS-Society of Systematic Zoology, 1959), New York (AAAS, 1960), Cleveland (AAAS-Ecological Society of America, 1963), and Knoxville (American Society of Zoologists-Society of Systematic Zoology, 1964). These symposia have not only facilitated communication between cave biologists, but have informed biologists who have never entered a cave that there is active biospeleological research being conducted in the United States. From a small, poorly attended afternoon session at Indianapolis, the symposia have grown to full-day sessions with audiences of 75 to 100 persons. The 1959 symposium was published *in toto* (Barr and others, 1960).

The publication of "Biology Briefs" in the *National Speleological Society News* has provided a running summary of current literature on cave biology in the United States, a small but very useful service of the Society to its biologically inclined members. In the past, biologists have generally not published their research in the *National Speleological Society Bulletin*, for a number of reasons. Until recently the *Bulletin* appeared sporadically, and faster publication could be obtained elsewhere. The majority of publications in cave biology were taxonomic descriptions and were regarded by authors and *Bulletin* editors alike as unsuitable material for this journal. Finally, authors were unwilling to submit their papers for publication in a journal which was then available in few libraries and which was read by very few fellow biologists. Under the present *Bulletin* editoral policy, most of these objections should disappear.

The latest chapter in better communication between cave biologists was the organization, at the Indiana University meeting in June 1965, of a Biology Section of the National Speleological Society. The Biology Section, open to all members of the Society with a professional interest in cave biology, will elect annually an Executive Secretary to handle minor business matters and plan the program of the section. The first Executive Secretary, to serve from June 1965 to June 1966, is Thomas L. Poulson, Department of Zoology, Yale University.

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Some Techniques for Cave Exploration

By William T. Plummer

Introduction

In earlier days of the National Speleological Society, explorers approached caves as a hostile environment. String was used to mark one's path (Stephenson, 1940). It was realized in time that one couldn't manage enough string for a large cave, and didn't need it for a small cave. For a time arrows were deposited on walls by carbide flame, and each set of rules stipulated that arrows were to point toward the entrance. The use of arrows has now almost vanished, with a gradual change in the attitude of the explorer toward the cave. Explorers now descend the deepest pits, and look for deeper ones. Featureless walls are scaled when necessary. Expeditions commonly spend days in extensive systems. Electronic devices make cave walls transparent for communication and mapping. Waterproof clothing gives access to major new caves in their earlier stages of formation, and cautious progress has been made toward the study of underwater caverns.

With knowledge has come a new level of confidence, and a better measure of the actual hazards of the underground. Parties isolated by passage flooding are no longer greatly surprised, for it has happened to many others – and the long wait is a more relaxed one. The most difficult caves become easy with time, and there is a general belief that all caves can be traversed.

But the caving pastime now attracts greater numbers, as well. Beginners hear better tales than ever of amazing exploits, and cannot wait to duplicate them. After each failure there is national publicity. Errors that once seemed minor because they "never got anyone into trouble" have begun to show. No one has yet strangled in a mud-jammed zipper, but we've seen examples of drownings in flash floods, death by exposure to cold water, tragic failures of untested ropes, passages sealed by rockfall, groups caught without light, and people trapped in pits because they lacked the skills to get out. These problems are serious enough to deserve attention. Knowledge never properly detracts from one's fun, and may enhance it. A climbing technique which works acceptably on 10 feet of dry rope suspended from a tree may fail under cave conditions. Similar remarks apply to cave diving; what is easy in a pool or quarry has claimed dozens of lives underground. Even the simplest cave may be formidable on the way out, when human endurance is ignored.

Caves are as safe or as dangerous as you choose them, and it is wise to know which you are picking. The potential hazards are a part of the attraction at all levels of skill. But the hazards of all caves may be tamed if they are matched against one's capacity in a systematic manner; the greatest satisfaction lies not in getting away with something beyond one's ability, but in matching one's abilities to any challenge which can come along.

Further information may be found in the REFERENCES, nearly all of them obtainable from the Society Library. Most of the newsletter references have been reprinted in the *Speleo Digest.*

Special Equipment

A rope is used for protecting climbers from injury. It is used for descending into pits and getting out of them. The type most generally used in mountaineering and caving is made of nylon filaments, is seven-sixteenths of an inch thick, and is firm for easy handling and long wear. Either Nylon or Goldine can be trusted to support a few thousand pounds, a range which cannot be exceeded under normal conditions except when a climber falls a long distance before snapping the rope tight. These synthetic fiber ropes do not rot. But any rope which will be entrusted with your safety should be inspected and tested regularly before use. A rope should be tested with a tension of about one thousand pounds. This will require about eight people pulling hard on one end. A car may be used to provide tension, but only if the tension can be controlled. A meter for this purpose may be made from a piece of nylon sling rope and a longer piece of sash chain (Plummer, 1960c). It is installed between the rope and the car. As tension is applied the nylon stretches. At a precalibrated load the chain becomes tight.

Manila rope is still widely used, and has several advantages. Half-inch rope avilable from hardware stores is rated at just under a ton and a half. By length, it costs less than half as much as mountaineering nylon. For all applications except catching leader falls it has more than adequate strength. It is less stretchy than nylon, and is larger and easier to grip. It takes just twice as long to burn through with a carbide lamp. It should be handled and stored carefully to avoid rot, however, and should be tested under tension before every use. The condition of the fibers may be estimated by twisting the rope open a little and looking inside. A rope which feels inelastic in the tension test is about shot. Destructive tests have shown that a manila rope with considerable wear may get to look pretty terrible, but still retain nearly all of its original strength (Patten, 1960). With reasonable attention a manila rope will last through two or three years of use, but some mysterious incidents have occurred which suggest caution (Deike, 1958; Will, 1960).

A particularly versatile piece of hardware is the carabiner, or snaplink. It is made as a large ring with a short gate which pivots open. The oval shapes are most useful. Some of them have a threaded sleeve which can be positioned over the end of the gate to keep it from popping open. With its gate open a snaplink is rather weak, and the steel ones have been known to stretch out of shape with the weight of two people. Aluminum links are bulkier, and wear faster, but are lighter and are subject to better quality control.

Other climbing hardware, such as pitons, are rarely used in caves. Cavers more frequently need apparatus scorned by climbers, such as rock drills, expansion anchors (Boyd, 1965; Leonard, 1956), and flexible ladders.

Most equipment needed in caves must still be made at home to meet special requirements. This will remain part of the challenge for some years.

Knots

The knots commonly used to tie packages are unsafe for climbing. Others such as the sheet bend are dangerous when tied in nylon rope, or when carelessly handled. Experience has shown that the safest and most useful knots are the bowline, butterfly, ring bend, prusik, and the short splice (fig. 1).

The bowline is used for anchoring a rope to a tree, or for fastening two ropes together. The free end is always secured with a few half hitches, for bowlines do come loose. The butterfly knot is used for making a secure loop in a rope when neither end is available. It is used for attaching a ladder to a rope previously anchored, or for tying in a middle man on a roped climb. The loop will support tension in all directions without slipping, and is easy to untie. The ring bend is used for making slings and such, which are generally never untied. Two ring bends in tandem form a very secure joint, superior to the fisherman's knot. The prusik knot is used for gripping a straight rope or pole with a sling of slightly smaller rope, and it is widely used for climbing directly on a rope.

The short splice is the strongest, most permanent way to join two ropes, or to make a sling. It is illustrated in most dictionaries and encyclopedias. Its construction is detailed in the excellent knot booklets distributed by rope companies (Anon., 1946). If it is made firmly it is nearly as strong as a solid rope.

Belaying

The use of a safety rope to protect a climber has been taken unchanged from mountaineering (Leonard, 1956; Klepinger, 1962). The climber attaches the rope securely around himself above the waist, with a bowline and half hitches. Some thought is given to how the rope will feel in a fall. The belayer's job is to keep the rope moving at a pace comfortable for the climber, but to control its motion

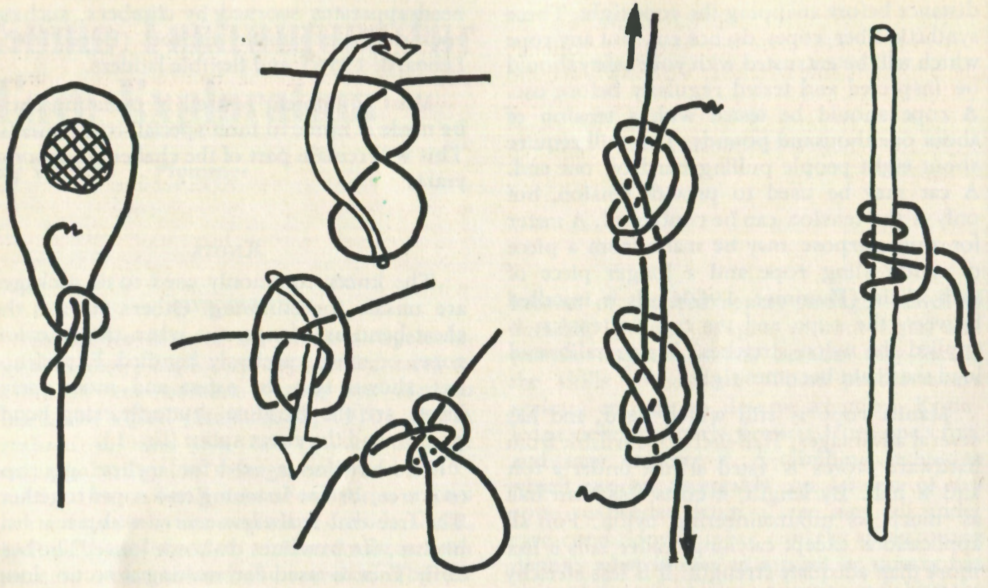

Figure 1.
Useful knots.

securely in the event of a fall. The belayer cannot control the rope with his hands alone, but uses a half turn of the rope around behind his hips to provide frictional snubbing. Gloves are worn. One hand holds the rope leading directly to the climber, to take it in or pay it out. After it has passed across the belayer's back the rope is held in the other hand. This is the control hand. A moderate tension here is amplified by friction across the body, and can readily support a man's weight. The belayer never removes the control hand from the rope.

The belayer chooses his position carefully so that a large tension on the rope will not upset him. Generally the belayer is seated, with legs braced. The climber may want to test the belayer's position by throwing his weight against the rope.

In mountaineering the climber is often above the belayer. The climber may fall 20 or 30 feet before the rope jerks tight, and the force felt by the belayer may be many times the climber's weight. The rope must be controlled uniformly to a smooth stop, to minimize the jolt to the rope and to the climber's ribs. The climber tries to reduce the risk by hammering pitons into the wall and attaching the rope to them in turn by snaplinks. The longest slack fall is then just twice the distance down to the last snaplink. The belayer is jerked *upward* by the force of the fall, and he must consider this in selecting his stance. The belayer is generally anchored to another piton, by a sling rope around his middle *above* the belay rope. When the belayer is working with a climber below him, his own anchor is *below* the belay rope.

In caving the leader is rarely belayed in this way, principally because most climbs are led downward. The rope is not slack. Piton cracks are rare, and bolts take too long to place. Generally the leader on an upward climb cannot actually be belayed, and the rope is for the benefit of those who will follow. This was also the situation in mountaineering until fairly recently. In caves the belay rope is used for whatever good it can do, but only with the aid of natural features such as stalagmites which may guide its route and help to catch a fall. The belayer's task is generally simpler in caves than on mountains, and he can catch a fall with less shock. Frequently the belayer is able to take a turn or two around a tree or speleothem to snub the rope and control it with easy tension. There will, however, be times when it is wisest to install expansion anchors and use the full technique.

Descending

By the time of the first attempt on Schoolhouse Cave, ladders of wood and rope were in use (Anon., 1939). The lighter and more compact ladders of steel cable and aluminum tubing were a French development. These have reached a high degree of refinement, and are widely used in exploration (Dunn, 1958). A flexible ladder is most easily climbed with one hand and one leg on the back, so your feet won't swing out from under you. Every attempt must be made to center your weight over your feet to free your arms from the lifting. When the ladder is hanging free in space it is never quite possible to keep your weight off your arms, and the climb can be strenuous. If the ladder rests against a wall the balancing will be easier, but it may be difficult to pull each rung away from the rock surface. This is generally accomplished by rolling your body sideways against the rock, or by bending your knee so that the foot already in the ladder pulls the ladder outward a little. Climbing downward is much more difficult than climbing upward on a cable ladder because the next rung you are reaching for is generally twisted out of position.

Ladder climbing is considered inherently unsafe, with more risk than climbing a rock wall. Older cable ladders tended to break at kinks, or to corrode electrolytically at the crimps which support the rungs (Allen, 1959; Gurnee, 1959). These difficulties have been eliminated in many modern ladders, but cables do break. The risk may be reduced by treating a ladder gently, testing it under tension before each use, and drying it before storage. But allowance must also be made for the ability of a climber to fall off. An explorer should not be exposed to open pits with no more protection than the grip of his tired and muddy hands. For these reasons it is wise to use a safety rope for nearly every ladder climb. When there is someone at the top to do the job this will involve standard belaying techniques. Frequently a double-length rope must be used so the people on the bottom can retain the end. When an entire party descends a ladder a double-length rope is often used to provide the belay through a snaplink or pulley at the top. Another method which works well with half as much rope is the sliding prusik knot. A prusik sling tied around the climber is secured to a standing rope, which is held from below. It is a problem for the climber to keep moving the prusik knot, as both hands are well occupied by the ladder. A gadget made of coathanger wire may be used for the job (Plummer, 1960a). It fits around the rope below the prusik knot and lifts it as the explorer climbs. In a fall, the wire is pulled out of the way. For certain caves where it is difficult to get the belay rope back down to the next man the sliding prusik knot eliminates the need for a double-length rope. The climber should have two additional sling ropes with him so that he won't be left hanging when the ladder breaks.

In Europe and Australia ladders are used for both ascending and descending. In this country the greater nuisance and effort of climbing down a ladder is more commonly avoided by a rappel down the rope, a technique initially borrowed from mountaineering.

The term *rappel* refers to a wide variety of techniques for descending ropes. Some of these methods are suitable in caves, and some are not. The mountain climber most commonly makes a rappel for a distance of 60 or 120 feet on a doubled nylon rope, which he can later pull down by releasing one end. The descent route is almost always along a sloping wall which provides footholds or friction. In a cave the rappel route is generally more vertical, and quite commonly is free of any wall. The distances often approach or exceed 200 feet. The rope is single, except in special cases, and is frequently made of manila fiber for economy and reduced stretch. In some cases the rappel is right at a cave entrance, and therefore heavy or bulky equipment may be used.

Many cave explorers have tried the classical dulfersitz body rappel, or "hot-seat" rappel (Manning, 1960). Some have permanent burn scars to show for it. This technique is essentially unsafe, and requires a belay rope. On a short rappel no special equipment is necessary, and the hot-seat rappel may be useful in an emergency. For long rappels the few surviving advocates use elaborate canvas and leather protective harnesses to take the abrasion and distribute the heat. Gloves are worn.

Mountaineers, too, have become dissatisfied with the body rappel. The most popular substitute uses one snaplink fastened (somewhere in the vicinity of the navel) to a seat sling. The rappel rope passes through this snaplink and back over the left shoulder, and is held in the right hand. As one walks down a wall the right hand applies a moderate grip to control the descent. The hot seat is eliminated – it is the *shoulder* which gets hot! Most of the people who advocate this rappel in caves are proud of their permanent scars, which are a little easier to show off than the dulfersitz type. A heavy towel under the shoulder of the coveralls will help a little.

The Army mountaineering classes suggest a modification, with the rope making an extra pass around and through the snaplink and going directly to the controlling hand (fig. 2). The rope is carefully kept clear of the snaplink's gate, and shirt tails and the like are kept from being pulled into the snaplink by the rope. This rappel works nicely on hillsides, but on a long free drop underground the controlling hand may be burned even through a heavy glove. The snaplink does not provide adequate snubbing friction.

A variety of devices now exist to provide more snubbing. All depend on the same principle, that the rappel rope must be made to wind around a solid object (Plummer, 1960b; Gordon, 1959). It is the total winding angle which is important, not the sharpness nor direction of the bends. Sharp bends are harder on the rope but give no real advantage for control.

One method employs a metal brake-bar, which slides over the gate of a snaplink and fits snugly onto the opposite side. The rope makes one hump over this bar instead of wrapping around the snaplink itself. The single brake-bar does not provide enough snubbing for a free rappel, and has been responsible

Figure 2.
A snaplink rappel rig for steep slopes. Inset illustrates seat sling.

for accidents. The rope is generally given an extra turn around a second snaplink or around the caver's back. Two brake-bar devices in tandem are more effective (Plummer, 1964c). They are joined by a large chain link (fig. 3). If the tandem rig provides too much snubbing the bars may be grooved with a file where the rope passes over them, to make the bending angles smaller. The brake-bar does not always operate well with large diameter manila ropes.

Three snaplinks may be rigged in tandem for a rappel with excellent control (Plummer, 1959a). The rope passes once through each, and does not touch any of the gates (fig. 3). The method works with large ropes, small ropes, twisted doubled ropes, and spliced ropes. The control force is about one fifteenth of the caver's weight, minus the weight of the trailing rope. Care must be taken to maintain some tension on the snaplinks as the rappel is rigged and the descent begins. A large excess of rope on the bottom may cause kinks to form. These may be cleared by moving the control hand in a circular pattern.

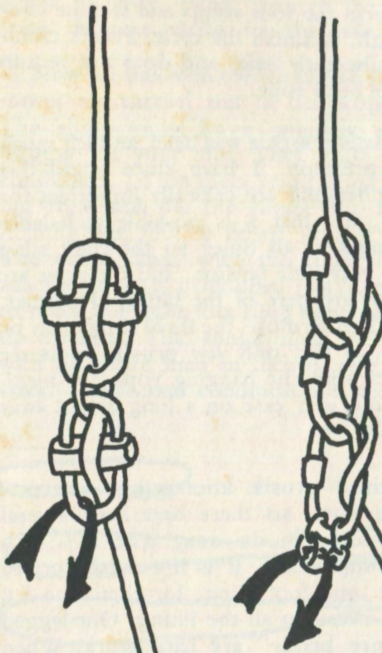

Figure 3.
Snaplink rappel rigs for free drops. Attachment to seat slings indicated by looped arrows.

Recently there has been interest in descending pits more than two or three hundred feet deep. The special problem here is that the weight of the long rope below may prevent the caver from moving at the beginning. The solution has been to use a large snaplink, two or three times the normal size. Initially it is wrapped with only two turns of rope. The control is still adequate because of the weight below. Later the control becomes difficult, perhaps in the last hundred feet, and a third turn is added around the snaplink. This is accomplished by lifting the trailing rope entirely over your head and shoulders and back to its original position. The snaplink must be specially made so that its gate may be opened while the link is under tension. Ordinary snaplinks are designed to lock with a load, and lose much of their failing strength when the gate is open. Suitable devices may be obtained through the local Fire Department. If it is large enough, the snaplink will pass a big, secure knot without fouling.

Except for the hot-seat and hot-shoulder techniques the rappel methods are inherently safe. If a tight and properly adjusted diaper sling is used, one can safely lean back, swing the feet up to the rope, and descend in an inverted posture without losing control. If the slings and main rope are inspected and tested with a tension of about 1000 pounds before each use, and if the rope is well rigged, it will actually be safer *not* to tie an additional rope to the caver as a belay. Such a sliding rope tends to dislodge debris and to tangle about the rappel line (Allen, 1964). Unless it is called for in unusual circumstances, and can be rigged well to one side, the belay rope may be expected to create more problems than it solves. An inexperienced caver on rappel can be aided without it, simply by pulling on the lower end of his rope. If it is felt that the rappel line and slings alone are not safe, then they should be rigged differently or replaced.

Ascending

Descending into a pit is precisely half the problem. If you prefer to rappel rather than climb downward on ladders, then perhaps you would like to eliminate much of the expense, weight, and physical effort of using ladders at all. With a little practice you can climb out of a pit on a single rope. A long climb is actually easier on a rope than on a ladder.

The technique seems to have originated with Dr. Prusik, a mountaineer, for such problems as getting out of deep crevasses and following the lead climber over a tough direct-aid pitch (Prusik, 1931; Debelakova, 1936). Mountain climbers consider it unethical to use the rope for such purposes except in emergencies. For this reason, and because most mountain applications were along sloping walls, the technique of prusik climbing remained undeveloped and inefficient for decades. Most versions in the climbing literature are poor, and the name "Prusik" is generally misspelled (Manning, 1960). Cave explorers are more practical about techniques for getting places, and have adapted the method for an extremely valuable means of climbing out of pits. The widest use is in the United States.

A free rope is difficult to climb by hand because it is difficult to grip. The thin ropes commonly used in caves and on mountains, with their usual coating of grime, make hand climbing an impractical method of ascending more than five or ten feet.

The problem of grip is solved by the use of slings of lightweight rope which can be attached to the hanging line with prusik knots. The prusik knot will hold securely when tension is applied to its sling, but can be moved easily when tension is removed. The term "prusik climbing" is applied to a variety of methods for using these slings and knots. The climber has to shift his weight systematically from one sling to another, so that the knots may be moved one at a time.

In the mountains, where the climb was generally against a wall, two approximately equal slings were used to support the feet. If there was any difficulty in maintaining balance a belay rope was added, tied under the arms. Sometimes a third prusik sling was attached to the hanging line and was tied under the arms. Progress was slow but steady. It is doubtful that anyone resorted to the method often enough to become proficient.

At times no wall was available. One early maneuver was to sit in a seat harness suspended from a prusik knot while a second prusik sling, supporting the feet, was raised. Then the weight was somehow shifted to the feet, and the seat was raised. Considerable struggling was involved, and the arms tired quickly.

By 1956 when prusik climbing was described in the *National Speleological Society Bulletin,* the procedure had improved (Bloxsom, 1956). Three rope slings were used. Two supported the feet, and one encircled the chest. The seat sling was a relic of the past, for it has been realized that one can rest fairly well by sitting on one heel, with the chest sling just snug. The climb was begun by placing the chest prusik knot as high as could be reached. The sling attached to the right foot was raised until one could sit on the right heel. Then the left foot was raised, to put the weight on both heels. Finally one stood up in the foot slings and slid the chest sling high, to finish the cycle. Prusik climbing is inherently safe, and does not require a separate belay rope.

The *Bulletin* article was brief, and left much for interpretation. I have since found that the sling lengths are critically important for efficiency, and that it is possible to balance one's weight at all times so the chest sling supports very little tension, and the arms are free from any part of the lifting (Plummer, 1959b). Furthermore, the three slings may be arranged so that only *two* prusik knots are in contact with the hanging rope, for maximum speed and ease on a long ascent away from walls.

The third prusik knot was a nuisance from the start, so there have been several other attempts to do away with it – each of them impractical. It is not satisfactory to leave out one foot sling, for then one leg at a time must do all the lifting. One-legged "deep knee bends" are hard work. When the lone foot sling is being lifted the weight is entirely supported by the chest sling. The usual way out of this new problem is to bring back the old seat sling and rig it to the chest sling to share the load. Some cavers have developed a regular parachute harness for this purpose (Olsen, 1961). A recent article in the *National Speleological Society News* proposed a wooden swing seat for especially long rests (Perera, 1962). There are two basic faults in all these schemes. First, there is no satisfactory way to balance one's weight over one's feet for the few seconds it takes to lift the sling supporting the seat harness. The other hand has to do an unnecessary amount of work to hold the body in position and compensate. Second, when one stands up in the foot sling or slings, the seat does not rise as *far* as the chest. The torso must actually *fall back* a few inches each cycle as the weight is returned to the seat sling. In a long climb the wasted effort may be equivalent to climbing an extra 30 feet or more.

A better solution, which retains full efficiency, is to do away with the third knot without doing away with the third sling. The prusik knot supporting the right foot sling is just attached to the chest sling, immediately

below its knot, rather than to the hanging rope. It goes along for the ride (fig. 4).

Now all this won't work unless the proper moves are carried out in the proper order. The slings must have precisely the right lengths for your size. They must meet *two* conditions. To test them, stand facing the hanging rope and put the slings on. The knot holding the foot is raised until it is tight. The chest sling, with the right foot sling attached to it, is positioned just high enough to make the right foot sling tight. Now stand up straight. The slings must permit this, with no more than an inch or two of waste slack. The second condition is tested now by

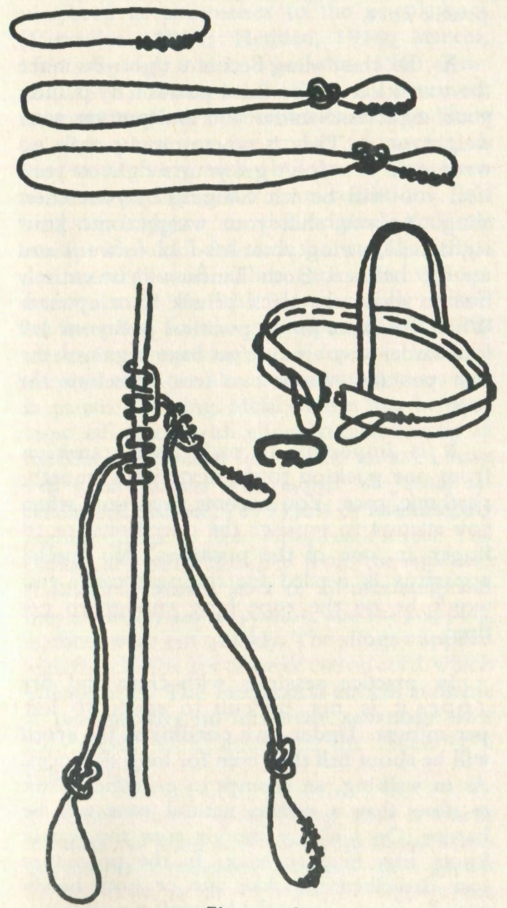

Figure 4.
Slings and their assembly.

sitting on your heels, is a squatting position. Move the prusik knots if necessary to get all the stretch out of the rope. While your weight is supported by your heels the chest sling must be *just right* beneath your arms. If too tight it will be painful to use, and will interfere with circulation. If the chest sling is slack you will need arm effort to keep your weight centered over your heels. Formulas for calculating the sling lengths have been published (Plummer, 1962a).

The chest sling will generally be a nuisance to put on and remove. Much of the trouble can be avoided with a detachable rig. Secure eyes are spliced in the ends of a three-eighths inch nylon rope for the part that fits around the chest. This rope is tied to an Army-surplus pistol belt to keep it in position. A loop of cord over one shoulder keeps the sling from slipping down to your waist. A snaplink with a threaded safety sleeve snaps through both eyes of the nylon rope, and joins it to a short prusik-knot loop made of five-sixteenths or three-eighths inch manila. Three-eighths inch laid polypropylene rope makes an excellent prusik knot, particularly for use on wet ropes, but you will need some practice to make a safe splice with it. Nylon rope makes unsatisfactory prusik slings because of its stretch: under load the rope forming the prusik knot stretches, then regains its original thickness and binds when the tension is removed.

For smooth prusik climbing there are three basic positions which should be learned well (fig. 5). The first is the squatting posture just described, with the weight on the heels. It will feel different high in the air. Your feet will tend to rotate beneath you, toward each other. The sling rope will be bearing on the outer side of each foot, not on the sole. The knees should be together and should be pointed slightly downward. It will be easier to balance if you lean forward with one shoulder against the rope. Both hands are free. The chest sling offers just slight support, and it needn't be padded. Your feet may get a little cramped in rehearsal, but on an actual climb the position isn't held long. Boots help.

Take hold of the rope gently and stand up, as in a "deep knee bend." Your legs are supposed to do all the work but you may

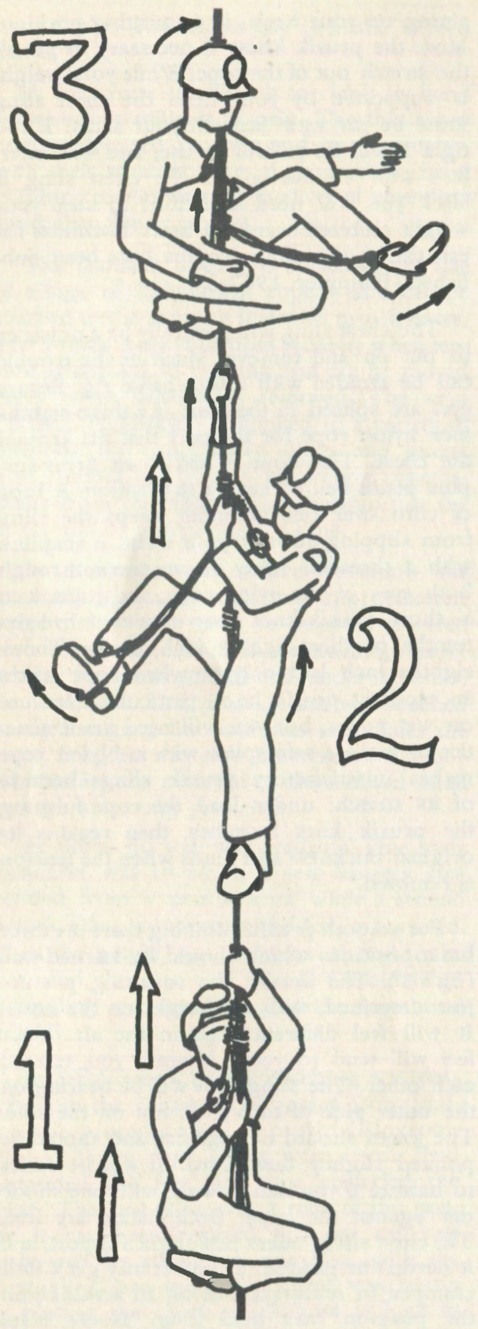

Figure 5.
Prusik climbing positions.

want to use your hands a little at the beginning, where your leg muscles have the least mechanical advantage. A couple of inches before you reach your full height grasp the rope high above you with your right hand. Reach high, so your elbow is straight. Simultaneously, *before you have quite finished rising,* swing your right foot forward in a high kick. When your left leg is straight and your weight is entirely *on* it you are in the second position. Your right leg is extended for balance. Its weight pulls you forward, against the rope. Your right hand is for stability only, not to support your weight. If the elbow is not straight there will be an unnecessary load on the arm muscles. Your left arm is entirely free. The chest sling, and the right foot sling attached to it, are slack. Raise them with your left hand on the prusik knot.

As the chest sling becomes tight you make the transition to the third position by pulling your right heel under you and putting your weight *on* it. This is where most people go wrong. If you don't get your weight on your heel you will be left hanging by your chest sling. As you shift your weight onto your right heel, swing your left foot forward and up for balance. Both hands will be entirely free to move the slack prusik knot upward. When the knot is in position pull your left foot under you also. You have regained the first position, about two feet higher on the rope.

It is important to make each transition from one position to the next with a smooth, rhythmic pace. You become tired only when you attempt to separate the operations, or to linger in one of the positions. No special apparatus is needed for resting because you won't be on the rope long enough to get tired.

In practice sessions with clean and dry ropes it is not difficult to reach 40 feet per minute. Under cave conditions the speed will be about half that, even for long distances. As in walking, an attempt to go either faster *or slower* than a certain natural pace will be harder. On a wet or muddy rope the prusik knots may tend to stick. In the procedure just described one has one or both hands entirely free to assist the loosening or tightening of each knot on the rope. The prusik knot cannot jam, and may always be freed by feeding a little slack into it. Cavers who find difficulty in doing this are the ones who haven't learned to balance in their slings. When you're hanging on for dear life with both hands it is naturally tough to move the knots.

On some climbs where the rope is never free of the wall it may be easier to use the three prusik slings separately. The right foot sling can then be removed from the chest sling and attached directly to the hanging rope, even if you are already high above the floor. This is the reason for holding those slings together with a third prusik knot.

In recent years several new knots have been proposed as alternatives to the prusik knot (Varnedoe, 1959; Hedden, 1959; Marchi, 1961; Spong, 1962; Schroeder, 1963; Russell, 1964; Plummer, 1962b). All represent attempts to find a knot which is less likely to stick when you are trying to move it. A few work fairly well, but most have been observed to fail under cave conditions. It's hard to improve on the original, and any attempt should be tested thoroughly before use underground. There are now various metal clamps available commercially which are intended for the same purpose. The illustrations advertising these depict techniques identical to those abandoned twenty years ago in prusik climbing. Metal clamps may be used most efficiently with slings rigged exactly as has been described for prusik knots. I have had great success with a pair of Jumar ascenders (Cordiner, 1959) just by attaching my regular slings to *them* with prusik knots. The clamps are easily detached from the rope and re-attached above a knot or an overhang. But they are bulky and expensive, and the gripping surfaces wear out quickly. The slings supplied with the clamps are of weak cotton cord, which quickly rots. The mechanical devices available at present offer no important advantage over the prusik knot, except in the hands of a beginner.

Another kind of climbing knot is worth learning for emergency use. Any of the knots or devices mentioned may fail on a glazed muddy rope, or on an unusually slippery thin rope. Some cavers have had trouble with prusik knots, and have made them grip a little better by forming another pair of turns around the hanging rope. In a really severe case another kind of escape knot is called for (fig. 6).

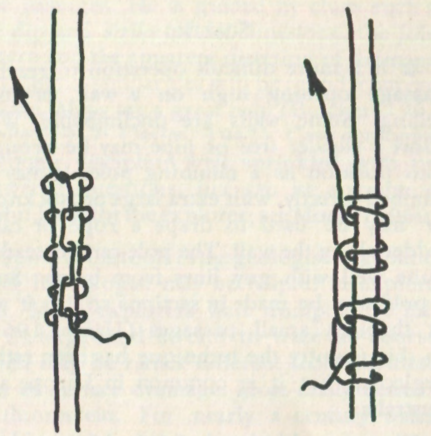

Figure 6.
Escape knots.

The simplest is tied by detaching the upper part of the prusik sling where it leaves the ankle knot. The long free end is used to form a pair of prusik knots, the second above the first on the rope (Plummer, 1961b). The final end is left free. With two prusik knots in tandem the gripping power is enormously amplified. I have successfully climbed a 30 foot piece of new quarter inch nylon cord with stiff old slings of three eighths inch manila rope. The grip was actually excessive, and a couple of turns at the top might have been left out. In a real emergency one could descend or ascend a slender hand line, but such thin ropes would not usually be safe.

A second escape knot consists of a series of half hitches tied around the hanging rope (Plummer, 1963a). Like the tandem prusik knot, this has the mechanical advantage of an Oriental finger trap (fig. 6). Four half hitches will be about equivalent to a normal prusik knot. The grip improves rapidly as half hitches are added at the top. With several, I've climbed a greased steel cable. At the top of the knot the end is left free, or is entwined into the top turn. It is important *not* to put weight on the upper end. The escape knots aren't intended for normal climbing because they take up too much space on the rope and grip too well. They are intended for saving cavers the embarrassment of a pit rescue (Anon., 1961).

Scaling

It is a more difficult operation to reach a passage opening high on a wall, or in a ceiling. Some walls are unclimbable. With effort a slender tree or pipe may be brought into position as a climbing pole. It may be climbed directly, with extra large prusik knots, or may be used to drape a rope or cable ladder along the wall. The pole can be steadied quite well with guy lines from below. Such a pole may be made in sections so that it will fit through small passages (Haarr, 1962). In this country the technique has been rather neglected, but it is common in Europe and Australia.

The same device may be used for crossing open pits to continue in a passage at the same level. A very readable account of a pit crossing appears in *Celebrated American Caves* (Brucker, 1955). Although the pit described was not actually crossed at that time the method is workable, and would be much as the author imagined it.

A more stoic approach has been used successfully by the Pittsburgh Grotto in Overholts (Blowing) Cave (McCrady, 1960; Schmidt, 1960). This consists of climbing the wall by drilling a series of holes and inserting expansion anchors. It was found that a climber wearing a support harness could insert two anchors in 45 minutes, for a gain of five feet. Another climber then took his place for the next five feet. The method is tedious but has advantages when the wall to be climbed is deep within a cave.

Wet Caves

Heights and depths are no longer a permanent barrier to exploration. Recent attention has been directed toward another obstacle, cold water. A total soaking is hard on the morale, and many really inviting passages have been avoided by cavers who preferred to stay dry.

About five years ago a type of dry suit available from diving supply stores for about 20 dollars suddenly became popular. Skindivers commonly prefer wet suits, which are more comfortable under high pressure and are more uniformly bouyant. But dry suits are better for cave trips since they are warmer, and are more comfortable when worn for 10 to 20 hours at a time. Wool socks and sweatclothes are worn under the dry suit, and coveralls, socks, and boots are worn over it. Even if it leaks a little the dry suit provides complete comfort in wet passages. It can be used for short swims and for crawling through near-siphons. The clothing is flexible enough for climbing and for moderate ropework. Kneepads are often worn to protect the suit in crawlways. Lightweight coveralls are used, to collect the minimum weight of water. Especially watertight containers are used for carbide and matches. Ordinary flashlights work well if they are taken apart for draining and drying immediately after use. A small air mattress may be carried for a float.

Thus equipped the caver is prepared for all but total immersion, and a great many passages have suddenly become inviting for the first time. Dry suits quickly led to the exploration of miles of new passage in Virginia and West Virginia alone, where cavers had long been content to stay in the abundant drier galleries. These wet passages are different in kind from the dry passages. They represent earlier stages in the continuous growth and evolution of a cave, and the explorer is privileged to witness the development itself. Mud is usually absent, and the rock glistens. By contrast the passages which have been high and dry for a few thousand years seem mostly drab and lifeless. Active stream courses now represent the most exciting prospects for exploration.

Wetter Caves

The actual pursuit of a stream through totally submerged passages with SCUBA equipment is quite another matter, and requires specialized equipment and knowledge (Balcombe, 1962). This is a technique which is so dangerous, and so difficult, that one can make an entirely successful dive without finding 20 feet of new passage. One merely has to get back out. In Florida alone more than two dozen explorers have failed to do so. The technique combines the very worst aspects of both skindiving and cave travel.

In an emergency flooding, cave explorers may be rescued through a blocked passage with simple equipment available from most hardware stores, based on two tire pumps and a length of garden hose (Plummer, 1961a). Cavers who feel that an exploration problem can best be solved by diving would be best advised to contact someone with experience. Underwater visibility is likely to be poor, and there is no room for an equipment failure or a lapse in judgment. Many of the special considerations have been outlined by Block (1958) and Cooper (1964); see also Anon. (1959).

Long Caves

In a really extensive cave system the endurance barrier can be extended only by establishing camps underground. Success lies in sound planning. The readable account of a mass trip to Floyd Collins' Crystal Cave appears in *The Caves Beyond* (Lawrence, 1955). Experiments on a smaller scale have been carried out by cavers in Indiana (Wischmeyer, 1963). Underground camps played an important role in the Pittsburgh chapter's work in Overholts (Blowing) Cave. Some details of the organization have been published by McCrady (1960) and Schmidt (1960). An article in the 1956 *Bulletin* (Smith, 1956) suggested several broad principles which may also be helpful.

When a cave is just a little too big for a long day's push, and an expedition of some sort is justified, the necessary effort expands enormously. The endurance barrier is not extended easily. Perhaps the best solution is to establish one or more semi-permanent camps which can be stocked with sleeping bags, cooking utensils, and food, for use over a long period of time, rather than attempt to accomplish everything in one mad week underground. The initial exploration is followed by mapping, later by photography, and eventually casual tourists, so the camp won't be wasted.

Eventually the mass expedition will become more common. But progress will be slow, simply because in this country it is still easy to find new passages within a few hours of an entrance.

Science in Exploration

An observant explorer will gradually learn where in a cave he may most probably find new passages. He is guided by clues such as the dip and strike of the limestone, the joint pattern and the apparent direction of drainage. Meaningful similarities will be found from cave to cave. Maps are a great help (Butcher, 1962; White, 1957; Davies, 1947). Cave geology is a young discipline well sprinkled with unanswered questions, but can be a source of useful ideas for the explorer; see Moore (1960).

Some of the tools of the geologist or groundwater hydrologist may be helpful in exploration. Many explorers have dumped dye into an underground stream to trace its course, which may be rather different from the direction of surface drainage. Most easily detected is fluorescein. For nearly a century water soluble forms of this chemical have been used for tracing streams. Occasionally a little too much is used, and the hydrologist is run out of town by irate citizens with green tap water. A method proposed by Dunn (1957) permits the use of very small quantities of the expensive dye. The suspected continuations of the stream are tested with the help of small packets of coconut charcoal. The charcoal may be left unattended in the stream for some period of time, and is then tested chemically for the presence of fluorescein. This and other methods have been discussed by Haas (1959). Applications have been reported by Zotter (1963).

Air, too, may be "dyed." An excellent smoke may be made with 36% zinc powder, 44% hexachloroethane, 10.5% ammonium perchlorate, and 9.5% ammonium chloride. The chemicals should be handled with care, and an effort should be made to avoid inhaling the smoke. Ethyl mercaptan has been used to verify the known presence of a connecting passage between Sinnett and Thorn Mountain Caves (Fetrow, 1960). It is a volatile and somewhat poisonous material that suggests the presence of several badly disturbed skunks. It may be cleaned from the hands and equipment with hydrogen peroxide.

Even without smoke or scent the air in a cave can reveal a lot about its structure. A wind generally implies a connection to a second entrance of some sort, and chimney action. But there are several types of cave wind (Plummer, 1962c). Observation can usually determine which kind is present, and what may be expected ahead.

One special sort of wind is characterized by systematic fluctuations in speed and sometimes in direction. This was first reported by Faust (1947) at Burnsville Saltpeter Cave, Virginia. The phenomenon is actually fairly common, and may be observed in much simpler form at Cass Cave (Plummer, 1959c). Victor Schmidt (1958) recognized that such a wind is a form of acoustical resonance, and found that the period was nicely predictable from the dimensions of the cave. Further confirmation has been made at several other caves, and the "breathing" mechanism may be considered well understood. It is not, however, easy to apply the theory to complicated caves, but in time it will be possible to learn much about a cave system by studying the air fluctuations mathematically. See Rayleigh (1878) and Plummer (1965a).

Early experiments with magnetic direction finding were carried out by the Bureau of Mines more than 30 years ago (Joyce, 1931), but the equipment was bulky. Vacuum tubes helped, but it was the transistor which finally made the apparatus portable (Roeschlein, 1960).

The direction finding is done with a pair of wire loops. A small oscillator excites an alternating current in one, and creates a magnetic field which easily penetrates the rock. By mutual induction a voltage is picked up in the other loop, and is amplified. The apparatus for two-way code communication and precise direction finding and depth measurement, with a range of a few hundred feet, weighs less than two pounds and fits in a very small pack. This "cave radio" draws little power and may be tapped in to the battery supply for an electric cave lamp (Plummer, 1964a, 1964b, 1965b). Several Society members have used similar equipment with great success.

A different kind of device of about the same size may be used to amplify the voice and apply the voltage to a pair of small metal probes, 20 or 50 feet apart, inserted in the fill in a cave passage. On the surface two more probes are used to detect the resulting voltage fluctuations. A calculation shows that a watt or two of power can readily be received a half mile away (Plummer, 1965c). This "cave telephone" seems ideal for establishing communication with a camp deep within a cave system, for weather forecasts and the like. It may be used to find the approximate location of the subsurface party.

Both devices have the effect of giving an exploring party eyes above the ground, to compare terrain features with cave structure. They eliminate thousands of feet of telephone wire.

It is harder to locate cave passages from above without an underground station. Methods which have been used include studies of the variation of gravity, of magnetic field, and of electrical conductivity over the cave (Meyers, 1962; Krinitzky, 1947; Chico, 1964). The equipment can get elaborate and expensive. Only the electrical conductivity studies appear within reach of the average explorer's budget. Measurements take time, but can tell a lot about a cave. Caves with no entrances have actually been mapped (Palmer, 1959), and tests show that these studies can be carried out with simpler field programs than have previously been used (Plummer, 1963b).

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Baltimore, Maryland 21218

History of the National Speleological Society*

Our Society came into existence 25 years ago this month. It began as an active organization, with nearly 100 members enrolled, which seven months before had published the first volume of this *Bulletin.* Its short-lived predecessor was the Speleological Society of the District of Columbia, established in May 1939.

That the founders of the Speleological Society of the District of Columbia planned from the beginning for the Society to grow into a national organization is clear from this statement on page 1 of the first *Bulletin:* "It is hoped that the Society may form an offical clearing house for all cave information and that one of the chief objectives will be the accumulation of a permanent library. . .It is a further objective to publish a periodical which will become the country's official organ for the science of speleology."

The constitution of the Speleological Society of the District of Columbia stated that "the purpose of this Society shall be to advance in any and all possible ways the science of speleology." This purpose is still the guiding principle of the National Speleological Society, which has broadly interpreted it to embrace all aspects of the exploration and study of caves. In realizing this purpose, the Society's activity has ranged from research in all the cave-related sciences to practical supporting work such as mapping caves, developing new underground-climbing techniques, and studying the most effective ways to protect caves and cave features.

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*The principal contributors to this article were George W. Moore, Hermine Zotter, William J. Stephenson, William S. Hill, and Julia L. Staniland. It is hoped that corrections and additions will be submitted for publication in the *National Speleological Society News.*

Organized Caving in Europe

The words *spelaeologie* and *spéléologie* were coined in France in the early 1890's from the Greek words meaning *cave-study*, and in 1896 the great French speleologist Édouard A. Martel first introduced the word *speleology* into the English language.

Although cave research in the United States by individuals began in the 18th century, organized speleology was late in making its appearance here. It began in Austria in 1879 with the founding of *Verein für Höhlenkunde* (Society for Cave-science). The first speleological journal was published in Vienna on September 15, 1882. It was the *Mittheilungen* (Communications) of the *Section für Höhlenkunde, Österreichischen Touristen-club.* In Germany, the *Schwabischen Höhlenvereins* was founded in 1889 and began publishing its *Schriften* (Publications) in 1892. To serve cavers of the classic karst region, number 1 of a short-lived hectographed cave journal was issued at Trieste in 1893. It was facetiously called *Hades – Mitteilungen aus der Unterwelt.* In 1895 the *Société de Spéléologie* was founded in Paris, and on February 1st of that year the venerable journal *Spelunca* began publishing under the editorship of Martel. A few years later, two Italian journals appeared almost simultaneously. The first was *Rivista Italiana di Speleologia,* which began publishing at Bologna in 1903. The second was *Mondo Sotteraneo,* an organ of the *Circolo Speleologico ed Idrologico Friulano.* Its headquarters were at Udine near Trieste, where it began publishing in 1904. A Hungarian speleological society was founded in 1910, and in 1913 began issuing its *Barlangkutatas* (Speleology). In Britain the first society devoted exclusively to caves was the Yorkshire Speleological Society, founded in 1906. The *Proceedings of the Bristol University Spelaeological Society* began publication in 1920 as the first journal in Britain and still continues its excellent articles. In

Figure 1.

Some of the founders of the Society at Lost River Cave, Kentucky, in September 1941. Left to right: Albert C. Lewis (Corresponding Secretary), Harvey M. Templeton, William J. Stephenson (President), H. T. Kirby-Smith, John S. Petrie, and John F. Meenehan. Photo by Florence I. Whitley.

1920 the *Institutul de Speleologie* at Cluj University, Romania, began publishing its *Lucrarile* (Bulletin). A speleological society was established in Spain in 1932, but its *Speleon* did not begin publication until 1950. In most European countries, the caving societies listed above were followed by others, so that organized speleology was well established in Europe by the time of the founding of our National Speleological Society.

Speleological Society of the District of Columbia

February 26, 1939, was an important date in the prenatal history of the National Speleological Society. On that day a feature story by Jo Chamberlin appeared in the Sunday *Washington Star* telling about Mammoth Cave and Carlsbad Caverns, and about Floyd Collins, Jim White, and Charles E. Mohr. This article caught the attention of William J. Stephenson and his wife Merle of Washington, D.C., who for some years had been exploring caves in northern Virginia with Stephenson's colleague at the U.S. Patent Office, Elmer W. Harmon, and several other friends. This activity began when Stephenson, who was the leader of a hiking group connected with his church, decided one day to take a trip to a cave. After that, cave exploration became the principal activity of the group.

Stephenson's eye was caught by a key

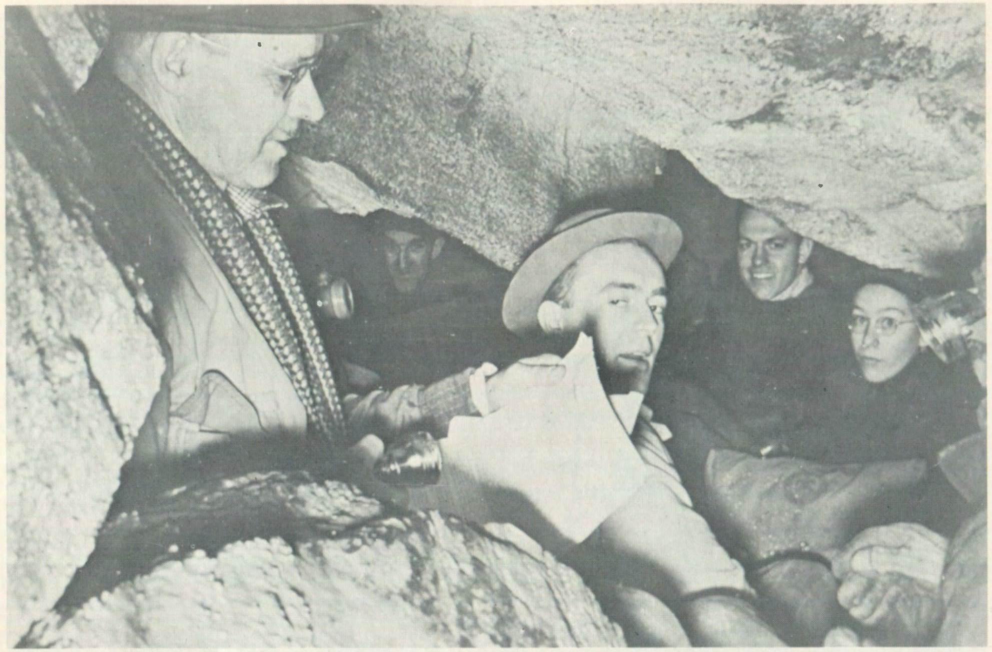


Figure 2.

Clay Perry reading the proposed constitution of the National Speleological Society in Pettybone Falls Cave, Massachusetts, December 1, 1940.

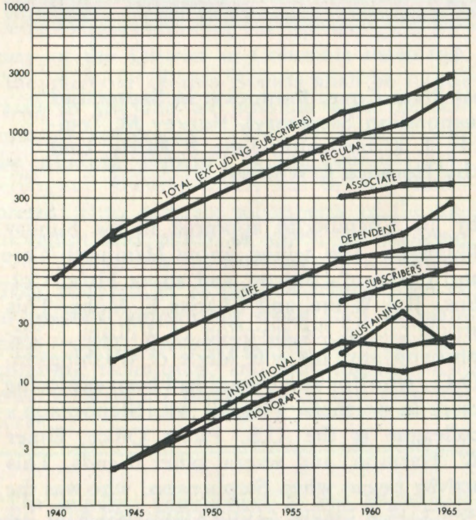


Figure 3.

Growth of the National Speleological Society.

Figure 4.

Taking a break in Schoolhouse Cave, West Virginia, 1943. Left to right: John S. Petrie (Vice President), William W. Welch, John F. Meenehan, John J. Wilson (Secretary).

sentence in Chamberlin's article: "*In England there is a national organization devoted to caving.*" Stephenson immediately recognized the many advantages such an organization could have for the United States, and he set himself the task of establishing one. On May 6, 1939, the Speleological Society of the District of Columbia was a reality.

Founding of the National Speleological Society

During the next year the Speleological Society of the District of Columbia proved to be very successful. Numerous field trips were taken, and by June of 1940, when the first *Bulletin* was issued, a significant proportion of the members already lived outside of the Washington area. The appearance of volume 1 of the *Bulletin*, under the editorship of Don Bloch, in combination with the fortuitous location of the Speleological Society in the Nation's capital, caused others interested in caves around the country to begin to look to the young Washington organization as the fountainhead of American speleology.

In the fall of 1940, the officers of the Speleological Society of the District of Columbia drafted a constitution for a proposed National Speleological Society. The constitution

Figure 6.

At the entrance to Breathing Cave, Virginia, 1944. Left to right: Henry Batcheller, G. Alexander Robertson, Merle O. Stephenson, Howard W. Silsby, William J. Stephenson, Burton S. Faust, James N. Drysdale, Mary Robertson, unknown, James T. Robertson.

Figure 5.

At Mystic Cave, West Virginia, 1941. Left to right: Robert L. Lutz, John Ford, unknown, James N. Beard, Edwin N. Gage, J. L. Wingfield, Keefer (foreground), George C. Dare, John Ford, George Mann, Arthur Shires.

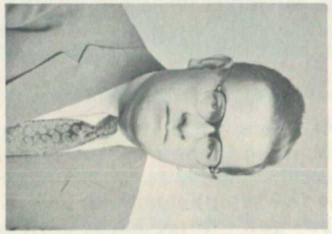
Figure 7.

At Torys Cave, West Virginia, 1946. Left to right: George C. Dare (No. 78), Alden E. Snell (No. 18), Merle O. Stephenson (No. 1), Sandra (Stephenson) Kuhn (No. 1056), Bonnie (Stephenson) Marland (No. 1057), Norma M. McLane (No. 1054), Clarence E. McLane (No. 960), William J. Stephenson (No. 3).


WILLIAM J. STEPHENSON
1941-1948

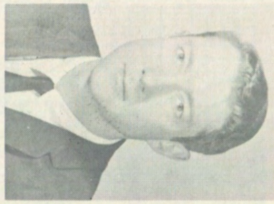

RALPH W. STONE
1948-1950


CHARLES E. MOHR
1950-1954


WILLIAM E. DAVIES
1954-1957


BRO. G. NICHOLAS, FSC
1957-1961


RUSSELL H. GURNEE
1961-1963


GEORGE W. MOORE
1963-1965


THOMAS C. BARR, JR.
1965 — —

Figure 8.
Presidents of the National Speleological Society.

Figure 9.

Don Bloch, Editor of the National Speleological Society Bulletin, 1940-1947.

followed the plan of the older one and stated that "charter members of this Society shall be all members of the Speleological Society of the District of Columbia as of January 1, 1941, and all members of any other society, whose main purpose is the study of speleology or exploration of caves, which gives notice in writing to the Board of Governors of the Speleological Society of the District of Columbia prior to January 1, 1941, that its membership desires to be included in this organization." This draft was sent to several other caving groups which had become active in different parts of the country. On December 1, 1940, a group of 24 people under the leadership of Clay Perry met in Pettibone

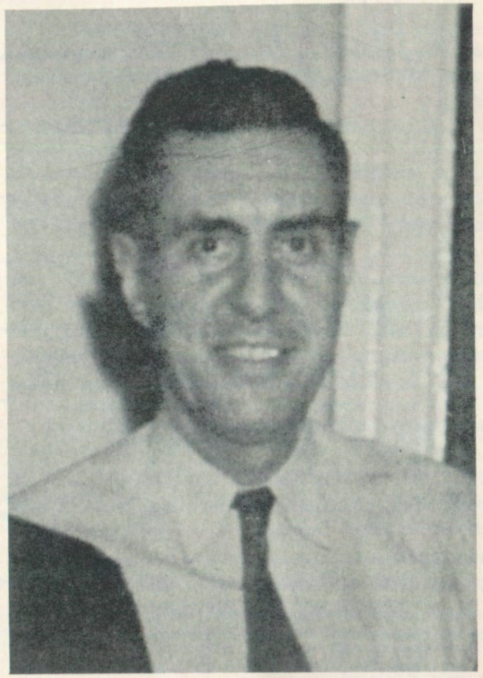


Figure 10.

William S. Hill, Editor of the National Speleological Society News, 1944-1955.

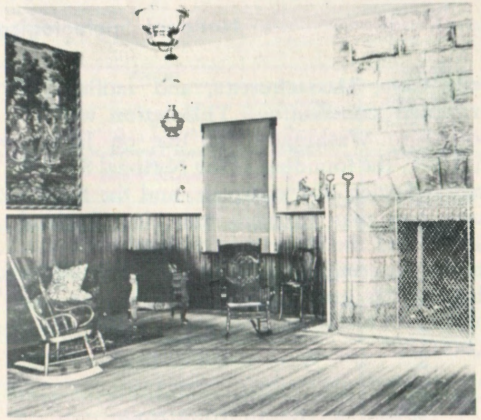
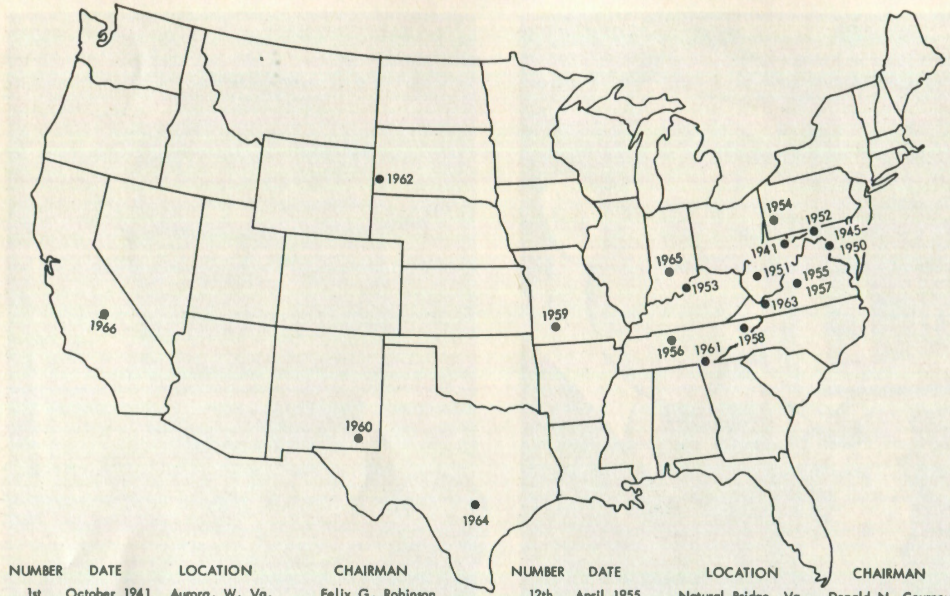


Figure 11.

Interior of the meeting hall of the Brookside Inn, Aurora, West Virginia, where the 1941 Symposium of Speleology was held. The building is no longer standing. Photo courtesy of Paul W. Price.



NUMBER	DATE	LOCATION	CHAIRMAN
1st	October 1941	Aurora, W. Va.	Felix G. Robinson
(Conventions suspended 1942-1944 owing to World War II.)			
2nd	January 1945	Washington, D. C.	James H. Benn
3rd	February 1946	Washington, D. C.	James H. Benn
4th	February 1947	Washington, D. C.	James H. Benn
5th	April 1948	Washington, D. C.	Burton S. Faust
6th	April 1949	Washington, D. C.	Burton S. Faust
7th	March 1950	Washington, D. C.	William J. Foster
8th	April 1951	Charleston, W. Va.	Emmons Graham
9th	April 1952	Hagerstown, Md.	Burton S. Faust
10th	April 1953	Louisville, Ky.	Miles D. Pillars
11th	April 1954	Pittsburgh, Penna.	John D. Parker
12th	April 1955	Natural Bridge, Va.	Donald N. Cournoyer
13th	April 1956	Nashville, Tenn.	Thomas C. Barr, Jr.
14th	April 1957	Natural Bridge, Va.	Henry H. Douglas
15th	April 1958	Gatlinburg, Tenn.	Donald F. Black
16th	April 1959	Springfield, Mo.	Oscar Hawksley
17th	June 1960	Carlsbad, N. Mex.	James K. Baker
18th	June 1961	Chattanooga, Tenn.	Donald F. Black
19th	June 1962	Custer, S. Dak.	John A. Streich
20th	June 1963	Mountain Lake, Va.	John R. Holsinger
21st	June 1964	New Braunfels, Tex.	James H. Estes
22nd	June 1965	Bloomington, Ind.	Richard P. Kuhlen
23rd	June 1966	Giant Forest, Calif.	David R. McClurg

Figure 12.

National Speleological Society conventions.

Falls Cave, Massachusetts, and ratified the proposed constitution. This action was reported to Washington, so that on January 1, 1941, the founding of the National Speleological Society was complete, and the Society soon had two chapters: the New England Grotto and the District of Columbia Grotto. In the succeeding 25 years, the number of chapters has grown from two to 88, and the number of members from about 100 to about 3,000.

Figure 13.

Burton S. Faust, developer of the Society's annual convention.

Organizational Structure

Since its founding the National Speleological Society has been governed by a Board of Governors, which has full power to conduct and supervise all business of the Society. Throughout the history of the Society, the Board of Governors has consisted at least in part of people elected by the whole membership. Before 1946 the officers were excluded from the Board, unless they had been separately elected as Board members, which was generally the case. Since 1946 the Board has consisted of directors and officers acting together, the directors choosing the officers.

Until 1946 the entire Board of Governors was elected by the members. In 1946 the officers as well as officers of the preceding year were added to the directors elected by the membership. In 1950 past presidents were added, in 1952 a representative of each regional organization, and in 1956 a commercial cave owners representative. The number of members on the Board of Governors gradually increased until by 1959 the Board of Governors consisted of an unwieldy group of 44 people, resulting in government largely by proxy.

In 1960, Joseph D. Lawrence, as chairman of a reorganizing committee, proposed the present system of government, which was adopted to provide more direct control by the members. The Board of Governors consists of the officers along with 12 directors elected by the members. Directors serve for three years, four being elected each year. They choose the officers and also fill any vacancies that may occur on the Board during a term.

At present the officers of the Society consist of a president, two vice presidents, and a treasurer. Through the years, however, the executive structure has undergone many changes, which are shown in table 1.

By 1949, the work at the Society headquarters, which had formerly been done by an unpaid secretary, became so heavy that it could no longer be imposed on a volunteer. Since 1951, the secretary has been a paid staff member rather than an officer. In 1954 the Society headquarters was reorganized by Donald N. Cournoyer, and at that time most of the present procedures were adopted.

In about 1942 a serial numbering system was established for members of the Society. It was then applied retroactively to members and former members on the basis of the date on which their first dues had been received, and it has been continued for all subsequent members. The current numbers are in the 8,000's, so that two-and three-digit serial numbers are now a source of pride to their holders.

The Society is divided into four classes of internal organizations: chapters, regional organizations, speleological surveys, and special sections. A congress to meet at the time of the annual convention was established in

	PRESIDENT	VICE PRESIDENT		SECRETARY			TREASURER
1939	William J. Stephenson	Daniel J. Tyrrell				Elmer W. Harmon	James I. Lavelle
1940	do	—			John J. Wilson (a)	Albert C. Lewis (b)	Alden E. Snell
1941	do	—			do	do	Daniel J. Tyrell
1942	do	—		Frank L. Durr (c)	John J. Wilson (d)	do	do
1943	do	John S. Petrie			Katherine E. Muma (a)	John S. Petrie (b)	LeRoy W. Foote
1944	do	Martin H. Muma			do	do	do
1945	do	do			Chrisey V. Mansfield (a)	do	do
1946	do	Charles E. Mohr				John S. Petrie (d)	do
1947	do	do				do	do
1948	Ralph W. Stone	Charles E. Mohr (e)	William J. Stephenson (f)			do	do
1949	do	do	do	John S. Petrie (g)		Ellen Moffett	do
1950	Charles E. Mohr	Burton S. Faust (f)	John S. Petrie (g)			do	Lewis C. Kibbee
1951	do	Burton S. Faust (h)	Jerome M. Ludlow (i)	William E. Davies (l)	Ivan T. Sanderson (k)	do	do
1952	do	do	do	do	do		do
1953	do	do	do	William E. Davies (l)	do	Joseph D. Lawrence, Jr. (m)	do
1954	William E. Davies	do	do	Brother G. Nicholas (j)	Albert C. Mauller (k)	do	Howard N. Sloane
1955	do	do	do	do	do	James D. McClung (m)	do
1956	do	John D. Parker (h)	George F. Jackson (i)	do	do	do	Burton S. Faust
1957	Brother G. Nicholas	George W. Moore (h)	do	Thomas C. Barr, Jr. (l)	Dorothy Reville (k)	Oscar Hawksley (m)	do
1958	do	do	do	do	Donald F. Black (m)		Barbara Munson
1959	do	Donald N. Cournoyer (h)	Thomas C. Barr, Jr. (i)	George W. Moore (l)	do		do
1960	do	do	Russell H. Gurnee (f)				do
1961	Russell H. Gurnee	Eugene P. Vehslage (h)	J. Robert Dunn (f)				Donald N. Cournoyer
1962	do	do	Frederick Benington (f)				do
1963	George W. Moore	Herbert L. Black (h)	Thomas C. Barr, Jr. (f)				do
1964	do	do	do				do
1965	Thomas C. Barr, Jr.	Robert S. Willis (h)	William B. White (f)				do

(a) Recording Secretary
(b) Corresponding Secretary
(c) Financial Secretary
(d) Secretary
(e) Vice President
(f) Executive Vice President
(g) Membership Vice President
(h) Administrative Vice President
(i) Publications Vice President
(j) Science Vice President
(k) Public Relations Vice President
(l) Research Vice President
(m) Organization Vice President

Table 1.

Officers of the National Speleological Society and the Speleological Society of the District of Columbia.

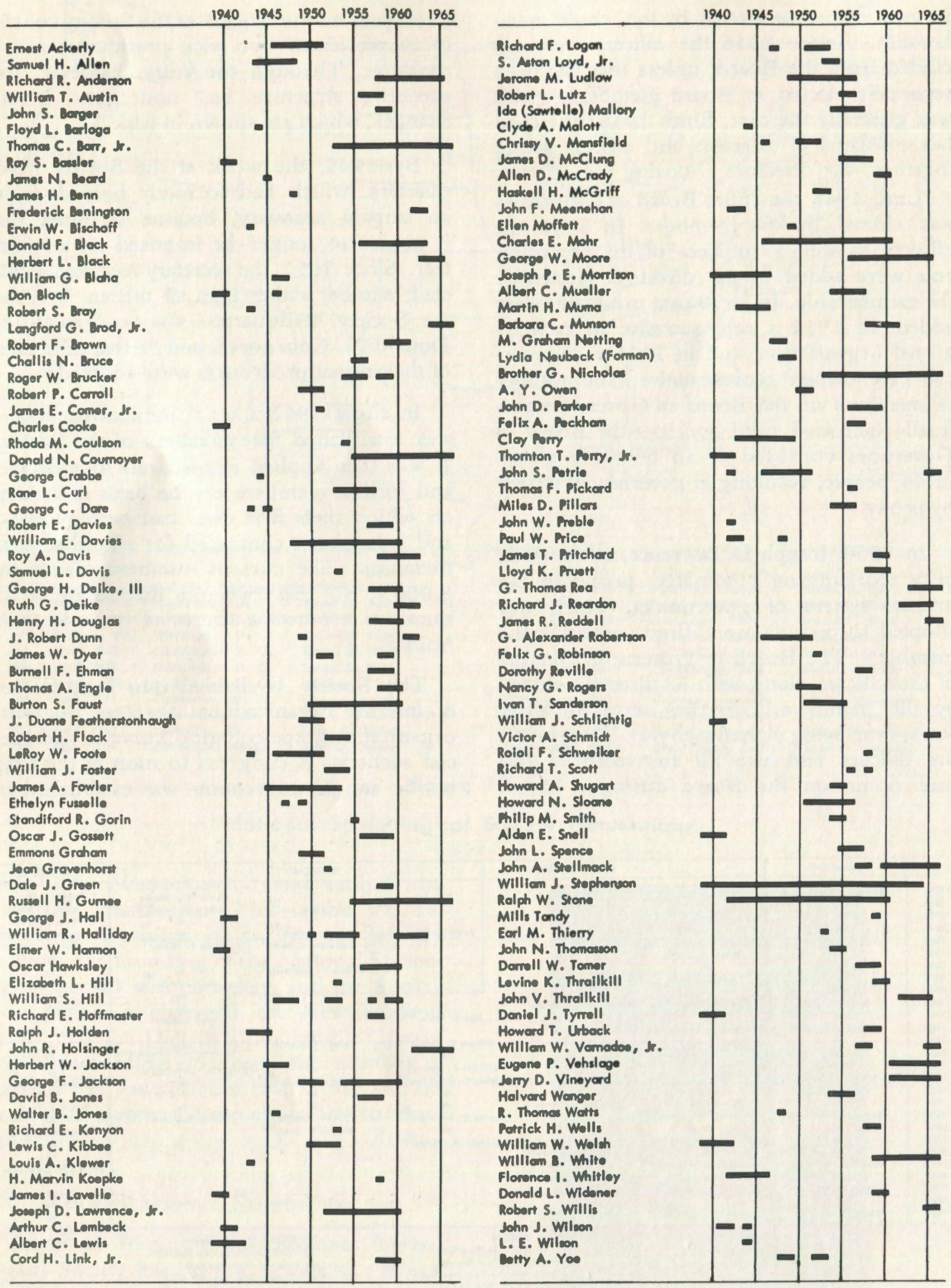


Table 2.
Members of the Board of Governors.

1949, where all the internal organizations can present their views on problems relating to the operation of the Society. Resolutions passed at each meeting of the congress must be considered by the Board of Governors at its next regular meeting.

Publications

The regular serial publications of the National Speleological Society have consisted of the *Bulletin* and the *News*. In addition to these the Society, with its committees and internal organizations, has issued numerous other journals (see table 3). Among the more important of these are the *Occasional Papers, Guidebooks, Speleo Digest,* and many chapter and regional publications.

Now, at the beginning of the Society's 26th year, the *Bulletin* is starting its 28th volume. The number is 28 rather than 26 because two *Bulletins* were issued in 1942 and volume 1 was the *Bulletin of the Speleological Society of the District of Columbia.* Except for these irregularities, the Bulletin has had annual volumes consisting of one number until 1958, of two numbers issued semi-annually from 1959 to 1963, and of four numbers issued quarterly since 1964.

Don Bloch was the founder and editor of *Bulletins* 1 through 9. Editors of subsequent volumes have been Charles E. Mohr, v. 10; Jerome M. Ludlow, v. 11-16; Roger W. Brucker, v. 17-18; William E. Davies, v. 19-25; and Jerry D. Vineyard, v. 26-28. Indexes for the first six volumes appeared in *Bulletin* 8, and for the first 20 volumes in *Bulletin* 20.

A nationally organized society also needs a regularly appearing news medium to be circulated among its members. At first this consisted of mimeographed sheets sent out by the Society's first secretaries, Albert C. Lewis and John S. Petrie. These contained such miscellany as general announcements, notices of coming field trips, lists of new members, and committee reports. In September 1942 the papers began to be called the *Speleological News Letter.* Subsequent names were the *National Speleological Society News Letter, Newsletter, Newsletter,* and finally *News,* the present name. The January 1944 issue was designated v. 2, no 1, so the sheets that preceded it could be collected as volume 1.

Since the demand for a regular publication was great, the *Newsletter* was reorganized in October 1944 with William S. Hill as editor, who soon had it appearing monthly. Letterpress printing began in 1948, and the present octavo size was adopted in 1954. Hill continued as editor until his resignation in October 1955, and Dorothy Reville took over the post until 1957. Roy A. Davis followed her until 1960, when John A. Stellmack began his present incumbency. Samuel L. Davis ended a faithful 11 year tenure as business manager In December 1964. One of the most valuable services performed for the *News* and for the Society has been its indexing. J. Robert Dunn compiled a cumulative index for the first five volumes, and George F. Jackson and Norma Jackson have prepared an annual index every year since 1948.

Library

It was apparent to the founders of the Society that a good working library is essential for speleological research. William J. Schlichtig as the first librarian in 1940 reported a collection of 62 items, consisting of nine books and 53 pamphlets. Robert S. Bray, Virginia Bray, Hugh Stabler, E.F. Moore, and E.I. Krmitsky compiled extensive bibliographies during the first ten years for publication in the *News* and *Bulletin.* Several donations of books and articles were received during that period, the most notable being that of Major Thornton T. Perry, who collected many rare titles while on duty in Europe.

By the end of the 1940's the collection was in storage in Richmond, Virginia, but Wilma J. Moyer started then to catalog it. About 1950 Burton S. Faust took it to his home in Washington. He then began developing the exchange program started earlier by E.F. Moore, and generally building up the collection with the help of Sylvia J. Craig, Chrissy V. Mansfield, Barbara J. Hagen, and Marguerite M. Klein. Scrapbooks were put together by Frances Snell and A.D. Therrien, while Robert H. Flack supervised collection of chapter publications. In 1956 the collection was moved to Pittsburgh, Pennsylvania, to be

Speleological Journals of the United States

Table 3.

Where unmarked, the set in the Society library is believed to be complete; * indicates a new missing number; ** indicates a very incomplete set. Members having collections of the journals that are incomplete in the library will confer a favor by advising the library of their holdings so that arrangements can be made to xerox the missing numbers. Notations of omissions and errors in the list will also be appreciated. Prepared by Julia L. Staniland.

ALABAMA

Birmingham Grotto Newsletter, 1965 –
Confederate Caver (Birmingham Grotto), 1963.
Huntsville Grotto Newsletter, 1960 –
Southeastern Caver * (Southeastern Regional Association), 1956-1959.
Tuscaloosa Grotto Newsletter, 1958-1962.

ARIZONA

Arizona Caver (University of Arizona Adventure Club Chapter), 1964 –
Cave Crawler's Gazette (Central Arizona Grotto), 1960 –
Southwest Caver ** (Association of Southwest Cavers), 1960 –

ARKANSAS

Arkansas Caver (Arkansas Speleological Survey), 1963 –
Arkansas Speleologist (Arkansas Speleological Survey), 1961-1962.
Trails Below ** (Shawnee Caving Club), 1963 –

CALIFORNIA

California Caver (California Regional Organization), 1949 –
California Speleological Survey (see Washington. Western Speleological Survey Serial)
Cave Notes (Cave Research Associates), 1959 –
Cave Studies (Cave Research Associates), 1953 –
Hanford Caver News (Hanford Grotto), 1955-1956.
Stanford Grotto Monthly Report, 1950-1952.
Valley Caver ** (Mother Lode Grotto), 1962 –
Western Speleological Institute Annual Report, 1954-1959.
Western Speleological Institute Bulletin, 1958.
Western Speleological Institute Observations, 1956-1959.

COLORADO

Caving in the Rockies (Colorado Grotto), 1952-1955, 1959-1962.
Colorado Grotto News and Notes (See Caving in the Rockies)
Colorado Speleogram ** (Colorado Grotto), 1958 –
Mines Caver (Colorado School of Mines), 1962.
Spelunk Junk (Southern Colorado Grotto), 1958-1960.
The Mole Meanders (Colorado School of Mines), 1962.

CONNECTICUT

Yale Speleological Society Journal (Yale Chapter), 1958 –

DISTRICT OF COLUMBIA

DC Speleograph (District of Columbia Grotto), 1947 –
Speleological Society of the District of Columbia Bulletin (see Virginia. National Speleological Society Bulletin)
Subterranean Sun * (American University Grotto), 1964 –
The Snooper ** (Friendship Heights Grotto), 1964 –

FLORIDA

Florida Speleological Society Special Papers, 1961.
Florida Speleologist (Florida Speleological Society Grotto), 1957-1962.

GEORGIA

Georgia Spelunker (Atlanta Grotto), 1957 –
Georgia Underground (Dogwood City Grotto), 1964 –

ILLINOIS

Windy City Speleonews (Windy City Grotto), 1961 –

INDIANA

Bloomington Indiana Newsletter (Bloomington Grotto), 1958 –
CIG Newsletter (Central Indiana Grotto), 1955 –
Cignal (see CIG Newsletter)
Guano News * (Edinburg Cave Club), 1959.
Lucifugus Letter (Geo-lucifugus), 1963 –
Monthly Spelunker (Indiana University Spelunking Club), 1959.
Petroglyph (Evansville Museum Grotto), 1961 –
Southern Indiana Subterranean Sentinel (Washington Indiana Grotto), 1958-1959.
Speleo Epitaph ** (Southern Indiana Speleo Group), 1960 –

IOWA

Intercom (Iowa Grotto), 1965 –
Iowa Cave Book (Iowa Grotto), 1957-1962.
Spelunking (Quint Cities Grotto), 1957-1961.

KENTUCKY

Bat Banding News (see Bat Research News)
Bat Research News (Institute of Speleology), 1960 –
Everlasting Darkness * (Central Kentucky Grotto), 1964 –
Kentucky Caver (Blue Grass Chapter), 1965-

MARYLAND

Baltimore Grotto News, 1958 –
Potomac Caver * (Potomac Speleological Club), 1958 –
Tri-state Caver ** (Hagerstown Grotto), 1953.

MASSACHUSETTS

Boston Grotto News, 1958-1962.
Eastern Caver (New England Speleological Society), 1958.
Massachusetts Caver (Boston Grotto), 1962 –
NRO Bulletin (Northeastern Regional Organization), 1954 –

MINNESOTA

MSS Surveyor (Minnesota Speleological Survey), 1965 –

MISSOURI

Foresight * (Chouteau Grotto), 1958 –
Gasconade Grotto Newsletter *, 1963 –
Hondo Rescue * (Hondo Grotto), 1964 –
Liaison (Missouri Speleological Survey), 1961 –
Liaison (Western Missouri Grotto), 1959-1961.
Mid-Missouri Speleological Club News Notes, 1958-1959.
Missouri School of Mines Grotto Bulletin *, 1953-1955.
Missouri Speleological Survey Newsletter *, 1956-1958.
Missouri Speleology (Missouri Speleological Survey), 1959 –
MSM Spelunker ** (Missouri School of Mines), 1957.
St. Louis University Grotto Newsletter *, 1962 –
The Underground (Mid-Mississippi Valley Grotto), 1958 –

MONTANA

Montana Speleological Survey Bulletin (see Washington. Western Speleological Survey Serial)
The Speleothem (Southwestern Montana Speleological Society), 1964 –

NEW JERSEY

Kittatinny Caver *, 1960-1963.
Speleothemes (Northern New Jersey Grotto), 1953 –

NEW MEXICO

New Mexico Speleogram **, 1961.
Southwestern Cavers (Southwestern Regional Organization), 1962 –
Underground Roadrunner ** (Southern New Mexico Grotto), 1961-1962.

NEW YORK

Column (Cornell University Grotto), 1952-1953.
Dripstone ** (Cornell University Grotto), 1963 –
IOCAver (Inter-collegiate Outing Club of America Caving Group), 1957 –
Met Grotto News (Metropolitan New York Grotto), 1951 –

OHIO

Cincinnati Speleological Society Newsletter **, 1960-1962.
Cleve-O-Grotto News (Cleveland Grotto), 1954 –
COG Squeaks (Central Ohio Grotto), 1957 –
GCG Electric Caver * (Greater Cincinnati Grotto), 1963-1964.
NEOG Log * (Northeastern Ohio Grotto), 1964 –

OREGON

Oregon Speleological Survey (see Washington. Western Speleological Survey Serial)

PENNSYLVANIA

Bucknell Grotto News, 1956.
Guacharo ** (Swarthmore College Grotto), 1960 –
MAR Bulletin (Mid-Appalachian Regional Organization), 1954 –

Moravian Grotto Semi-annual News Report, 1958.
Netherworld News (Pittsburgh Grotto), 1948-1950, 1955 –
Nittany Grotto Newsletter, 1952 –
Philadelphia Grotto Digest *, 1962 –
Shippensburg Grotto Newsletter, 1961.
Speleo Digest (Pittsburgh Grotto), 1957 –
World's Below ** (Chambersburg Grotto Club), 1960-1962.
York Grotto Newsletter, 1959 –

TENNESSEE

East Tennessee Grotto Occasional Papers, 1957-1958.
Limestone Ledger (Chattanooga Grotto), 1963-1964.
Speleo News (Nashville Grotto), 1953-1957, 1961 –
Troglodyte (Cumberland Grotto), 1955-1957.
Twilight Zone (Memphis Grotto), 1962-1963.

TEXAS

Association for Mexican Cave Studies Newsletter, 1965 –
Texas Cave Survey (Dallas Speleological Survey), 1958-1959.
Texas Cave Survey (Texas Speleological Association), 1961 –
Texas Caver (Texas Speleological Society), 1955 –

UTAH

Salt Lake Grotto Technical Notes *, 1953 –
Utah Speleological Survey (See Washington. Western Speleological Survey Serial)
Utah Speleologist (Utah's Dixie Grotto), 1953.

VIRGINIA

Cavalier Caver (University of Virginia Grotto), 1959 –
Cave Notes ** (Lexington Grotto), 1946-1947.
National Speleological Society Bulletin, 1940 –
National Speleological Society Guidebook, 1960 –
National Speleological Society News, 1941 –
National Speleological Society Occasional Papers, 1954-1959.
Tech Troglodyte * (Virginia Polytechnic Institute Grotto), 1962 –
Virginia Polytechnic Institute Grotto Grapevine *, 1944-1954.
Virginia Polytechnic Institute Grotto Training Bulletin *, 1950-1951.

WASHINGTON

Cascade Cave Report (Cascade Grotto), 1951-1953.
Cascade Caver * (Cascade Grotto), 1962 –
Washington Speleological Survey (See Western Speleological Survey Serial)
Western Speleological Survey Serial *, 1955 –

WEST VIRGINIA

Charleston Grotto Poop Sheet, 1954-1955.

WISCONSIN

WSS Newsletter (Wisconsin Speleological Society Chapter), 1960-1961.
Wisconsin Speleologist * (Wisconsin Speleological Society Chapter), 1960 –

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organized on a professional basis by Julia L. Staniland.

The library's growth, stimulated by donations from its many friends, a good budget allotment, and a fine exchange program, has now resulted in its containing about 5,000 items. The last 25 years have witnessed an enormous increase in speleological research and publication throughout the world, and the Society hopes to make this special library the largest collection of works devoted primarily to caves and caving in the United States.

Cave Files

Even during the early years of the Society, it became clear that in addition to a library it would be necessary to maintain a file of data on individual caves. At first the cave records that accumulated were kept by William J. Stephenson. This task was later assumed by Robert E. Morgan who was able in 1943 and 1944 to publish a partial index to the known caves of the world. Since then the cave files have been kept up to date by a series of hard-working committee chairmen. In 1960 they were taken over by Richard R. Anderson, who subsequently transferred the data to machine-sortable cards that made it possible to handle the growing volume more easily. It is hoped that Anderson will soon publish a new index to the limestone caves of the United States.

Conventions

An annual convention has been one of the most important parts of the Society's activity. The forerunner of the conventions was held October 17-19, 1941, at Brookside Inn, Aurora, West Virginia. This meeting was called the Symposium of Speleology – First Annual Conference of the National Speleological Society. As has been the pattern for many conventions since, papers were presented, a meeting of the Board of Governors was held, and field trips were conducted. The principal field trip of this first convention was one to Schoolhouse Cave, led by John F. Meenehan.

Owing to wartime conditions, no conventions were held from 1942 to 1944. From 1945 to 1947 they were held in the winter in Washington and called annual meetings. In 1948, under the chairmanship of Burton S. Faust, the meeting was called a convention for the first time and set the standard for all those that followed. At this convention the annual International Salon of Photographic Art was inaugurated by Faust and Earl Porter. The month for the meeting was changed to April, when weather would be better for field trips than it had been in the winter.

Conventions were held in April from 1948 to 1960, when the date was changed to June to coincide with the beginning of school vacation. In that year, also, publication of field-trip guidebooks became a regular part of convention planning.

In recent years many of the regional organizations have begun to hold their own conventions, and many of the most recent of these have been larger than the first Society meetings. In 1949, the Old Timers' Reunion, an unofficial, more informal national get-together, was inaugurated by G. Alexander Robertson, and has met every year since then in West Virginia in September.

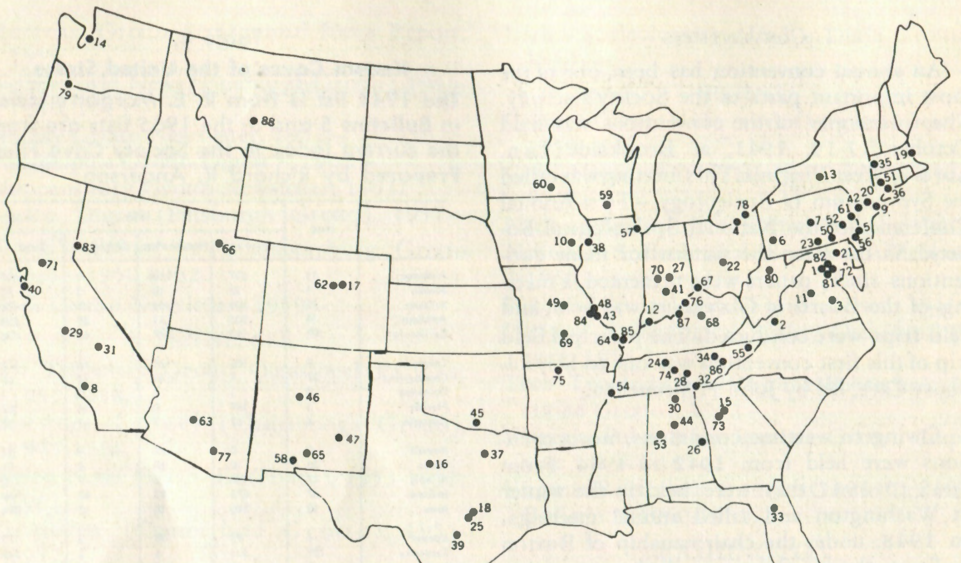
Field Trips

In the early days of the Society, all sponsored field trips were arranged by the Society officers, but this responsibility was soon taken over by convention committees, chapters, and regional organizations. In recent years, however, three expeditions have been organized in the name of the Society: the Crystal Cave, Kentucky, expedition of 1954 under the leadership of Joseph D. Lawrence; the Wind Cave, South Dakota, expedition of 1960 under the leadership of Robert F. Brown; and the Rio Camuy, Puerto Rico, expedition of 1964 under the leadership of Russell H. Gurnee.

Table 4.
Known Caves of the United States

The 1944 list is from R. E. Morgan's index in Bulletins 5 and 6; the 1965 lists are from the current index to the Society Cave Files. Prepared by Richard R. Anderson.

	1944	1965			
		Solution	Nonsolution	Unknown	Total
Alabama	51	607	10	0	617
Alaska	1	12	10	5	27
Arizona	22	104	46	24	174
Arkansas	18	203	11	39	253
California	102	163	587	46	796
Colorado	9	105	28	42	175
Connecticut	27	7	34	19	60
Delaware	0	1	0	0	1
Florida	1	169	0	18	187
Georgia	4	62	7	9	78
Hawaii	0	0	31	0	31
Idaho	36	10	58	3	71
Illinois	17	106	6	7	119
Indiana	67	675	23	62	760
Iowa	10	245	12	17	274
Kansas	6	99	12	2	113
Kentucky	109	301	6	3	310
Louisiana	0	1	0	2	3
Maine	29	3	23	8	34
Maryland	19	51	6	10	67
Massachusetts	78	28	22	36	86
Michigan	0	13	7	10	30
Minnesota	3	81	13	6	100
Mississippi	2	10	1	3	14
Missouri	132	1,280	0	0	1,280
Montana	15	94	17	42	153
Nebraska	1	0	1	1	2
Nevada	27	71	32	37	140
New Hampshire	23	0	13	16	29
New Jersey	4	75	22	4	101
New Mexico	13	151	59	20	230
New York	22	377	52	20	449
North Carolina	7	4	5	2	11
North Dakota	1	1	3	1	5
Ohio	37	48	9	4	61
Oklahoma	1	117	22	26	165
Oregon	23	24	73	15	112
Pennsylvania	154	514	50	91	655
Rhode Island	3	0	1	0	1
South Carolina	3	2	0	0	2
South Dakota	13	27	4	13	44
Tennessee	137	700	0	0	700
Texas	9	942	49	124	1,115
Utah	7	141	194	23	358
Vermont	42	44	27	13	84
Virginia	154	1,800	0	0	1,800
Washington	0	33	77	6	116
West Virginia	114	650	0	0	650
Wisconsin	6	55	28	39	122
Wyoming	2	25	5	14	44
Total	1,561	10,231	1,696	882	12,809



1. D. C. Grotto, District of Columbia, 1941
2. Virginia Polytechnic Institute Student Grotto, 1943
3. Richmond Grotto, Virginia, 1943
4. Cleveland Grotto, Ohio, 1945
5. Philadelphia Grotto, Pennsylvania, 1947
6. Pittsburgh Grotto, Pennsylvania, 1947
7. Nittany Student Grotto, Pennsylvania, 1948
8. Southern California Grotto, California, 1948
9. Met Grotto, New York, 1949
10. Iowa Grotto, Iowa, 1949
11. University of Virginia Student Grotto, Virginia, 1949
12. Evansville Museum Grotto, Indiana, 1949
13. Cornell University Student Grotto, New York, 1950
14. Cascade Grotto, Washington, 1951
15. Atlanta Grotto, Georgia, 1951
16. Abilene Grotto, Texas, 1951
17. Colorado Grotto, Colorado, 1951
18. University of Texas Student Grotto, Texas, 1951
19. Boston Grotto, Massachusetts, 1952
20. Northern New Jersey Grotto, New Jersey, 1952
21. Baltimore Grotto, Maryland, 1952
22. Central Ohio Grotto, Ohio, 1952
23. Shippensburg State College Student Grotto, Penna., 1953
24. Nashville Grotto, Tennessee, 1953
25. Balcones Grotto, Texas, 1954
26. Auburn Student Grotto, Alabama, 1954
27. Central Indiana Grotto, Indiana, 1955
28. Cumberland Grotto, Tennessee, 1955
29. San Joaquin Valley Grotto, California, 1955
30. Huntsville Grotto, Alabama, 1955
31. Sierra Mojave Grotto, California, 1956
32. Chattanooga Grotto, Tennessee, 1956
33. Florida Speleological Society Student Grotto, 1956
34. East Tennessee Grotto, Tennessee, 1956
35. Berkshire Hills Grotto, Massachusetts, 1956
36. Yale Speleological Society Student Chapter, Conn., 1957
37. Dallas-Fort Worth Grotto, Texas, 1957
38. Quint Cities Grotto, Iowa, 1957
39. Alamo Grotto, Texas, 1957
40. San Francisco Bay Chapter, California, 1957
41. Bloomington Grotto, Indiana, 1958
42. Kittatinny Grotto, New Jersey, 1958
43. Middle Mississippi Valley Grotto, Missouri, 1958
44. Birmingham Grotto, Alabama, 1958
45. Arbuckle Mountain Grotto, Oklahoma, 1958
46. Sandia Grotto, New Mexico, 1958
47. Pecos Valley Grotto, New Mexico, 1958
48. St. Louis University Student Grotto, Missouri, 1958
49. Chouteau Grotto, Missouri, 1959
50. York Grotto, Pennsylvania, 1959
51. Central Connecticut Grotto, Connecticut, 1959
52. Reading Grotto, Pennsylvania, 1960
53. Tuscaloosa Grotto, Alabama, 1960
54. Memphis Grotto, Tennessee, 1961
55. Holston Valley Grotto, Tennessee, 1961
56. Swarthmore Student Grotto, Pennsylvania, 1961
57. Windy City Grotto, Illinois, 1961
58. Southern New Mexico Grotto, New Mexico, 1961
59. Wisconsin Speleological Society Chapter, Wisconsin, 1961
60. Upper Mississippi Grotto, Minnesota, 1961
61. Moravian Student Grotto, Pennsylvania, 1961
62. Colorado School of Mines Student Grotto, Colorado, 1962
63. Central Arizona Grotto, Arizona, 1962
64. Southeast Missouri State Student Grotto, Missouri, 1962
65. White Sands Grotto, New Mexico, 1962
66. Salt Lake Grotto, Utah, 1962
67. Greater Cincinnati Grotto, Ohio, 1962
68. Bluegrass Chapter, Kentucky, 1962
69. Gasconade Grotto, Missouri, 1962
70. DePauw Student Grotto, Indiana, 1963
71. Mother Lode Grotto, California, 1963
72. Friendship Heights Grotto, District of Columbia, 1963
73. Dogwood City Grotto, Georgia, 1963
74. Tennessee Central Basin Chapter, Tennessee, 1963
75. Shawnee Caving Club Chapter, Arkansas, 1963
76. Central Kentucky Grotto, Kentucky, 1964
77. University of Arizona Adventure Club Student Chapter, 1964
78. Northeastern Ohio Grotto, Ohio, 1964
79. Oregon Grotto, Oregon, 1964
80. Monongahela Grotto, West Virginia, 1964
81. National Capitol Grotto, District of Columbia, 1964
82. American University Student Grotto, District of Columbia, 1964
83. Great Basin Grotto, Nevada, 1965
84. Hondo Grotto, Missouri, 1965
85. Little Egypt Student Grotto, Illinois, 1965
86. Smoky Mountains Grotto, Tennessee, 1965
87. Louisville Grotto, Kentucky, 1965
88. Shining Mountains Grotto, Montana, 1965.

Figure 14.

Active chapters of the National Speleological Society. Compiled by Allan P. Haarr.

Joint Activities

In 1953 the first International Speleological Congress was held in Paris, and Chrissy V. Mansfield was the Society's delegate. The chairmen of the delegations to subsequent international congresses have been Russell H. Gurnee, at Bari, Italy, 1958; John A. Stellmack, at Vienna, Austria, 1961; John A. Stellmack, at Ljubljana, Yugoslavia 1965. At the 1965 congress, 15 papers were presented by Society members.

In 1950, before the establishment of the present series of International Speleological Congresses, the Society took a particularly active part in a World Convention of Speleologists at Monterrey, Mexico. The convention was attended by delegates from France, England, Spain, and Canada, as well as by many from Mexico and the United States.

In 1949 the Society became affiliated with the American Association for the Advancement of Science. Since 1950 it has conducted annual technical sessions in conjunction with the December national meeting of the Association. A noteworthy feature of the Society's participation in these meetings has been the presentation of several symposia on speleological topics, most of which were later published.

Conservation Activity

In the early days of the Society, no clear need was recognized for protecting the caves on which the life of the Society depends. Few people damaged caves wantonly, but some visitors were careless, and several hurtful practices were widely employed, such as that of marking arrows on the walls.

As the years went by, however, and damage began to accumulate in heavily traveled caves, it became apparent that the problem needed study. In 1949 William J. Stephenson proposed that a Conservation Committee be established in the Society. In succeeding years it became increasingly evident to the committee and to individual members, particularly in the western states, that the Society must assume a position of leadership in matters of cave conservation.

In 1960 the Conservation Committee wrote the present conservation policy of the Society, which was subsequently adopted by the Board of Governors. Since then, Victor A. Schmidt, as chairman of the committee, has worked vigorously to bring conservation consciousness to all who visit caves, and has led the Society to a prominent position in the conservation movement.

This energetic conservation program has brought the activities of the Society into good balance. As this program is now combined with encouragement of cave investigation and the publication of effective journals, the Society is better able than ever before to work toward the goal stated in its constitution: "to advance in any and all ways the study and science of speleology."

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ERRATUM

Volume 27, Number 4, October 1965

Semidiurnal movement along a bedrock joint in Wool Hollow Cave, California, by Stanley N. Davis and George W. Moore.

At both places on page 141 where the time 0458 is given, it should be 0358.