Chronology of Diving Activities and Underground Surveys in Devils Hole and Devils Hole Cave, Nye County, Nevada, 1950-86

By Ray J. Hoffman

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DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

COVER PHOTOGRAPH: Entrance to Devils Hole, March 15, 1988. Pool-surface altitude, about 2,360 feet above sea level (and about 50 feet below the general land surface). Boxes adjacent to pool contain electromechanical equipment that continuously records level of pool surface. Area of pool at surface, about 10 by 50 feet. At near end of pool is a slightly submerged shelf, about 10 by 20 feet in area, on which the Devils Hole pupfish feed and breed.

For additional information
write to:

U.S. Geological Survey
Room 227, Federal Building
705 North Plaza Street
Carson City, NV 89701

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ILLUSTRATIONS

CONVERSION FACTORS

"Inch-pound" units of measure used in this report may be converted to metric (International System) units by using the following factors:

Multiply	*By*	*To obtain*
Foot (ft)	0.3048	Meter (m)
Mile (mi)	1.609	Kilometer (km)

For temperature, degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) by using the formula °F = [(1.8)(°C)] + 32.

ALTITUDE DATUM

In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929), which is derived from a general adjustment of the first-order leveling networks of both the United States and Canada.

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ABSTRACT

A chronology of diving activities and underground surveys in Devils Hole and Devils Hole Cave, southern Nevada, is presented for 1950-86. The report acknowledges the efforts of past underwater explorers, scientists, and observers of the cavern system, and provides a historical perspective for comparison with present investigations at that site.

INTRODUCTION

Devils Hole is a planar fissure formed by faulting at the base of a carbonate-rock (limestone and dolomite) hill in Ash Meadows near the Amargosa Desert, Nye County, Nev. (figure 1). The site is an isolated 40-acre tract of Death Valley National Monument, about 30 miles east of the main monument area. The fissure intersects the ground-water table to form a pool of water with a surface area about 50 feet long and 10 feet wide, nearly 50 feet below the general land surface (Worts, 1963; Dudley and Larson, 1976). The pool is deceiving: to the casual observer above water, the pool may appear to be somewhat unremarkable and, depending on the viewpoint, relatively shallow. To the diver, however, the pool provides a warm (34 °C) and weightless entrance to a deep and dark labyrinth of subterranean chambers and narrow passageways. Some chambers are air filled and one is extensive (figure 2). The maximum depth of the water-filled fissure is unknown and perhaps unmeasurable.

The upper 80 feet of the pool (the main chamber) is the sole habitat of the endemic Devils Hole pupfish, *Cyprinodon diabolis*, an endangered species (figure 3). These small fish (maximum length about 1 inch) evolved from a Pleistocene-age ancestral stock. The adult female pupfish and the juvenile offspring are olive-drab along their back. The adult male, however, has a much darker color along its back and, at times, an iridescent sheen along its sides. The diet of the Devils Hole pupfish consists mainly of microscopic plants and small aquatic invertebrates that also inhabit Devils Hole (Minckley and Deacon, 1975). These unique pupfish typically spawn throughout the spring and summer months, with an apparent peak spawning activity in April and May (James, 1969; Chernoff, 1985). Interesting to watch, the pupfish are very active creatures. Seemingly always busy, they dart about with tail-wagging intensity, pecking at the substrate or chasing one another, then resting briefly, only to again dart about like playful puppies--hence their common name.

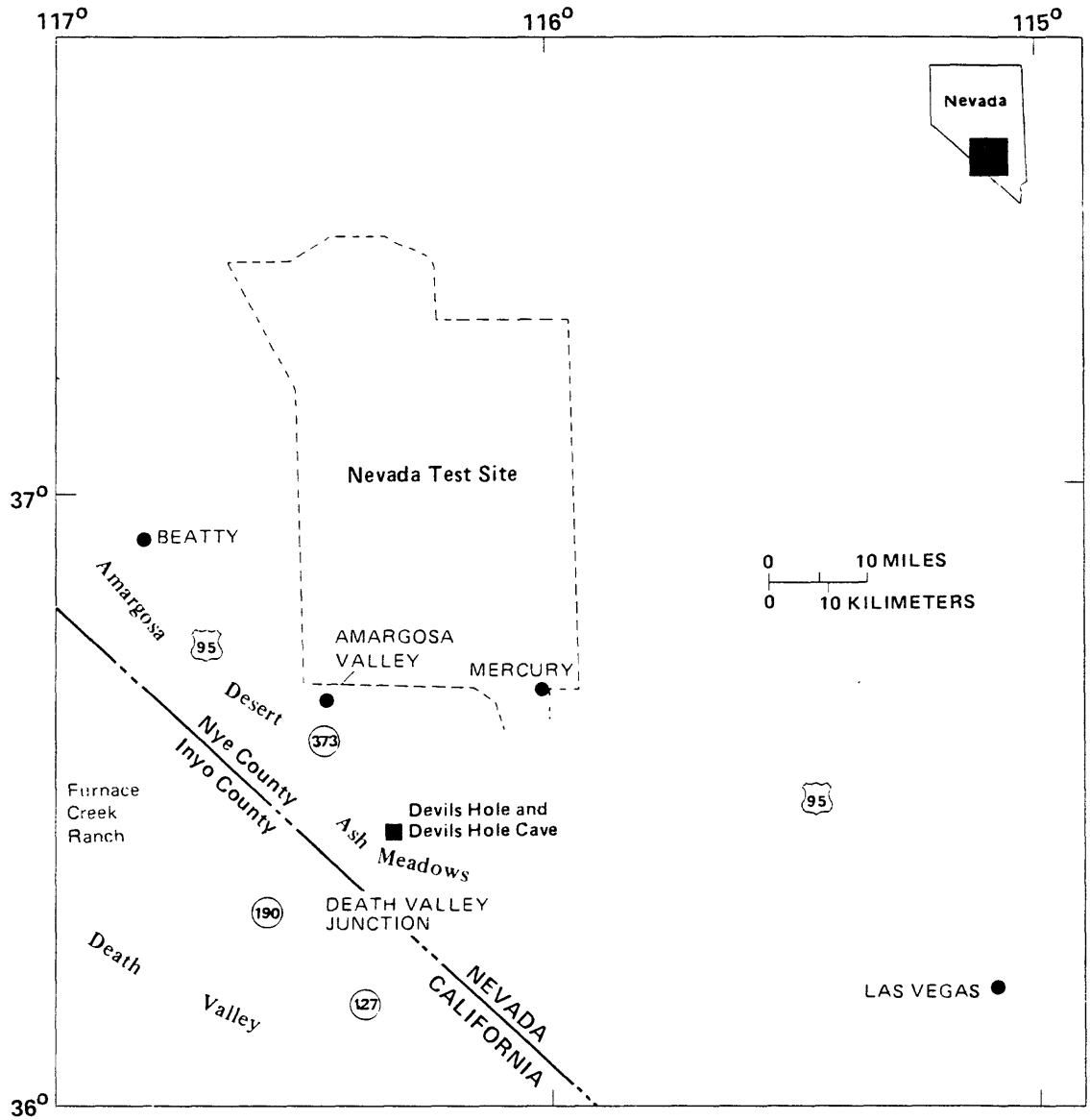

FIGURE 1.--Location of Devils Hole and Devils Hole Cave.

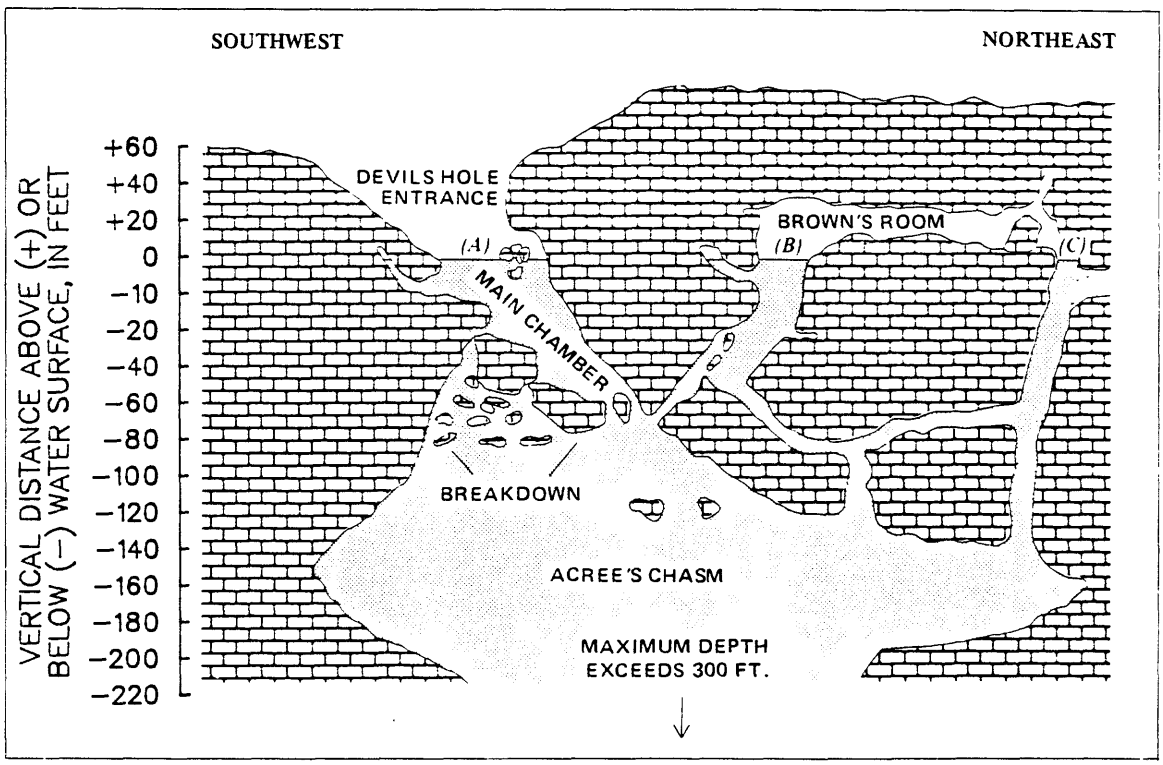

FIGURE 2.--Sketch showing underground features of Devils Hole cavern system above and below the water surface (modified from a drawing by William L. Acree, National Park Service, May 1973). *A*, pool at Devils Hole entrance; *B*, main pool in Brown's Room; *C*, Leinhaupel's pool. "Breakdown" refers to rock fragments that have fallen from the ceiling or wall of a cave (Halliday, 1959, p. 195); at Devils Hole, these have become wedged in the narrow fissure. Although the fissure is extensive vertically and in a northeast-to-southwest direction, its average width is less than 6 feet. Horizontal scale is approximately the same as that indicated for the vertical scale.

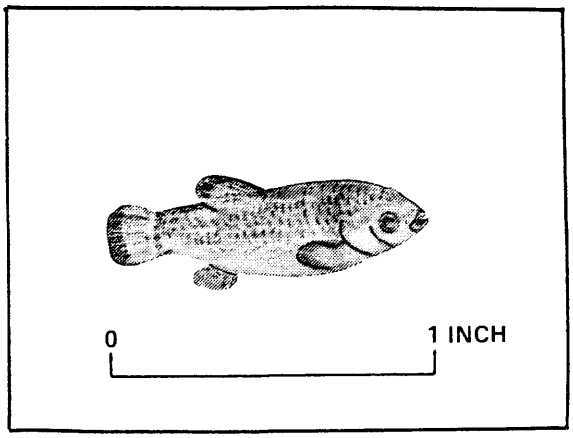

FIGURE 3.--Devils Hole pupfish *(Cyprinodon diabolis* **Wales).**

Devils Hole Cave is a nearly vertical hole about 600 feet northeast of Devils Hole. The hole is about 3 feet in diameter at the entrance, then widens abruptly to about 20 to 25 feet, and extends to a depth of about 130 feet. There it meets the water table, forming four crescent-shaped pools, and widening to over 50 feet. The physical shape of Devils Hole Cave resembles a tall boot (figure 4). The depths of the pools are unknown, but they may be extensive enough to connect to Devils Hole (William M. Brown, formally of the National Speleological Society, written communication, 1987).

The U.S. Geological Survey has collected water-resource data from Devils Hole intermittently from 1953 to 1962 and almost continuously since 1962. Most of these data are water-level measurements made as part of a ground-water monitoring program managed in cooperation with the National Park Service to assure the survival of the Devils Hole pupfish. In 1969, and coincident with increased irrigation pumpage in Ash Meadows, the water level in Devils Hole began a dramatic decline. The drop in water level threatened to expose the normally submerged shelf on which the pupfish feed and breed (see back of title page). Cessation of pumpage in the vicinity in 1973 apparently caused a reversal in the trend of declining water level. By 1986, the water level in Devils Hole had risen to near the pre-1969 level.

In late 1984, the Geological Survey began to collect other earth-science data from Devils Hole. A major goal of this new data-collection program is to estimate the isolation time of the Devils Hole pupfish by using uranium series dating and other techniques. Many of the scientific data that are needed in pursuit of this research endeavor can be obtained only by using self-contained underwater breathing apparatus (SCUBA). The underwater surveys indicate that Devils Hole is a unique natural laboratory that can be used to increase our knowledge of hydrogeology, paleoclimatology, geochemistry, microbial geochemistry, and evolutionary biology.

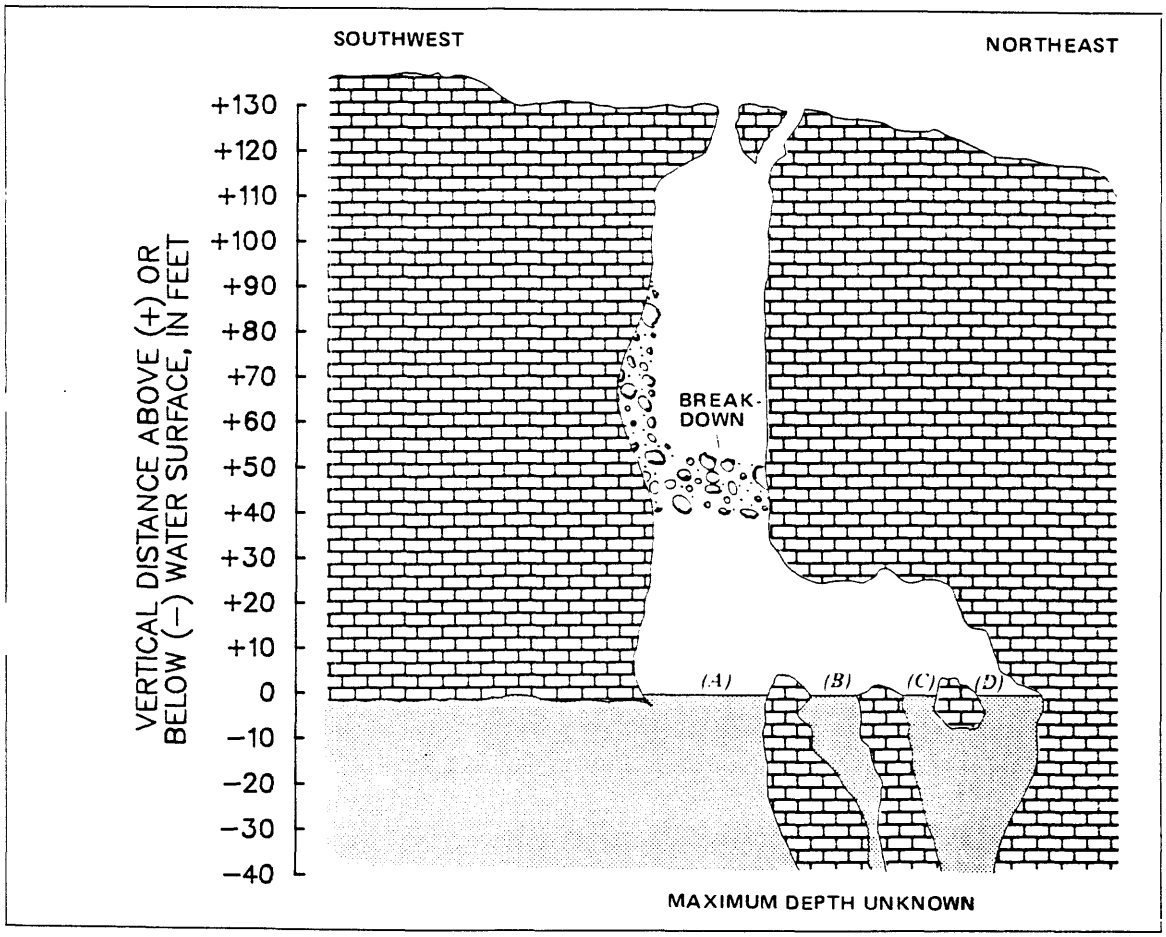

FIGURE 4.--Sketch showing underground features of Devils Hole Cave above and below water surface (modified from a drawing by William M. Brown, 1987). *A*, main pool; *B-D*, smaller pools northeast of main pool. Location of pools with respect to one another is approximate. Access to the main pool was gained by using an 80-foot steel-cable ladder attached at land surface, then crawling through the 2- to 3-foot-wide opening in the cemented breakdown at the 50-foot level, and finally "shuffling" down to the crescent-shaped pool (which is about 5 feet wide). Horizontal scale is approximately the same as that indicated for the vertical scale.

The purpose of this report is to document briefly the chronology of the dives and surveys made in Devils Hole and in nearby Devils Hole Cave. In doing so, the report also acknowledges the efforts of the pioneer divers who first explored and partially described the underwater cave system of Devils Hole. The purpose of their dives and selected details of their findings are given. Additional information on the Devils Hole system may be found in the references listed at the end of this report.

The cooperation and assistance of the National Park Service and the U.S. Fish and Wildlife Service is greatly appreciated in granting the Geological Survey permission to dive and to collect samples in Devils Hole for scientific research purposes. In particular, thanks are extended to Shirley A. Harding, Edwin L. Rothfuss, Peter G. Rowlands, Peter G. Sanchez, and Wayne W. Westphal of the National Park Service; and Donald W. Sada of the U.S. Fish and Wildlife Service for providing copies of old dive reports, and for their concern that the research activities did no harm to either the U.S. Geological Survey dive team or to the pupfish. James E. Deacon of the University of Nevada at Las Vegas also provided assistance by sharing his long-term observations, both above and below water, concerning the history of events in and about Devils Hole and the ecology of Devils Hole pupfish.

CHRONOLOGY OF DIVING ACTIVITIES AND UNDERGROUND SURVEYS

February 1950 — A preliminary survey of Devils Hole by Peter Neely, cave diver, William Halliday, cave explorer, and members of the National Speleological Society (NSS), set the stage for future underwater exploration of Devils Hole and Devils Hole Cave (Halliday, 1959, page 47-59).

June 1950 — A three-man team, led by Walter S. Chamberlin of the NSS, descended to 75 feet in Devils Hole using hard-hat diving equipment. However, the cumbersome, umbilical-like air hose prevented exploration of lateral passageways (Halliday, 1959, p. 52)[1].

August 1953 — The first recorded use of SCUBA in Devils Hole and the beginning of serious underwater explorations in the area was made by William Brown, Edward Simmons, and others of the NSS. The maximum depth reached during these dives was 150 feet. William Brown, wearing a single SCUBA tank, discovered the large, air-filled subterranean cavern now known as Brown's Room (figure 2). His stay in the newly discovered grotto, about 150 feet northeast of the Devils Hole entrance, was brief, and he continued to use his life-support system because of fear that the atmospheric gases were toxic.

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[1] All diving depths are measured in feet below water surface (the ground-water table). In Devils Hole and Devils Hole Cave, the water surface is about 50 and 130 feet, respectively, below the general land surface. Devils Hole at land surface is about 2,410 feet above sea level.

The next day, Frank Leinhaupel and Leroy Arnold of the NSS extensively explored Brown's Room. Monitoring each other closely soon after surfacing in the grotto, they determined that the trapped air was breathable. The air temperature in the subterranean chamber was measured at 33 °C, 1 °C cooler than the water.

During the August 1953 expedition, Devils Hole Cave was briefly explored by the NSS team (figure 4). Diving to a depth of 40 feet below the water surface (about 170 feet below land surface), the dive team encountered no obstruction that might prevent them from swimming to Devils Hole, but this was not actually accomplished (William M. Brown, National Speleological Society, written communication, 1953; Halliday, 1959).

November 1954 Six divers from the NSS spent 4 days exploring and collecting rock samples in Devils Hole. For added safety, guidelines were installed in various underwater passageways in the event of a diving-light failure. Telephone lines were also strung underwater between the entrance to Devils Hole and Brown's Room. At a depth of about 150 feet, Peter Neely, Richard Lawhorn, and Robert Lorenz swam laterally about 130 feet through a convoluted passageway in a northeasterly direction that led to Leinhaupel's Pool (at the north end of Brown's Room, figure 2). The divers saw an opening at the 120-foot depth and speculated that it might lead to Devils Hole Cave. A sketch map of the underwater system of Devils Hole was drawn, and an unofficial pupfish count (300) was made. Pupfish were reportedly seen at the 50-foot depth, and the following temperatures were recorded in the dive report (Peter M. Neely, National Speleological Society, written communication, 1955):

	Main chamber	Brown's Room
Air above water surface	--	33.2 °C
At water surface	31.7 °C	33.7 °C
6 feet below surface	33.9 °C	--
50 feet below surface	34.0 °C	--
98 feet below surface	34.0 °C	--

May 1960 — A team of eight divers from the NSS made a 4-day geological reconnaissance of the underwater system of Devils Hole. A maximum depth of 240 feet was reached by Ray Jerecke and Don May. A sample of air was collected from a pocket in the undersurface of the headwall about 10 feet deep in the pool in Brown's Room (but no analytical results are given in the dive report), and a sketch map of the Devils Hole system was drawn by Duane R. White (National Speleological Society, written communication, 1960).

February 1961 — Thirteen divers and one nondiver spent 4 days at the site to survey and map parts of Devils Hole and Devils Hole Cave (Don May, Southwestern Speleological Society, written communication, 1961). Underwater communications were established between Brown's Room and the Devils Hole entrance, but the 100-percent humidity in the subterranean chamber adversely affected the speakers and garbled the transmissions. Bob Autrey teamed with Don May, and Larry Reynolds teamed with Gary Sauls. They dove to 200 and 240 feet, respectively, in the fissure which they described as dipping 70 degrees, being curved, and about 20 feet wide, with an upper surface "clean, smooth, brownish white, with no deposition," and a lower surface "smooth, covered with fine sediment." Drift meters indicated no detectable water movement at 200 feet.

During the February 1961 survey, Devils Hole Cave also was explored. A series of west-trending grottos were visited by diving to a maximum depth of 70 feet. Physical measurements of this cave were not recorded in the team's field report.

April 1961 — Seven members of the NSS spent 2 days on a photographic mission of Devils Hole and its subterranean chambers. They estimated the pupfish population to be "a few hundred," and reported the following water temperatures: 4 feet, 34.0 °C; 25 feet, 34.3 °C; 60 feet, 34.2 °C; 90 feet, 34.3 °C (Southwestern Speleological Society, written communication, 1961).

January 1964 — James Houtz led three divers on a 3-day photographic survey of Devils Hole. According to Jacobs (1964), who wrote a magazine article about this trip, Houtz stated that he dove to a depth of 284 feet in Devils Hole the previous year. (Note: The author of the magazine article incorrectly reported that Devils Hole was formed by past volcanic activity.)

June 1965 — During a valiant, but vain effort to locate two missing divers (Paul Giancontieri, 19, and David Rose, 20) in Devils Hole, 44 searchers made numerous dives round-the-clock over a 3-day period. The divers were from the NSS, U.S. Navy, U.S. Air Force, and local agencies. For safety reasons, most of the search was at depths not exceeding 200 feet (McKinley, 1965a, 1965b, 1965c; Reible, 1965). However, in a last attempt to locate the missing divers, James Houtz reportedly descended to 315 feet (Reno Evening Gazette, 1965). With his underwater light, Houtz further reported that he could see an additional 30 to 40 feet below without seeing bottom. No trace of the missing divers was ever found. (In this same newspaper, Houtz is credited with stating that he had "made 28 trips to Devils Hole, more than 300 dives.")

August 1966 — Handwritten remarks on the results of a chemical analysis of a water sample state that the sample was collected "at the cavern a few hundred feet north of Devils Hole, Ash Meadows, Nev., by a skindiver 180 feet below the water surface" (Oliver S. Page, written communication, 1966). This remark suggests that the sample may have been collected from Devils Hole Cave, which implies that the diver was 310 feet below the immediate land surface. [Note: Although serious attempts were made to verify this feat, no further documentation could be found as of this writing (1988), nor the diver identified.]

April 1972 — The first official attempt at counting Devils Hole pupfish using SCUBA was made by William Acree and Howard Dimont, National Park Service, and Charles Osborn, U.S. Bureau of Sports Fisheries and Wildlife (now U.S. Fish and Wildlife Service). They counted 38 fish at depths from 10 to 70 feet. They also noted that the fish "were, without exception, judged to be entirely at ease, even curious, in the presence of divers." (Charles E. Osborn and William L. Acree, National Park Service, written communications, 1972.)

June 1972 — A 2-day field trip to examine the geological evidence of former fluctuations in the water level of Devils Hole was commissioned by the University of Nevada, Desert Research Institute. After examining the main chamber to a depth of 30 feet, the divers reported that they could find no obvious evidence of lower-than-present (1972) water levels (Mehringer and Haynes, 1972).

April 1972 to Sept. 1986	James Deacon and his students at the University of Nevada, Las Vegas, continued use of SCUBA for research into the life history of the Devils Hole pupfish. They made near-monthly pupfish counts for almost a decade. The population ranged from a minimum of 140 to 300 fish in the winter to a maximum of 200 to 600 fish in the summer (James E. Deacon and Thomas M. Baugh, University of Nevada, written communication, 1985). In addition, scientific studies by James Deacon and his colleagues, provided valuable information concerning the life history of certain desert pupfish, including *C. diabolis*, when increased pumpage in Ash Meadows in 1969 caused the water level in Devils Hole to dramatically decline, thus threatening the survival of the resident pupfish. Cessation of irrigation pumpage in 1973 of certain wells in the vicinity apparently caused a reversal in the trend in the declining water level. The maximum decline was about 2 feet.
December 1983	Hydrogeochemical investigations of Devils Hole were initiated by Isaac J. Winograd, Alan C. Riggs, and Ray J. Hoffman of the U.S. Geological Survey. Riggs and Hoffman made five reconnaissance dives to a maximum depth of 100 feet to collect samples of rock and water for chemical analysis.
November 1984	Alan Riggs and Ray Hoffman made 13 dives in Devils Hole to begin making a detailed map of the main chamber, to collect samples of travertine for chemical analysis, and to install artificial substrates (calcite crystals) in Acrees Chasm (figure 2) for a long-term geochemical experiment.
March and November 1985	The Geological Survey underwater work continued in Devils Hole. Riggs and Hoffman made 12 dives in March and 5 in November to collect samples of travertine, water, and algae for analysis; and to survey and map the underwater parts of the main chamber and the air-filled part of Brown's Room. Most of the underwater work was at depths ranging from 20 to 100 feet.
May 1986	On May 7, while gearing up to leave Brown's Room after completing some measurements, Riggs and Hoffman experienced the effect of a major earthquake. The two scientists were suddenly startled by low, moaning sounds in the naturally dark and normally silent chamber, followed by noises that mimicked the draining of a bathtub.

May 1986, *continued*

Their surprise was heightened by the action of the main pool in Brown's Room in that it began to drain! The water level would fall, then rise, and with dampening oscillations, cease; then again begin to fluctuate (maximum about 6 inches above and below the static water level). The fluctuations, decreasing in amplitude over time, continued for over an hour. In Devils Hole pool, this event caused numerous algal mats on the shallow shelf (less than 3 feet) to be flushed off and sink into the depths of the main chamber (figure 2). The epicenter of the earthquake, which measured 7.7 on the Richter scale, was nearly 3,000 miles from Devils Hole, near Atka Island in the Aleutian Islands.

EPILOGUE

The Geological Survey, with permission from the National Park Service, is planning to continue gathering earth-science data from the Devils Hole cavern system. For example, cores of vein calcite were collected 100 feet below the water surface in the summer of 1987, and this sampling will be continued. The underwater coring in 1987 provided a calcite sample of sufficient thickness to extend our present 300,000-year paleoclimate record in southern Nevada to perhaps 800,000 years (Isaac J. Winograd, U.S. Geological Survey, written communication, 1987).

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