AMCS
ACTIVITIES NEWSLETTER

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The AMCS Activities Newsletter is published by the Association for Mexican Cave Studies, a Project of the National Speleological Society. The AMCS is an informal, nonprofit group dedicated to the exploration, study, and conservation of the caves of Mexico.

The Activities Newsletter seeks articles and news items on all significant exploration and research activities in the caves of Mexico. The editor may be contacted at the address below or at editor@amcs-pubs.org. Text and graphics may be submitted on paper, or consult the editor for acceptable formats for electronic submission. Exceptional color photographs for the covers are also sought. They need not pertain to articles in the issue, but the original slide or negative must be available for professional scanning.

This issue was edited by Bill Mixon, with help from Katie Arens, Melonie Alspaugh, Don Broussard, Ramón Espinasa, Andy Grubbs, Jeff Horowitz, Denise Prendergast, and Laura Rosales.

All previous issue of the Activities Newsletter are available, as are various other publications on the caves of Mexico. Contact sales@amcs-pubs.org or write the address below.

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Front cover

The natural tunnel on the Río La Venta in Chiapas.
Photo by Ernie Garza.

Back cover

The Pit entrance in Sistema Dos Ojos, Quintana Roo.
Photo by Paul Heinerth.

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MEXICO NEWS

Compiled by Bill Mixon

CHIAPAS

Canadian Jean Pierre Paucherou and Mexican Victor Ballinas, both Red Cross workers, were rescued Tuesday, April 18, 2000, after spending 60 hours lost [more likely stranded] in **Cueva de El Chorreadero**. They were found cold and dehydrated by a team of forty-five rescue workers from the Red Cross and local police, who started searching for the men on Monday. The two had left on Saturday, telling friends to notify authorities if they did not return within 18 hours. Ballinas had himself helped rescue Mexican university students from the cave the year before. *Source:* The Canadian Press, April 20, 2000.

In January 1998, a group of U. S. and Italian cavers convened in the Cerro Blanco region of Chiapas. Within a few days, the Italians found the elusive connection between **Sistema Soconusco** and **Cueva de Aire Fresco**, making the entire system just over 21.7 kilometers long. (See also article on page 88 of *AMCS Activities Newsletter* 23.) The depth of the system is 513 meters; the previously published depth of 539 meters was incorrectly calculated.

Another cave, **Sima La Pedrada**, 2090 meters long and 348 meters deep, is potentially part of the system but has not yet been connected. Several other caves in the immediate area were mapped, for a total of 2611 meters surveyed during the trip. *Source:* Nancy Pistole in *Descent* 147, April 1999.

CHIHUAHUA

The mine at Naica has long been famous for the Cave of the Swords, a natural cavity intersected by the mine that contains large selenite crystals. In April 2000, miners intersected an even more spectacular cave, which has been walled off for its protection. The new Cave of the Crystals contains selenite crystals up to 7 meters long and a meter or more in diameter. Exploration and photography are difficult, because the temperature in the room is about 60° C (140° F) and the humidity is 100 percent. An article by Carlos Lazcano and spectacular photos by Richard Fisher appear in the June 2001 NSS News.

COAHUILA

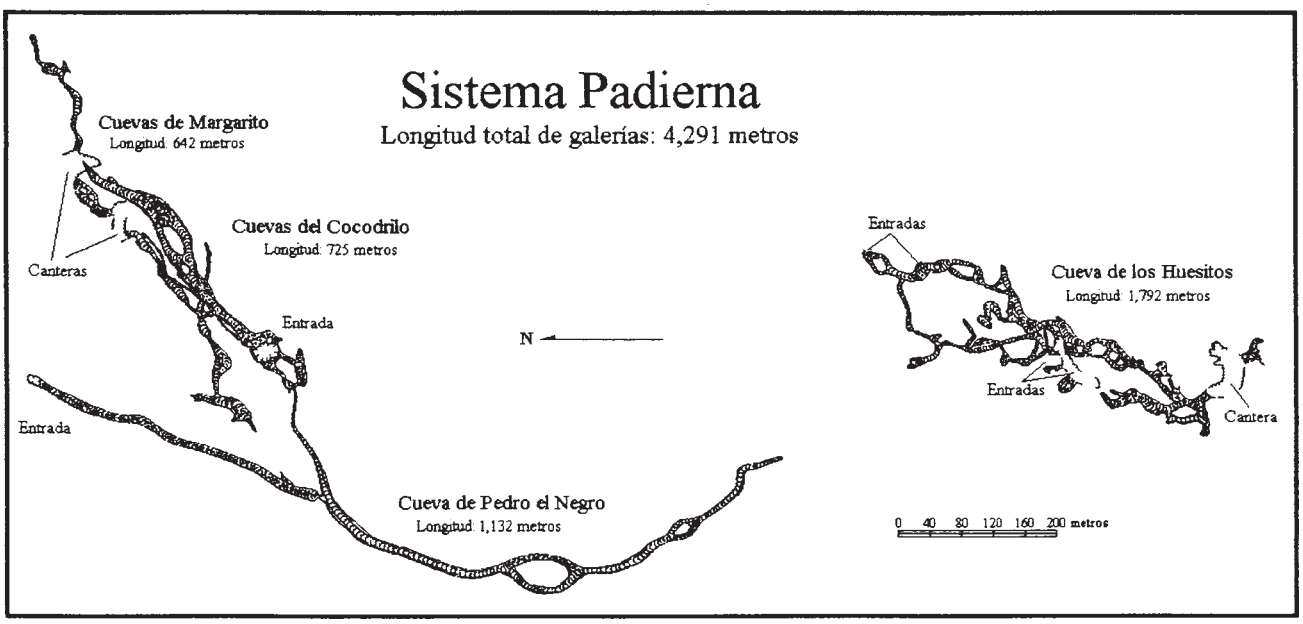
An area just west of Piedras Negras was checked out by Austin cavers in January 1998. The Rancho Tío Tacho comprises hills and canyons with many short caves that extend into the hills from the canyon walls. The entrance to one cave called **El Abra** was formed in a canyon bottom and led to a stream passage that was explored a short distance. A return trip in April 2001 pushed the cave to 750 meters length, and it was explored quite a bit farther. *Source:* Peter Sprouse.

Near San Antonio de las Alazanas, a blowing entrance had been found by Alejandro Rojas of the Monterrey Tec group. Monterrey, Victoria, and Texas cavers explored **Pozo Cuba** in September 2000, finding it to be a tectonic fissure 58 meters deep. *Source:* Peter Sprouse.

The "Black Hole of Coahuila," later known as **Pozo Chuzo**, was found south of Cuatro Cienegas from the air in 1999 by the Oztotl Flying Club. In January 2001 a trip set off to explore it. Austin and Monterrey cavers found it to be 20 meters in diameter, with a 50-meter drop to a large breakdown mound. A wind blew strongly up through the boulders on one side, but only 15 meters progress was made into this lead. A trip back in February got only a little bit farther in the dig. *Source:* Peter Sprouse.

DISTRITO FEDERAL

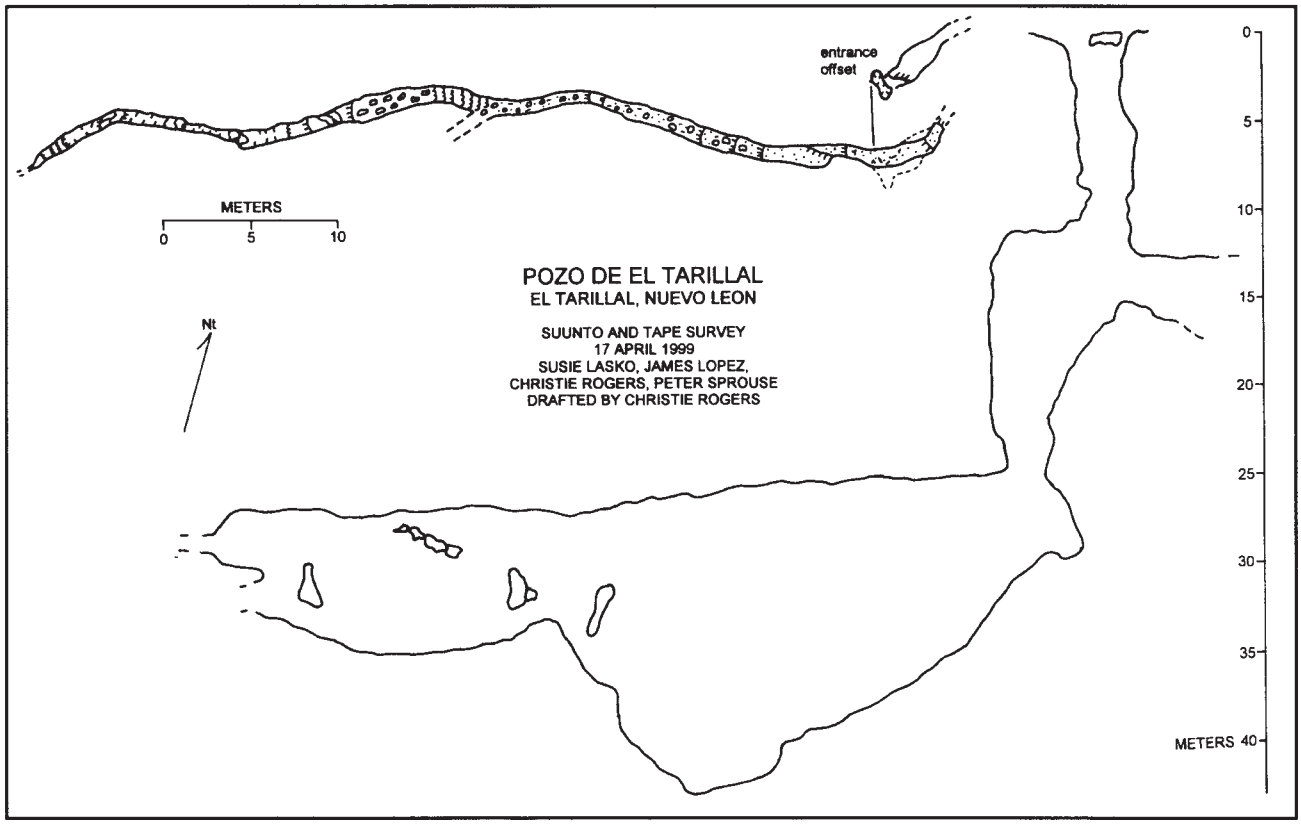
The **Padierna** lava-tube system, located at the Predio Los Encinos south of Mexico City, is in danger of being destroyed. This cave system, with more than 4 kilometers of tunnels, includes **Cueva de Huesitos**, which at 1.79 kilometers is the longest known cave in Distrito Federal. The Los Encinos lot is private property, but as a "green area" it is managed by the Secretaria de Desarrollo Urbano y Vivienda (SEDUVI). It is the only stretch of the Xitle lava field, the famous Pedregal, that has not yet been destroyed by urbanization. Although studies made by Consejo de Recursos Naturales del DF show the ecological importance of the area, including the presence of several endemic or threatened species of plants and animals, SEDUVI has given permission to Grupo Frisa to begin construction of a housing project in the area. This will not only destroy the only remaining area of Pedregal's ecosystem, but also, in addition to Huesitos, the caves **Pedro el Negro** (1.13 kilometers long), **Cocodrilo** (725 meters), and **Margarito** (642 meters). The primary volcanic structures inside these tubes are of geological interest. In order to preserve this area and its caves, a protected area status should be given to it. Current information can be obtained from Ramón Espinasa at ramone@igeofcu.unam.mx. *Source:* Ramón Espinasa.

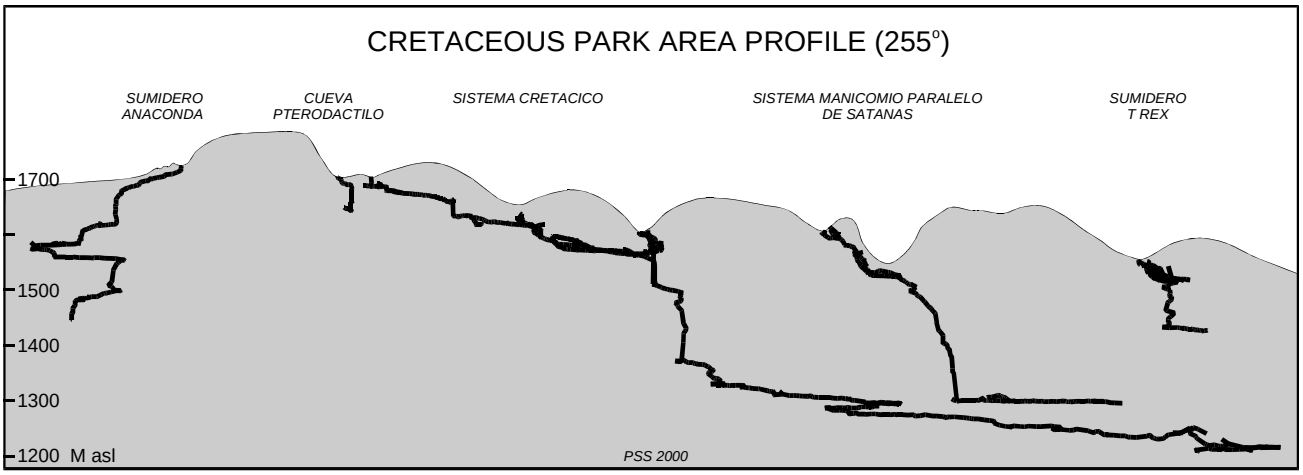


In December 2000, Ramón Espinasa, Taco van Ieperen, and others found a lava tube at the base of Volcán Pelado, south of Mexico City. Although the cave was only about 70 meters in length, at 3455 meters elevation it became the highest mapped cave in Mexico. They may find even higher caves at the base of Tlaloc volcano. *Source:* Ramón Espinasa.

GUERRRERO

The weekend of May 26, 2001, there was a serious accident in **Cueva de la Joya**, a multi-drop stream cave near Cacahuamilpa, Guerrero. A member of Asociación de Excursionismo del Instituto Politécnico Nacional (AEIPN) apparently lost control of his rappel part way down the last pitch and fell for about 20 meters, breaking his ankle and bruising his pelvis and chest. At the time, his pelvis was thought to be broken. Twelve hours after the accident, the first rescuers, cavers from UNAM and URION, reached the victim, and with the help of cavers from SMES, Draco, Cruz Roja, and other groups he was brought to the out in a 24-hour effort and taken to a hospital





in Mexico City. *Source:* Ramón Espinasa.

NUEVO LEÓN

I had heard about a pit high in the mountains east of Saltillo from Francisco Camargo, a Monterrey caver who had found the entrance but not gone down. We decided to set up a date to meet and explore the pit. So on the weekend of April 16, 1999, Susie Lasko, James Lopez, Christie Rogers, and I headed south from Laredo. At Arteaga we turned east up Cañón Carbonera and followed it up to the high pass called Puerto el Tarillal, where we camped for the night in near-freezing temperatures.

There was no sign of Francisco in the morning, so we decided to drive on up to the top of the ridge south of the pass and try to find the cave. We had been given a description of where the pit is, and after making guesses at several intersections, we reached to top of the ridge. The road got steep at one point, but not too rough. At the end of the road, we went off in the described direction and quickly found a pit that matched the description. **Pozo de El Tarillal** has a small entrance partly covered by a boulder. The Sierra Rancho Nuevo is only about 500 meters wide at this point and covered with sparse pines and agaves. The view off the south edge of the mountain was spectacular, since we were at around 3150 meters elevation.

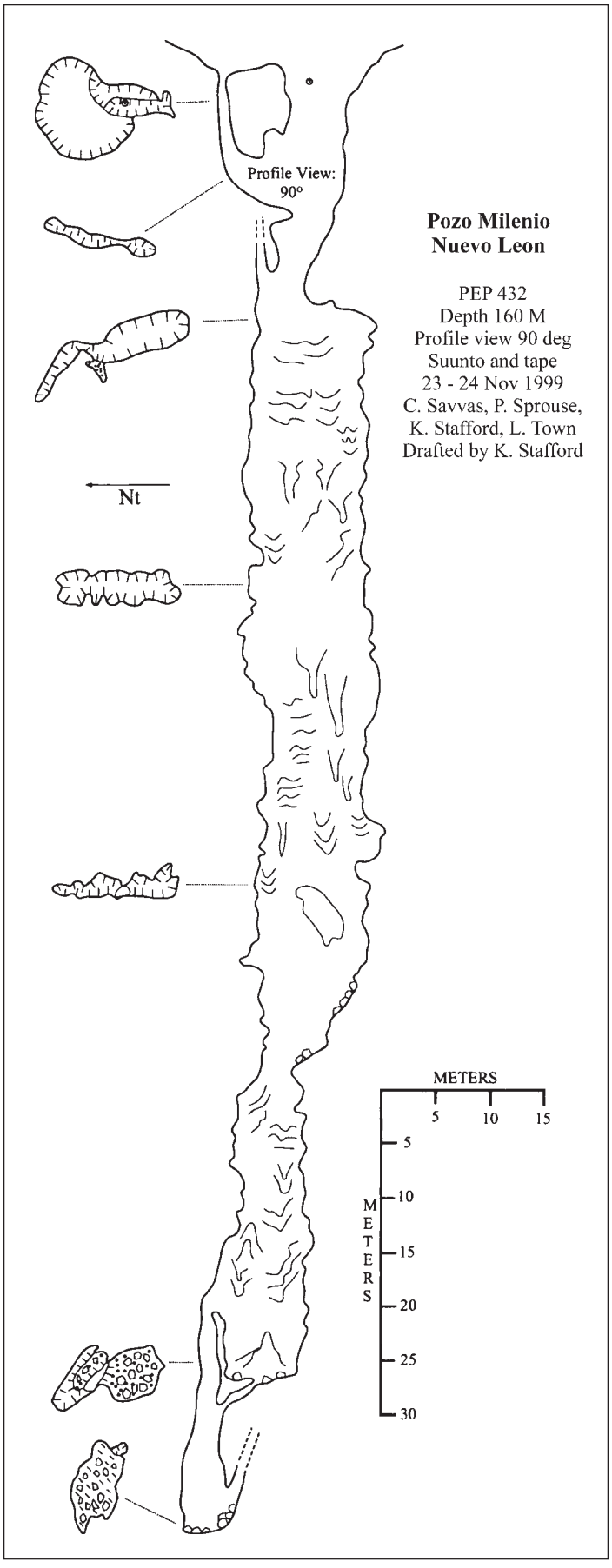
We were able to find some nice anchors to rig a free-hang. A 15-meter drop got us into a dirt-floored rift going two directions. To the east, it went up to a formation choke, while to the west it dropped down a steep dirt slope. I rigged this while Susie helped Christie with her first sketching experience. At the base of the slope was a short, narrow drop to a ledge, with a final drop down into a high canyon. A few more climb-downs got me to the bottom, a tiny drain. But I could see passage continuing above this, so I returned to the others to guide the survey along. We mapped up the climb into the continuing passage. At times we were chimneying along with no floor under us, and the passage finally ended at a formation choke. I believe this cave is essentially a tectonic rift, formed along a crack caused by a block that is beginning to fall off the mountain. *Source:* Peter Sprouse in *Texas Caver,* November 1999.

Cavers of the Proyecto Espeleológico Purificación checked a new area southeast of Zaragoza in November 1999. A shale contact at Santa Marta produced a nice line of pits, including **Pozo Milenio**, 160 meters deep, and **Pozo de las Pantaletas**, 140 meters.

In December 1999 the PEP had its much-anticipated return to the Cretaceous Park area. **Sumidero Suchomimus** was connected to **Pozo Plesosaurio** to form **Sistema Cretácico**, 465 meters deep. Leads remained in the lower part of the cave. **Sistema Manicomio Paralelo de Satanas** (also known as Pink Socks), was bottomed at 321 meters deep, 1562 meters long. **Sumidero Tiranosaurio Rex** got too tight at a depth of 127 meters, but mapping of upper level passages did get the length to 1112 meters. A follow-up trip in March 2000 mopped up previously explored passage and side leads in the bottom of Sistema Cretácico, making it 5908 meters long. Five cavers made a canyoning descent of Infierno Canyon in March 2001, entering at El Niño and exiting at Los Angeles eight days later. They found a wet-weather resurgence cave below Cretaceous Park that sloped 100 meters down to a sump.

To the west, some caves were checked out around La Encantada in June and July 2000 by Troy Lanier, Peter Sprouse, Kevin Stafford, and Cathy Winfrey, but nothing very large was found. Another trip in July concentrated on the Cerro el Viejo area, where a pit was found at 3440 meters elevation just below El Viejo's summit. **Sima el Viejo** was 70 meters deep. Leads at the bottom of **Pozo Primero de Septiembre** and **Cueva de Más Cable** were checked with no further progress, but mapping **Pozo Después de Cenar** did leave a promising dig. *Sources:* Peter Sprouse, *Death Coral Caver* 10, 2000.

On the southern edge of Monterrey, Troy Lanier and Peter Sprouse joined the Monterrey Tec cavers to survey **Cueva San Francisco de Asis** in July 2000. Located in Chipinque park, this is a partially mined cave that intersects a large vertical chamber. It is 126 meters deep. *Source:* Peter Sprouse.


Profile View:
90°
Pozo Milenio
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C. Savvas, P. Sprouse,
K. Stafford, L. Town
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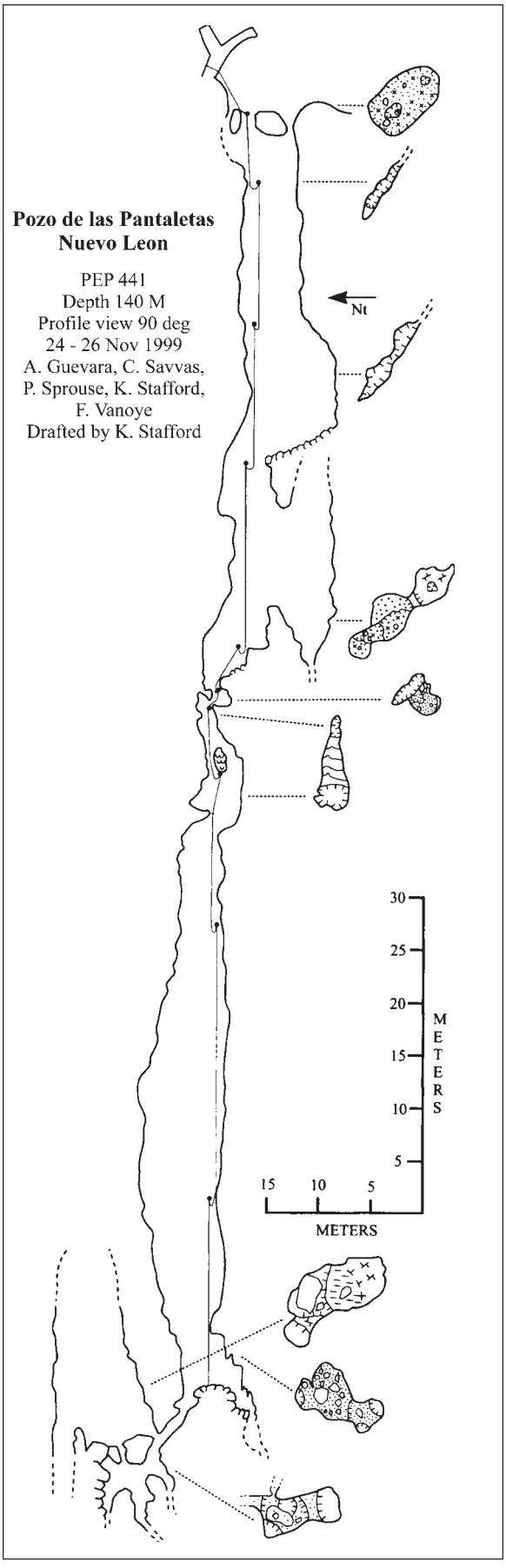
Pozo de las Pantaletas
Nuevo Leon
PEP 441
Depth 140 M
Profile view 90 deg
24 - 26 Nov 1999
A. Guevara, C. Savvas,
P. Sprouse, K. Stafford,
F. Vanoye
Drafted by K. Stafford
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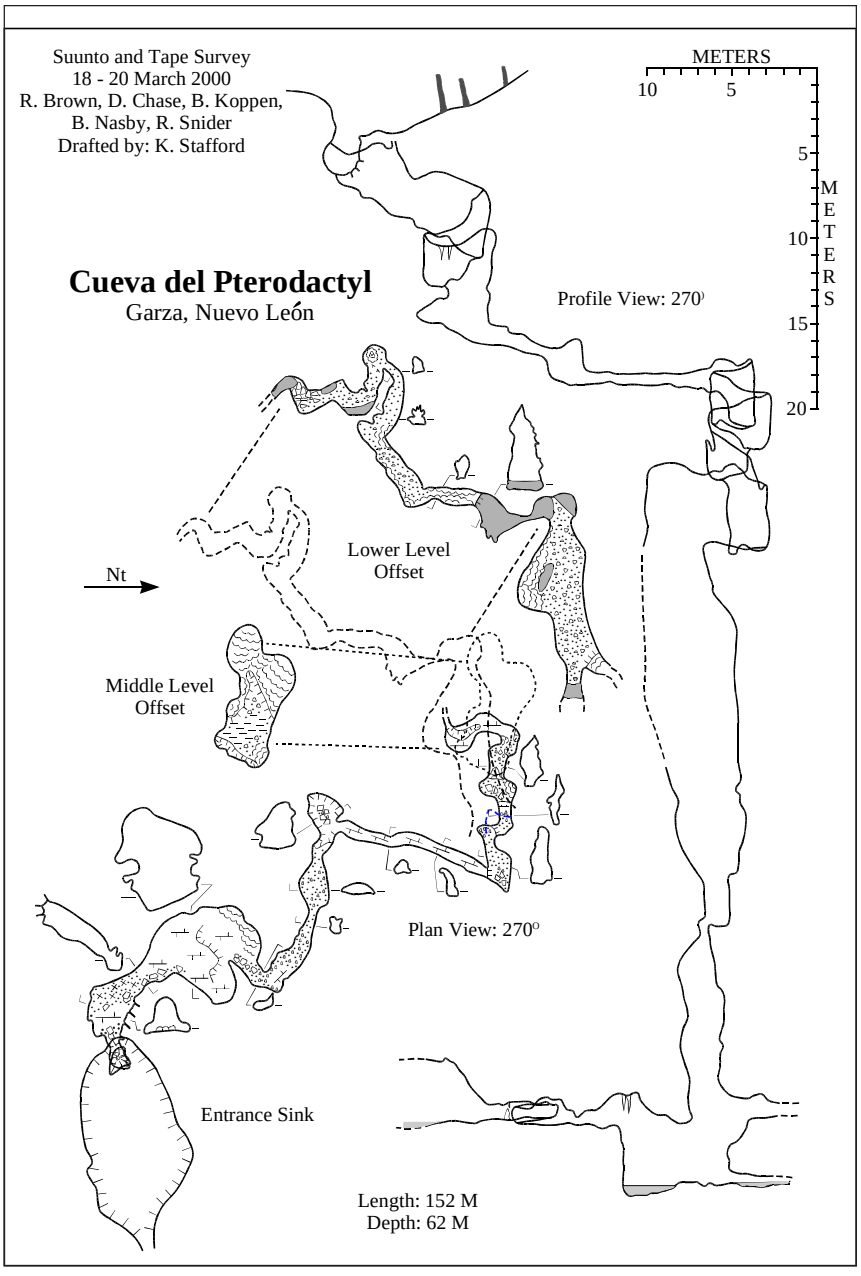
OAXACA

During the first phase of the U. S. Deep Caving Team's spring 2001 project in Mexico, four Americans, two Mexicans, two Poles, one Brit, and one Canadian were based in the village of San Agustín Zaragoza, near the main entrance to **Sistema Huautla**, the deepest cave in Mexico. The goal was to push harder in some of the other caves in the area in an attempt to find a route downward that might enter the Huautla system beyond Sump 9 (see *AMCS Activities Newsletter* 21). The main focus was **Cueva de San Agustín**, where two camps were set at the bottom at –465 meters in a chamber 200 meters long, 30 meters wide, and up to 115 meters high. Water enters the room through several waterfalls, and attempts at digging to follow it downward through the breakdown were unsuccessful. Extensive bolt-climbing was done to reach black holes in the ceiling. One climb to the waterfall in Sala Doble Dome involved six pitches to horizontal passage. A total of 150 meters in height was gained in this route, which was rigged with nearly 500 meters of rope, but it connected back into known cave.

During a camp at the –350-meter level in **Sótano del Río Iglesia**, cavers tried to follow the large river down through the floor of the Penthouse chamber, but water levels were too high to pursue a dig there. Another dig, to remove silt that had washed into a passage explored only once, back in 1967, was successful, but before a team could return with tackle for the reopened passage, heavy rains has caused it to sump shut. The river in Río Iglesia reappears in Sistema Huautla just above Sump 9, so further efforts in this cave are needed.

Some effort was also expended in the San Miguel doline, in **Sótano del Cangrejo** and **Cueva Inclinada**, both of which presently end at depths of about 125 meters, where the water disappears into impassible cracks. At the bottom of Inclinada, two long aid-climbs were done, but the leads did not continue and did not carry air. The strong air flow in the cave apparently disappears higher up somewhere. *Sources:* Bev Shade, Bill Stone, and Andy Zellner.

We spent two and a half weeks at **Cueva Charco** in March 2001, based in two small houses near the entrance. The group consisted of eleven members, five Americans, four Mexicans, and two Brits. At the beginning of the trip, the crew seemed plagued with injuries. However, six relatively healthy cavers made it to the underground camp, after the requisite gear-hauling trips. The cave is too narrow in many places for a full-size camp duff, so gear is shuttled in. The same camp spot as last year was used, from which it was over 1.5 kilometers to the previous end of survey. There are no flat, dry places in the cave, so moving camp was not possible. Unfortunately, that meant long survey trips from camp, typically twenty hours or more. More minor injuries occurred, and PVC suits and packs were shredded. The cavers stayed underground for five days and surveyed 661 meters, adding 124 meters to



Map from *Death Coral Caver* 10.

the depth The nature of the cave does not change at all: tall, narrow stream passage with many wet squeezes in rotten rock, consistently heading north and downward. It is not getting any bigger or easier, but it does continue. This means we will be back.

When the underground campers were leaving the cave, they were in for a surprise. It had been raining for a couple of days, and, although the water level had only started to change in the stream crawls at –300 meters, several low crawls near the entrance had filled with water and sumped. The cavers spent hours scooping out the cold water using empty packs. They knew they were close to the entrance, because the water was full of maggots that had washing in from a dead cow at the bottom of the entrance pit. Once they had bailed enough to create adequate airspace, they pushed their way through the maggots to the surface.

Meanwhile, the surface crew surveyed more passage near the entrance to Charco, adding length and depth. From our preliminary calculations, Charco is now 5.29 kilometers long and 1166 meters deep.

Several other pits and caves were located and surveyed. Although none of them continued, they are a reminder that there is still a lot of area to be checked for new caves.

Thanks to our sponsors this year: the Dogwood City Grotto, the National Speleological Society, Gonzo Guano Gear, and Cancord Rope. *Source:* Nancy Pistole.

Following the work in San Agustín, the Deep Caving Team moved into the Santo Domingo Canyon, where the resurgences to both Sistema Cheve and Sistema Huautla are located. At **Cueva del Mano** (see *AMCS Activities Newsletter* 20), on the Cheve side of the river, bolting in a complex labyrinth of domes gained 125 meters in elevation, but finished off all the leads. Diving in the southern Mano sump penetrated 430 meters to where all leads were blocked by underwater collapses.

The big news is that the **Huautla resurgence** sump was cracked. (See the article on the Río Tuerto expedition in *AMCS Activities Newsletter* 22.) Using Cis-Lunar MK5 rebreathers, diver found that the passage rose to air at a penetration of 1250 meters. Because the maximum depth of the dive is 65 meters, forty minutes decompression is required just to reach the surface here, and there is no easy way out of the water into the 8-by-5-meter tunnel with stal that takes off from the inner end of the sump. A round-trip to the lead is a five-and-a-half-hour dive. It will take a dedicated expedition to establish a base beyond the sump and push the lead. *Source:* Bill Stone.

PUEBLA

In February 1997, the Groupe Spéléo Alpin Belge again visited the area in Puebla that is has been exploring since 1982 (see *AMCS Activities Newsletter* 16, page 51, and "Mexico News" in *AMCS Activities Newsletter*s 18 and 23). With a small team and little time, the objective was to continue exploration of the **Atlixicaya** system, originally discovered in 1982 and explored to just over 11 kilometers during 1985, 1989, and 1995. This enormous cave has the second-largest resurgence in the mountain range and drains an area with elevations up to 3000 meters. Continuous rain storms thwarted the original plans, and the first team to enter the cave narrowly avoided being trapped behind a kilometer of flooded cave at 50 meters depth. While waiting for the water to recede, smaller caves were explored, including **OZ 5–6** and **OZ 7**, for a total of 2.5 kilometers, and a fossil resurgence of the **Xantilco** that gave 400 meters of new cave. They prospected in the dense and undulating forest above the Atlixicaya system, but did not find any higher entrances. When water levels finally permitted visits to Atlixicaya, they did some dye-tracing in the lower section and explored 800 meters of passage in the middle section. Time did not allow safe exploration of the upper section.

They then made a few trips into **OZ 21**, pushing it to 2.5 kilometers in length and 280 meters depth. Near the end of the expedition, they finally succeeded in reaching their objective at the end of the main passage in Atlixicaya, where the previous limit of exploration, a enormous breakdown slope of large boulders, was bypassed. Beyond that point, they found a continuation in a large, beautiful passage, over which lay another huge fossil level, all with lots of air flow.

Altogether, participants Fernand De Cock, Serge Delaby, Stépahne Nicolas, Vincent Remy, Sophie Verheyden, Richard Grebeude, David Gueulette, and Nathalie Strappazon got a total of 6 kilometers of new cave. *Source:* Richard Grebeude and Serge Delaby in *Regards* 28, 1997, translated by Melanie Alspaugh.

On the first day of our Cuetzalan 2000 recce, we visited the Río Zempoala gorge with three Mexican students. We went upstream for a few kilometers and found a resurgence cave on the west bank. This was entered for a short distance and is worth further investigation. We then took the time to learn how the *colectivo* system works, which subsequently cut out 12 kilometers or so of unnecessary walking each day.

Our first objective was to visit the entrance of **Alpazat** and take a GPS reading. We met a very friendly Nahuatl family who fed us and showed us a number of other entrances in the area, one of which is worth another visit. We then concentrated for a number of days on looking for entrances in areas that may contain caves that would provide better and safer routes into the ends of the major systems in the area. We used a Nahuatl caver named Jimmy who had been a member of the CSCA 1994 expedition (see "Mexico News," *AMCS Activities Newsletter* 21) to help with translations, although my Spanish is now quite reasonable. We found several cave entrances, many of which were in riverbeds and only accessible because water levels were exceptionally low. The most productive area was from Tonalix to Xaltipan. Although nothing particularly exciting was found, two of the entrances are worth a second

visit, and a third, which we did not see, sounded interesting.

Our attention was diverted to the far side of the Zempoala after a discussion with Mike Boon in Francisco's Bar convinced us that the area had not been looked at by the Americans. We first went to San Miguel via a tortuous route of about 60 kilometers, requiring an overnight stay in Zapotitlan. While on the final approach to the town, I mentioned to a local Totoneca Indian that we were looking for caves. "Ah, caves," he said, "We have caves over there and caves over there, many caves." This put a fresh spring in our steps, and shortly afterward we found our first group of major entrances. After this success, I decided that it was time to go and ask the *presidente* if we could look for caves. After queuing for a while, we were ushered into an office full of people. It was easy to tell which one was the *presidente*; he was the one with a huge pile of $200 notes in front of him. Nice chap, interested in our activities, he offered to send two teenagers with us to show us some entrances. Off we went, assuming we would just be shown the ones we had already found. First we were shown our big entrance, but then they took us to yet another stream sink. This area has excellent potential for a 10-plus-kilometer cave.

Our final objective was to find the main resurgence. This we did on our penultimate day. It was about 1.5 cubic meters per second coming from small gaps between boulders on the south bank of the Río Zempoala. Our last day was spent looking in another area to the northwest, on the far side of the Zempoala. We *colectivo*ed to a town called Huehyetla and had a general look around. This area did not have any significant entrances and is of relatively little interest. We were, however, told of a resurgence cave in the Teuhancate gorge. *Source:* J. M. Sims in *International Caver 2000*.

QUERÉTARO

Sótano de Los Hernández, in the San Joaquin area, was reported to have been completely mapped some 20 years ago by Roy Jameson and Patty Mothes. But cavers from the UNAM and Politécnico groups had been visiting the cave, saying that it went deeper than the old 330-meter depth. Victor Chávez and Ramón Espinasa of SMES went to check this out in April 2001 and found the old survey to be accurate, but they found the sump at the bottom dry. A tight squeeze and a series of nine new, virgin drops led to an horizontal passage with a stream, which was followed for about 600 meters in horizontal length to a sump at 507 meters depth. Several upstream leads were not pushed or mapped, and the main stream was followed upstream (no survey) for about 300 meters to a large chamber with a climbing lead at the end. *Source:* Ramón Espinasa.

QUINTANA ROO

We've always known where the water was going. The difficult part comes in trying to prove it. Finally, some inland systems have been connected to the Caribbean Sea by diving: November 7, 1995, **Nohoch Nah Chich** (length 60985 meters), by Chuck Stevens and Eric Knofftal; June 19, 1998, **Dos Pies** (length 3516 meters), by Fred Devos; July 12, 1998, **El Punto** (length 1216 meters), by Fred Devos; and March 13, 1999, **Ox Bel Ha** (length 70650 meters), by Christophe LeMaillot, Bernd Birnbach, and Daniel Riordan. Two additional connections from Ox Bel Ha to the sea have been found since. *Source:* Fred Devos.

The Carbonate Processes and Palaeoenvironments Research Group at the University of Bristol is undertaking an exciting multidisciplinary research program in the underwater cave systems of the Caribbean coast of the Yucatan Peninsula during 2000–2002. To date, over three hundred kilometers of submerged passage in the area have been cataloged by the Quintana Roo Speleological Survey, including such notable systems as Nohoch Nah Chich, 61 kilometers, Dos Ojos, 56 kilometers, and Ox Bel Ha. The latter, with over 70.6 kilometers of mapped passage, is now the longest known underwater cave system in the world. In the past, scientific investigations in the Yucatan caves have focused on the biology and taxonomy of cave fauna such as remipedes and blind fish or on geochemical or hydrological work in open cenotes, which are not representative of groundwater conditions. We are undertaking linked investigations of the hydrology, geochemistry, geology, geomorphology, and geomicrobiology of the cave systems and associated limestone aquifer, using cave diving for sampling and installation of monitoring equipment. We hope to advance the conceptual model of the whole aquifer system, provide a quantitative understanding of the processes present, and determine the time and space scale over which these processes operate.

Almost all precipitation rapidly infiltrates the porous limestone and forms a relatively thin layer of fresh water that overlies deeper saline water. The divide between the fresh potable water and the salt water is called the halocline, and its structure and position are of particular interest. The halocline is implicated in important geologic processes, such as carbonate dissolution and dolomitization, both of which may also be mediated by bacterial processes.

The halocline may be less than 10 centimeters thick, forming a sharp boundary between the water bodies. Towards the coast, there is progressive mixing of fresh and saline water, so that the mixing zone may span several meters. By the time the cave water discharges at coastal springs, it is typically brackish. To compensate for the saline water flowing out of the aquifer, there is a deep inland flow of saline water from the coast to the interior of the peninsula. The behavior of the deep circulation pattern is one focus of our studies. Previous geochemical studies have shown that the mixing of fresh and saline water occurring within the aquifer drives dissolution of the limestone bedrock. This is probably the most important process of cave development, although our studies suggest that bacterially mediated processes may be important, and this topic is being studied further.

The Caribbean Yucatan caves are unlike either the branching systems typically found in continental areas or the sponge-like chambers explored in small carbonate islands such as San Salvador in the Bahamas. Instead, they comprise large-scale anastomosing networks of passages, some of which are very large, trending inland for over 10 kilometers from the coast and generally at shallow depth, less than 20 meters below the present water table. The carbonate sequences of the Yucatan platform, which are generally more than two kilometers thick, formed in many stages, with progressively younger rocks deposited on the outside fringe. Caves immediately behind the coast are developed in young limestone deposited during the last interglacial period, when the sea level was high some 117–130 thousand years ago. However, multiple generations of cave development are found below and behind this young fringe in the older rocks. This is the opposite sequence to the usual continental setting, where older passages are abandoned at higher levels as the rivers cut down through carbonate sequences. Unraveling the phases of cave development is a major challenge, complicated by the fact that sea levels have frequently fallen as much as 120 meters below present levels during glacial periods. At these times, the shallow caves were air-filled, and this is when the impressive cave decorations in these underwater caves were deposited. Dating of speleothems deposited during these periods of low sea level allows recognition of the stages of cave development, as well as yielding critical information on low sea levels that cannot readily be obtained from other sources.

We are conducting long-term monitoring of fresh and saline groundwater circulation to understand the dynamic behavior of the system in response to seasonal changes, rare events such as tropical storms, and semi-diurnal tides. To better understand the relationship between the host limestone and the caves, we are using dye tracing from drilled holes to link the groundwater flow through the host limestone rock matrix to the cave systems. Major-ion and stable-isotope chemistry is being used to establish a regional water-chemistry database against which future changes may be evaluated. To evaluate the extent to which geochemical processes such as dolomitization are mediated by naturally occurring bacteria, we are culturing them in multiple growth media. We are studying the cave systems' geomorphology in relation to their history of development and past sea levels. This last aspect of investigation will provide better understanding of the timing of the collapses that are pervasive in some systems, the lithological and structural control of the passages, and the presence of dissolution notches that represent present and past positions of the halocline and therefore give information about past sea levels.

We hope that the results of these investigations will not only provide a better understanding of the role and importance of the caves, but may guide the development of sustainable potable water and waste disposal management in the area. Currently the Caribbean coast of the Yucatan, the Riviera Maya, is a major tourist destination based around Cancún and is a prominent source of foreign currency for Mexico. The aquifer is the sole source of potable water in the peninsula, and yet it is also used to dispose of sewage effluent via "deep" wells, often drilled to about 60 meters per Mexican government guidelines. This practice is based on the misconception that pollutants will be filtered by slow groundwater flow through small pores in the rock. Unfortunately, as is often the case in karst environments, the groundwater flow is predominantly through the caves at velocities on the order of kilometers per day. The low residence time makes it unlikely that breakdown of the effluent has time to occur. The pristine nature of the cave environment and its unique endemic fauna are thus at great risk. Furthermore, the groundwater discharges from the cave systems via numerous coastal springs and *caletas* and may thus deliver contaminants and excess nutrients to the Meso-American Barrier Reef System, which is the second longest barrier reef system in the world.

We will have a major cave-diving science expedition for two months in summer 2001, with a multidisciplinary team including two scientists from Mexico. We also benefit from the support of many of the cave divers who have explored and surveyed these underwater systems. This trip will supplement long-term monitoring of the cave hydrology using meters that were deployed in 2000. We hope that the

Rebecca Jones on the Fossil Room Drop in Resumidero El Borbollón, San Luis Potosí. *Dave Bunnell.*

knowledge gained will prove useful to the local government agencies with whom we are cooperating and enable them to prevent deterioration of these precious cave systems despite the growing development stress to the aquifer. *Source:* Patricia Beddows.

On Monday, February 26, 2001, Ronald Fraga, a certified cave diver with 125 logged dives, drowned in **Cenote Mayan Blue** (**Cenote Escondido**), part of **Sistema Naranjal**. Ron and his wife had completed a cave dive, touring the A Tunnel gold line and the passage known as the Death Arrow Passage. (See the map elsewhere in this issue.) After that dive, Ron decided to do a second dive, solo, using a fresh set of aluminum 80s. He told his wife that he would dive the A Tunnel, following the line until he reached his air turn-around point. Ron began his dive at 2:18 P.M. After two hours, Nancy Fraga became concerned and drove to Tulúm to ask for help.

Gunnar Wagner, Robbie Schnittmer, Connie LoRe, and Steve Gerrard entered the cave at about 6:00 P.M. for a search and recovery. Following the gold line in the A Tunnel, they noted that the water was abnormally cloudy, but this was not unexpected, since there had been several groups of divers in the tunnel that morning. About 340 meters in, the cloudiness was more distinct. High in a shallow area, Schnittmer spotted Fraga lying face down on top of a white off-shoot line, facing toward the main gold line, which was about 21 meters away. Ron was found with mask in place, regulator out of his mouth, and tanks empty. His safety reel was tangled in the line. There were no signs of struggle, the water at the site was crystal clear, and all his equipment was later found to be working properly. The recovery was completed by 8:00 P.M.

No one is exactly sure what happened. The accident report cites lack of a continuous guideline, since Ron had not installed a temporary line from the gold line to either end of the offshoot line where he was found. But this is just a facile reference to one of the prime rules of cave diving. In the large, clear passages in the Yucatan, divers do not always keep in contact with the line, but just keep it in sight. It may be that Fraga, in an effort to stay shallow to extend his air supply and reduce decompression time, had lost sight of the gold line. In his search for it, he may have found the offshoot line, but run out of air before having a chance to deploy the line on his safety reel for a sweep for the main line. *Sources:* Accident report by Gunnar Wagner and Steve Gerrard, note from Steve Gerrard.

During a recent visit to Cozumel, I was observing the impact of development of Cozumel's roads and hotels on one of their cave systems. One cenote had already been filled in for road expansion. On one of the days our group was diving, we passed a major road-expansion project. We had already been informed by German Mendoza that the new road would be directly over one of the passageways in the cave system, **Aerolito**, that we would be diving that day. After we entered that passage, we understood German's concerns. In the midst of the mud- and clay-covered floor there was a line of small pieces of limestone. They protruded approximately 20 centimeters above the floor. They reminded me of a mountain range seen from an airplane at thirty thousand feet. As I looked up to the ceiling of the cave, I noticed a fracture that was identical in shape to the line of particles on the floor. Later, as we were returning through that same passage, we began to hear a strange noise. We could feel vibrations that grew stronger the closer we got to the debris line. When we were directly over the debris, the vibration got so strong it felt like we were the ones using the jackhammers. Later we learned that the lunch period for the workers had ended and the bulldozers and vibratory rollers were hard at work. During that time we witnessed more debris falling from the fracture in the ceiling. Engineering crews claim the road has sufficient base to handle the anticipated traffic and weight. Having seen the underside of that road, I have my doubts. Parts of this system, too, are likely to be lost to development. *Source:* Denny Willis in *Underwater Speleology,* volume 18, number 1, 2001.

Don Inocencio has lived on his land for over thirty years. Over the past four years, many exploratory dives have been made from several cave entrances on his property, and passages run under most of the dense jungle. It was a surprise when he told Christophe Le Maillot that he had discovered a new cenote. Given descriptions of clear, blue water, we raced a set of gear and a diver to the site. The jungle floor dropped to reveal a large breakdown with a promising cave entrance under the northwest wall. A small altar stood by the water, and Don Inocencio explained the early Mayan belief in the *alux*, similar to leprechauns, and how these altars were a way to appease these powerful midgets. It was a spiritual setting, and more so once I descended through the rays of sunlight piercing the cool water. The crack opened to a large decorated cavern, and the floor sloped toward a definite passage. Having only a small amount of line kept greed from taking over, and after twenty minutes I left to make a plan for the following day.

With help from Don Inocencio, I made a second dive in the newly named Sistema **Mino-mi** and added to the line of the previous day. The passage was unexpectedly deep, soon narrowed, and finally pinched shut. Returning, I poked around the cavern zone, but the only water-flow passed through the muddy banks. It is unlikely that this system will grow larger than the present 334 meters, but no doubt more cenotes exist here, hidden in the thick jungle. *Source:* Fred Devos.

Isla de Cozumel, the Island of the Swallows, contains a number of underwater caves. The longest caves on Cozumel are located on the island's western shore. Both **Cueva Quebrada** (9000 meters) and **Cueva Aerolito** (6100 meters) release large volumes of fresh water directly to the Caribbean through

submerged coastal entrances. Many outstanding biologists and explorers have studied these caves since the early 1980s. However, much survey and exploration work in the 1990s remains unaccounted for, and we hope to be able to report more accurate facts on these two caves as they become available. (Cueva Aerolito was reported to be over 18 kilometers in length in *Underwater Speleology,* volume 27 number 4, in an article by Tim McMahon. We are seeking confirmation of this length.)

Diving in Cueva Quebrada requires an official permit from the Chankanaab Park office. Cavers applying for this permit must produce a Full Cave certification card. Exploration in Quebrada is limited to scientific purposes.

German Yanez Mendoza, a resident caver on Cozumel, provided us with these descriptions of inland (on the island) underwater caves:

Cenote Bambu, length 60 meters, depth 50 meters. Cenote Bambu was explored in spring 2000 and is very similar to the Cenote Tres Potrillos . Maximum visibility in this classic sink is 3 meters. It appears that the initial entrance gallery is huge, yet poor visibility makes it extremely difficult to fully explore this deep cave. Furthermore, the floor of the cave is very deep and heavy silt, which makes it nearly impossible to tie off survey guideline.

Cenote Chu-Ha, upstream 240 meters to 38 meters depth, downstream 300 meters to 18 meters depth. This cenote is closed to the public due to the presence of archaeological artifacts, and it is also surrounded by very private commercial property. About nine large Mayan artifacts were recovered from this cenote. According to INAH, these artifacts are about four hundred years old. The most interesting quality of these artifacts is their style, which is exclusive to the Maya of Cozumel.

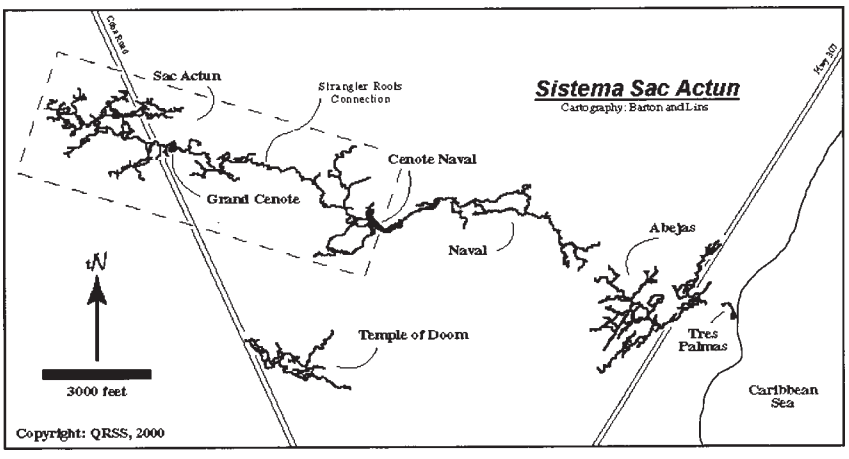
Cenote Tres Potrillos, 94 meters long, depth of sink 38 meters, depth of tunnel 15 meters. This cave was discovered in late 1998. Its entrance is a series of minor restrictions that open into a vary large chamber at –9 meters. Without a daylight zone, the main chamber and its one branching passage are rich in speleothems. Farthest penetration into the tunnel is 60 meters. This cave is on private property and has an entrance fee. *Source:* Jim Coke in www.caves.org/project/qrss/cozumel.htm.

Exploration in **Sistema Sac Actun**, 17078 meters long, has revealed connections with **Cenote Naval** to the east and **Cenote Calimba** to the northwest. Explorations with sidemount techniques have added nearly 13 kilometers to the cave since 1993. A southeast passage from Naval seems likely to connect to **Sistema Abejas** (9742 meters), but further survey efforts within Cenote Naval are restricted by order of a nearby military base. *Source:* Jim Coke.

In November 1999, three British cave divers visited the Yucatan Peninsula. It was basically a tourist trip, but a British diver's observation might be useful: "Visitors to the area should be aware that the heavy American influence leads to some unfamiliar practices. Lines are nearly always white, and hence difficult to see against calcite walls and floors, marked in feet, and only 2 millimeters thick. Caves are *not* lined to the surface. Should you be returning to the entrance after dark, you may not be able to see the exit. Within the caves, rather than clearly marked line junctions, side passages and continuations are entered by means of a 'jump,' where divers have to join the fixed lines with their own. There is an ambiguous arrowing system where lines are arrowed, but [the arrows] do not necessarily point to the exit. This has inevitably led to some unpleasant incidents in the region in recent years." *Source:* Martyn Farr, *Cave Diving Group [UK] Newsletter* 135, April 2000.

A cave-diving expedition organized by Christian Thomas and consisting of nine French and three Portuguese divers visited Quintana Roo in February 1998 and discovered and mapped 5.5 kilometers of new passage, including extending the underground rivers of **Xeil-Ha** and **Xcaret** in the biological reserve. *Source: Regards* 33, 1998, page 36.

In October 2000, Hervé Gordon, Christophe Le Maillot, and I made the first exploration dives in recently discovered **Cenote Camino**. Tanks needed to be lowered by rope, and a tree was used to climb down to the water. Rain made for a muddy entrance and had tainted the surface water with tannin. The water cleared below 2.5 meters, and I began to lay line heading northwest. I quickly came upon another entrance and tried to push around the muddy breakdown. Christophe and Hervé concentrated on the eastern fortifications, trying to find a downstream opening. Decorated walls pushed them north and to the same breakdown. A fissure hinted at deeper cave being present, but it was too narrow, even in our sidemount configuration. After forty minutes, we left the water with 2500 psi in our tanks. Although disappointing in size, this new cave is



rich with beautiful columns, and all three of us deemed it worth the effort.

With plenty of air still in our tanks, we opted for another push from **Cenote Chan Pek** (Small Dog). Christophe introduced Hervé to the downstream area, and they proceeded to add more line. I returned to the leads I had marked on a previous dive and found bedding planes heading upstream and downstream. **Sistema Carrillo** currently holds over 2100 meters of line, and the remains of ancient sea turtles proves a former link to the ocean. A restriction near the Chan Pek entrance required the use of sidemount equipment. We suspect that future progress here will be slow, now that all the obvious leads have been pursued. *Source:* Fred Devos.

Back in August, I had originally looked at the entrance to **Sistema Cubera** and was startled to see a large *cubera* snapper guarding the entrance. I presumed there must be a passage to the sea. Now, in late October 2000, Daniel Riordan and I entered the water for the first exploration dive. This same snapper greeted us a second time, and never have I seen a fish so old and haggard. Who knows how many years it has lived here, trapped in a brackish cenote with no obvious escape to the sea.

Past the cubera, the compass read northwest. This direction generally denotes upstream, but this section of cave is littered with large tree trunks, and scars on the floor tell of reverse tidal flows. Large crawfish scurried out of sight, and light from the entrance disappeared. The floor started to drip, revealing a slight halocline at 5.5 meters, with brown-tainted saltwater below.

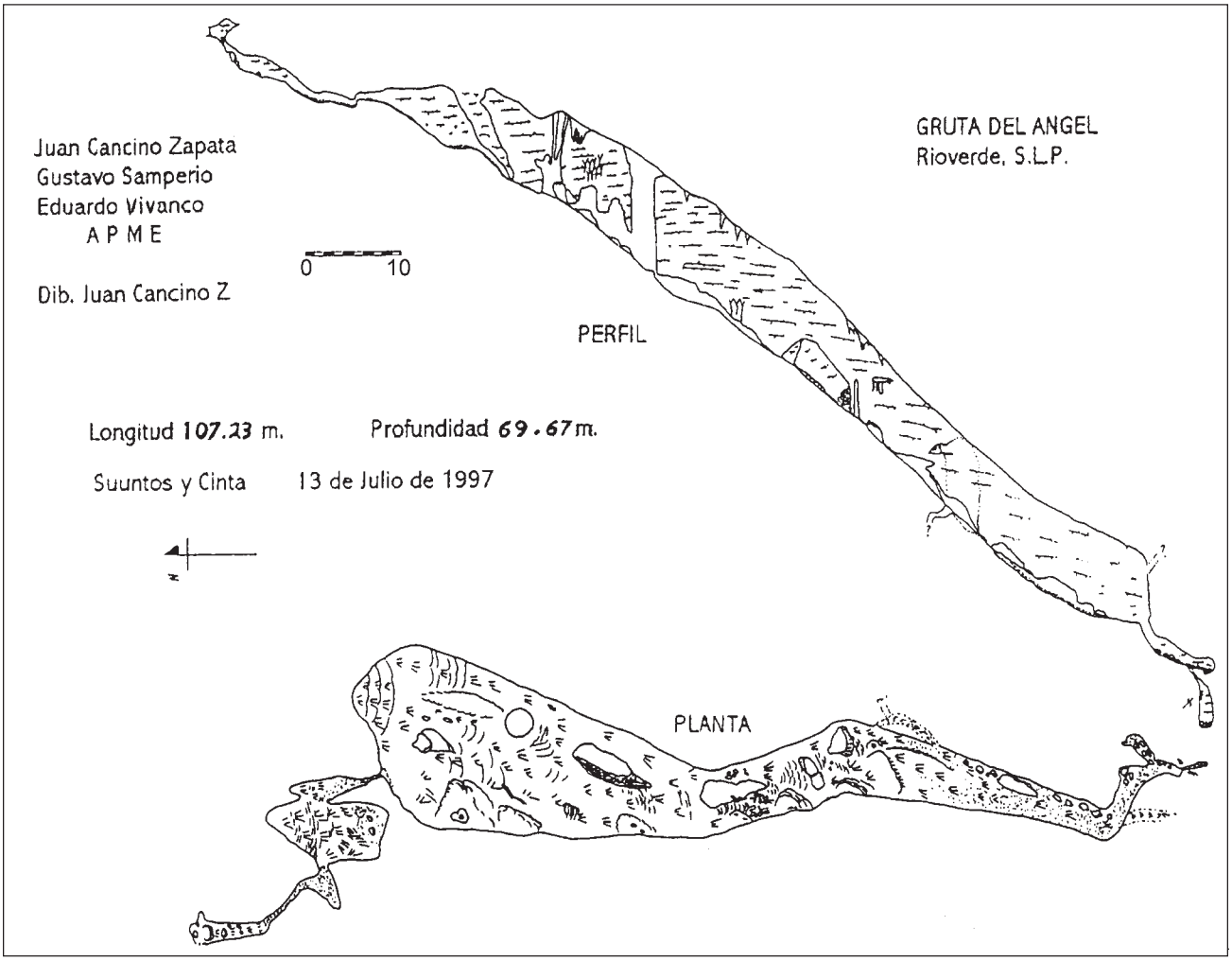
The passage continued deeper into a milky layer of hydrogen sulfide, and the smell of rotten eggs permeated my skin. This area of cave was obviously stagnant. Large animal bones indicated an opening nearby, but orange mangrove water blocked much of the light from the new **Cenote Garafon**. Pushing under the collapse revealed the welcome sight of a large lead to the west supplying clear water.

Oddly, flow headed northeast, and the improved visibility allowed string to quickly spool off the reel. **Cenote Dobladillo** was the end of the line, and with 377 meters of passage discovered, it was time to survey out.

Trails lead to two other nearby cenotes, and indications suggest that Sistema Cubera will become larger on our next visit. *Source:* Fred Devos.

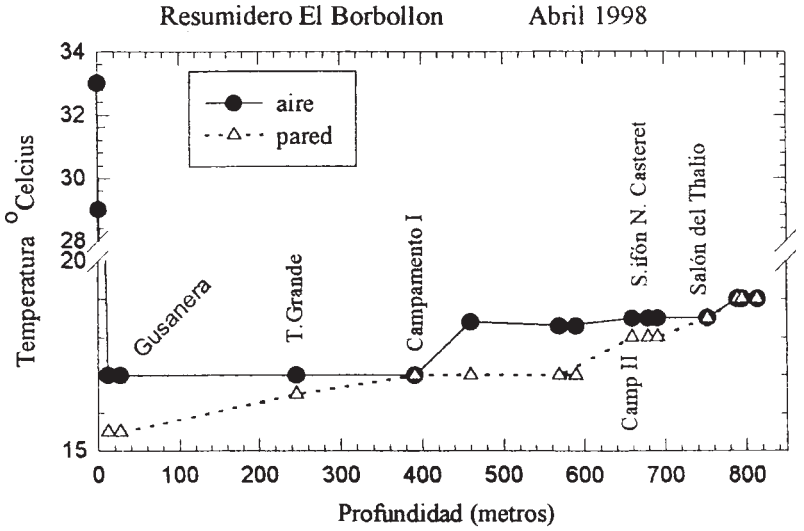
SAN LUIS POTOSÍ

Gruta del Ángel has been known by Río Verde locals for quite some time. It is located next to **Gruta de**



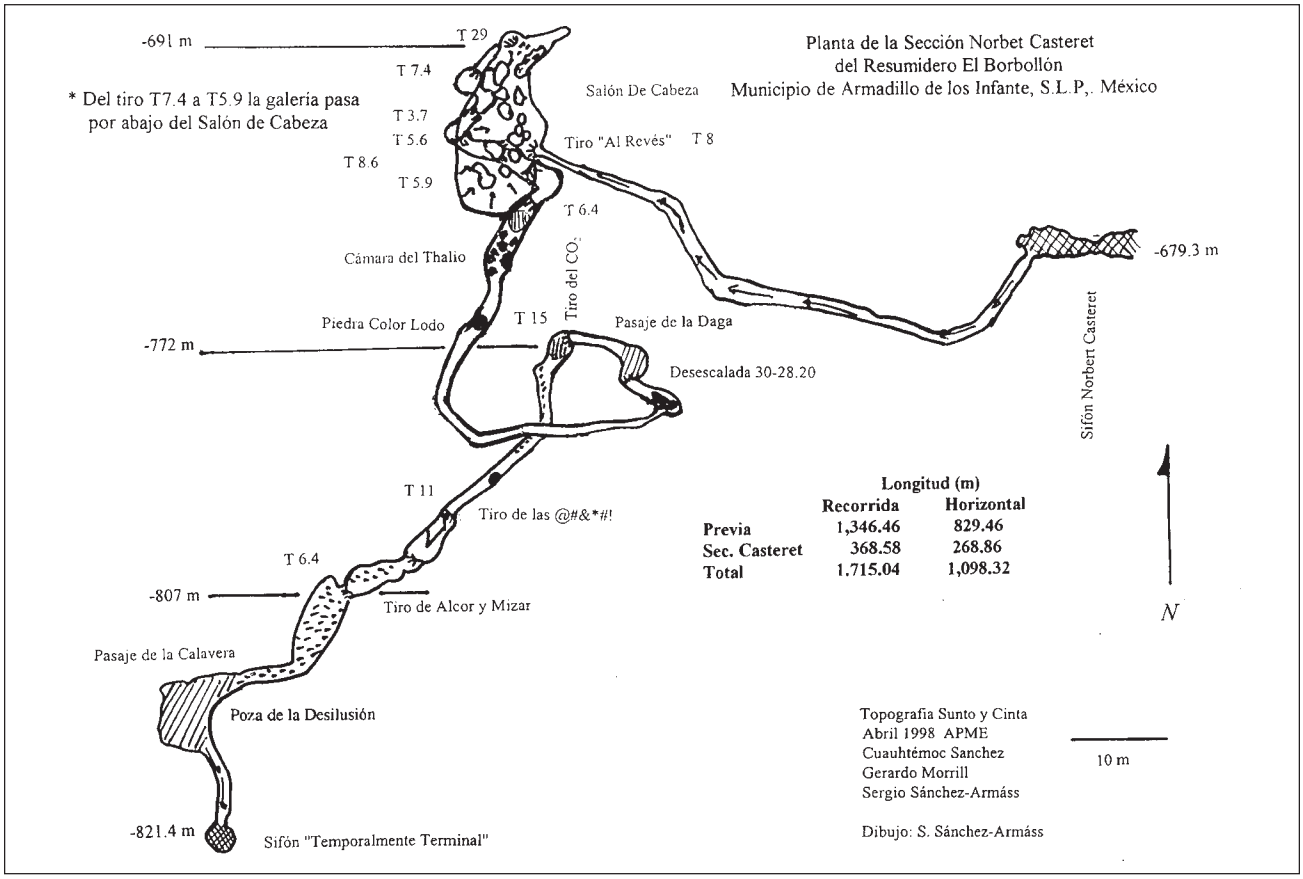
la Catedral, or **Gruta de la Iglesia Vieja**, near the town of Alamitos, on the same hill. The caves are likely to be connected at some time in the future. Gruta del Ángel is a beautiful cave, but, unfortunately, easy access has resulted in destroyed and damaged speleothems. Regardless of that, the cave remains attractive.

Arturo González Pérez, a Río Verde local, reported on the first explorations of Gruta del Ángel, back in October 1970. Friends from Río Verde who accompanied him included Benedicto Aguilar Rodríguez, Abel Ramírez Nieto, Manual González Martínez, and Pablo González, along with others. After searching for the surface location of the skylight in Gruta de la Catedral, they found a small cavity with several bats in it. After removing some rocks, they found that the cave seemed to continue, and they decided to return and dig the following weekend. With digging equipment and more time, they discovered the large passage of this famous cave and were impressed with its pristine beauty. They tried to keep its location secret, but, as usual, someone spilled the beans, and the Gruta del Ángel became famous to locals and nearby cavers. Some years later, locals decided to place a locked gate to prevent more damage, but, sadly, someone stole the entire locked gate. In 1990, the cave was still fairly clean, and it still had side passages that were passable and continued to the cave's end. Now they are blocked with rocks and mud due to natural occurrences. *Source:* Juan Cancino Zapata in *Tsaval* 6, pages 24–25, translated by Oscar Berrones.



Variación de la temperatura del aire y de la pared con la profunidad de la cueva

Sergio and Omar Sánchez-Armáss reported in "Mexico News" in *AMCS Activities Newsletter* 23 that



additional passage had been found beyond the sump in **Resumidero El Borbollón**. Additional information has become available, and the map of the new section and the graph of air and wall temperatures printed here are taken from an article in *Tsaval* 6, pages 7–16. A map of the older part of the cave appeared in *AMCS Activities Newsletter* 18.

SONORA

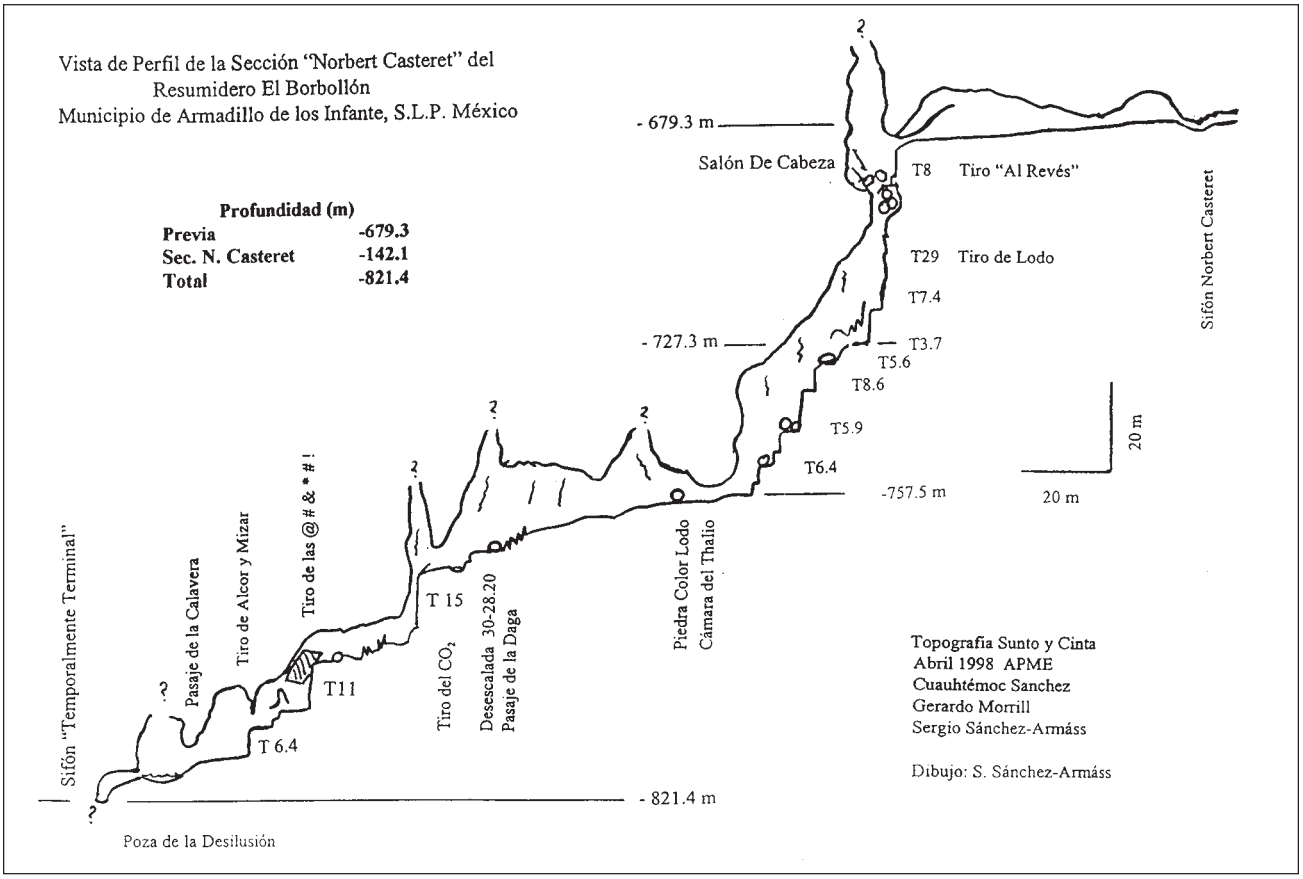
Direct measurements of ammonia in the atmosphere of **Cueva del Tigre**, a dry cave containing several million insectivorous bats, revealed a peak concentration of 1779 parts per million. Observations indicate that the origin of the ammonia is rapid microbial decomposition of bat urea, not chitinous guano. Modeling of ammonia distribution and diffusion indicates that ammonia production is approximately 250 grams per day, equivalent to the decomposition of about 450 grams of urea. *Source:* Donald McFarlane, Ray Keeler, and Hiroshi Mizutani, *Biogeochemistry*, volume 30, pages 1-8, 1995.

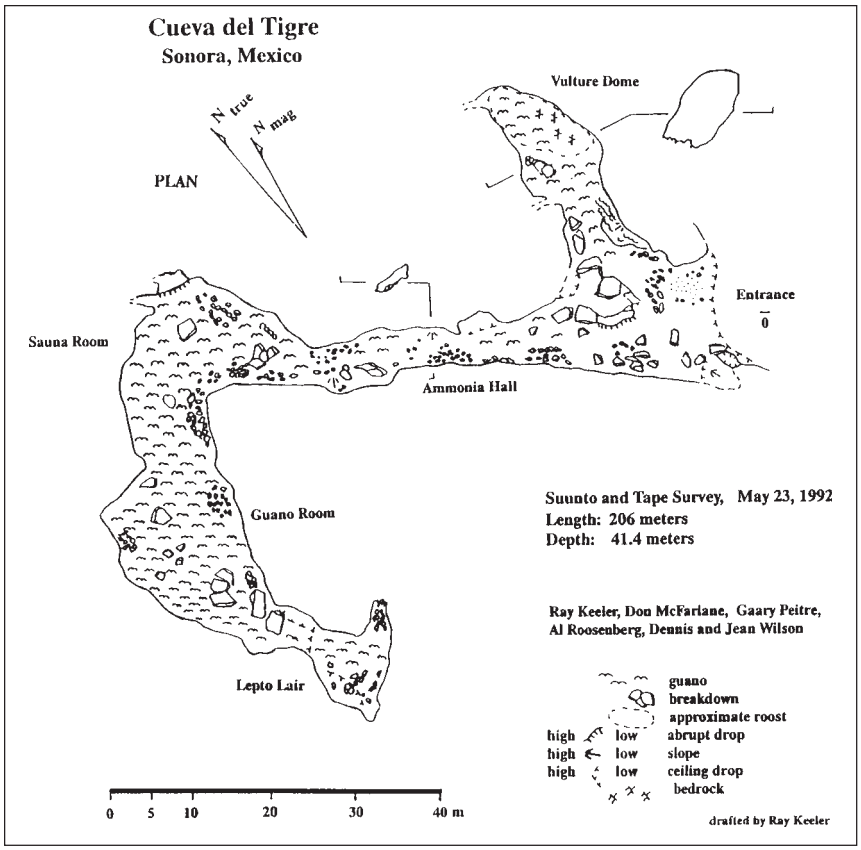
TAMAULIPAS

During the final phase of the U. S. Deep Caving Team's 2001 project, divers Jim Brown, Bill Stone, Peter Mulholland, and Robbie Warke set up a camp in the **Infiernillo** entrance to **Sistema Purificación**. The left and right sumps were connected, and Jim got about 500 meters upstream in three dives. The passage seems to be headed toward the downstream sump in Isopod River, still about a half kilometer away. In the downstream direction, a connection was made to Echo Sump, a small sump near the entrance. This would enable downsteam pushes to bypass the first 300 meters of diving, very up-and-down and wasteful of gas, but unfortunately pushes downstream from a platform built at Echo Sump led down 50 meters to a restriction with no flow. Additional diving was done in the tunnels from the main sumps, but there was no progress there beyond Jim's earlier dives. (See also *AMCS Activities Newsletter* 20). *Sources:* Mark Minton and Bill Stone.

A number of trips over the last few years have added to the length of **Sistema Purificación**. In May 2000, divers Jon Bojar and Jason Richards dove the upstream sump in the Valkyrie River for 150 meters, and it kept going. Pushes in the Lunar Way area led to the gnarly LA Freeway, which was connected to the Tequila River off the World Beyond during a return trip a month later. In November 2000, a trip was made to Camp VII in the World Beyond in order to push the ascending Batwing Boulevard lead. Three more pitches were climbed, and they stopped at another aid pitch. Another camp a month later concentrated on the Confusion Tubes in the lower part of the cave. The area yielded 1500 meters of new passage in the eastern part of the tubes. Unfortunately Terri Treacy took a fall in the tubes, which broke her leg in two places, and she had to be evacuated to Texas.

Other activities during the December 2000 PEP expedition took place around Conrado Castillo. More survey was done in a lower level of **Cueva del Borrego**, and Bill





Farr pushed a low, wet belly-crawl in Cueva de los Allarines to continuing passage. A number of new pits were mapped near Revilla and Las Chinas, including **Cueva Jardín** and **Pozo Diamante de Kirsten**, both around 100 meters deep.

In June 2000, Sandra Laura Gómez, Troy Lanier, Peter Sprouse, and Blanca Estela Zapata checked out a cave Blanca had found earlier above Peregrina Canyon. **Cueva del Molino** began as a dusty crawl, but soon teed into a nice walking passage that led to a drop, still unexplored.

North of Reforma, the **Ojo Encantado** resurgence cave was revisited by PEP cavers to continue the push upstream begun by Jean Krejca and Steve Taylor the year before. A new route to the cave up Trejo Canyon sucked up most of the trip, so only a little more passage was surveyed, up a waterfall climb, where the cave continued. *Sources:* Peter Sprouse, *Death Coral Caver* 10, 2000. The PEP's *Death Coral Caver* can be obtained from Box 8424, Austin, Texas 78713.

The fish *Astyanax mexicanus* from the states of Tamaulipas and San Luis Potosí has both eyed surface-dwelling and eyeless cave-dwelling forms. Eyes begin to develop in all embryos, but degenerate in the blind forms. Experiments show that a lens from a surface embryo transplanted into one side of a cave embryo causes development of a normal eye on that side. Conversely, transplanting a lens from a cave embryo into a surface one causes no eye to form. This suggests that the blindness mutations in the cave fish affect primarily the nature of the lens, and the lens then controls whether an eye develops or degenerates. *Source:* Yoshiyuuki Yamamoto and William R. Jeffery in *Science*, volume 289, page 631, 2000.

While some members of the U. S. Deep Caving Team spring 2001 project were diving in Infiernillo, others pushed the bottom of **Sótano de Caracol** (see Mexico News, *AMCS Activities Newsletter* 22). Bev Shade detected air flow at a very low airspace over a pool. No airflow had been detected here before, but the cave was drier this time. The floor of the pool was dug for 5 meters, until Mark Minton and Yvonne Droms broke through into horizontal canyon passage, surveyed for 80 meters. Beyond, after opening up an extremely tight squeeze, Bart Hogan, Bill Stone, and Bev Shade surveyed to a large breakdown area with good airflow in open passage. Windows in the sides of two of the lower pits were reached with a grappling hook. One of the parallel pits reached got too small, and the other continued beyond the length of the available rope, but did not seem to have airflow. The depth of Caracol is now 282 meters, and the total length doubled to 677 meters. *Source:* Mark Minton.

Sótano de Caballo Moro in southern Tamaulipas is a karst window with a large river in it that sumps both upsteam and downstream. It seems likely that this river comes from a large system draining the El Cielo area. El Cielo is a heavily karsted range towering 2000 meters over its resurgences. About eighty caves have been explored on top of it, but none has gone over 400 meters or so deep yet. Caballo Moro might be a way into the system, but divers will have a strong current to fight.

Sótano de Caballo Moro is unusual in that its population of *Astyanax mexicanus* is a mixture of eyed and eyeless forms. Usually eyed forms are not found underground. There is no access for fish to the lighted portion of the cave river in the karst window except

through the water-filled passages upsteam and downstream. To investigate the genetic background of the usual population of sighted fish in the cave, scientists did some DNA fingerprinting of both kinds of fish in the cave and some samples from other cave and surface sites, including one at Micos in San Luis Potosí. They report that the eyed population in Caballo Moro is closer genetically to the blind fish in the vicinity than to surface populations and that in fact the genetic distance between the two forms of Caballo Moro fish is less than the distance between either of those forms and any other sample. Still, the distance between the two Caballo Moro populations is greater than the average distances within either the eyed or the eyeless samples collected there. Taken together, these finding suggest, although the authors say more data are needed, that sight in the forms in Caballo Moro have re-evolved from the eyeless forms there. *Sources:* Peter Sprouse; Luis Espinasa and Richard Borowsky, *Journal of Cave and Karst Studies,* volume 62 number 3, 180–183, 2000.

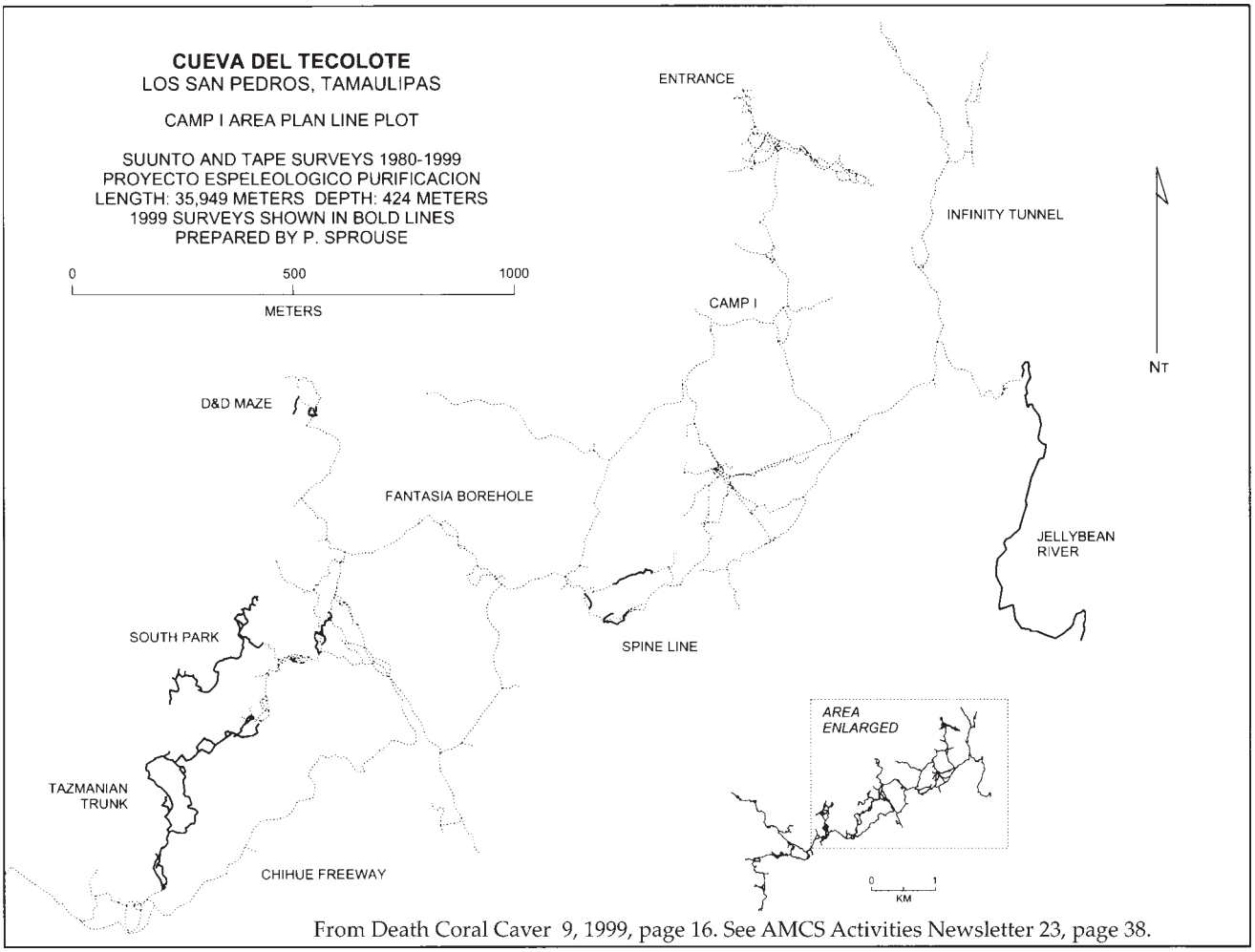
VERACRUZ

Cavers from the Oztotl Flying Club were taken to a cave west of the port of Veracruz by cavers of CEMAC-Veracruz in February 2001. **Cueva del Cabrito**, located near Las Palmas, opened into a hill at the foot of the mountains, and quickly led to a flowing stream contained *Rhamdia* catfish. The cave was mapped for 100 meters, but it goes much farther, according to the CEMAC cavers. *Source:* Peter Sprouse.

At Tampico Alto, a new karst area was looked at briefly by Peter Sprouse and Terri Whitfield. A crawlway cave is bisected by the main highway, but the west side was filled with vampire bats and strong ammonia, so it couldn't be explored even though it appeared to go. On the east side it got too low after 5 meters. *Source:* Peter Sprouse.

YUCATÁN

On July 13, 2000, an experienced cave diver was exploring **Cenote Sabak Ha** with a fellow cave diver. The planned dive was fifteen minutes to a depth of 55 meters. Oxygen cylinders for decompression were left at 6 meters, and the divers continued on compressed air to 45 meters, where they switched to bottom mix, trimix 21/20. After five minutes at maximum depth, the victim signaled to begin the ascent. The divers ascended to 45 meters, switched back to air, and continued. At 42 meters the victim was observed to have difficultly breathing from his regulator. He switched regulators, but still appeared to be having difficulty breathing. The buddy tested the second regulator by depressing the purge button; it



From Death Coral Caver 9, 1999, page 16. See AMCS Activities Newsletter 23, page 38.

appeared to be operating properly. The buddy rapidly carried the victim to the first decompression stop at 27 meters. During this ascent, the victim was gripping the buddy's harness with one hand and clutching at his chest with the other. At 23 meters, the victim released his grip and floated away. A few minutes later, he was located on the ceiling at 12 meters. His regulator was out of his mouth, and he was unresponsive. The buddy pulled him from under the ledge and released him to float to the surface. Ascending to 6 meters, he did two minutes of his required twenty-three minutes of decompression, then went to the surface to drag the victim to shore. He instructed the surface support to attend to the victim and descended to complete additional decompression. The buddy later exhibited signs of decompression illness, but upon examination at a recompression chamber was not treated. When he arrived at the shore, the victim was unconscious, unresponsive, not breathing, and without a pulse. All of the victim's equipment was examined and found to be functional. An autopsy was performed, which found that the victim had had a major heart attack, as well as a major cerebral air embolism.

This event appears to have been caused by a heart attack while at depth during the dive. No cave-diving rules were broken. In fact, the victim was the president of one of Mexico's leading cave-diving organizations, Exploradores Subaquaticos. *Source:* Jeffrey Bozanic in *Underwater Speleology,* volume 28, number 2, 2001.

Two short papers by Slawomir Tulaczyk on the geology of the northern Yucatan Peninsula appear in recent Cave Research Foundation annual reports. The first is a geophysical paper on the influence of the Chicxulub impact crater (thought to result from the impact that caused the K/T extinction event) and the Holbox fracture zone on karst (1993, pages 37-39), and the second discusses possible plate-tectonic origin of the Holbox fracture zone itself (1994–1997, pages 61–63).

BATS

Bats inhabit every corner of Mexico. Of the country's 140 species, 38 are also found in the United States, and many are migratory. This means that only a concerted, binational effort can protect them. Established in 1994, the Program for the Conservation of Migratory Bats is a partnership between Bat Conservation International and the Institute of Ecology at Mexico's National Autonomous University, and the effort has grown to include both the United States and Mexican governments. We initially focused on three migratory species: the Mexican free-trailed bat *Tadarida brasiliensis* and the endangered less and greater long-nosed bats, *Leptonycteris curasoae* and *L. nivalis.* Through research and environmental education, we have been able to implement a wide variety of critical conservation actions.

Currently, we are working to find ways to conserve habitats along migratory corridors and protect key roosts along migration routes. We are monitoring twenty-two important caves in fifteen Mexican states, learning more about their bats' population fluctuations, diet, reproduction, genetics, and other aspects of biology. We are examining the value of bats to local economies.

Our environmental education group, led by Laura Navarro, has worked closely with communities near bat caves, teaching local people about the bats' vital ecological roles as pollinators, seed dispersers, and regulators of insect pests. To introduce bats to children, we have created a series of bilingual books with bat mascots. Complete educational packages include storybooks, toys, activity booklets for children and teachers, and games, all emphasizing the value of bats and teaching about their needs.

Finally, the award-winning radio series *Aventuras al Vuelo* (Adventures in Flight) has been broadcast through Radio Educación, the official station of Mexico's Secretary of Public Education. The series of twenty fifteen-minute programs has now reached many thousands of Mexican school-children.

Other conservation initiatives have included amendment of Mexico's Federal Law of Wildlife to encompass all caves and crevices as *de facto* protected areas, designing management plans for specific caves, and establishing partnerships with local organizations to protect their caves. The governor of Nuevo León has announced that the state is establishing a new protected natural area that includes Mexico's largest bat cave, **Cueva de la Boca**, Nuevo León, and the surrounding mountains. Because of BCI and the Program for the Conservation of Migratory Bats, numbers of bats in the cave have grown from one hundred thousand to nearly one and a half million since 1995. The success of these initiatives is evident in the significant growth of bat populations in this and other caves identified as immediate priorities, as well as in changing attitudes across the country. *Source:* Rodrigo Medellín in *Bats,* spring 2001.

DEEP PITS OF MEXICO

Peter Sprouse
June 2001
Depth in meters

1	El Sótano (de El Barro)	Entrance drop	Querétaro	410
2	Sótano de las Golondrinas	Entrance drop	San Luis Potosí	376
3	Sótano de Tomasa Kiahua	Entrance drop	Veracruz	330
4	Zacatón	Entrance drop	Tamaulipas	329
5	Sótano de Alhuastle	P'tit Quebec	Puebla	329
6	Nita Xonga	Psycho Killer	Oaxaca	310
7	Sotanito de Ahuacatlán	Second drop	Querétaro	288
8	Sótano del Arroyo Grande	Entrance drop	Chiapas	283
9	Sima Don Juan	Entrance drop	Chiapas	278
10	Sima Dos Puentes	La Ventana	Chiapas	250
11	Hálito de Oztotl	Entrance Drop	Oaxaca	250
12	Resumidero del Pozo Blanco	Entrance drop	Jalisco	233
13	Sótano del Aire	Entrance drop	San Luis Potosí	233
14	Sistema Ocotempa	Pozo Verde	Puebla	221
15	Sótano de los Planos	Puits Tannant	Puebla	220
16	Sótano de Eladio Martínez	Entrance drop	Veracruz	220
17	Sótano de Coatimundi	Entrance drop	San Luis Potosí	219
18	Sótano de Sendero	Entrance drop	San Luis Potosí	217
19	Sima de la Pedrada	Entrance drop	Chiapas	217
20	Resumidero el Borbollón	Tiro Grande	San Luis Potosí	217
21	Sima del Chikinibal	Entrance drop	Chiapas	214
22	Cueva del Tizar	Third drop	San Luis Potosí	212
23	Kijahe Xontjoa	Son On Jan	Oaxaca	210
24	Nacimiento del Río Mante	Macho Pit	Tamaulipas	206
25	Hoya de las Guaguas	Entrance drop	San Luis Potosí	202
26	Sistema H3-H4		Puebla	200
27	Kijahe Xontjoa	Lajao Se	Oaxaca	200
28	Sistema de la Lucha	Entrance drop	Chiapas	200
29	Sima La Funda	Entrance drop	Chiapas	198
30	Sótano de Soyate	Entrance drop	San Luis Potosí	195
31	Sótano de Alpupuluca	Entrance drop	Veracruz	190
32	Cuaubtempa	Pozo con Carne	Puebla	190
33	Sótano de Tepetlaxtli no. 1	Entrance drop	Puebla	190
34	Sótano de Puerto de los Lob	Entrance drop	San Luis Potosí	189
35	Sótano de Hermanos Peligrosos	Second drop	Veracruz	186
36	Sistema Soconusco	Darwin	Chiapas	180
37	Sima de Veinte Casas	Entrance drop	Chiapas	180
38	Ahuihuitzcapa	Entrance drop	Veracruz	180
39	Hoya de la Luz	Entrance drop	San Luis Potosí	180
40	Sima del Cedro	Entrance drop	Chiapas	175
41	Sótano de la Cuesta	Entrance drop	San Luis Potosí	174
42	Sima Dos Puentes	Entrance drop	Chiapas	172
43	Sótano de los Monos	Entrance drop	San Luis Potosí	171
44	Sótano de Otates	Third drop	Tamaulipas	171
45	El Socavón	Entrance drop	Querétaro	171
46	Sótano de los Ladrones	Entrance drop	Oaxaca	170
47	Nita Diplodicus	Entrance drop	Oaxaca	170
48	Sótano de Tepetlaxtli no. 2	Entrance drop	Puebla	170
49	Sótano de Agua de Carrizo	Flip Pit	Oaxaca	164
50	OC8	Entrance drop	Puebla	160

DEEP CAVES OF MEXICO

Peter Sprouse
June 2001
Depth in meters

1	Sistema Huautla	Oaxaca	1475
2	Sistema Cheve	Oaxaca	1386
3	Akemati	Puebla	1226
4	Kijahe Xontjoa	Oaxaca	1209
5	Cueva Charco	Oaxaca	1166
6	Sistema Ocotempa	Puebla	1070
7	Akemabis	Puebla	1015
8	Sonconga	Oaxaca	1014
9	Sistema Purificación	Tamaulipas	957
10	Guixani Ndia Kijao	Oaxaca	956
11	Sistema Perrito	Oaxaca	906
12	Nita Cho	Oaxaca	894
13	Sistema de Tepepa	Puebla	850
14	Sótano de Agua de Carrizo	Oaxaca	843
15	Sótano de El Berro	Veracruz	838
16	Sótano de Trinidad	San Luis Potosí	834
17	Resumidero el Borbollón	San Luis Potosí	826
18	X'oy Tixa	Oaxaca	813
19	Nita Ka	Oaxaca	760
20	Sistema H31-H32-H35	Puebla	753
21	Sistema Ehécatl-Xalltégoxtli	Puebla	747
22	Sonyance	Oaxaca	745
23	Nita Xonga	Oaxaca	740
24	Yuá Nita	Oaxaca	704
25	Aztotempa	Puebla	700
26	Sótano de los Planos	Puebla	694
27	Sótano de Alfredo	Querétaro	673
28	Sistema Cuetzalan	Puebla	658
29	Sótano de Tilaco	Querétaro	649
30	Nita Nashí	Oaxaca	641
31	Cuaubtempa Superior	Puebla	640
32	Sistema Atlalaquía	Veracruz	623
33	Cueva de Diamante	Tamaulipas	621
34	R'ja Man Kijao	Oaxaca	613
35	Nita He	Oaxaca	594
36	Meandro Que Cruce (H54)	Puebla	588
37	Sistema del Encanto	Puebla	584
38	Yometa	Puebla	582
39	Sótano de las Coyotas	Guanajuato	581
40	Sótano Arriba Suyo	San Luis Potosí	563
41	Sistema Tepetlaxtli	Puebla	535
42	Sótano del Río Iglesia	Oaxaca	531
43	Sótano de Nogal	Querétaro	529
44	Resumidero de la Piedra Agujerada	San Luis Potosí	521
45	Grutas de Rancho Nuevo	Chiapas	520
46	Sótano de Ahuihuitzcapa	Veracruz	515
47	Sistema Soconusco	Chiapas	513
48	Sótano de las Golondrinas	San Luis Potosí	512
49	Hoya de las Conchas	Querétaro	508
50	Sótano de Los Hernandez	Querétaro	507

Updates and corrections:

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Peter Sprouse
June 2001
Depth in meters

LONG CAVES OF MEXICO

1	Sistema Purificación	Tamaulipas	94288
2	Ox Bel Ha	Quintana Roo	70650
3	Nohoch Nah Chich	Quintana Roo	60985
4	Sistema Huautla	Oaxaca	55953
5	Sistema Dos Ojos	Quintana Roo	55322
6	Sistema Cuetzalan	Puebla	36000
7	Cueva del Tecolote	Tamaulipas	35949
8	Kihaje Xontjoa	Oaxaca	25000
9	Sistema Cheve	Oaxaca	24300
10	Sistema Soconusco	Chiapas	21733
11	Coyalatl	Puebla	20000
12	Sistema Naranjal	Quintana Roo	19394
13	Sistema Yax Ch'en	Quintana Roo	18181
14	Sistema Sac Actun	Quintana Roo	18181
15	Sistema Pondazul (PonDeRosa)	Quintana Roo	14932
16	Sistema Nohoch Kiin	Quintana Roo	13615
17	Cueva del Alpazat	Puebla	13000
18	Atlixicaya	Puebla	12200
19	Cueva del Río La Venta	Chiapas	12000
20	Sistema Ehécatl-Xalltégoxtli	Puebla	11037
21	Sistema San Andrés	Puebla	10903
22	Grutas de Rancho Nuevo	Chiapas	10218
23	Cueva del Arroyo Grande	Chiapas	10207
24	Cueva del Mano	Oaxaca	9790
25	Sistema Abejas	Quintana Roo	9742
26	El Chorro Grande	Chiapas	9650
27	Sistema Tepetlaxtli	Puebla	9600
28	Sumidero de Jonotla (Teponahuas)	Puebla	9381
29	Cueva Quebrada	Quintana Roo	9000
30	Sistema de Tepepa (Niebla)	Puebla	8511
31	Sótano de Las Calenturas	Tamaulipas	8308
32	Cenote Chac Mool - Mojarra	Quintana Roo	8182
33	Sumidero Santa Elena	Puebla	7884
34	Cueva Yohualapa	Puebla	7820
35	Cueva de la Peña Colorada	Oaxaca	7793
36	Cueva de Comalapa	Veracruz	7750
37	Actún Kaua	Yucatán	7446
38	Sótano del Arroyo	San Luis Potosí	7200
39	Sistema Perrito	Oaxaca	7148
40	Cueva de la Puente	San Luis Potosí	6978
41	Xongo Dwi Ñi	Oaxaca	6500
42	Sistema Zoquiapan	Puebla	6489
43	Cueva Vinata	Michoacán	6460
44	Cueva del Ferrocarríl	Morelos	6100
45	Cueva Aerolito	Quintana Roo	6100
46	Cenote Zapoté	Quintana Roo	6000
47	Sistema Cretacico (Suchomimus)	Nuevo León	5908
48	Gruta del Río Chontalcoatlán	Guerrero	5827
49	Sistema H31-H32-H35	Puebla	5745
50	Cueva de la Iglesia	Morelos	5700

RESCUE IN THE SIERRA NEGRA

Alain Goupil

Even with the best possible precautions in our caving adventures, bad luck sometimes strikes. Here is an account of the most recent expedition of Quebec cavers to Mexico from the point when it was transformed into a rescue operation. I summarize information from more than twenty people involved in the operation, along with my own personal impressions.

Mexpé 2000 was the eighth expedition in the past twelve years of the Société québécois de spéléologie to the Sierra Negra, 300 kilometers southeast of Mexico City. There were fourteen cavers, twelve from Quebec and two from France. At the time of the accident on December 23, 1999, only seven cavers were present, with the other seven en route and expected on December 25.

The first team had arrived on December 15 to rig the caves and begin exploration. The caves are very deep. One of them, TP4–13, is a significant cave that has been explored since Mexpé II in 1989. It is part of Sistema de Tepepa in Puebla. To reach the site of continuing exploration in the Adromède section, it is necessary to descend a series of pits to –200 meters. There is a narrow horizontal meander at approximately –180 meters. From –200 to –300 meters, the passage is more horizontal, the first part being easy and the second much more varied. Starting from the surface, with all the pits rigged, it normally takes a small team of experienced cavers less than three hours to arrive at the accident site.

Day 1, December 23. At about 11:00 A.M., two teams enter TP4–13 in order to continue exploration of an area nearly 1 kilometer from the entrance. One person, such as me, in each team is very familiar with the area. The first team moves to a stream passage at –350 meters, the last point found during the 1997 expedition. My team, Bastien Michau, Eric Hamel, and I, set about exploring various leads at –300 meters. We all plan to meet at 8:00 P.M. and leave the cave together. Around 4:30, Bastien sets off to check an ascending virgin passage. As he does not return after a few minutes, I follow. The canyon, at first passable by bridging near the top, widens, and it is necessary to continue on the right wall, where there are many holds. I move with caution along the wall, facing sideways. The footholds are obvious and solid and stained with mud left by Bastien's boots. Many formations and cracks for handholds enable me to climb well and keep my balance. Farther on, there is an angle in the wall that I must cross by using a handhold far to the left. With it, I must pull myself up and gradually transfer my weight to a hold for my left foot. The hold yields under the pull of my left hand. It is a stalagmite the size of my thigh, and it comes off the wall attached to a good-sized block of bedrock as a bonus. Completely unbalanced, I fall into the air, accompanied by the block, which weighs several kilograms.

For a second, I think that I may die by breaking all my bones. When I hit the bottom of the small canyon, the most violent blow is to my right side. In a crouching position and conscious after the fall of more than 6 meters, I howl in pain for a long minute. An idea comes and never leaves me: I am alive and, whatever problems arise, I will leave this cave alive. Eric, who sees my fall and is thrown into a panic, rushes to my aid while calling for Bastien at the top of his lungs. Having heard everything, Bastien runs quickly to Eric and sprains an ankle in his haste.

A first assessment of my health is made visually. I am conscious and speak and breathe well, I do not have visible bleeding, I am sore everywhere, and I am worried about my spinal cord because I have a lot of pain in my lower back and cannot raise my right leg. My head seems untouched, but I cannot move. Bastien limps off in search of the other team. Eric places ropes and empty bags under me to make the wait more bearable. For more than an hour and a half, Bastien searches, gets lost, and goes in circles, and he finally returns empty-handed.

I then write a note to my girlfriend Sandra Quesnel, recommending that she not come join me, because I fear for her safety in this emotional time. I include my own medical checkup in detail: Pain in the right shoulder, right elbow, and right leg. Sprained left thumb. Pain in left heel. Significant pain in lower back, right side, level L5. Pain in the

Reprinted, slightly revised, from the *Canadian Caver,* volume 30 number 2, fall 1999–spring 2000. The article also appeared in French in *Sous Terre,* volume 15 number 1, summer 2000. It was compiled with the help of all the members of Mexpé 2000, québécois reinforcements, Michel Cadieux, and Juan A. Montaño Hirose.

right hip and totally impossible to raise right leg. As I fear spinal injury, there is no question of moving me with the few available people.

Bastien and Eric place obvious signs for the other team where they should pass on their return, directing them toward me. Bastien sets out again, toward the surface, marking the way as he goes. Despite limping, getting lost, and a flooding cave, he takes only three and a quarter hours to reach the base camp on the surface. During this time, I examine my wounds more closely with the assistance of Eric. I discover and treat contusions and abrasions on my right side, shoulder, elbow, hip, and leg. Eric deals with a painful trouble spot. At the very uncomfortable site of the fall, he cares for me the best he can during the long hours of waiting. Very conscious of the gravity of the situation, the only person I do not worry about is me.

Once out of the cave, Bastien arrives at camp at 9:45 P.M. in a pouring rain. Entering the main tent, he informs Eric Sanson and Sandra of my fall. He tries to be reassuring, but Sandra senses that it is serious. He gives them my notes on my condition and my message for Sandra. It is only half readable, partly erased by Bastien's sweat and water poured on him during the ascent. She reads my note that says I know I will need assistance to get out, but advise her not to go down with the first wave, to rest well before going down, and note that there will in any case be plenty of work to be done in camp. Recalling our past difficult excursion to this site, she interprets this to say that the cave was too difficult for her and that it would be best if she did not descend, which is not what I meant.

Eric S. and Bastien draw up a preliminary schedule for work underground. Bastien marks the accident site on the map. By superimposing the cave survey on the topographic map, they determine that I should be directly below a small, dry pond halfway between camp and the entrance. The Nicola radio will be placed here, directly above another to be taken underground. Eric S. explains the operation of this radio system, which was borrowed from the cave rescue group of Isère, France. They also make a preliminary list of the hardware that might be needed. This task completed, Sandra helps Eric S. prepare supplies for underground: space blankets, carbide, drugs, iodine, food, stove, warm clothing, hardware to rerig certain very wet passages, and the other radio.

DAY 2, DECEMBER 24. Bastien and Sandra decide to go to Tepepa to see about using the village radio. In Tepepa, they knock on the door of a villager they know and wake him and his family for help. Sandra manages as best she can in Spanish to explain the situation to them, but the village radio is not usable. One of the villagers, Ventura, arranges to meet with Sandra at 6:00 A.M. to lead her on the two-hour walk to a telephone in Tlacotepec. She and Bastien return to camp, Bastien holding out in spite of the pain of his sprained ankle.

They next work to build a shelter close to the small pond and install the Nicola radio there in preparation for the first underground transmission, scheduled for 4:00 A.M. The site is approximately eight minutes' walk from camp toward the cave entrance. Their installation complete, they await the call from Eric S., who has gone underground.

At about 1:00 A.M., Eric S. descends into the cave, which is in full flood, with the stretcher and two bags of hardware. He makes a stop at the Pendulum Pits at –200 meters, where the waterfall is swollen by the storm. There he tests the radio and communicates successfully with Bastien and Sandra. He follows the marked route to me and establishes the Nicola connection with the surface from near me at about 5:15. Taking the microphone, I recommend trying to contact the American cave rescue people. There is still no news of our other exploration team, which is unusual. We conclude that they must be trapped somewhere by the flood.

After thirteen very uncomfortable hours at the place where I fell, I have to move. I believe I would be able to stand up with the help of analgesics and muscle relaxants. With assistance, I again put on my seat harness, my cowstail, and my chest harness. At about 7:00 A.M., using an improvised handrail and supported by my two companions, I manage painfully to move 30 meters to a much better bivouac site, where the stretcher can be used as a makeshift bed. My right leg can support me, but I am unable to raise it.

In the morning, Bastien contacts me regularly from the surface, initially every hour and then when necessary. I tune in for five minutes

every hour. He remains alone at camp all day as his ankle worsens. Nevertheless, his rescue experience will be invaluable.

At about noon, Eric S. leaves me to search for the trapped team. He finds them on a ledge over a flooded stream of about 20 liters per second, where they have spent the last eighteen hours. They make their way to the surface to finally get some rest. Eric H. makes me a shelter using space blankets over the stretcher and remains with me for the coming night.

After trying to sleep for an hour, Sandra sets off from camp at 5:45 A.M. She hikes with Ventura for two hours on muddy and uneven paths descending 800 meters to Tlacotepec. Here there is one radiotelephone powered by solar cells, and it is unusable in the current weather. She then takes the 10:30 bus for the two-and-a-half-hour trip to Tezonapa. There she stays at the bus station to await the arrival of the remaining Québécois. Distraught and overcome by emotions, she does not phone. They arrive about 6:30 P.M., and she can finally release the tension she has endured for more than twenty hours. A series of telephone calls are placed. My insurance company is contacted, and various contacts in the USA and Mexico are called without answers. Finally Michel Cadieux is reached in Quebec at 8:00 P.M. through the Quebec cave rescue pager number.

Michel alerts cave rescuers on a broad scale. He contacts the Canadian embassy in Mexico City and the person in charge of the National Cave Rescue Commission in the United States. A member of this organization, Joe Ivy, sends two messages by electronic mail to the Mexican cavers' Internet list-serve Iztaxochitla. One requests the assistance of cavers with vertical experience, particularly multi-drop caves with European rigging. In the second, he provides details on the accident and its location.

At midnight, I speak by radio with Eric S., who has just arrived on the surface with Denis Lacasse and Guillaume Pelletier. We wish each other Merry Christmas and good night.

DAY 3, DECEMBER 25. Someone has to go underground to supply Eric H. and me, but manpower is limited and everyone has slept little for the past two days. Denis volunteers and goes underground about 3:00 P.M. with sleeping gear and food. Finally I am able to really sleep in the comfort of a sleeping bag and a real mattress, which I receive like gifts delivered by Father Christmas down a quite long chimney. There were also surprises, like chocolate and French nougat. Denis remained for the night, in anticipation of the start of stretcher transport the next day.

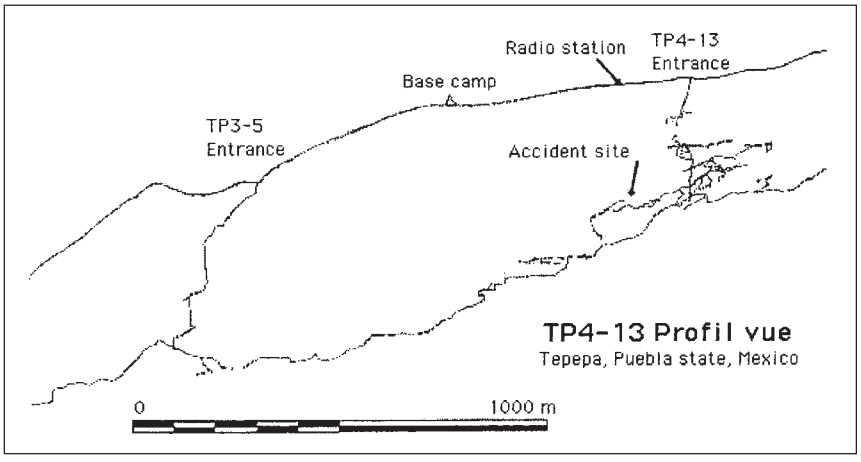
On Christmas night, the messages sent on the Internet are read by Juan A. Montaño Hirose, who immediately alerted his companions of the Grupo Espeleológico Universitario at UNAM. He also contacts the Mexican Red Cross (Cruz Roja), as well as the Unión de Rescate e Investigación del Medio Ambiente Natural (URION). He sends messages on Iztaxochitla asking for more information, but does not get an answer.

Within a short time, people from all these groups, including José Montiel of the Asociación Base Draco, get underway towards the Sierra Negra, along with Cruz Roja personnel from Córdoba, Jalapa, Mexico City, and San Luis Potosí.

Elsewhere, a team of six Quebec cavers, all experienced Mexpé caving veterans, prepare to head south to join the effort—the québécois reinforcements. Six American cavers are ready to leave from Texas, and others are contacted by Joe Ivy. The United States Air Force is contacted, and if Mexico requests assistance from the American government, the cavers will be flown down on military aircraft.

Sandra and the second wave of expedition participants head from Tezonapa toward base camp. They are on the road by about 10:00 A.M. in a truck belonging to the old *presidente* of Tezonapa, which brings them to Zacatilihuic. The road is too rough to go farther by vehicle, and the rest of the trip is on foot, with mules transporting the equipment. Sandra arrives just in time for the radio contact at 6:00 P.M. It is her first contact with me in two and a half days, the Christmas present I have been hoping for. We apprise each other of the events of the last few days. I thus learn the extent of the help spurred by the announcements and of the preparations by québécois reinforcements, which I find disturbing and touching at the same time. Thereafter, radio communications will almost always be between the two of us.

Things are organized in preparation for the arrival of reinforcements. Two lists of necessary hardware are drawn up, one for the camp and the other a request for explosives to enlarge a narrow section of passage. One will be transmitted to Quebec the following day and the other to people from Cruz Roja on site. By evening, a team of auxiliary medical Cruz Roja and cavers arrives. A medical assessment is made over the Nicola radio. A meeting of the heads of the various groups is organized to pass on information about the cave and assess the abilities of the available personnel. In



spite of this, it is only by experience that we learn that few of them are cavers able to deal with technical vertical caving of such depth on European rigging.

Day 4, December 26. At about 9:15 a.m. Quebec time, the québécois reinforcements fly from Dorval Airport, landing in Mexico City at 1:30. They are accompanied through the airport by Mr. Plamondon of the Canadian embassy, whose diplomatic interventions speed their passage. He tells them that explosives will be difficult to obtain, since these are controlled by the army in Mexico. There is also a rumor, denied by the embassy, that the cavers have refused Mexican help. Outside the airport, five members of the Cruz Roja transport the québécois to the Sierra Negra in an ambulance. Cultural differences are revealed in their questions. Where are their uniforms? Who has the highest rank? With eleven crowded in the small van with the luggage, they head to Tezonapa, where they arrive about 9:00 p.m.

At base camp, non-cavers arrive, police and civil security armed with automatic weapons. The list of needed hardware, not having gotten anywhere with the Cruz Roja, is passed on to the Veracruz police officers. In the morning, a caver leaves the camp for Tlacotepec to transmit news to Michel Cadieux in Quebec. He must pass on information about our situation to family members before they hear through the media. Rescue progress is much slower than anticipated owing to differences of language, culture, and pace of work. The afternoon is marked by the landing of a helicopter, which deposits only one person from Cruz Roja.

At about noon, another meeting with the heads of all the groups present is held. Expedition members give a complete report on the situation, point out the difficulties of travel in the cave, and ask for the creation of a team of ten Mexican cavers for the next day's stretcher carry.

Underground, having just spent my best night of sleep in the past three days, five continuous hours, I feel better and better, so much so that I have the impression that if the rescue takes too much longer, I will be healed before I get out. This makes me feel ill at ease. Denis and Eric H. wait near me all day for the team of stretcher carriers, who do not arrive. While listening on the radio to the difficulties of removing obstructions with explosives, I mention that I believe myself capable of passing the narrow area out of the stretcher, with assistance.

The plan in the morning was that a caver would accompany into the cave two Cruz Roja paramedics, who would examine me. Notice of the imminent arrival of a doctor from URION changes the plan, and all await his arrival. Unfortunately, a vehicle breakdown delays his arrival a few hours. Mission planning for the various teams is modified significantly. He goes underground in late afternoon with two paramedics and two Quebec cavers and reaches me in about six hours. The doctor finds that I have no fractures and injects powerful analgesic and anti-inflammatory drugs to help me during the carry.

Experienced members of the UNAM caving group arrive at the camp this evening. They are very familiar with the sort of rigging in the cave, which will make them an invaluable asset.

Elsewhere, many Quebec, Alberta, and British Columbia cavers are put on alert, and other cavers have been alerted by the information on the Iztaxochitla mailing list, included some from Puerto Rico, Cuba, Brazil, and even South Africa.

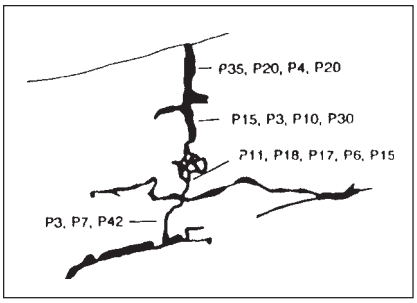
Day 5, December 27. At about midnight, the medical team starts their ascent, which takes about ten hours. The doctor, new to caving, is exhausted after almost no sleep for the past three days.

Surface conditions are difficult. Strong rains have devastated badly placed tents, and the pretty meadow has been transformed into an ankle-deep sea of mud. The long-awaited québécois reinforcements arrive at Tepepa about 10:00 a.m. and set to work. Some help with coordination, some help with camp logistics, and some go underground to inspect the difficulties of the passages. Regulations for obtaining explosives in Mexico are a problem, and the army asks that five soldiers be allowed to assess the need. They eventually agree to bring only three of them the following day, on the condition that we equip them and that we teach them our techniques.

Many teams enter the cave to rig and carry the stretcher. Speed of progress is very variable. Some will spend ten hours carrying half the way, while others will remain at the entrance rigging jammed up at the first rebelay. Teams rerigging the pits go slowly for lack of hardware. In the early evening, ten cavers reach me, five from SQS, four from UNAM, and one from Draco. Ten members of the Red Cross expected to arrive are missing. Stretcher carrying starts about 8:30 p.m. Two québécois rig in front of the stretcher for a half hour, then head for the surface to prepare for another mission. The initial objective of the day is achieved in four hours, with three tyroleans crossed.

Day 6, December 28. The proposed new bivouac site does not satisfy Claude Paradis, so all continue derigging in back and rigging in front. As the hour advances, exhaustion increases. Often nobody is in a key place to grab the stretcher handle, so that on several occasions I run up against the walls or am completely overturned or find myself head down. Occasionally a rescuer loses his balance and runs into stalactites, which fall on the helmet and visor protecting my head and face. At 4:00, the team is met in the passage by two exhausted Cruz Roja cavers who have been lost in the cave since yesterday. They follow behind the stretcher. We arrive at the end of the difficult horizontal section at about 6:30 a.m., after ten long hours of stretcher carrying. Everyone collapses in sleep except Claude, who leaves the cave, preferring to sleep in his tent outside. The impromptu bivouac is made tolerable by the comfortable temperature and everyone's need for sleep.

A fresh team of québécois cavers and UNAM personnel arrives from



the surface between 10:00 and noon. My health being much improved over the past five days, I feel well enough to walk in the easy horizontal parts of the cave. In the afternoon I am accompanied to the base of the pits. I manage so well on my own two legs that I pass over some rigged sections without assistance. As my state improves, I feel increasingly embarrassed. I begin feeling guilty; a walking casualty is not normal, and it will appear ridiculous if I surface cured. My concern is reinforced when I hear of news in the Mexican media about treasure in the pit, hidden explosives, espionage, a false casualty who does not want to come out—in fact, all that one can invent from scanty information coming out of the zone controlled by the soldiers.

On the surface, tension rises because of the number of people, their fatigue, and the difficulties of communication due to both the language and cultural differences and control of information by the Mexican organizations. The Canadian Embassy offers support in dealing with authorities, and a representative visits the site by helicopter. This same person brings batteries, food, and water, which are immediately collected for use by the Cruz Roja. The complex situation is explained to him, and he promises to help, but must leave quickly because of the bad flying weather. All learn that the eight Cruz Roja members missing since yesterday had simply not entered the cave without telling anyone.

In the afternoon, General Juarez of the Mexican army arrives and takes control of the operation. He cleans house, sending home all people not essential for the rescue. There remain only about fifteen civil servants. Nothing more is done without his authorization, including entering the cave.

About 5:00 P.M., two Quebec cavers arrive at the base of the pits with the soldiers they are escorting. At 6:00, the cavers at –200 meters in the Milky Way are alerted by radio that an "elite group" of soldiers is heading for the entrance with inadequate equipment. Their mission is to enlarge the passage with hammers, but they never reach their objective, being stopped by the third pit.

I insist that I can pass through the narrow zone without the stretcher, but the risk of aggravating my injuries is mentioned. The decision is entrusted to the doctor, who gives his consent, and I set off at about 5:00 P.M.

DAY 7, DECEMBER 29. During the night I am hoisted in the stretcher up two pits to the narrow area, where I leave the stretcher. Since I feel well, I suggest a test at the next small pit, and I am hoisted to the top without the stretcher, suspended in my seat harness, slackened to avoid pressure on my wounds and give a higher point of attachment.

It is 4:30 A.M. The plan was to bivouac and wait for a team change to hoist my stretcher to the outside. Now I learn that there are no more fresh rescuers on the surface, because they spent the night rigging the series of pits. I would have to wait twenty-four hours. I therefore convince some companions to continue in the same manner, without the stretcher. Four cavers volunteer for this operation on the condition that we eat first. A good freeze-dried meal is eaten, and we set out again a little after 7:00, after the few remaining obstacles have been rigged. We soon arrive at the part of the cave that has been carefully rerigged for rescue, and from there at –150 meters our progress accelerates.

The elite military group from the day before is soon reached. They offer their assistance, but cannot be very effective because of their lack of experience in vertical caving. They are sympathetic, but do not seem to be aware of the dangers specific to the underground. Most of them are not wearing helmets and do not have ascending devices, so they are stuck at the bottom. They descended by attaching their long 12-millimeter rope to a natural anchor, making it rub a little everywhere along the multi-pit descent, dislodging stones that careened down the pits. They had stopped at the third pit due to lack of rope. Fortunately, 12-millimeter rope tolerates abrasion. They accompany my ascent by free-climbing a pit. Fortunately, somebody brings them ascending gear, so we continue with a quieter conscience. Outside, we are met by a score of other soldiers at about 1:00 P.M.

No cavers are present at the entrance because the soldiers blocked off the area when they heard that my arrival was imminent. After allowing me to walk, closely escorted, halfway to the base camp, they put me on a stretcher to carry me to my tent, where their doctor examines me. Then I was left to spend some time with Sandra, and I was helped to pack by several buddies. The soldiers accompany us to vehicles, where we join Bastien, whose ankle needs care, and Claude. In less than two hours, the four of us, chased by reporters, are taken to Tezonapa, where a twenty-four seat helicopter awaits us on the soccer field. From there, we fly to the military hospital in Puebla, where Bastien and I are further examined. The doctor diagnoses a sprained right hip and a cutaneous infection. He prescribes me antibiotics and anti-inflammatory drugs and gives me my leave. Bastien's sprain is considered to be rather severe, and his ankle is put in a cast. Mrs. Margaret Félisiak of the Canadian Embassy comes to join us at the hospital, helps deal with the formalities, and takes us all to a hotel in Mexico City.

Upon examination in Quebec on January 10, I find that, in addition to the sprained hip that prevented me from raising my right leg and my many contusions and scratches, some infected, I also suffered from a dorsal sprain, a crushed vertebra, and torn muscles in my back. It is believed that I will

recuperate with no permanent after-effects. Five months later, I am starting to cave again, carefully, while undergoing treatments to my back. Bastien still has problems with his complex ankle injury, which is taking a long time to heal and is still being treated.

This cave rescue was the first such large-scale one of a québécois caver in all the history of the Société québécois de spéléologie. It put our emergency plan to the test. It was a remarkable occasion to once again witness the solidarity and the spontaneous aid that is the mark of cavers everywhere. It showed us the importance of good communication and good mutual comprehension to overcome differences of language and culture. Bad luck chose me to be the wounded, since I was one of those with the most knowledge about this section of the cave, one of the best-trained in cave rescue and first aid, and the one who spoke the best Spanish of those cavers on the expedition. One valuable element was the pair of Nicola radio units that allowed continuous contact between the surface and me. Its absence would have made the whole operation very different.

It is practically impossible for me to name here all the more than two hundred people who contributed from near and far to my rescue. I make a point of thanking them all very warmly, those who experienced the difficulties of the operation on site, those who were put on standby thousands of kilometers away in several countries, and those who spent long days taking steps of all kinds to help.

Rescate en la Sierra Negra

Al inicio de la expedición Mexpé 2000 de la Société québécois de Spéléologie a la Sierra Negra, Puebla, Alain Goupil se accidentó durante una caída ocurrida a -300 metros en el Sistema Tepepa. El accidente ocurrió el 23 de diciembre de 1999, y la víctima salió de la cavidad el 29 de diciembre, tras el rescate efectuado por muchos espeleólogos Canadienses y Mexicanos, con la ayuda de la Cruz Roja Mexicana y el Ejército. Para cuando terminó el rescate, la víctima se había recobrado lo suficiente de sus golpes como para ayudar en su propio rescate. Inmediatamente después del accidente, otro espeleólogo se rompió el tobillo, pero logró salir de la cueva sin ayuda.

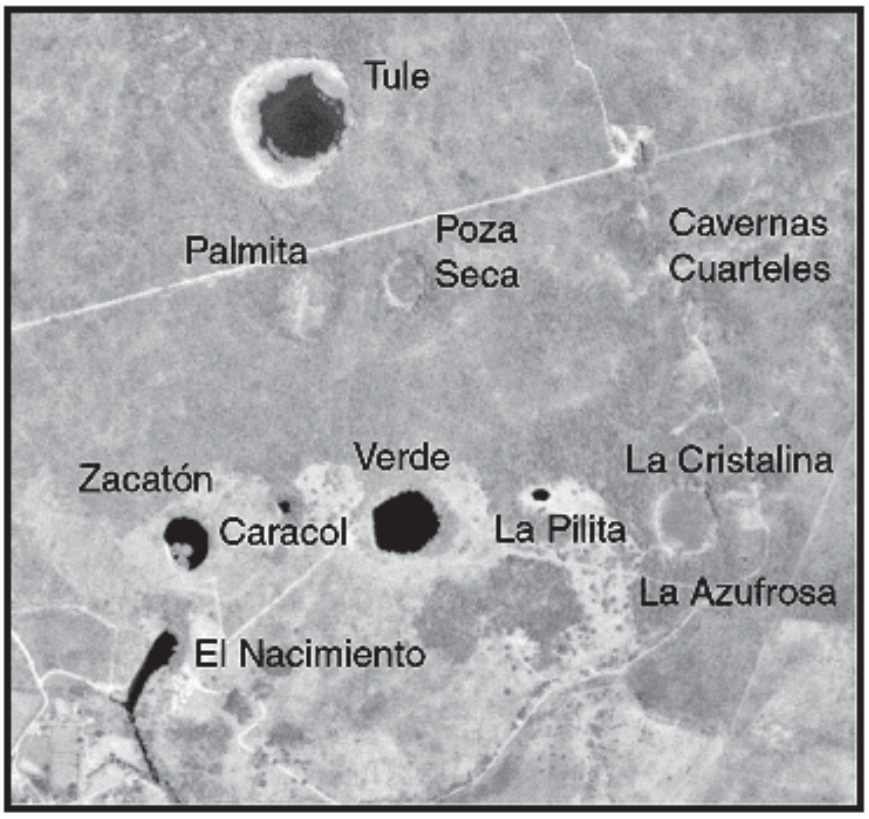
LOS CENOTES DE RANCHO LA AZUFROSA

Marcus Gary

My first visit to Rancho La Azufrosa, Tamaulipas, seven years ago was a time I'll never forget. Jim Bowden and Sheck Exley were preparing to try to reach the bottom of Zacatón, possibly the deepest water-filled pit in the world. Ann Kristovich, Karen Hohle, Mary Ellen Eckhoff, and I made up the support team. (See *AMCS Activities Newsletter* 21.) Diving in the incredible cenotes on the ranch amazed me every time I ventured into their waters. The curiosity I developed that first month at Azufrosa has had a great influence on my life ever since.

The Proyecto de Buceo Espeleológico México y America Central is a small group of explorers that continues to work in the area. Most recently, expeditions have focused on scientific research aimed at describing the incredible karst features at the ranch. This line of hydrothermal springs and pools displays characteristics of a hypogenic karst system, one that forms when deep groundwater is the agent for rapid rock dissolution. Their location is unique, stemming from a combination of geologic conditions that has provided the perfect setting for the formation of deep pits. Karstification processes continue today, as water strips away the limestone and redeposits the material in the form of massive travertine formations. Four expeditions since January 2000 have been intended primarily to collect data to support theories on the speleogenesis of Zacatón and the surrounding cenotes.

The Cenotes de Rancho La Azufrosa, from an aerial photograph by INEGI.



After celebrating the new millennium in Xilitla at Las Pozas, the Birdhouse, with a multitude of other cavers, I joined the rest of our team in camp at Rancho La Azufrosa. The January 2000 group included Jim Bowden, Ann Kristovich, Karen Hohle, Liz Hunt, and Mellie Price. We spent six days on the ranch diving, collecting water data, and searching for undocumented karst features. Most of the diving on this trip was done at La Pilita, a 110-meter-deep cenote on the ranch. The shore of this water-filled pit is also the site of our camp on all expeditions. Warm, 88-degree F water made for wonderful swimming in the cool winter temperatures experienced during the week. Bowden, Kristovich, and Hunt all made deep dives here, reaching the bottom several times. These were primarily training dives intended to build up nitrogen-narcosis tolerance.

One day was spent diving into Zacatón, but water conditions were less than ideal. Visibility in Pasaje de la Tortuga Muerta, which leads to the deep cenote, was less than three meters. Bowden and

Kristovich dove through the cave and surfaced in Zacatón. There, they discovered visibility to be poor, but they still made a dive to 85 meters depth. On their return trip through the Tortuga Muerta passage, dive lines were removed for safety reasons.

Basic water-quality parameters were collected at Rancho La Azufrosa during a two-day period, using a Hydrolab multiprobe instrument. This is a versatile piece of equipment that can be used in a wide range of conditions, and it proved ideal for data collection in the cenotes. Readings were taken at all of the major cenotes—Zacatón, Caracol, Poza Verde, La Pilita, La Azufrosa, and Cristalina—as well as the resurgence from Zacatón, El Nacimiento. The measurements confirmed that the water in all but Verde is acidic and substantially warm. The lack of dissolved oxygen in the acidic waters was also seen in this first set of data.

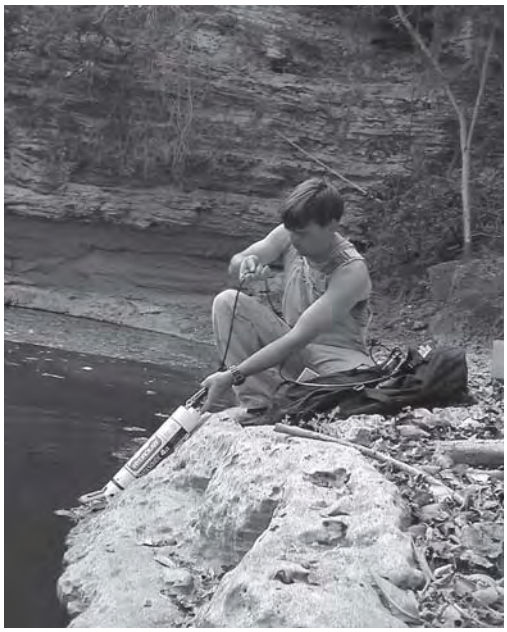
On a reconnaissance trip in the northern part of the ranch, our team discovered a new large cenote, but this one had a solid travertine floor. Karen Hohle and her husky Mante found the sinkhole after dodging a rotting goat corpse. Since we had no idea what the local name of the feature was, we temporarily called it Cabra Muerta. Later, we discovered the true name was Poza Seco, or Dry Well. It truly is a dry well, as only a small pool of water less than a meter in diameter exists here. Liz Hunt and I later returned to collect information on the water in the cenote, and as we walked across the flat floor around the perimeter, it sounded hollow, with a thumping sound.

The flat travertine floor of Poza Seca is densely covered with an *acacia* shrub. *Marcus Gary.*

In March 2000, our team returned to Rancho La Azufrosa with some new faces. Four cavers from the University of Texas Grotto joined Bowden, Kristovich, and me to help with the work here. Aimee Beveridge, Andy Grubbs, Robin Havens, and David Turner were primarily interested in surveying the dry cave passages that are nearby. Cavernas Cuarteles lies in the northeastern corner of the ranch and is a relatively level series of rooms and tunnels, frequently interrupted by skylights. After three days of surveying, over 700 meters of passage had been surveyed in Cuarteles. Huge collapsed rooms where *higueron* trees grow up through the openings characterize the upstream portion of the cave. Downstream the cave gradually narrows, although it was still walking passage as far as the survey went during this trip.

Cavernas Cuarteles appears to be heading directly toward La Cristalina, a crystal-clear pool along the edge of Cenote Azufrosa. La Cristalina was dived by Bowden and Gary Walten in 1990, but the passage soon closed to small dimensions that limited exploration to only 50 meters. It seems quite likely that La Cristalina is a discharge feature of a shallow groundwater system that incorporates Cavernas Cuarteles.

While surveying was being conducted in Cuarteles, Bowden, Kristovich, and I made preparations for a deep dive in Zacatón. Jim planned a dive in the 170-to-200-meter-depth range, since conditions looked much better than they had during the previous trip. Two days were spent in camp at La Pilita configuring gear, running decompression tables, and making acclimation dives to 100 meters.



Marcus Gary collecting water-chemistry data at Caracol with a Hydrolab multiprobe. *Robin Havens.*

On our third full day, equipment was ready to transport to Zacatón. Ann and I dove through the Pasaje de la Tortuga Muerta and surfaced in Zacatón. Jim lowered his stage bottles from atop the 20-meter cliff that separates the water from the land surface. Grubbs and Turner assisted him, while Beveridge and Havens helped with gear transfers on the water surface, paddling a kayak that had been lowered into the pit past a massive killer-bee hive. Luckily, only one bee sting was experienced, and we were able to ready all the diving equipment. A down-line was dropped past a depth of 200 meters, and then Ann and I placed decompression stage bottles down the line at various depths for Bowden to use the next day on his deep dive.

With everything in place, Bowden made a deep, mixed-gas dive into Zacatón the next day. He made it to –170 meters, where observations of the rock walls were made. No problems occurred during decompression, and Jim surfaced after being underwater just less than four hours.

The final day was spent breaking down equipment in camp and collecting water-chemistry data. Andy Grubbs and I made measurements

WEST

LOS CENOTES DE RANCHO LA AZUFROSA

EAST

Marcus Gary, The University of Texas at Austin - Department of Geological Sciences


Photo by Ann Kristovich

EL NACIMIENTO


Photo by Ann Kristovich

EL ZACATÓN


Photo by Robin Havens

POZA CARACOL


Photo by Robin Havens

POZA VERDE


Photo by Ann Kristovich

POZA LA PILITA


Photo by Robin Havens

LA AZUFROSA (La Cristalina)

Pasaje de la Tortuga Muerta

30°C

31°C

?

25°C

?

32°C

34°C (27°C)

? ?

? ?

X

X

X

100 m

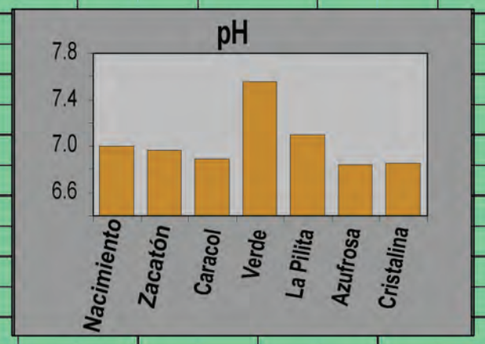
200 m

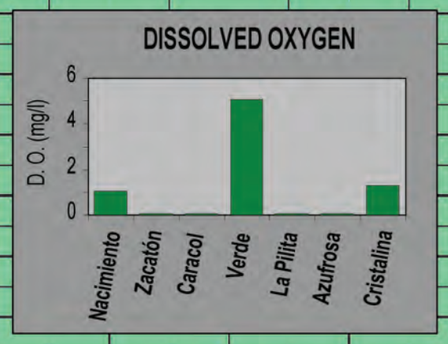
300 m

100 m

200 m

300 m






Biomat coating along the walls of La Pilita. (Photo by Marcus Gary)

X Extent of SCUBA exploration.

Zones of biomat coating.

Areas of secondary travertine deposition.

0 m 200 m 400 m

Large *higueron* trees near the entrance to Cavernas Cuarteles. *Robin Havens.*

with a Hydrolab minisonde at Zacatón, Caracol, Verde, and Azufrosa. Data were collected at intervals of 10 meters depth, and a bottom was reached at all locations except Zacatón, where we reached the instrument's limits at 200 meters depth. These measurements revealed that the waters of Zacatón and Caracol are primarily homogeneous, with only a thin surface layer showing any difference from the rest of the water column. Except at the surface, virtually no dissolved oxygen is present, the temperatures are constant (29°C at Zacatón and 30°C at Caracol), and pH is a slightly acidic 6.9.

Verde is substantially different, much more like a typical body of water. Significant changes are encountered, as dissolved oxygen is quite high at the surface and gradually decreases with depth. Small thermoclines are encountered, and the pH is a much more basic 7.6. Azufrosa proved to be the warmest cenote, even though it is only a small pool 1 meter deep. Like at Zacatón and Caracol, the water is acidic and anoxic, and it has a strong odor of sulfur. La Pilita was measured the next day, as we were packing up camp. The water there is most similar to Zacatón and Caracol, being homogeneous from the surface to the bottom at –114 meters.

Following a series of last-minute changes of plans, a small team made it to Rancho La Azufrosa in January 2001. Jean "Creature" Krejca, Vivian Loftin, Robin Havens, and I arrived at the ranch ready to get to work. Since Creature and Viv would be able to stay only a few days and they had hauled most of the tanks and compressor, we decided to do most of our diving at the beginning of the trip. One of my primary objectives on this trip was to collect some underwater core samples of the travertine surrounding La Pilita. This process involves using a drill powered by air from scuba tanks to turn a diamond-tipped coring bit that is 5 centimeters in diameter and 50 centimeters long. Two cores were drilled, one at 1 meter and one at 6 meters, and successfully recovered.

The first week was unseasonably cool, so the four of us took a day out of the water to return to Cavernas Cuarteles. Here we completed the survey, adding another 260 meters. At the end of the surveyed passage, one more room remains unexplored because it was inhabited by thousand of free-tail bats, making the air quality very poor. During the survey, the positions of the skylights in Cuarteles were determined from above using a Garmin GPS receiver.

More diving was done the next day, as Krejca and I swam into Zacatón through the Pasaje de la Tortuga Muerta. Once there, we observed the colorful biomats that coat the walls of this massive sinkhole. After returning back through

Marcus Gary drillling cores in the travertine surrounding La Pilita. *Robin Havens.*

the passage, we met Havens and Loftin, who had been diving in the basin and entrance of the resurgence.

Creature and Viv returned to Texas the next day, leaving only Robin and me. For such a small team, we were able to get a lot accomplished in the next eight days. One of our first tasks was to collect GPS data on all the important karst features. The perimeters of each of the cenotes were traced, either on foot on by kayak, and GPS positions were collected at 10-meter intervals. This information is important for creating accurate digital maps. These maps can then be used with other information, such as satellite imagery, that is referenced to geographical coordinates. The gathering of the GPS data was spread over the rest of the trip.

One day the resident ranch hand, Nacho, gave us a tour of the entire 37,000-hectare ranch on horseback. During a day in the saddle, many new discoveries were made. A beautiful *ciénega*, or wetland, lies on the southern part of the ranch. Here, crystal-clear springs emerge from old travertine deposits, and the water flows into broad swamps filled with many species of waterfowl. One of the springs seemed a promising dive site, since there was a substantial volume of water flowing from a cave entrance. We noted its location and continued on our equestrian tour.

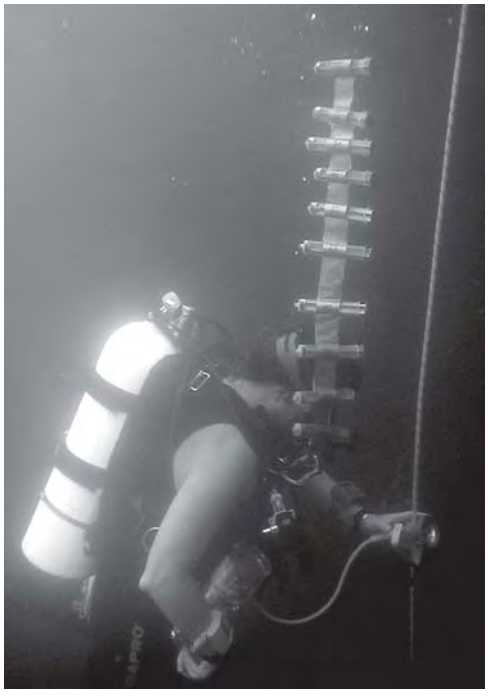
The next major event of the day was a visit to Cenote Tule, which lies on the ranch directly north of Rancho La Azufrosa. Nacho led us over the fence and down a trail to the largest sinkhole, in surface area, that I have ever seen. A huge fortress of spiked acacia shrubs and dense reeds surrounds the large body of water in the center, however. We chopped our way around the northern perimeter of the cenote until the vegetation got so thick it was virtually impassible. It was time to turn around and get the horses back to the ranch anyway, so we headed back.

Marcus Gary surveying at the entrance to Caverna Travertina. *Robin Havens.*

The next day, we returned to the spring at the *ciénega* with some diving gear. Unfortunately, Creature and Viv had left with most of the tanks, and there was only 450 pounds pressure left in one of my tanks. But it was enough to get in a dive in the entrance. Here, the ceiling and floors were nothing but massive travertine structures of stalactites, stalagmites, and flowstone. The walls pinched off 15 meters back into cracks that I could not pass with my back-mounted tank. I went out and let Robin go in for a brief look. The visibility had remained quite good even with our swimming around in the tight room, so I looked forward to returning with side-mounted tanks to explore a little more thoroughly.

The last few days of this trip were spent collecting water samples and taking field measurements at each of the cenotes. Samples were later analyzed in the lab for major dissolved elements. The level of dissolved sulfide in the water was also measured in the field. Azufrosa, 0.36 parts per million, and Caracol, 1.02 ppm, were the only two that had levels within our detection range.

Ann Kristovich collecting water samples for sulfide analysis at La Pilita. *Marcus Gary.*



Two months later, in March 2001, I returned to Rancho La Azufrosa with Robin Havens, Jim Bowden, Ann Kristovich, and Karen Hohle. We spent a relatively relaxed five days diving and collecting data. One of the main accomplishments during the week was acquiring vertical sulfide concentration profiles in Caracol and La Pilita. Caracol showed a peak concentration at –60 meters, and sulfide was not detected in La Pilita down to –70 meters, which was as deep as the water was sampled. Although we did not measure sulfide at La Pilita, the smell of rotten eggs at the surface is a good indication that hydrogen sulfide is being outgassed. A higher-resolution instrument will be needed to quantify the level of dissolved sulfur here.

I returned to Caverna Travertina

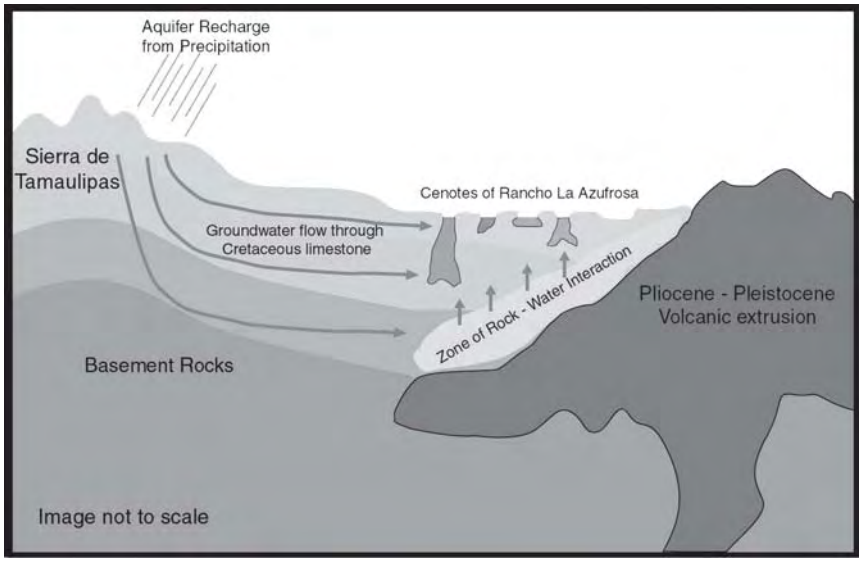
with small side-mounted tanks to see if any passages existed in the tight cracks of this spring. The flow was much lower than earlier in the year, and a layer of fine silt had collected on the floor of the cave. We had planned to photograph the entrance room, taking advantage of the crystal-clear water, but the easily stirred up silt thwarted that. Diving alone, I squeezed through the travertine formations that make up the entire floor and ceiling. Ahead of me, water clarity was good, with visibility of 1 to 2 meters, and I noticed large turtles flashing by every now and then. Finding a gap in the flowstone formations, I pushed into a domed room about 2 meters in diameter. There, all the turtles that had been buzzing me were huddled together, hovering at the back of the room. When my bright dive-light illuminated them, they scattered and started to swim out in a frenzy. Unfortunately, I was blocking the exit. Only a small space above my head was open, and they aimed for that area. It was a good thing I was wearing a helmet, for more than one of the turtles smacked squarely into my head and violently clawed its way by. I checked out the now-vacated room and saw no passages. No leads were observed anywhere in the cave, and a complete survey will be conducted during higher flow, when visibility is good.

Later in the trip, Kristovich and Bowden dove through El Pasaje de la Tortuga Muerta into Zacatón and made a dive there to 85 meters depth. The goal of this dive was to determine the extent of the biological mats that cover the walls there. The algae and bacteria that make up this biomat appear to be phototropic, as the walls were devoid of coating below –35 meters.

On the way back to Texas, Havens and I stopped in Ciudad Victoria and picked up some aerial photographs at the IENGI office. On them, six unexplored water-filled cenotes and four new travertine-filled cenotes in our area were identified. Of the water-filled group, Tule looks like a promising dive site. A dark, deep area is apparent in the center of this largest sinkhole. Many days of challenging logistics at Tule will test our team's ingenuity and stamina before we will be able to explore its depths.

Robin Havens checking out the *ciénega* at the southern edge of Rancho La Azufrosa. *Marcus Gary.*

The geologic history around Rancho La Azufrosa is favorable for deep-seated karstification. Thick beds of limestone were deposited during the late Cretaceous, when the Gulf of Mexico covered the area. Following aerial exposure and lithification, these limestone beds were uplifted during the Laramide Orogeny, about forty million years ago, forming the Tamaulipas Arch, a 200-kilometer-long domal anticline that makes up the Sierra de Tamaulipas. The axis of this structure is immediately west of Rancho La Azufrosa. By the late Oligocene, volcanic intrusions began to dissect the Sierra de Tamaulipas. Then the extensive volcanic field around Villa Aldama became active in the late Pliocene, producing basaltic lava flows throughout most of the Pleistocene. During this period of volcanism, thick deposits of travertine were deposited from springs discharging hot, mineralized water.



These conditions have allowed meteoric groundwater to mix with the rock in the Villa Aldama volcanic intrusion, resulting in deep-seated hypogenic karst. The resulting massive collapse structures are nearly circular and lie together within a fairly small area. The cenotes are among the eighteen circular karst features that have been identified in a 7-kilometer distance. Of these sinkholes, eight have evolved into shallow dolines that have floors of travertine. The closed cenotes were once deep, open sinkholes that were most likely water-filled. A shift in the local geochemistry as volcanic activity cooled down caused precipitation of calcite in the form of thick deposits of travertine. These travertine-filled sinkholes are now densely covered with vegetation, which is often flooded during the rainy season.

The karstification processes taking place at the active cenotes includes the action of microbes that may be

processing dissolved sulfide in the water to produce a hyper-acidic zone along the walls. Initial field and laboratory data indicate that these biocoatings may, in fact, contain sulfur-oxidizing bacteria capable of producing sulfuric acid, which then dissolves the limestone host rock. A much more thorough analysis will be required to verify this hypothesis.

Some of the individuals and organizations that have played a critical role in these early stages of research at Rancho La Azufrosa are Jim Bowden, Ann Kristovich, Alejandro Davila, Robin Havens, Becky Sikes, Hydrolab Corporation, Austin Aquasports, and Jack Sharp at the University of Texas Department of Geological Sciences.

Los Cenotes del Rancho La Azufrosa

Desde enero de 2000, el autor ha estudiado la geología y la química de las aguas de estos profundos cenotes en Tamaulipas. El agua es termal y sulfurosa. El diagrama muestra la temperatura, pH y nivel de oxígeno disuelto en los cenotes. Algunos de los cenotes presentan pisos formados por depósitos masivos de travertino. Se piensa que la naturaleza agresiva del agua en estas grandes formas kársticas es debida a la reacción entre las aguas pluviales y rocas volcánicas relatívamente recientes de Villa Aldama. Algunos de los cenotes presentan áreas cubiertas por grandes masas de materia orgánica en las paredes, que pueden incluir bacterias que oxidan el azufre, produciendo ácido que acelera la disolución. Caverna Cuartéles, una cueva fósil en el rancho, presenta muchas claraboyas y tiene cerca de 1 km de largo.

Cenotes of the Riviera Maya. Steve Gerrard. Published by the author, Puerto Aventuras, Quintana Roo, Mexico; 2000. 8.5 by 11 inches, 244 pages, softbound. ISBN 0-9677412-0-3. $49. May be ordered from Riviera Maya, PO Box 768, Placida, Florida 33946; add $4.95 for U. S. shipping, $14.95 outside the U. S.

The short stretch of Quintana Roo's Caribbean coast south of Cozumel, through Akumal and Tulum, is turning out to be one of the most cavernous areas on earth. Virtually all the cave passage in the area is under water, but that has not prevented the exploration and survey of some 350 kilometers of cave, including three systems more than 55 kilometers long. It is hard to keep up with the actual lengths, because it is not uncommon for a project in the area to survey a mile of virgin cave a day. (One suspects, though, that the sketches aren't too wonderful.) Much of the cave passage is well decorated by speleothems deposited when water levels were lower during the ice ages.

This book is a visitors' guide to the caves and their cenote entrances. The descriptions of the sixty-odd caves or cave systems and their many entrances are in outline form, with at most brief descriptions and no cave maps, but the information includes locations and access policies. The book also contains sections on safety and training, as well as analyses of the known cave-diving accidents in Quintana Roo. Probably most attractive to the non-diving caver are the numerous nice color photographs, about one per page, with many full-page or larger. Some cavers may be a bit put off by the fact that the book is obviously intended to promote recreational cave diving in the area, which has hotels, dive shops, guides, and instructors catering to the cave-diving trade. But the cave-diving community, unlike ordinary, dry caving in North America, has a long tradition of professional training, which has significantly reduced the fatality rate, and other commercial involvement.

Not cheap, but worth it for the beautifully illustrated introduction to a spectacular and unusual caving area.—*Bill Mixon*

SISTEMA EHÉCATL-XALLTÉGOXTLI: A NEW –700 IN THE SIERRA NEGRA

Ramón Espinasa Pereña and Chris Lloyd

In December of 1989, Ruth Diamant, my brother Luis, and I, all members of Sociedad Mexicana de Exploraciones Subterráneas, took part in Mexpé IV, a Société québécoise de spéléologie expedition to the Sierra Negra, in the state of Puebla. Based first from the town of La Cumbre and later from the town of Tepepa, the Quebec cavers had explored, since 1988, several large pit systems, including Sótano de los Planos, over 600 meters deep, and Sótano de Alhuastle, with an underground pit 329 meters deep, as well as two parallel cave systems, Sistema Tepepa, almost 8 kilometers long and 730 meters deep, and Sistema Ehécatl (also known as Sistema de Ángel), 5 kilometers long and 533 meters deep. On Mexpé IV, we participated in the connection of a new entrance, Nelfastle Tlacuatetl, near the bottom of Sistema Tepepa and surveyed upstream in the main river of Sistema Ehécatl for about 1 kilometer. On that same expedition, two other inlets were surveyed in Ehécatl by the SQS, bringing the total to over 8 kilometers. A new cave, called Brumas, was also explored by the SQS to over 3 kilometers and 380 meters depth, and it was located in the direction of the Ehécatl inlets.

Halfway through the expedition, while looking at the maps, I was very intrigued by the canyon of Huitzilatl, towards which the Ehécatl system was heading. Marc Tremblay, one of the Quebecois, was also interested, so on our last days in the Sierra Negra we decided to take a look. We were delighted to discover two large caves, both known as Xalltégoxtli, one of them an active resurgence and the other the obvious continuation of the previous one before the cave was bisected by the surface canyon. In two days we surveyed 1 kilometer upstream, through several long lakes to the base of a brutal cascade, unclimbable with the means at hand, going straight towards the bottom of Sistema Ehécatl, and another kilometer in the fossil, downstream cave, through some highly decorated sections. We left many leads.

Since then at least four SQS expeditions to the Sierra Negra have been fielded at the town of Tepepa and have concentrated on further pushing Sistema Tepepa, which is now over 10 kilometers long and very close to 900 meters in depth. Some of these trips have also attempted, without much success, to find caves on a higher plateau farther west than the areas probably drained by Tepepa and Ehécatl. However, Sistema Ehécatl, Brumas, or the Xalltégoxtli caves were not revisited for over ten years. (A plan map of the two Xalltégoxtli caves appears in Mexico News in *AMCS Activities Newsletter* 20.)

On the other hand, other groups have been active since then in different portions of the Sierra Negra. In 1988 the British Black Holes Expedition, in which I took part, explored nearly 8 kilometers in Cueva Yohualapa, a resurgence near Tlacotepec de Díaz. Since 1989, the Grupo Espeleológico Universitario, based in the town of Iztaxochitla, started exploring the northern side of the Sierra Negra with relative success; their best find to date is El Encanto, over 3 kilometers in length and over 500 meters in depth. Since 1992, Mauricio Tapié of the SMES and members of the Asociación de Excursionismo del Instituto Politécnico Nacional have been exploring Sistema Tepetlaxtli, located east of La Cumbre, to over 500 meters deep and nearly 5 kilometers long. Sótano Tapoztotl, located near Tlacotepec de Díaz, was explored in 1990 by Mauricio and Pablo Tapié to 348 meters deep.

After many unsuccessful attempts to convince Marc Tremblay to return to Xalltégoxtli, we finally decided to organize an SMES expedition in Easter 1999.

—Ramón Espinasa Pereña

The seed had been planted some eight years previously and had lain dormant since then. But while on our annual Dos Aguas Expedition at Christmas 1998, we were kicking around ideas on where to go for our Easter-week break, and Ramón finally decided it was time to revisit what was to become known as Ramón's Most Amazing Cave—beautiful active river passages, large, well-decorated fossil passages, aragonite bushes, 2 kilometers of survey, and with over 2 kilometers straight-line distance and 300 meters down to the resurgence still to go and an 8-kilometer-long, 533-meter-deep cave just upstream to connect into. It had it all. It just happened to be a thousand-kilometer drive from my house.

Logistics were, as usual, left to the very last minute, with the final team membership still not known

twenty-four hours before departure time. I knew that I was going, along with Vicente Loreto from Guadalajara, and we had tried to convince British caver Nick Hawkes to come with us, but he was still up in Chihuahua on the Friday morning before our planned 7:00 A.M. departure Saturday from Ramón's house in Mexico City. Fortunately he hadn't forgotten, and he called me Friday morning to check on things or, more to the point, to be convinced that it was worth his wrangling permission from his wife to go. So I worked on him off and on through various phone calls during the day, with the result that by 5:00 P.M., when I planned to depart from Guadalajara, he committed to going, but he could not leave until 10:00. So it was that we arrived at Ramón's house at 5:00 Saturday morning.

Saturday's departure from there was fortunately a bit late, too, allowing us a couple hours more sleep before heading east past the smoking volcano down to the Veracruz coastal plain. Along from Mexico City were Ramón, his wife Ruth Diamont, Francisco "Curro" Ruiz, Sergio Nuño, and the Castillo sisters Iztaccíhuatl and Illiniza. We reached the end of the road, at Zacatilihuic, in the afternoon, just in time to organize mules for the following morning. For a modest tip, we were given the local school to camp out in, and we were treated to the first rainstorm in about two months not minutes after being told by one of the locals that this was not the time of year for rain and that those big, nasty, black clouds weren't going to amount to anything.

Seven o'clock came all too early. The mules were loaded, and off we went, under crisp blue skies. The whole of the Sierra was visible, and it was clear that a lot of the upper area that Belgian cavers had explored had been burned in the fires of 1998. Finding entrances up there would now be a whole lot easier. From just out of town, a huge black hole that must be at least 30 meters wide by 40 meters tall was seen across the valley. This turned out to be the Belgians' main resurgence cave, and it had been mapped for 20 kilometers. Two hours of slightly up-and-down trail brought us out at the cavers' chalet of Don Rutilio Fierro at Huitzilatl. Unfortunately he hadn't been maintaining it, and besides we were now nine people, and so we headed up to camp in the entrance, as I had been planning all along. Another two hours got us and our gear installed in the ample entrance. The name Xalltégoxtli means Cave of Sand in the local Nahuatl language, because they used to haul sand out of it to mix with their cement, there being no other source of sand in the valley. We used what was left of their sand pile to make flat sleeping areas and settled in. The cave was blowing out a nice comfortable 16° C wind, which was a respite from the heat building outside.

The majority opted to do a slow trip in to get to know the cave and see the pretties and maybe push the main fossil route. I talked Vicente into trying to connect the two parts of Xalltégoxtli by way of a climb noted by Ramón on his previous survey. This was really laziness on my part, as the climb was right by camp and I counted on Vicente doing the actual climbing. So while the rest of the group went right, on into the cave, we went left into the bypass series. Out of curiosity, we popped down into the sump along the way and noticed that it had a lot of air flow. It also looked like it had dropped a lot since the previous visit. It looked so good, in fact, that we decided to go back and change into shorts to go for the swim and see if it connected. I was the book person and reading instruments, so Vicente got the honor of testing the waters and dragging the survey tape through. Sure enough, it was only 10 meters across to the other mud bank, and out he walked into the other cave, now this cave. One survey shot and we doubled the length of the cave. I didn't even have to get wet.

That project completed, we set off to look for the presumed active downstream route, also conveniently close to camp. A narrow chimney that had been noted by Ramón led us down into a passage with picturesque calcite-rimmed pools. Water dripped down from stalactites and continued downstream over gour dams and big flowstone drops. Pool, drop, pool, drop, all of it picture-perfect. We ogled our way down this until we came to a drop that would have required swimming at the bottom; we had changed back out of our shorts and left the survey gear behind. This was certainly going to be a gem to push. We spent the rest of the afternoon pushing climbs in the roof around the top of the chimney. The cave just seemed to go off in every direction, and we still hadn't gotten more than 100 meters from camp.

Ramón and gang had meanwhile gone to the end of the previous survey, only to find the main passage

Early morning in base camp. *Chris Densham.*

closing down into a mud-bowl section not enticing to push. So they back-tracked a bit and climbed up a 10-meter-high flowstone into a large side passage. It ran along up and down, 5 to 10 meters wide, to end at another 10-meter-high flowstone climb. Numerous aragonite-encrusted calcite stal decorated the way, along with an abundance of spaghetti-like helictites. Not a bad start to the week.

Monday was the first day I could finally say I awoke well rested, and off went three different teams. Vicente and Nick were talked into going upstream to see if they could pass the Brutal Cascade and see what difficulties were beyond. Ramón commandeered the beautiful active downstream with Curro and Ixta, while I took a team to push the climb at the end of the new fossil section. Our first order of business was to repeat the first climb, which was now a little mud-slicked from seven people doing it the day before. Ruth scampered on up and threw down a rope for the rest of us to use as a hand-line, and we Bat-Manned our way up. The 350 meters of passage they had netted on their stroll yesterday was indeed quite lovely, but not, in my opinion, quite up to its promotion, because most of the stalactites and helictites had a slight brown smudging on them, as if dust from the ample air movement was being caught up in their formation. (I was duly chastised for my comments and forbidden to mention the Lechuguilla word for the rest of the week.)

Our first goal was a pit off the side of the passage that was about 8 meters deep and had a tall rift going off in two directions. I rigged it, and Ruthy dropped in to find that it quickly turned into crawls both ways. Not this year. We continued on to the end of the previous day's exploration, and Ruthy dispatched our intended climb and graciously threw down another rope for us. This put us into a continuing large passage, with stal poking up and down all over the place. The way on led up yet another steep flowstone climb, which Ruthy had to do in her socks to get a better grip. It unfortunately pinched out in a flowstone block, calling for a retreat and a few photos.

Not wanting to believe this way on could end, we poked into the holes around the base of the climb, and Ruth climbed down into one and disappeared. Eventually we heard her faint voice rising from a different pitch, but we could not guide her back to the one she had gone down. The word was, once she had made it back, that the way on was "a bit complex." But a way on was what we were there for, so down we went, surveying through steep rifts that dropped down in strange directions. After the initial narrow stuff, the passage opened up into a 4-meter-wide and 10-meter-tall passage that had to be traversed with care, as there was no flat floor. It went down to a sump that Ruthy wisely decided not to go into, since it looked like she would need a rope to get back out. Before heading out in retreat, I climbed up above the hole Ruthy had led us down and found that the air actually went up into a continuing rift. I didn't check it out very thoroughly and sent Ruth ahead with the tape, only to have her call back that there was a 20-meter pitch ahead that I must have looked right across into large, going passage on the other side. As we lacked the needed rope, this seemed like a reasonable place to call it a day.

Ruth in the Hyperspace.
Ramón Espinasa.

The upstream team had been successful in getting past the Brutal Cascade and had followed some "very sporting" stream passage, with the raging water right beneath hand or foot, that climbed up very steeply. The others had followed the active downstream route, gone only one pool past were we had been on Sunday, and turned around because some of them didn't want to get wet, despite being told that we had left it at a swim.

After much badgering, I agreed to let Ramón have another crack at the active downstream on Tuesday, although I figured that by preempting it the previous day and then failing to push it he had lost his exploration rights. But there was the active upstream that sounded even more exciting to push and survey, so I convinced Vicente to guide for Ruth and me, and we managed to set off well before noon, expecting a long day. This was just as well, since Vicente managed to get us lost within 100 meters of the entrance, before even getting to the active streamway. To be fair, the size of the entrance section was rather overwhelmingly big, and going under the house-size boulders as opposed to over them seemed like a reasonable thing to do at the time. We got a weird surprise as we were climbing down through these blocks and found an overflow rift with a pool of water in it. Staring up out of the pool was a set of gleaming eyes. They could have been a cat or some such thing, but after they did not move while Ruth caught up to us, we figured we'd approach more closely to see what it was. It turned out to be the reflector from Vicente's headlamp, which had fallen off yesterday when he was climbing over the top of the pool. So we weren't lost after all; it just wasn't the best route to get to where we wanted to be. Once into the streamway, we were quickly forced to swim a series of long canals. A 200-meter one

was shortly followed by a 150-meter one and numerous other, shorter ones, before we popped out into some lovely tall, 15-meter-wide canyon passage with only ankle-deep water, flowing over gravel. Delightful. It had rained yesterday afternoon, and Vicente was surprised to see a waterfall that hadn't been there the day before falling from the roof of one chamber. The Brutal Cascade was soon reached, and the rope was a nice psychological aid to climbing up the wall beside the raging cascade, much larger than it had been the day before. Ramón had been here previously, over Christmas, when it rained almost every day, and the water then fell half way down and bounced out off of a ledge, actually preventing them from even getting near the climb. At this time of the year it was simply very noisy and intimidating, but quite doable.

The size of the passage, 2 to 4 meters in diameter, was ample, but not as big as the previous swims, and here the water continued to pound down with an incessant fury. We weren't sure what we were more scared of, taking a fall as a piece of the incredibly eroded rock broke under our weight, being dumped into the stream and pummeled to little bits, or both. The climbs were steep and in places actually overhanging, but fortunately the rock was really quite solid, despite being eroded into ribbons less than a centimeter thick in places—you just didn't use those places.

Ruth lights the first lake in the Gours Passge. *Ramón Espinasa.*

The surveying went well and took us through the big chamber they had found the day before. But from the description we had, there shouldn't have been a lake on the other side, and besides we hadn't gone the required 300 meters. So we plunged on into the lake, a wade as it turned out, and continued on into steeply climbing passage. The walls now varied between solid bedrock and house-size boulders, with holes going off everywhere. We followed the stream as best we could to a point where it created a waterfall that looked impassable, coming out of a flat bedding plane. We spent almost an hour looking for a way around it and finally surveyed up into a probable bypass with a big room visible beyond, but one that required a rope to enter. That seemed like a good place to turn back. On the climb down, I spotted an opening that went in right above the waterfall and immediately popped up into the same big room. A quick look around showed that the stream came out of a sump there, and the strong airflow we had been following, along with the water, was nowhere to be felt. Though the air obviously had to go somewhere around here, we left it for a another day. Our hoped-for easy connection to Ehécatl was apparently not going to be easy.

Meanwhile Ramón and team had taken the plunge and pushed the active downstream for a 700-meter survey day, having gone down an 18-meter pitch to a gorgeous rift passage called Jug Alley, where bizarrely eroded rock provided many handholds for climbing around very deep pools of crystal-clear water and which ended at the edge of a 30-meter pitch. Below, a large, mud-floored borehole was followed to a T junction. Going left, they entered the Snakes and Ladders Rift, leaving it still going.

Wednesday turned into a rest day

for everyone, and Nick and Curro left early to regain the favor of their spouses. This reduced the team to seven people, and on Thursday Vicente and I took the two Castillo girls on a photo trip. We first hit the active downstream to get the gours and flowstone drops, and then we went up into the fossil section, mainly snapping pretties in Hyperspace, a profusely decorated chamber on the main route. On the way back, I checked into a bunch of side leads off the main route in an effort to get the map up to date. Meanwhile Ramón took Ruth and Sergio down the active downstream on a long, slow push trip. They only managed to add about 150 meters of passage and were all intimidated by the loose rock and the amount of climbing required. Mind you, if they had taken more than one piece of rope, as we recommended, they could have avoided some of that. Climbing down pitches is not to be recommended anywhere, let alone where the rock is crumbly. As they figured this was going to be a major effort to push, they derigged, knowing nobody was going to want a really long day Friday before our early departure on Saturday. Yeah, we're all getting soft.

Friday was to be our last chance to connect into Sistema Ehécatl, and Ramón was the one talked into going up, with Ruthy and Vicente. I decided to push with Illi some of the side leads I had checked the previous day. The other two, *really* soft, rested up for the departure on Saturday. It wasn't much more than 300 meters from camp that we stooped through a low opening and popped up into a large chamber that hadn't been explored before. We surveyed into an 8-meter-long room with a large, sloping sand-bank heading up and up. After passing the bony remains of some rodent, we climbed steeply into a narrow rift. After hitting a T junction, we tied into one of Ramón's original survey markers from 1989. We then followed the outlet streamway, now dry, which started as nice walking, but quickly degenerated into a crawlway. Fortunately it just as quickly opened back up again, justifying the steady airflow. Soon it began heading down with a vengeance. As Illi was out front with the tape, I was letting her call the shots on whether we should continue, but down-climbing was not going to turn her back. She chimneyed down a 1-meter-wide chute and said that it still looked reasonable. She didn't mention that it was an undercut, vertical down-climb with another 5 or 6 meters to the floor below. But as she had disappeared down it, I had little choice but to follow.

Below and horizontal again, it looked like it was opening up, though the going was still slow, as the rock was incredibly eroded, with bits sticking out here and there that had to be passed slowly. Sure enough, just when it got big enough that you didn't have to brush against the projections, it went vertical again. We had emerged near the top of a 2-to-3-meter-wide rift that was 10 to 15 meters high. At the bottom could be seen a slowly flowing stream. It was so tempting to climb down into it, but the rock was now just like Ramón had described it in the other downstream route, really rotten. So we turned around, leaving a completely new flowing stream to follow for next year.

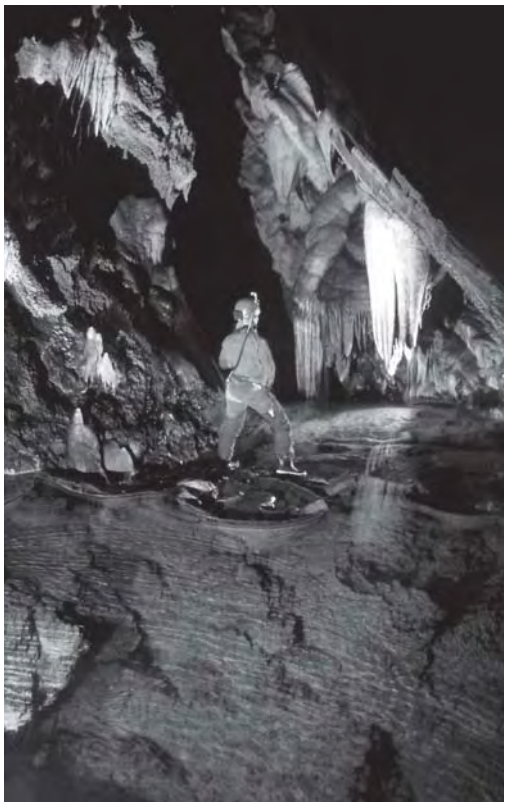
The news that we were all really waiting for, though, was what happened upstream with Ramón's team. They returned after dark with news that things were pretty complicated up there, and the air flow had finally been followed to a small hole that easily blew out their ceiling burners. As it needed enlarging, it had to be left for next year.

The week joined the two Xalltégoxtli caves together and made a 4160-meter-long cave with 220 meters of vertical relief (+90 m, –130 m). —*Chris Lloyd*

Chris Densham on the last pitch in Cañón Tenebroso. *Joel Corrigan.*

After the usual night at Zacatilihuic, a group of nine cavers arrived at Huitzilatl on Sunday, April 16, 2000, and started ferrying gear up the almost vertical slope to the Xalltégoxtli entrance. Along for the adventure this time were Vicente Loreto and Chris Lloyd from Guadalajara, Jesús Reyes, Humberto "Tachi" Tachiquin, Ruth Diamant, and I from Mexico City, Joel Corrigan and Chris Densham from Britain, and Brad Wilson from Canada. After getting settled in the entrance chamber, Chris Lloyd, Brad, and Joel went into the downstream fossil route. The pitch lead left from last year connected back into the main passage just before the last muddy section of rift. Meanwhile I went with Jesús and Chris Densham to rig the two pitches on the downstream active route.

The following day Marc Tremblay, Diana Gietl, and Miguel Puerto from the SQS joined us. Tachi, Brad, Joel, Ruthy, and I decided to go to the boulder choke that had stopped us on our quest for a connection to Ehécatl last year. The Brutal Cascade was soon reached and rigged by Ruthy, while the rest of us climbed over, under, and above her in our attempt to "help" her rig. There was a bit of confusion in the narrow portions of the Cascade Series, but we were soon laying fishing line through the nastiest bits



Ruth across the third lake in the Gours Passage. *Ramón Espinasa.*

of the breakdown to help in finding the route, and last year's terminus was soon reached.

Joel, Agent Orange (a crowbar of obvious color), and Lumpy (a lump hammer) went to work and had the first squeeze opened in a matter of minutes. Joel then disappeared ahead, after casually mentioning that he was running out of carbide. The rest decided to stay put and wait for news of the awaited connection. After fifteen minutes of freezing in the howling wind, Ruthy decided to join Joel in his search for glory. About half an hour later, while I was battling with the first signs of hypothermia, they returned, Ruthy having rescued Joel from beyond three other squeezes, where he had run out of light. They had checked ahead, determining that the cave had definitely turned nasty and would need another serious push by thin people.

Meanwhile, Chris, Chris, Jesús, and Vicente went to the downstream lead at the end of the Snakes and Ladders Rift. After rigging four pitches that had been free-climbed last year, they reached the lead. The water was followed down a narrow crawlway to a sump 20 meters beyond, and the airflow was traced to the base of a narrow rift, which was soon climbed by Jesús and Vicente, only to find that it got too narrow. On their way out, two leads were noticed in the area of the newly rigged pitches, both narrow rifts.

Tuesday the eighteenth saw Tachi, Jesús, and Chris Densham, the thin team, leave early to push the Bed of Nails at the end of the upstream breakdown. They were joined by Marc, Diana, and Miguel, who, besides getting acquainted with last year's discoveries, checked a series of high leads between the Cascade Series and the beginning of the breakdown. Meanwhile, Joel and Brad returned to the muddy rift at the end of the fossil section to brave the mud and follow the passage to an end. After getting completely covered in mud, they reached the lake seen on the previous trip, and they soon found that it was not a lake but a sump. Vicente, Ruthy, and I took a few photos in the gour section downstream, discovering an inlet passage before the first pitch.

Late at night the thin team returned, enthusiastically announcing the connection. Although they didn't know where exactly, they had reached an enormous chamber after getting past the Bed of Nails and climbing nearly 70 meters in a very narrow and jagged rift they named Night of the Long Knives. No survey stations had been seen, but they felt confident this was the final breakdown chamber in Ehécatl, as its shape was similar to that shown on the survey that Marc had brought.

Believing that the work upstream was basically finished, we concentrated the next days' efforts on the downstream sections, in an effort to increase the depth of the new system. Chris Lloyd, Brad, and Joel returned to the leads previously seen in the Snakes and Ladders Rift, managing to survey only 30 meters before a squeeze stopped them. Joel managed to push the tight lead for another 50 meters to a sump. Not finding any other leads, they returned somewhat bummed. Meanwhile Ruth, Vicente, and Ramón pushed the supposed upstream lead at the T junction before the rift. Beyond a few complicated climbs, the passage changed direction and started heading down. We quickly reached a complex junction with what seemed seven different ways on. Vicente the probe was dispatched and quickly found that two of the leads led to sumps and four others were just two small loops. Following the only remaining lead, we mapped into Cañón Tenebroso, a narrow rift with many bizarrely eroded horns, blades, and spades of rotten chert protruding from the walls and providing easy, if not safe, ways to make progress. To add to the fun, a water mark was obvious along this passage, below which everything was coated in a thin layer of very slippery mud, brown in color, which aided in distinguishing it from the black, slimy, and very slippery oxide coating that covers all the rocks above the water mark. After surveying about 200 meters, we rigged a very dodgy climb and proceeded to a sand-floored little room whose only apparent outlet was a 10-centimeter-wide slot at the base of a wall. Intrigued by the missing airflow, we spotted a balcony 5 meters above, which was easily reached and rigged by Vicente. Twenty meters away a pitch for which we had no rope stopped our progress, but the steady airflow promised more cave beyond for the next team.

Thursday the twentieth saw Tachi, Jesús, Joel, and Chris Densham leaving early to continue pushing Cañón Tenebroso. The Quebecois also left early to walk up the hill to Tepepa in search of white gas for their stoves and to assess the feelings of the locals after the Christmas rescue. Ruthy and I had a semi-rest day, surveying the inlet before the first pitch on the gour passage for about 100 meters, to where we popped out of the floor-drain in the third room in the fossil

route. The Tenebroso team returned late, with bad news. Although the cave beyond the pitch had changed character, becoming clean-washed and with many gorgeous formations and gour pools, it had sumped less than 200 meters beyond, only half a meter deeper than the Snakes and Ladders route.

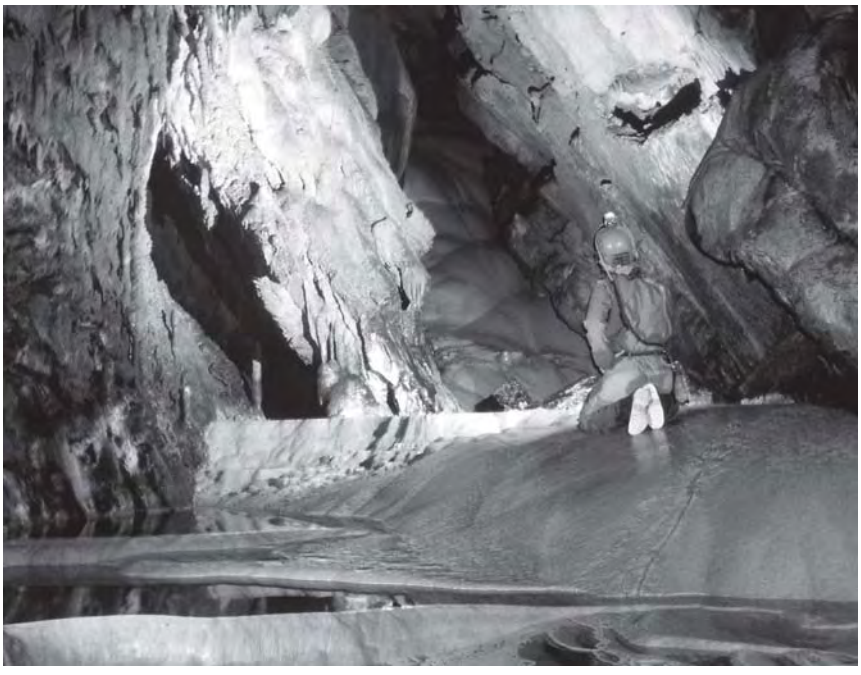
On Wednesday, Tachi and Jesús left the expedition in the early morning hours to return to school. During breakfast, Brad volunteered to survey the Bed of Nails and Night of the Long Knives with Vicente and Ruth, but they wanted still another team member. Miguel was soon persuaded to join them, splitting the Quebecois team for the only time. Meanwhile, Marc and Diana surveyed a small lead near Hyperspace, and Chris Lloyd and I surveyed a few odds and ends near the actual resurgence, 20 meters below the main upstream entrance. Brad's team returned late that night. He had had a lot of trouble with some of the squeezes, but had eventually managed to fit through. Arriving at the chamber, they had first surveyed left, toward downstream, stopping at the edge of a climb. Vicente climbed down 8 meters to a beautiful canyon that he followed down three more climbs to the edge of a pitch into a large chamber. This route is poised to connect to the beginning of the breakdown and would bypass all of the nasty narrow sections. Surveying back upstream into the main passage, they soon discovered its huge proportions of over 100 meters wide in the center, with large side leads in many directions. Not having found any footsteps or been able to correlate their find with the existing survey of Ehécatl, they left a large cairn after surveying 140 meters in this large chamber. On their return to camp, after expressing their doubts that the connection had been made and their suspicion that this big chamber was something entirely new, they went to bed.

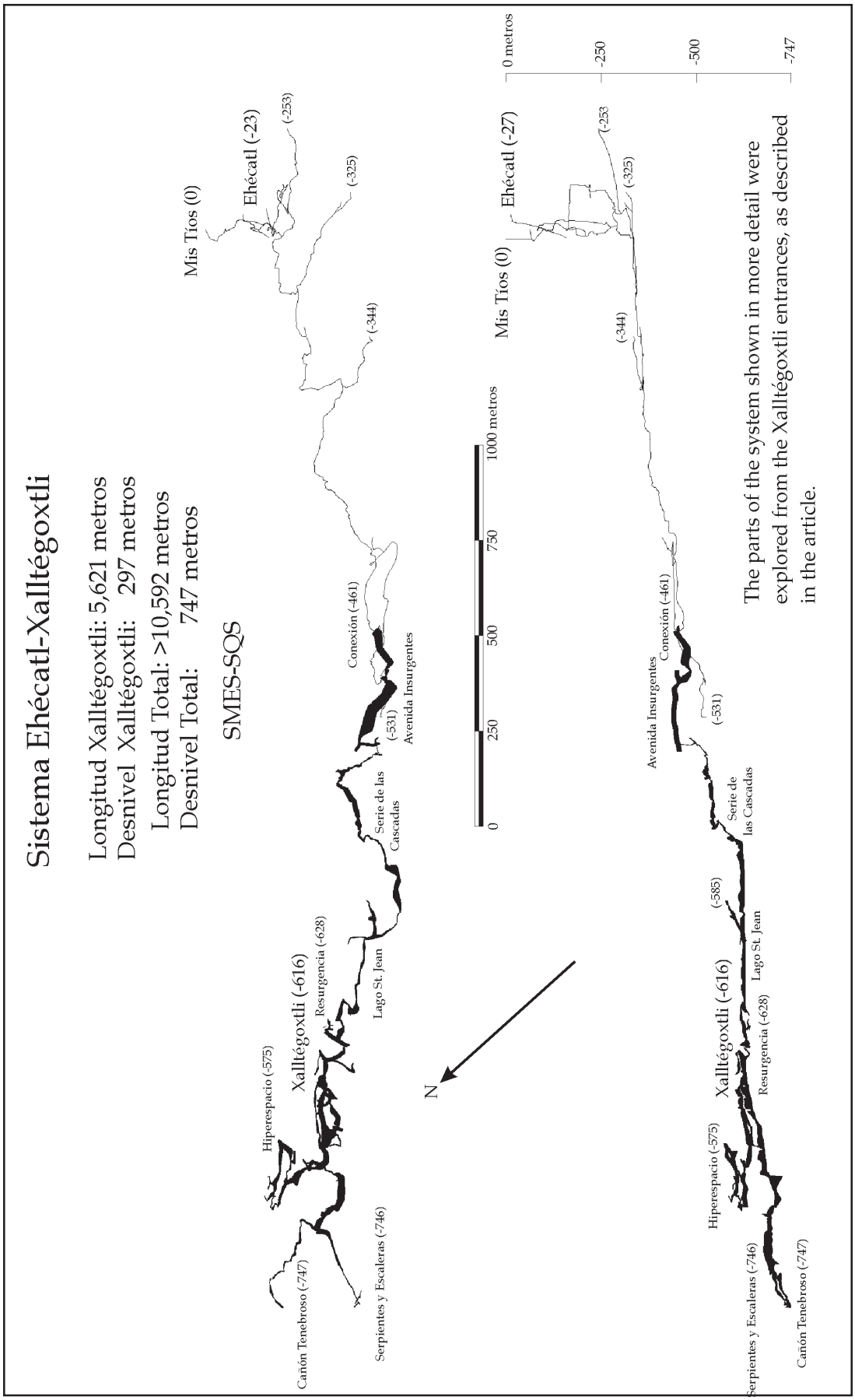
That night, discussion centered on the facts that we only had one day left and all the thin members of the team were very tired. Finally, Joel and Chris Densham volunteered to use their digging skills to open the squeezes to Chris Lloyd's and my dimensions. The following day we actually managed an alpine start (before noon) and soon reached the Bed of Nails. The two Brits hammered, chiseled, and levered all of the squeezes into submission in less than two hours, allowing us generals to drive our jeeps through. The Night of the Long Knives proved to be a suit-shredder, but soon we were in the big stuff. It was *big*. The large room, now known as Avenida Insurgentes, ended after nearly 250 meters at a vertical drop down into a huge passage, a drop deeper than any of the ropes we had with us. We retreated to the first side lead on the left, which went steeply down, coming out at a ledge halfway down the pitch. Instead of following the narrow rift below, we traversed along a ledge into a large lead visible on the opposite wall, which joined the huge passage we had seen from above. Covered in sweat and amid the clouds of steam rising from our suits, we clambered over house-sized boulders, semi-lost in this huge, steeply climbing borehole 40 meters wide and at least as high. Totally disoriented, we came to a junction. Two large passages continued steeply up, covered in breakdown, while to the left the sound of the stream could be heard through large holes in the breakdown. Here we basically ran out of enthusiasm, energy, and carbide supplies, our packs having been left at the top of the crawls. While Chris Lloyd and I tried to make sense out of the survey, Chris Densham and Joel climbed above a few more boulders, and, still within sight of us, found a survey tag, complete with flagging tape and identifying number. Thank God for that!

A slow trip back through the nasty stuff with heavy bags, followed by increased speed through the swims, saw us back at camp at about 4:00 in the morning after a sixteen-hour trip that had battered our bodies. A very satisfying day.

On Sunday the twenty-third, the expedition was officially over, and everyone packed their belongings for the return trip, except the Brits and Quebecois, who had a few extra days. The Quebecois went on a tour of shallow pits on Don Rutilio's land. On Monday, Cañón Tenebroso was derigged by the Brits, and on Tuesday Chris Densham went on a walk down the Huitzilatl valley, locating eight different resurgences, the last two of which had substantial flow. Unfortunately, neither of them was enterable. Meanwhile, the

Ruth Diamant enjoys the beauty of the Gours Passage.
Ramón Espinasa.




Sistema Ehécatl-Xalltégoxtli
Longitud Xalltégoxtli: 5,621 metros
Desnivel Xalltégoxtli: 297 metros
Longitud Total: >10,592 metros
Desnivel Total: 747 metros
SMES-SQS
Mis Tíos (0)
Ehécatl (-23)
(-253)
(-325)
(-344)
Conexión (-461)
Avenida Insurgentes
(-531)
Serie de las Cascadas
Lago St. Jean
Resurgencia (-628)
Xalltégoxtli (-616)
Hiperespacio (-575)
Serpientes y Escaleras (-746)
Cañón Tenebroso (-747)
(-585)
0
250
500
750
1000 metros
N
Mis Tíos (0)
Ehécatl (-27)
0 metros
-250
-500
-747
The parts of the system shown in more detail were explored from the Xalltégoxtli entrances, as described in the article.

Ramón, Joel, and Gustavo, and the view north from Cerro Zinzintéprtl. The white top of Pico de Orizaba is visible in the distance. *Ramón Espinasa.*

Quebecois found a side passage right above the sleeping area that they mapped to the edge of a pitch with airflow. Some ancient-looking pottery was also found in this lead. The twenty-sixth was the final departure day of the remaining team members.

After many days of working with the surveys, and with the help of the survey data of Sistema Ehécatl provided via internet by Steve Worthington, one of the original explorers of that cave, I was finally able to make sense of the connection area. In reality, the whole Avenida Insurgentes passage was virgin, and we didn't enter known cave until the very last few survey shots in the breakdown-covered borehole. The original explorers had gone down into the breakdown following the noise of the river and had not noticed the continuing borehole at the upper level. The old bottom of Ehécatl is below the Avenida Insurgentes, within less than 100 meters of the Bed of Nails.

With this connection, 5621 meters were added to the known Ehécatl cave. The survey data provided by Worthington does not include the Mexpé IV surveys, so the total surveyed length of the system is over 10,592 meters, which is the figure for the parts I have data on. The total height difference between the highest entrance, Mis Tíos, and the sump in Cañón Tenebroso is 747 meters, while a sporting through-trip 616 meters deep could be made to the Xalltégoxtli entrance, the second deepest sporting through-trip in Mexico.

The area above the Ehécatl and Mis Tíos entrances has barely been touched by the SQS expeditions, and the main upstream lead was left still going at the base of a 20-meter cascade. A connection with Brumas or any of the higher caves explored by the SQS (Sumidero de Año Nuevo, La Ciudad) would boost the depth of the system to over 1000 meters. We hope to explore the upper Ehécatl basin with the SQS in the near future.

Finally, from May 5 to 7, Joel, Chris Densham, Ramón, and Gustavo Vela made an ascent of Cerro Zinzintépetl to search for entrances in the highest plateaus of the Sierra Negra. After climbing to the summit despite the incredibly hard terrain of karren covered with thorny plants that made travel very slow, we made our way towards an immense doline east-southeast of the summit. On the way, we found a small 3-meter pitch that Chris entered to a potential dig site. Cueva de Chris, at 3140 meters, became the third-highest limestone cave known in Mexico. On reaching the bottom of the doline, we promptly found several pits. Although the two of the three that were entered ended quickly (the third was too deep for the short rope we had with us), the area looks very promising, considering that the resurgences are nearly 3000 meters below, and at least four other pits were not entered. We then attempted to traverse towards the main plateau, but the terrain made it impossible, so after several hours we had to backtrack almost to the summit before managing to go back towards the camp, which had been placed at the prominent saddle west of the peak. Lack of water made us abandon plans to check the main plateau on our way down. Although it is very interesting, logistics for exploring the high Zinzintépetl plateau are mind-blowing, since there is no water and no flat area for campsites, and no mule would ever make it up there, meaning everything would have to be carried in.

—*Ramón Espinasa Pereña*

Sistema Ehécatl-Xalltégoxtli, un nuevo -700 en la Sierra Negra

Una resurgencia descubierta en diciembre de 1989 por la SMES y la SQS no fue explorada nuevamente hasta las Semanas Santas de 1999 y 2000, en dos expediciones de la SMES. La resurgencia de Xalltégoxtli resultó bastante complicada, y fue explorada por mas de 5.6 km hasta una conexión con el Sistema Ehécatl, una cavidad de 500 m de profundidad previamente explorada por la SQS, estableciendo un sistema de mas de 10 km de largo y 747 metros de desnivel, con una travesía de 616 m.

THE ACID TEST: CUEVA DE VILLA LUZ

Jim Pisarowicz

The lead was low and wet. There was only about 10 centimeters of air space, and I floated into the lead on my back. The hydrogen sulfide levels were in the toxic range, so it was important to keep my H_2S filters dry. I arched my back to keep the filters, which nearly scraped the ceiling, out of the water. It looked as though the Buzzing Passage, named for the large number of midges living there, would open up just a short distance ahead.

Behind me, Louise Hose was making her way through another of the tight, wet squeezes in this section of the cave. Louise was having somewhat more difficulty, because she was carrying a "blinky," one of the gas meters we were using to monitor levels of hydrogen sulfide, carbon dioxide, carbon monoxide, oxygen, and flammable gases. If the blinky got dunked, it would quickly turn into a fifteen-hundred-dollar bunch of fried circuit boards. Suddenly the blinky started to go wild. A loud alarm sounded. I could hear Louise splashing around behind me trying to get into position to turn off the alarm and look at the readings. She could not silence the alarm. She yelled to me that the oxygen level was 9 percent and dropping and that we should "get the f——k out of here." As she popped the SpareAir, with its five minutes of breathable air, in her mouth, she turned to leave. I reached down and pulled the plastic bag off the regulator attached to the scuba diver's pony tank strapped to my side. I yelled back that I was continuing and again wondered what I had gotten us into.

I had first entered Villa Luz in 1987 while caving with Warren Netherton in the southern Mexican state of Tabasco. (See *AMCS Activities Newsletter* 16.) We had been told of a cave with *azufre,* sulfur, and had made our way over to Tapijulapa on the next-to-last day of that year's small expedition. Asking around town, we were told to go up the river until we located a *río blanco,* a white river. We were instructed to follow the white water through the jungle until we found where it flowed out of a cave. After fumbling our way through the outskirts of Tapijulapa, we followed a trail, found the white river, and arrived at the entrance to the cave. Firing up our carbide lamps, we climbed down into the entrance, immediately struck by the milky, bluish-white water. The cave smelled of rotten eggs, and there appeared to be wet gypsum crystals all over the walls. Skylights produced eerie shadows as we waded our way downstream and then upstream.

A series of largish rooms with high skylights, some easy wet crawls, and finally a very large room were encountered that first day. Just off the largest room was a walking passage with strange-looking stalactites. As I bent over to look at them more closely, the stalactites started to waver from the heat of my carbide lamp. I eventually christened these strange speleothems snottites, because they look like mucus hanging off the walls of the cave.

That evening, Warren and I had a heated discussion. Warren, who had to fly back to the States the next evening, wanted to begin a survey of the cave in the morning. I argued that we should instead spend the day taking pictures to document this unusual cave. We were planning to return to Tabasco the following year, and we could use these pictures to entice other cavers to explore this fascinating cave.

The next morning, we noticed that the shirts and pants we had worn in the cave had holes in them. We began to speculate that the cave was dripping acid instead of water. That day we photographed in Villa Luz, which we where then calling Cueva de Azufre. After shooting a roll of film in the cave, we left Tapijulapa and headed to the airport. After another week of reconnaissance in the area, I too headed north on a long drive back to the States.

The following year saw Warren and me in Tabasco again, but this time with a larger contingent of cavers. (See *AMCS Activities Newsletter* 17.) I had given several programs about the previous year's finds and had generated some excitement among South Dakota cavers about the potential for caves in Tabasco. I had also discussed the acid in the cave with Norm Pace and Mark Minton. Norm had suggested that we test the pH of the drips with litmus paper. Mark provided us with an entire book of the acid-sensitive paper to take into the cave.

After experiencing a major rain of 1.5 meters in a thirty-six-hour period, we settled into a rented house in Tapijulapa to begin the 1988 expedition. Several survey trips were made into Villa Luz

during the next few weeks. Those mapping trips were unlike any I had experienced in the past. Several cavers complained that they felt ill when they got out of the cave. One caver had some sharp gypsum crystals fall down his shirt, where they injected sulfuric acid under his skin, resulting in second-degree chemical burns. Survey crews were mutinying and refusing to go back into the cave. Measurements of the pH of drips in the cave were showing pHs of 1 or less. This was one nasty environment.

That year the expedition ran into political problems because of xenophobia connected with some election campaigning. This resulted in several of the expedition members spending a day in the local jail, and the group routed, leaving the Tapijulapa area to do some caving in a less politically-charged part of Mexico. But we did return with some water samples from Villa Luz that were eventually analyzed by Art Palmer. I gave a talk on Villa Luz and some other caves in Tabasco at the 1988 NSS Convention in Hot Springs, South Dakota.

The next year, I tried to get some cave geologists to return with me to Villa Luz. I contacted Mark Maslyn in Colorado because I knew of his interest in hydrogen-sulfide speleogenesis, but he could not get away to accompany us. Art Palmer also had other commitments and could not participate. Norm Pace, Louise Hose, and several other scientists who I thought would be useful for the project were also contacted. All seemed to be interested, but not that interested.

So the 1989 expedition saw Warren Netherton and me in Tabasco with a group of Swiss cavers. Although most of the caving that year focused in the Agua Blanco cave system near Mascuspana, several trips were taken into Villa Luz to begin measurements on the air in the cave, using equipment funded by the National Speleological Society. Measurements were taken throughout most of the easy sections of Villa Luz using a hand-held air pump and chemical-reaction tubes. Litmus-paper sampling of pH was also continued. Preliminary data on H_2S levels shed some light on conditions in the cave. Although H_2S concentrations near the entrance and in rooms with skylight tended to be relatively low, less than 10 parts per million, they were found to be considerably higher, up to 55 ppm, in rooms and passages at greater distances from outside air. It was also noted that the H_2S concentrations could vary widely from one day to the next. About this time, the United States Occupational Safety and Health Administration changed its standard for permissible H_2S exposure from 10 ppm to zero.

Louise Hose points out sulfur deposit on the wall of Villa Luz. *Jim Pisarowicz.*

Samples of gypsum and sulfur were also collected. Kim Cunningham of the USGS analyzed these later. Sulfur in the samples was found to be isotopically light, indicating that the sulfur was probably being processed through some sort of biological mechanism, most likely sulfur-reducing microbes living in the cave.

Our findings were initially presented at the Rocky Mountains Speleo-Seminar in 1992. Two years later, the unusual conditions in Villa Luz were a keynote presentation at a symposium titled Breakthroughs in Karst Geomicrobiology and Redox Geochemistry. Louise Hose was the local coordinator for this event, which was held in Colorado Springs.

The Caves of Tabasco Expedition of 1996–97 was the turning point in the study of Cueva de Villa Luz. It was the first expedition to include a professional geologist. Louise Hose accompanied the expedition and made her first trip into the cave. The unusual features of Villa Luz struck her as they had me ten years before—the pungent odor of hydrogen sulfide, the milky-white cave stream, the thick gypsum crusts and pastes on the walls, the snottites, and the abundance of cave life. I remembered her saying to me after one of my talks that she thought I was exaggerating the features of the cave, but after seeing it for herself, she accused me of underplaying the cave's significance. She thought that the cave needed a better map, which we began during that trip.

Once back in the States, Louise and I began making plans for the

La Pesca de la Sardina

Louise Hose

In 2001, the harvest yielded about twenty kilograms of cave-adapted fish from Cueva de Villa Luz, also known as Cueva de las Sardinas.

La Pesca de la Sardina began before the historic memory of local residents. It was most likely an indigenous sacred ceremony. Centuries ago, when the Zoque of the region adopted Catholicism, it became a blend of the old and new belief systems. The old people of the local village, Tapijulapa, remember the ceremony from the 1930s and 1940s. At that time, a procession of several dozen Zoque began in town, crossed the Río Amatán, and walked the approximately three kilometers to the cave. (The Chols, who also inhabit the region, did not participate.) The women pulverized barbasco root, scraping it on karst rocks in a stream outside the cave. The crushed barbasco was mixed with lime and wrapped into packets in leaves. The procession then proceeded into the cave, each person carrying baskets with lit candles and offerings such as flowers or tobacco. The lead man carried an urn of *copal*, the common Latin American incense. He led the group in offering a prayer inside the cave.

The mood was reverent. Small children were admonished not to curse or cry out, even if they tripped and hurt themselves. Pregnant women were not allowed in the cave. Women who entered the cave covered their heads with a scarf, as was required in church at the time. Once the participants felt that they had received permission through their prayers, the fish harvest began. Men took the packets of barbasco farther into the cave and released the mixture in the stream. Barbasco is the root of a vine that grows in the nearby Chiapas Highlands. It contains rotenone, a natural toxin that inhibits the use of oxygen by tissues, causing the fish to become *borracho* and sluggish and to cluster along the shallow edges of the stream. The offerings and candles were left along the shore of the stream, while everyone scooped up the fish in the baskets.

The ceremony took place during Semana Santa, the week between Palm and Easter Sundays. The fish were a delicacy that did not violate the restrictions of lent. They were dried and eaten in *mone*, with eggs, and as part of tamales. If the dry season did not break by May, the Zoque made another procession to the cave to ask for rains and to replenish their dwindling food supplies.

Today, *La Pesca* is performed on Palm Sunday weekend as a reenactment by young men from Tapijulapa. Local officials encourage tourists from Villahermosa and elsewhere to attend. Approximately five thousand people typically come into the area for the day. Folk dancing has been added to the activities, and drinking is allowed. Some older Zoques see the changes as blasphemy. Hundred of men, women, and children swarm into the cave to join the harvest, as electric lights brighten the cave for about two hours. The Zoque seem torn by the event. They enjoy the attention and money *La Pesca* draws to Tapijulapa, but they express regret at the lack of sensitivity to the sacredness of the caves. Most tourists seem to view the event as a grand party.

For the caver, *La Pesca* makes for a remarkable experience. Perhaps the most remarkable statement one can make about this extraordinary cave is that the event seems to have almost no long-term and only minor short-term impacts on the cave and its rich biological community. The abundant energy of the cave's ecosystem and the dynamic nature of speleogenesis in the cave appear to make this highly exploitative event sustainable. Could any other cave in the world lose twenty kilograms of cave-adapted fish in a two-hour period and recover in less than a year? Cueva de Villa Luz, the Cave of the Sardines, can.

CUEVA DE VILLA LUZ

Tabasco, Mexico

COMPASS and TAPE SURVEY By:

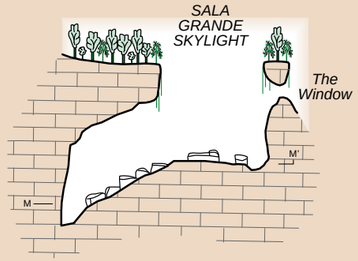
Jim Pisarowicz, Louise Hose, Kelly Mathis, Abby Wines, Noel Daniels, Chris Long, Dave Lester, Chuck Porter, Bob Addis, Fred Luiszer, Alda Del Porto, Mike Taylor, Carl Allen, Ricki Sheleon, Alan Cressler, Steve Alverez, Doug Soroka, Lynn Kleina and Bob Richards.

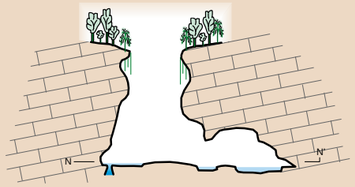
SURVEYED DATES: *January 1997, January & April 1998, January & August 2000.*

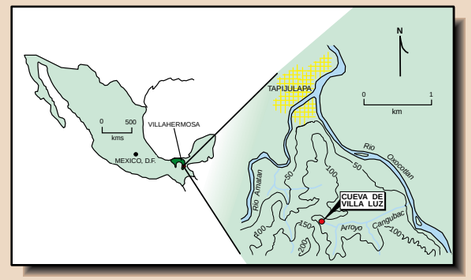
CARTOGRAPHY BY: *Bob Richards and Louise Hose*

CAVE LENGTH: *1,987 meters*
CAVE DEPTH: *23 meters*

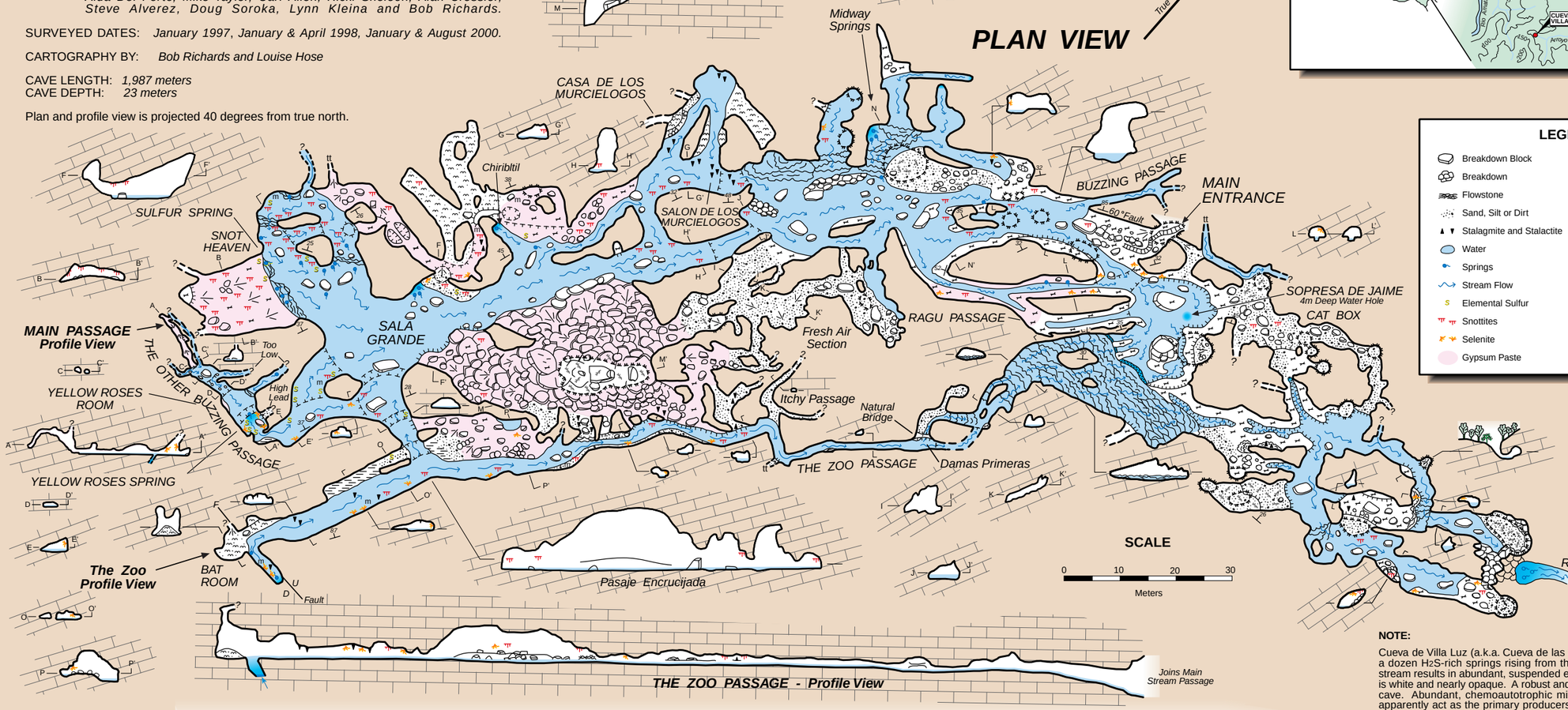
Plan and profile view is projected 40 degrees from true north.

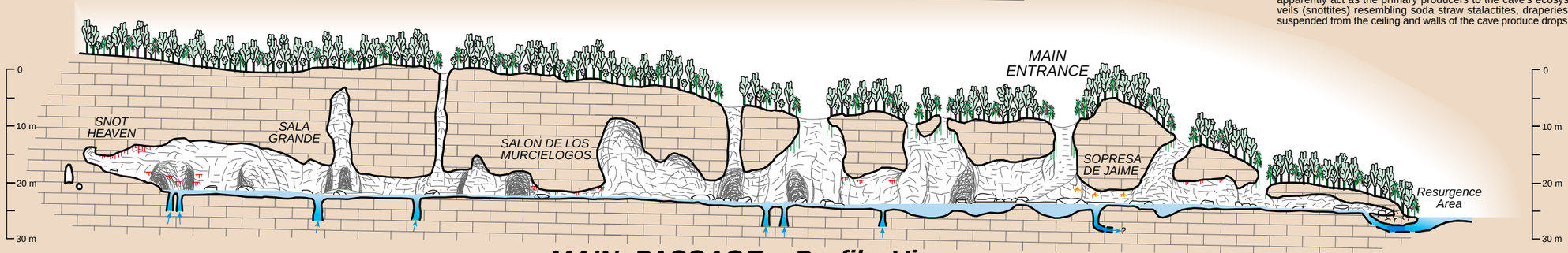






PLAN VIEW





MAIN PASSAGE - Profile View

LEGEND

- Breakdown Block
- Breakdown
- Flowstone
- Sand, Silt or Dirt
- Stalagmite and Stalactite
- Water
- Springs
- Stream Flow
- Elemental Sulfur
- Snottites
- Selenite
- Gypsum Paste
- Drop or Ledge
- Ceiling Drop
- Organic, Surface Debris
- Bedrock Floor
- Slope
- Not Surveyed
- Skylight or Entrance
- Bat Guano
- Mud or Silt
- m Moonmilk
- 38 Strike and Dip
- ?, tt Lead, Too Tight

SCALE
0 10 20 30
Meters

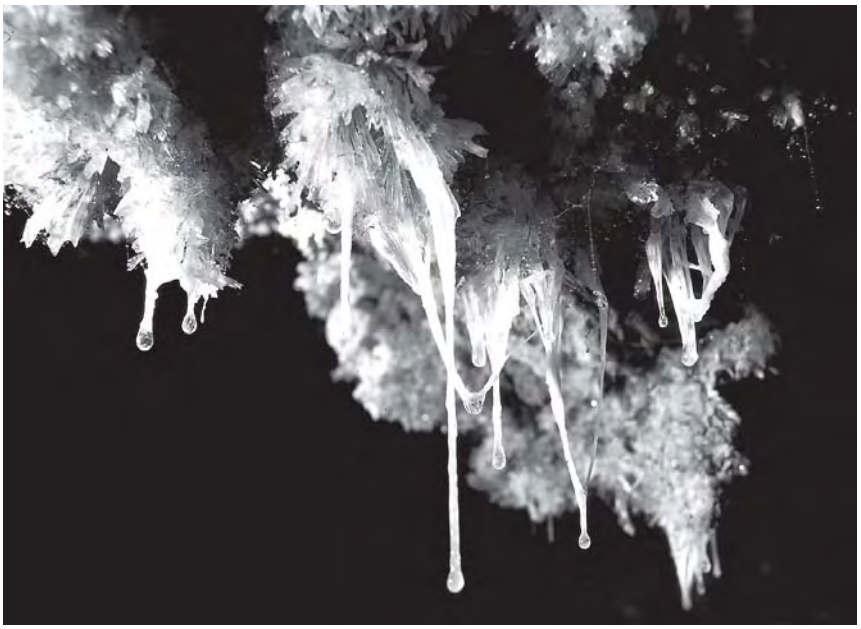
NOTE:

Cueva de Villa Luz (a.k.a. Cueva de las Sardinas) is a stream cave with over a dozen H_2S-rich springs rising from the floor. Oxidation of the H_2S in the stream results in abundant, suspended elemental sulfure in the stream, which is white and nearly opaque. A robust and diverse ecosystem thrives within the cave. Abundant, chemoautotrophic microbial colonies are ubiquitous and apparently act as the primary producers to the cave's ecosystem. Microbial veils (snottites) resembling soda straw stalactites, draperies, and "u-loops" suspended from the ceiling and walls of the cave produce drops of sulfuric acid.

following year's expedition. As director of the NSS's Caves of Tabasco Project, I appointed her science coordinator. Other scientists were brought on board. Art and Peggy Palmer, Fred Luiszer, Harvey DuChene, and Louise Hose composed the geology-hydrology group. Penny Boston, Diana Northup, and Kathy Lavoie were the initial scientists in the biology group. Westminster College provided a video crew and a publicity coordinator.

Several cavers from the previous year's expedition and several who were new to the project accompanied the 1997–98 expedition. Notable among them was Carl Snider. Through the generosity of his employer, Carl arrived in Tapijulapa with an electronic toxic-gas meter. This multi-gas, data-logging instrument accompanied us into the cave on our first trip. Unlike the hand-pumped, reaction-tube instrument used previously, this instrument provided continuous monitoring, and it monitored other gases in addition to H_2S. As previously observed, toxic gas levels varied from room to room, but they also varied drastically from moment to moment in the same place, sometimes by an order of magnitude from one minute to the next. From this trip on, everyone wore H_2S-filtering masks, as we were anticipating working for longer periods in the back parts of the cave.

The expedition was a whirlwind of activity. Daily water samples were analyzed by Art and Peggy, who had a chemistry lab set up in the field house. Geologists and biologists held sessions nightly to discuss the day's discoveries. Experiments, such as Harvey's aquarium pump that bubbled cave air through various chemical solutions, were set up throughout the cave. The next year saw a host of papers describing results from the expedition. Water, rock, and crystal chemistry were described. Preliminary biological results, both micro and macro, began to be discussed in professional literature. Microbiological techniques provided photographic evidence that the snottites were actually colonies of microbes living in baths of sulfuric acid.



Snottites, including a U-loop, in Villa Luz. *Jim Pisarowicz.*

It was now obvious that Villa Luz was a world-class laboratory. Not only was the cave the prime example of active hydrogen-sulfide speleogenesis, but it also had an easily accessible ecosystem based on chemoautotrophic organisms. In order to do the cave justice, some rather high-tech (i.e., expensive) equipment needed to be procured. With these thoughts in mind, Louise began a campaign to acquire the necessary funding to support the scientific work that the cave warranted. Grants from organizations such as the National Geographic Society and the Research Advisory Committee of the NSS were sought, as well as the kinds of publicity necessary to support such a project. Villa Luz has appeared in ABC News, *National Geographic, Newsweek,* and a host of other general mass media, as well as science forums such as the Discovery Channel, *New Scientist,* and *Geotimes.* One could tell that Villa Luz had "arrived" when articles started appearing in publications such as the *Weekly Reader.* Today there is even a web site on the cave in Korean. It probably could go without saying that the scientific investigations at Villa Luz will go on for years to come. One science-news web site even called the supposed 1998 discovery of snottites the most radical scientific discovery of the year. As Penny Boston and Diana Northup said in a television interview, the questions that have arisen from these first looks at Villa Luz could probably support many dissertations.

But there was one last lead to push, and I was in it. Louise had had to make a hasty retreat on her five-minute supply of air, due to the spiking levels of H_2S, CO, and CO_2 and the crashing level of O_2. Breathing from my pony tank, I could push on a bit. Just ahead, the cave opened up, and I could almost sit up. The floor of the cave in this area is mounded with gypsum paste, and this paste, along with clusters of gypsum crystals, covered the walls. On the floor, the stream split. I first headed into the larger passage, to the left, but it soon tightened. The gypsum paste is essentially gypsum mixed with sulfuric acid, and I felt burning all over my body.

One last lead to push. Gypsum paste from the ceiling started to get into the filters and my regulator as I tried to wiggle my way into the quickly restricting passage. My face started to burn from the acid, and when the exhaust port on my regulator clogged with paste, it was truly time to get the f——k out of there.

So the caving exploration of Cueva de Villa Luz is essentially over. All the passages have been pushed and pushed hard. But the rest of the story of Villa Luz has only just begun, and the answers to the mysteries of this fascinating cave have yet to be revealed.

Cueva de Villa Luz, Tabasco

La Cueva de Villa Luz fue explorada originalmente por espeleólogos en 1987, pero no fue hasta el invierno de 1996-1997 que otros científicos se interesaron. Su atmósfera contiene concentraciones peligrosas de ácido sulfhídrico y otros gases nocivos, y el agua, especialmente la que gotea de masas orgánicas conocidas como snottitas, es muy ácida. Un ecosistema muy activo, basado en bacterias que sintetizan el azufre, permite la recolección en la cueva de 20 kilogramos de peces para una ceremonia local, la Pesca de la Sardina, cada Domingo de Ramos, sin afectar su población de manera permanente.

Caves: Exploring Hidden Realms. Michael Ray Taylor. National Geographic Society, Washington, D. C.; 2000. 23 by 30 cm, 216 pp, hardbound. ISBN 0-7922-7094-2. $35. *Science at the Extreme: Scientists on the Cutting Edge of Discovery.* Peter Lane Taylor, McGraw-Hill, New York; 2001. 20 by 23 cm, 271 pp, hardbound. ISBN 0-07-135419-0. $29.95.

Each of these new books, by two different Taylors, has a chapter on Mexican caving. The National Geographic book was prepared to accompany the release of the IMAX film *Journey into Amazing Caves.* Pages 68–133 are about the Yucatan and its underwater caves. Mike Taylor writes about the filming of the cave-diving part of the movie in the Dos Ojos system in Quintana Roo. Well-known underwater photographer Wes Skiles was in charge of the diving there, where a hole was drilled from the surface to hold cables to supply power to the underwater lights. IMAX frames are very wide-angle and shot on film almost 3 by 5 inches in size, so a lot of light is required. Sidebars by various experts discuss some related topics; one by Louise Hose is about Cueva de Villa Luz and its snottites. As would be expected from National Geographic, the book is nicely illustrated with color photos.

Three of the chapters of Peter Taylor's book are about caving. One, pages 37–59, is about Cueva de Villa Luz in Tabasco. (See the article in this issue.) The others are about cave diving in northern Florida and caving in a glacier in Switzerland. This book is also well illustrated with color photos, but the prose is breathless and overwrought, and the main theme seems to be defying death. There is a lot of exaggeration, partly because of the gullibility of the author—enthusiastic or egotistical cavers and Peter Taylor are a bad combination. There are lots of mistakes, small or gross. But if you can stomach it, you'll read about some unusual caving.—*Bill Mixon*

ATEPOLIHUIT DEL TEPONAHUAS

Chris Lloyd

So about what time was it when that flood hit you guys last weekend? Oh, between 6 and 7 P.M., eh? I guess we had better get going, then." Two minutes later, upon arriving back at the streamway, I said, "I have some bad news for you. The water has gone muddy, and the stream is in flood." So there we were in Cuetzalan, Puebla, in the midst of the dry season experiencing a typical occasional afternoon thunderstorm, or at least the effects of one. When I had left the surface at 3:00 P.M., the weather had been mainly sunny. But that is Cuetzalan.

I can now feel truly baptized in the ways of Cuetzalan, just like the long line of explorers before me, a list stretching back to the early seventies, when the area was first explored by some American cavers. Enthusiasm and cave lengths increased into the early eighties, before it just died. Yet few caves had been explored to their ends. Maybe this flooding thing put people off. It certainly wasn't lack of cave.

My first trip had been three weeks earlier, looking for another infeeder to the Cueva de Guayateno that Ramón Espinasa had mapped to 4.6 kilometers during a nice through trip. After trying one entrance in the second doline from the road, we poked into a small entrance just above a small stream. It went into a long bedding-plane crawl, so we went to look for a nicer one. We found one in the next doline downhill to the left, with a bigger stream. Unfortunately, it was completely blocked by sand and debris, probably from the big floods of 1999.

We got directions to a better entrance back over the hill and to the right, which turned out to be one that Ramón and gang had walked over to from a skylight in Sima Esteban a few weeks earlier, in February 2000. Now this looked more like it. Two separate holes about 2 meters across went down into the hill, with the sound of running water at the bottom of both. After checking them both, Ruth Diamante suggested that we take the right one, as it was the one going downstream and connected, anyway, to the other below the dirt we were standing on. A short climb down popped us into a sizeable entrance chamber, 12 meters across and 8 meters high, with the stream going off in passage almost as big. While crossing the room, we noticed fragments of what must have been Huasteca-culture pots and, later, a platform that was typical of those leveled for their rituals. One team surveyed in, while I photographed behind. About 100 meters in, we turned a corner and had to climb down into a pool that was followed by an undercut 6-meter drop into another big room. We rigged a ladder off some dubious small stal on the left wall and climbed on down.

The roof became lower and lower, as the passage almost changed into a wide, bedding-plane one, with the water going to the right and us being forced to the left. A short hands-and-knees crawl popped back into some more comfortable stuff, before it got low again. This time we popped out at the top of another drop, this one with a 6-meter waterfall on the right and an easy slope for a ladder on the left. Then more large passage took us to yet another drop for which we had no ladder, so we turned back with 350 meters surveyed and big passage beckoning.

The next day, we did a bottom-to-top through trip in Sima Esteban and surveyed a couple of side leads they had missed before. The trip is a very enjoyable one up an active streamway with numerous skylights in the lower sections. In only one place do you have to crawl, and then only briefly. In another spot, you must climb up through a 1-meter-diameter hole with the whole stream pouring down right in front of you. Emerging from the upper entrance is like coming out into Jurassic Park, all lush vegetation including a rare and strange fern tree that dates back to the Cretaceous. The advantage of doing the trip from bottom to top is that you come out almost at the car.

That first trip whetted my appetite for more, so when Ramón called two weeks later to say he had relocated the 100-meter-wide entrance to Sumidero de Jonotla, I was ready. Not really near Jonotla at all, the cave had been explored and mapped to 6.5 kilometers by some Americans in the early seventies. No article or map was ever published, and a request for the survey notes fetched only a line plot and some photographs. Here was a cave begging to be documented, and if that meant resurveying, that is what we would do. Ramón had already done that for the main Cuetzalan system explored in the eighties and also never published, and now that system stands at 36.2 kilometers. Jonotla doesn't appear to have that potential, but who knows what

awaits inside.

I must admit that I thought Ramón was exaggerating when he said we would be camping in an entrance 100 meters wide, but, sure enough, there it was. It really doesn't look that wide, being obscured by vegetation and a breakdown pile, but a survey verified the figure. It even has a few sandy areas that are not under drips when it rains, and that made for a comfortable campsite. The clear stream that sinks under boulders in the entrance gave us an idea of what we would be following inside.

The first day we began surveying our way in, and I never did get a look at the far wall of the entrance chamber to get it into my sketch. From the huge entrance, we finally dropped down into the active stream passage, which was still some 10 meters wide. The floor and much of the wall are, like in Sima Esteban and many other caves in the area, composed of conglomerate of the Cahuasas Formation of Triassic to early Jurassic age. Here it is polished smooth, with long grooves attesting to the velocity and volume of water that must flow over it at times. Hopefully we wouldn't run into one of those times.

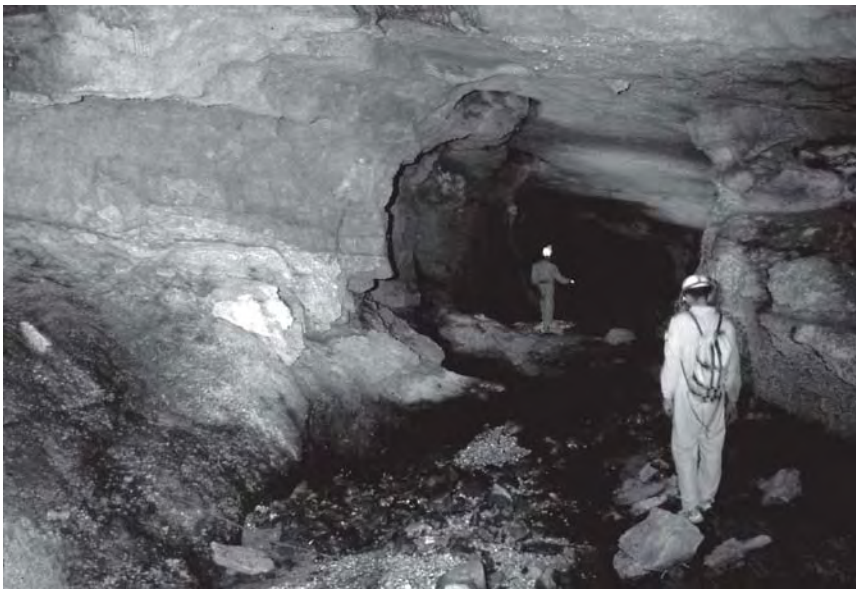
The description by Nevin Davis from 1973 was reasonably good up to the point where they turned back, at a place where the water goes under a large flowstone coming in from the left. We passed this obstacle by climbing up it and traversing across on rimstone dams about 8 meters above the river. That is followed by a steep climb back down to a pool that continued down the passage. It was not apparent at first that the passage was getting bigger, because the lower part where we were walking was getting narrower, and we were forced into a short swim up to a 6-meter waterfall. Dave Jones and Vicente Loreto rigged that and dropped into the narrow canyon below, while Ramón, Ruth, and I surveyed after them. The canyon was about 2 meters wide, with a raging river below the pounding waterfall. Some tricky moves on a traverse called for a bolt that we didn't have. After much hemming and hawing, I decided to go back and get the bolt kit, as we weren't all that far in.

By the time Ruth and I returned with the bolt kit, Dave and Ramón had scouted around and found a high traverse that avoided the waterfall. A bolt at the start of it and a piton on an exposed ledge were obvious evidence of previous explorers. While waiting for Dave and Vicente to rig the drop beyond this traverse, the survey team headed up the 40-degree slope above into a passage much bigger than the stream route, although I'll call it a side passage. It was only after adjusting my sketch several times that I realized just how tall the main passage was at that point. I had originally estimated 25 meters to the ceiling, but it turned out to be more like 60, as seen from the vantage point of the side passage, still 25 meters below the ceiling.

We were now up above the sound of the river, in upper-level passage about 35 meters wide and 25 meters high. Mud still covered all the big blocks that we wound our way through looking for the easiest way on. After passing two depressions in the floor, we came to one that went down to the sound of water. On a prominent boulder above this, a yellow survey-tape said station 039. We used it for our own station 36. Obviously we were following the old route pretty closely. We continued in the main borehole another 100 meters, to where there was another passage, which took off to the right to more sounds of water. This went 60 meters in a 2-to-4-meter-wide canyon to the top of a 20- or 30-meter drop that we left for another day. Ahead, the borehole quickly stopped down to only 2 meters wide, with a large slab partly blocking progress. Past this, the passage continues, varying between 2 and more than 10 meters wide. There are profuse gypsum crusts and occasional flowers along the walls, as well as numerous lovely calcite formations, including a couple of mediocre shields. The rounded passage shape suggests phreatic development, unlike the active streamway we had left behind. We noted numerous side leads, and we called it a day at station 65, with 1340 meters of survey. Not a bad first day in the cave we were told is called Atepolihuit de Teponahuas. *Atepolihuit* is a Huasteca word: *atepa* for *water* and *lihuit* for *sink*. Some of the American cavers mistook the word for the name of the cave, rather than just another word for a *sumidero*.

The next morning, Ramón, Ruth, and Dave headed in to continue in the stream, while Vicente and Sergio headed in to explore the end of the borehole and I stayed behind

Victor Hugo and Vicente Loreto just inside the entrance to Teponahuas. *Chris Lloyd.*



Victor Hugo on the second pitch. *Chris Lloyd.*

to guard camp. Unfortunately, the side borehole shut down after only 150 more meters, so the survey team there contented themselves with photographing the beautiful formations. The group heading downstream, having rigged the new drop from some boulders on the left slope, descended about 25 meters to the stream, where they immediately had to swim. The first pool went for about 30 meters to where they had to surmount a rock pile. The second pool turned out to be the biggie, at 130 meters long, with only an occasional rock to rest on. About midway through this, the roof comes to within 10 to 20 centimeters of the water. It won't take much of a flood to seal the river shut.

After a third, shorter swim, one climbs out onto a gravel bank that leads up into a huge passage containing a climb over breakdown blocks the size of small houses. At the start of this section, a large black hole was noted up on one wall, but it was not checked. Wandering in the area on my own later, I saw no trace of their passing, and I heard, more than saw, two inlets pouring in on the left wall, no doubt the ones we had heard from the side borehole the day before. After much scrambling and backtracking, I caught up with Ramón and Ruth where the stream came back out from under boulders farther on, where the passage had become much smaller again. They had climbed up to the right into a large stal-filled alcove to bypass yet another boulder pile, and after rinsing the sand out of my boots in the stream, I joined them to help with the survey.

Two more shots, and we were looking into what looked like a sump pool. With nobody wanting to swim again, Ramón climbed up and around on a huge rock in the center of the room and discovered an easy climb up to a sump bypass. He wandered around up there and found a drop into another pool, as well as a view up into what appeared to be yet another side borehole. We decided to call it a day at this point, as we had no rope to protect the climb or do the next drop.

It was on my return to the streamway that I noticed that the water had changed from the clear-flowing stream in which I had cleaned my boots to a muddy flow that was already higher on the gravel beach. Obviously the various clouds I had left behind outside at 3 P.M. had opened up, leaving us with a race to see if the duck in the swim was going to close. Memories of various flood stories about Cuetzalan I had read kept me moving. Ramón managed to set a new record changing his carbide, while I headed forward into the third swim. There was no noticeable difference at first, so we hoped that the flood was just in the inlets and not the main drain. But at the duck in the long swim the water was noticeably higher, and I had to push my nose up to the ceiling to sneak through. But that was it, and we were on our way. Getting out of the water proved a little more difficult, as there was now current pushing us away from the rocks, and we also had to fight current in the pool below the rope. It was a good thing that we didn't have to go through the narrow canyon and past the waterfall. Once over and past the traverse, we abandoned plans to take some pictures in our desire to get out of the possible path of a flood pulse. All the pools in the stream were now full, and any pulse that arrived would just ride over everything on its way to the sump. It wasn't until we arrived in the entrance chamber that we stopped to take a few pictures, of the Huastecan platform we had noticed there. On our way back up to camp, all kinds of drips and waterspouts had to be dodged in the main chamber. Once safely arranged around the campfire, we all agreed that that had been the closest we wanted to be to a flood in a cave.

About thirty minutes after I had left the surface, it had rained hard for about thirty minutes, and then it rained on and off for the next two hours. Fortunately that wasn't enough to close the duck. It was sometime in the night that the new showers in the entrance chamber finally subsided.

The next day enthusiasm levels were varied. Everyone wanted to do the through trip we knew to be possible in Teponahuas, but those of us who had been almost caught in the flood were not anxious to go back through the duck. While the rest of us were still

lollygagging around, Dave decided to go in first and see what the duck looked like. The rest of us would catch up with him. Sergio decided to watch camp and dutifully requested some contact phone numbers in case we didn't return. Back in the streamway, we noticed that the water level was still high and all the pools were overflowing. All the way in it was the same. Each rock that we had used to cross the stream was now underwater. With conditions like that, any new water would instantly flow right into the lower part of the cave, without being absorbed by any of the pools as it had been yesterday. By the time we were at the drop past the waterfall, Ramón and I were convinced that we didn't want to be on the other side of the duck today, especially with so much still to explore on this side. Unfortunately, Dave had obviously gone on and was expecting us to follow. Vicente volunteered to go find him, while Ramón and I decided to go up into the side borehole and survey one of the side passages.

From our station 36, we checked out the hole with the sound of water and found a small stream. Upstream, the passage was a comfortable 3 to 6 meters wide and at least as high. After passing one large inlet, we decided to have a quick look up a second one that didn't look like it would go far, but was pretty. Here a stream trickled down the flat, calcite-covered floor, through mud banks with evidence of past flooding. Despite initial appearances, the 4-meter-diameter passage just kept going, occasionally getting bigger. Twice there were lower levels, while a bigger bypass was visible above. The formations began increasing in number, and the stream disappeared. In the second lower route, straws were abundant everywhere, and many had speared themselves into the mud floor, since calcited over. Gypsum crusts were here, as were beautiful flowstones. One drip-point in the mud had spectacular spatter cones all around it, looking like a shark's mouth full of teeth. After passing through this straw gallery, we passed another, or possibly the same again, stream, and then we encountered it again in 8-meter-wide passage. It was followed to its source in a lovely flowstone-lined gallery with a small lake blocking the way on. The water could be seen flowing out of a small hole on the far side of the lake, so I plunged in to check it out. The triangular hole was only about 30 centimeters high, but the water was swimming depth below. I followed this for about 13 meters to a little chamber that had a too-tight rift and what looked like a blind alcove above it.

Retracing our steps to bigger passage, we decided to have a look at the high bypass, and we worked our way up into what looked like a smaller version of Lechuguilla's Tower Place. Tall white stalagmites were scattered all over a sizeable chamber that we couldn't see the back wall of. Once we got used to the size, we noticed three huge columns, about 8 meters in diameter. Dry and active pools had calcite crystals in them 2 to 5 centimeters long, some with flat tops on them at the water surface. Behind one of these pools was hidden what Ramón declared the most beautiful chamber in all Cuetzalan, if not Mexico. Water trickled over coarse crystals of pure-white flowstone surrounded by numerous stalactites and stalagmites, all framing an aquamarine pool.

After the requisite ogling time, we continued on into the large chamber, taking some time to figure out a way up over the huge slabs of breakdown. Eventually we stopped at the highest point and could look out over the rest of the room, with the sound of water beckoning in the distance again. But as dinner time was approaching, we left the 60-meter-wide passage for another day. After all, we had to have something to come back to.

Back in camp, we found Dave and Vicente, who claimed that the duck actually had more airspace today and that they had gone on to complete the through trip, leaving by an entrance significantly larger than the one we were camped in. It turned out that the way on was swimming through what we had thought was a sump pool where we'd turned back the day before. Past the 25 meters we could see, the pool continued 1 meter wide for another 30 meters before opening up again into a larger pool with a climb up on one side. This climb came out farther along the upper level where Ramón had been. Where that passage dropped back down into the main passage, they easily rigged a rope to a big stal, rappelled down, and walked 100 meters to where they could see daylight.

Our survey total for the three days, including the thousand meters Ramón and I did up "just another side lead," was 3.14 kilometers, so we still have 3 kilometers to go before finding all that was explored before. Undoubtedly, a lot is still waiting to be found up those side leads, and Dave also found a passage at the top of a climb he did. It appears that the cave may be occasionally intersecting an old fossil upper level, and potential remains very intriguing. We'll be back.

Atepolihuit de Teponahuas

Esta cavidad fue explorada a principios de los 70's por norteamericanos, pero el mapa nunca fue publicado. Se inició una retopografía, y hasta ahora se han mapeado más de 3 de los aproximadamente 6 km de galerías conocidas. La galería principal, activa, es una travesía que, como en la mayoría de las cavernas del área de Cuetzalan, Puebla, es peligrosa por las crecidas que pueden ocurrir incluso en plena época de secas.

SURVEYING UNDERWATER CAVES

Jim Coke

Perhaps one of the more intriguing facets of underground surveying is exposed through a breed of caves that happen to be filled with water rather than air. Imagine two neutrally buoyant explorers suspended in the midst of a liquid landscape. Lofty passages, black pits, and unsteady slopes of boulders cannot escape their appraisal from a position far above the floor. Nearby lies a nylon guideline that had been knotted at 10-foot intervals before being placed to mark the path through borehole that continues beyond sight and beyond the final tie-off of the line. To the explorer, the impulse to attach a fresh reel of line and push on is tremendous. But the level of air reserves forces the team to retreat to the distant exit while surveying their new discovery. With the depth of the first station recorded, the lead diver starts to tow the dumb end of the tape to the next station. There's no time to dally about with the cave's cross-section dimensions; this will have to wait for another dive. Right now, the priority lies in collecting accurate data along the line. As the second diver watches the yellow tape roll off the spool, she prepares for the lead diver's on-station signal. After the two quick tugs and a stretch of the tape, the first segment is complete. Now only a dozen stations remain, as they waltz the stretched tape through the next segment.

This article appeared, in somewhat different form, in *Underwater Speleology*, volume 13 number 2, April 1998.

The exploration of a cave is never complete without an honest attempt to document the character and configuration of its known passages. For underwater surveyors, this venture might require minutes or years to conclude. Zero visibility, equipment failure, or confusion could cause an inexperienced caver to draw his last breath short of the exit. Consequently, most underwater surveyors are well drilled in preventing or managing these predicaments. The true challenge for these mappers evolves as the team begins to push a survey farther and farther into the cave. Both large and small loops start to close, bringing a sort of personality to a part of the greater watershed. How accurate is this survey? Is the precision of the underwater instruments and techniques adequate to form a reliable basis for a cartographic rendition of this natural wonder?

Ultimately the survey exceeds the range of standard cave-diving equipment. Now the logistics problems become more complicated, as additional life-support equipment is needed to follow an explosion of leads. The survey grows more distant from an entrance, and an increasing amount of time and air is used in commuting to and from the end of the line. Unless additional entrances are discovered along the way, the air that can be earmarked for exploring and mapping quickly dwindles to near uselessness.

Do massive decompression obligations and extreme depths begin to have an influence on the detail and accuracy of the data? At what point does the surveyor decide to use more expedient means of data collection, as prudence adds its indescribable taste to the flavor of exploration? These and similar factors are just as important to the mapping of underwater caves as the Koh-i-Noor and Mylar. Each affects the view of the final map in the cartographer's heart and mind. At best, one should assume that a map reflects a delicate balance between the surveyor's repertoire of techniques and commitment to detail and accuracy and the realities of managing time and air reserves in the cave.

Underwater cave maps have taken an evolutionary path similar to that of dry cave maps. Long ago they began as basic, simple portrayals, and eventually they matured into an art that utilizes a wide spectrum of media to display the final results. The example in this article is a relatively traditional map of an underwater cave. Cenote Mayan Blue is the central section of a very large underwater cave in Quintana Roo. In roughly three years, over three hundred and fifty survey dives were completed, not counting those aborted due to rather stimulating misadventures. This equates to nearly one thousand fifty underwater hours spent collecting the data. A laptop computer was used to manage the basic survey-line data with SMAPS 4.4, which generated coordinates of the stations. The actual cave and its features, however, were all drawn by hand on vellum. The final draft appears quite similar to a dry-cave map in style and presentation, aside from a smattering of uncommon symbols. But the techniques used to gather the data were variations on

the methods developed for use in dry caves, where there is an abundance of air.

Other than silly mistakes or blunders, the accuracy of a survey depends largely on the instruments used to collect the raw information on the cave. Unfortunately, it is difficult to reduce errors in underwater surveying, due to the crude nature of underwater instruments. Many waterproof compasses are constructed only for the most basic navigation by recreational divers. Their compass cards are poorly marked and rarely show increments smaller than 10 degrees. Fortunately, Suunto produces a more refined side-reading compass, the SK-6, that is marked in 5-degree intervals. It is used much like a Suunto KB-14. With a bit of practice, it is possible to make estimates to a degree on its spacious compass card.

Silva models are also used successfully, but catching the azimuth is a bit of a juggling match. The straight-edge on the compass body has to be aligned perfectly to the tape or guideline as the compass is leveled, but the compass must not actually touch the line, which would push it out of position. After turning the bezel to bring the printed arrow into exact alignment with the compass needle, the azimuth is finally recorded from the outside scale on the bezel. Each Silva model has its own scale on the bezel and other characteristics, which leads to various styles of collecting the azimuth data. The models also differ in needle damping and how well machined and corrosion-resistant the degree-marks are.

An important instrument for underwater surveying is the depth gauge. It replaces the clinometer in adjusting the length between stations to its horizontal projection. The change in depth between one station and the next is one side of a triangle, and the measured distance is the hypotenuse. A quick exercise in Pythagorean geometry supplies the horizontal length of the shot. The depth readings themselves provide the elevation data relative to the surface of the water at the entrance. It is best to avoid using the less expensive depth gauges. The simple mechanism that rotates the indicator hand cannot be relied on to yield consistent depths as the surveyor moves up and down in the water column. For those with deep pockets, a more dependable depth gauge by far is the computerized sort with a claimed accuracy of plus or minus one foot. However, even these have shortcomings when used for precise work. The displayed depth on station could vary by up to two feet. In experimenting with one such machine (no two are alike), I found this error to average 6 to 12 inches. Should a traverse line include a series of long shots at a near-constant depth, the error generated is usually negligible. But a sequence of short shots of 25 feet or less that are steeply descending or ascending can play havoc with a survey. One possible solution would be to average the depth display on two computers with known errors, but this can become overly complicated. In any case, it's critical to record the water level (zero datum) at the beginning of a particular survey project. Should the water table fluctuate between seasonal flooding and dry periods, the changes can be added to or subtracted from the depths recorded on future survey dives.

Until more accurate depth gauges and underwater compasses are available for underwater survey use, azimuth and depth estimates will plague the accuracy of underwater surveys. It should be obvious that using the same set of instruments throughout a survey project eliminates a giant source of headaches. This does not imply a wholesale inaccuracy in these surveys. One needs to be familiar with his instruments and willing to resurvey, hopefully not too often, until the desired degree of accuracy is obtained.

What of the lengths between stations and ultimately the length of the cave? There are two methods that are currently accepted for measuring the distance between underwater survey stations. Both have been adapted to the continuous-guideline rule for safe underwater cave exploration. This states that a continuous guideline is always maintained to the cave's exit. As exploration time is rather precious, the guideline is first installed to just trace the path of the exploration. Then this guideline may be repositioned on subsequent trips to yield longer survey shots or avoid delicate areas. Once this line has been surveyed, it is seldom repositioned, as the series of stations along it becomes the backbone for tying in offshoot tunnels and measuring the cave's dimensions and features. A quantity of air is always reserved for the survey back, on top of the customary reserves held for the safety of the exit swim. It is these reserves that determine when exploration stops and the team starts surveying on the way out.

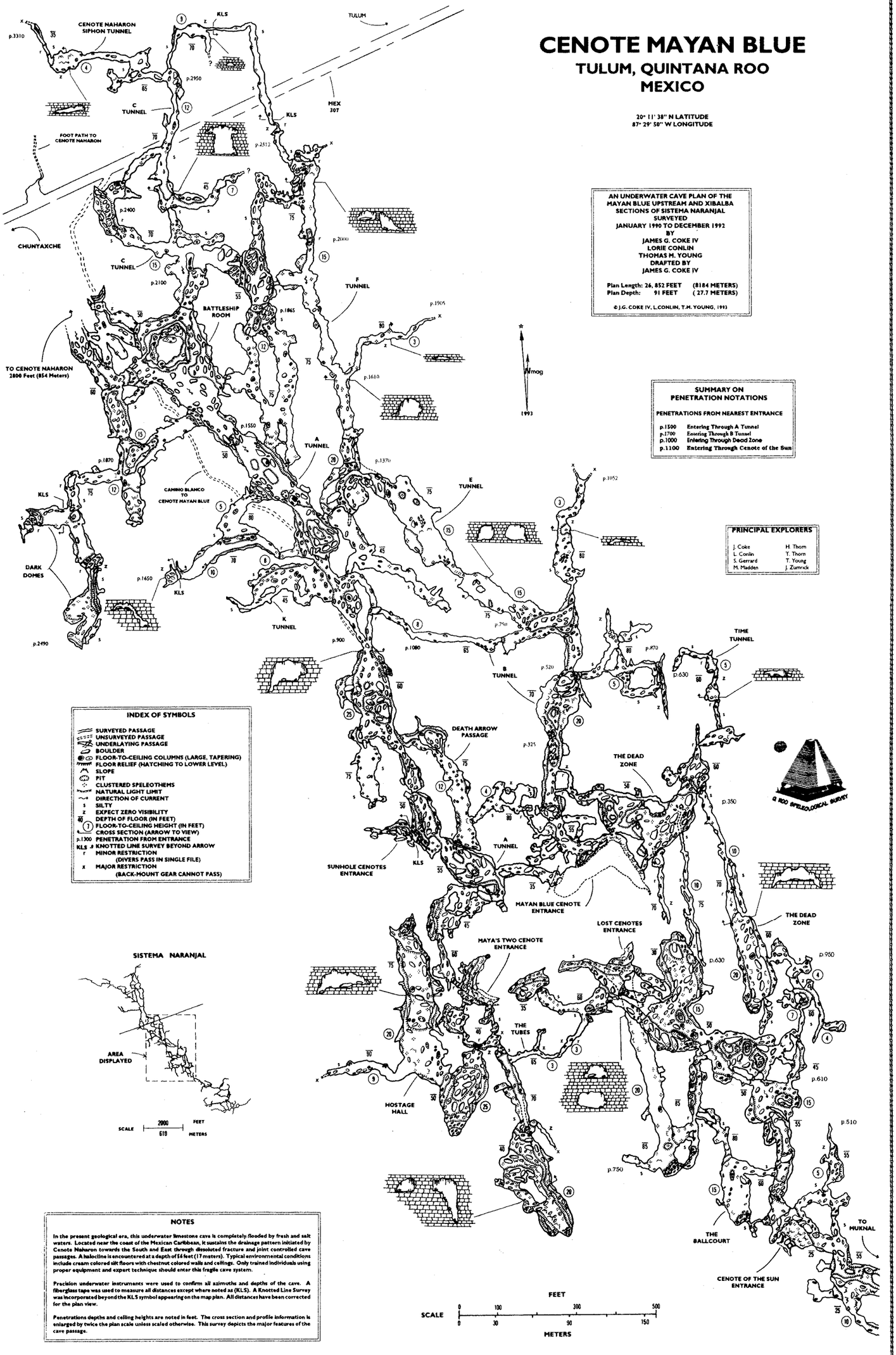
The first method of measuring distance employs a fiberglass tape. It is used in the same way as in a dry cave, although voice signals such as "on station" are replaced by a predetermined set of coded tugs on the tape. The survey team normally consists of two members. One diver records the azimuth between stations while swimming with the dumb end of the tape, while the second records the exact distance once the tape is in position at the next station. Both members of the team record the depth at each station. This may sound redundant, but it is extremely difficult to compare notes underwater, where verbal communication is impossible. So when the two sets of data, distances and azimuths, are combined on the surface, matching stations by their depths becomes a simple task. This method prevents some potential giant blunders, while also serving as a double-check on station depths.

The second method is known as a knotted-line survey. It relies on counting knots on the guideline and estimating portions between knots to the nearest foot. The survey team in this case can consist of only one person. The KLS concept was first suggested by John Zumrick in the early 1960s as an alternative to taping survey shots. As new guideline is loaded onto an empty reel, an overhand knot is tied every 10 feet.

CENOTE MAYAN BLUE

TULUM, QUINTANA ROO
MEXICO

20° 11' 38" N LATITUDE
87° 29' 50" W LONGITUDE



AN UNDERWATER CAVE PLAN OF THE MAYAN BLUE UPSTREAM AND XIBALBA SECTIONS OF SISTEMA NARANJAL SURVEYED JANUARY 1990 TO DECEMBER 1992

BY
JAMES G. COKE IV
LORIE CONLIN
THOMAS M. YOUNG

DRAFTED BY
JAMES G. COKE IV

Plan Length: 26, 852 FEET (8184 METERS)
Plan Depth: 91 FEET (27.7 METERS)

SUMMARY ON PENETRATION NOTATIONS

PENETRATIONS FROM NEAREST ENTRANCE

p.1500	Entering Through A Tunnel
p.1700	Entering Through B Tunnel
p.1000	Entering Through Dead Zone
p.1100	Entering Through Cenote of the Sun

PRINCIPAL EXPLORERS

J. Coke	H. Thorn
L. Conlin	T. Thorn
S. Gerrard	T. Young
M. Madden	J. Zumrick

INDEX OF SYMBOLS

- SURVEYED PASSAGE
- UNSURVEYED PASSAGE
- UNDERLAYING PASSAGE
- BOULDER
- FLOOR-TO-CEILING COLUMNS (LARGE, TAPERING)
- FLOOR RELIEF (HATCHING TO LOWER LEVEL)
- SLOPE
- PIT
- CLUSTERED SPELEOTHEMS
- NATURAL LIGHT LIMIT
- DIRECTION OF CURRENT
- S SILTY
- Z EXPECT ZERO VISIBILITY
- 85 DEPTH OF FLOOR (IN FEET)
- 7 FLOOR-TO-CEILING HEIGHT (IN FEET)
- CROSS SECTION (ARROW TO VIEW)
- p.1300 PENETRATION FROM ENTRANCE
- KLS # KNOTTED LINE SURVEY BEYOND ARROW
- r MINOR RESTRICTION (DIVERS PASS IN SINGLE FILE)
- x MAJOR RESTRICTION (BACK-MOUNT GEAR CANNOT PASS)

SISTEMA NARANJAL

NOTES

In the present geological era, this underwater limestone cave is completely flooded by fresh and salt waters. Located near the coast of the Mexican Caribbean, it sustains the drainage pattern initiated by Cenote Naharon towards the South and East through dissolved fracture and joint controlled cave passages. A halocline is encountered at a depth of 54 feet (17 meters). Typical environmental conditions include cream colored silt floors with chestnut colored walls and ceilings. Only trained individuals using proper equipment and expert technique should enter this fragile cave system.

Precision underwater instruments were used to confirm all azimuths and depths of the cave. A fiberglass tape was used to measure all distances except where noted as (KLS). A Knotted Line Survey was incorporated beyond the KLS symbol appearing on the map plan. All distances have been corrected for the plan view.

Penetrations depths and ceiling heights are noted in feet. The cross section and profile information is enlarged by twice the plan scale unless scaled otherwise. This survey depicts the major features of the cave passage.

After this prepared line is laid through a previously unexplored tunnel, the knots between the stations can be counted quickly and easily. The guideline is usually wrapped around a projection at each place where the tunnel changes direction. These become the stations, and there is a portion of a knotted interval on the line to be estimated on each side of each station. This technique was adopted immediately by most American cave divers.

The primary advantage of KLS is the speed with which the line can be surveyed. When diving at great distances from the entrance or at great depths, heavy air or decompression requirements make a slower technique very uninviting. KLS also has the advantage of being compatible with surveying while driving an underwater scooter, which is particularly important today, when technology has allowed explorers to push deeper and farther into parts of caves that were impossible to visit just a few years ago. Another advantage is that the distance measurements can be made in near-zero visibility by feel, while team members remain close together and in contact with the guideline. Of course, visibility cannot be so poor that the instruments cannot be read. The compass reader needs only to be able to align the compass with the guideline locally; he need not be able to see the target station. Finally, KLS is easy for beginning surveyors to learn and execute underwater.

But knotted-line survey is not without shortcomings. Added to the problem of the other instruments, this technique can further erode the accuracy of the survey. Its greatest fault is that it requires a surveyor to estimate a distance measurement not once, but twice. The first instance occurs when the line is knotted before it is spun onto the reel. Even when the knots are spaced accurately, an unknown factor is introduced, because the tension on the line as it is being knotted may not be the same as the tension when it is installed underwater. To misjudge the tension during either process will undermine the most fastidious efforts to make the intervals between knots constant. The second estimation occurs when the surveyor has to estimate the lengths of the portions of the line between both ends of the survey shot and the nearest knots. Each part is estimated only to the nearest foot. To check on the resulting state of affairs, I decided to tape over one hundred and fifty alleged hundred-foot sections of guideline in various underwater caves around Quintana Roo. Each of these caves had been previously surveyed with the KLS technique. From the range of results obtained, I estimate that the typical 100-foot KLS segment is 1 to 5 feet longer than the true, taped length. To be extremely conservative, I estimate that a KLS survey can boost the length of an underwater cave by as much as 10 percent. You might be interested to know which method of measuring distances is the vogue these days. KLS has won hands down. Even within the most easily surveyed portions of caves, a taped survey is almost never the method of choice.

Most underwater surveyors choose between two bookkeeping systems for recording their raw data. They are nearly identical and quite dependable, unless the two systems are inadvertently mixed together. During a normal survey dive, data are recorded on underwater slates that have been permanently engraved in a four- or five-column grid. Each row in the grid represents a survey station, and the first three columns are used to record depth, azimuth, and distance entries. The remaining columns are used to record only the most basic station and passage appearance, if they are used at all. During the line survey, there is rarely time or need to collect data on both the passage's trend and its structure.

When preparing a complete map, most cartographers prefer to postpone drawing the passage until all of the surveys in that region of the cave are known to be accurate. After the dive, the data on the survey line are converted so that the survey appears to lead into, not out of, the cave and then transferred to a notebook or a software program that accepts depths rather than inclinations. SMAPS 4.4, CAPS, and COMPASS programs provide this feature, and they are the most popular programs among divers at this time. Finally, the data are converted to rectangular coordinates, and a simple line plot of the cave, from the zero point at the water level at the entrance to the farthest surveyed points, is made.

The majority of underwater caves in Quintana Roo contain a labyrinth of loops, where passages branch off to rejoin at a point farther into the cave. Whether the loops are long or short, they have become a convenient standard for judging the accuracy of our line surveys. This is by no means the best way to determine the accuracy, but checking loop closures is the most reasonable way for this type of cave. Ideally, a branch of the loop will start at one survey station and end exactly at another on the main line. The closure error is a measure of the accuracy of the two lines making up the loop.

What is an acceptable amount of loop error in underwater surveying? This is not an easy question. Using the best survey tools will obviously reduce errors in the loop, but it won't preclude inaccurate work and resurvey dives. In fact it was essential to resurvey nine of the thirty-six loops in Mayan Blue to reach the final accuracy that I expected. A few of these loops were easy to resurvey, while others were far more difficult because of their depth and distance from the entrance. Interestingly enough, azimuth errors were the sole culprit in each bad closure.

What accuracy of line survey to demand is a large hurdle for cartographers to leap before they start to pencil in the details of the cave. Most caver divers would jump at the opportunity to explore a new passage, but the underwater surveyor is forced to strike a balance between an accurate map and an elevated risk of decompression sickness or other calamities. What if a survey loop includes knotted-line data taken at extreme depths,

Quintana Roo Speleological Survey Raw Data Form V. 7/93

Cave_____ Date_____ Area_____

Team_____ Survey IN OUT Line Name_____

(circle one)

Please sketch tie-in area

Reported by

_____

Tie-in's Need
2 dpths
2 azms
1 dist

_____ azm dist_____

in sta dpth_____

tie-in sta

dpth_____

out sta dpth_____

_____ azm dist_____

fm	to	dpth	azm	dist	comments	fm	to	dpth	azm	dist	comments
0	1					13	14				
1	2					14	15				
2	3					15	16				
3	4					16	17				
4	5					17	18				
5	6					18	19				
6	7					19	20				
7	8					20	21				
8	9					21	22				
9	10					22	23				
10	11					23	24				
11	12					24	25				
12	13					25	26				
						26	27				
						27	28				
						28	29				

DPTH is depth of "fm sta"
AZM is from "fm sta" to "to sta"
DIST is from "fm sta" to "to sta"
RECORD DEPTH OF FIRST AND LAST STA

ASSIMILATED SURVEY DATA ⟷ FOR QRSS SURVEY RECORDS USE

Data Into Cave

Survey Data Prefix_____ Tie-in Station Name_____

1st Raw Data Station #_____ Tie-in Sta Prefix/#_____

Raw Data Survey Grade_____ Recorded by_____

and the closure error is 5 percent? What is considered an acceptable error for a 2500-foot loop that begins 3500 feet from the entrance? Good underwater surveying requires a lot of time and depends on the survey team having a good time doing it. Clearly there are no easy answers. The mapping team ultimately decides which errors to correct and which they are willing to live with, in order to get on with the map.

Organizing raw data into a line plot is a simple task if only one or two teams are surveying the cave. Mayan Blue was in this category, as very few cavers were involved. But what if many teams are surveying an underwater cave? These teams may generate one or two thousand feet of raw data per day; woe to the poor data processor who must decipher and organize this torrent of information. In years past, each team would invariably use a slightly different format for passing data along to be assimilated into the growing map. Where their new survey tied into an existing passage may have been crystal-clear to those surveyors, but it is usually clear as mud to the survey organizer. Having had some experiences with this, Harve Thorn and I created a data form that will hopefully alleviate this problem and also serve as a hard-copy archive for raw data. Although this form requires a little extra effort from the team, it attempts to clarify a number of questions that might arise. It not only organizes and asks the most obvious questions about the raw data, but it also provides a means for a person who is not acquainted with the cave to interpret the relation of the data to the rest of the cave. This is especially true in the case of surveys of offshoot and loop lines. (This form, shown in the figure, is not to be confused with the slate used to record the data during the dive.)

As an example, let's say that one group originally surveyed a main trunk passage using a digital depth gauge, tape, and side-reading compass to get the best results. Later on a second group discovers an obscure lead in this passage that opens up a totally new area of the cave. For whatever reason, they elect to use knotted-line survey in this area. To add the new data to the original survey, they must tie into a recognized trunk station and collect five pieces of information about this station for the data organizer. The first is the depth of the station where they begin their new line. From this station, they record the azimuth that the trunk line takes leading farther into the cave. Then a second azimuth, a backsight, is taken on the line leading back toward the entrance. They also record the distance of this "exiting" segment, as well as the depth of the station at its end. This information makes it possible to identify the tie-in station in the main trunk, even if the data processor is not familiar with the cave.

This form became fairly popular with Quintana Roo cavers, as it simplified the rather mundane task of adding data to a computer file and providing a team with a copy of their work for future reference. With line plots being generated at a faster pace, spotting errors and planning the next day's explorations were made easier. These instant maps were also great morale-boosters.

I have tried to address how most survey data is collected in order to build a map of an underwater cave. For an average underwater cave in Quintana Roo, with a total length of fifteen thousand feet and the normal number of offshoots and loops, a reasonably accurate line map can be constructed during about sixty dives, or nearly one hundred hours of dive time, excluding decompression. Usually, this type of map is the final form of most maps of underwater caves. With the bulk of the exploration complete, it takes a committed team to fill in actual details of the cave.

The diving required to gather data on the walls and other features, or to present the cave's true personality, will more than triple the number of dives. Looking at the Mayan Blue map, you may see that there is a bit more detail in the vicinity of the various entrances. It is much easier to spend a lot of time in these areas drawing details.

The drawing method I prefer to use in these areas is fairly simple. I prepare a stacked set of five underwater slates with a selection of survey segments drawn to scale on each side of each slate. The segments on the slates are arranged to lead deeper into the cave. Such details as station depths and the positions of offshoot lines can also be included on the segment lines. Once in the water, it becomes a matter of stretching a tape to the side walls from each station and adding boulders and stals on the slate in the proper scale. Taking back-azimuths to the station from the features assures their proper position. After the dive, the passage minutiae on the slates are immediately transferred to a vellum master map of the cave. This master copy contains all of the cave's survey lines, drawn from the coordinates, and the printed grid on the vellum provides the scale for drawing the details. Although it is very time-consuming, the first fifteen hundred feet from an entrance can usually be drawn in this way as long as the cave's depth does not become excessive. Multiple dives may be required to sketch a large room. The greater the depth, the less can be drawn on one dive. Most underwater mappers use a variation of this theme, as it is an efficient way to record the particulars of a cave.

However, this technique has a disturbing idiosyncrasy. The line on which the passage is being drawn must be known to be correct. If a resurvey of that line is needed, the passage details cannot be reconstructed without fudging. Once the in-cave drawings have been transferred from the slates to the master map, the slates are cleaned in preparation for the next dive, and the original drawings are lost forever. Although a good Xerox machine may produce a readable copy of these drawings, I have never had much success with either the machines or the permanence of such copies in Mexico. Underwater surveyors have yet to discover a viable equivalent to the dry caver's survey

book. We have experimented with taking small sheets of acetate and marking pencils underwater, but with little success. So unless a small fortune is spent on storing the original slates, the drawings eventually become graphite down the drain. That is why most underwater cartographers prefer to complete the line survey first and draw later.

The ultimate challenge in drawing these caves starts when the cave grows beyond the range of normal cave-diving kit. That is, underwater scooters may be needed to reach the work area, and stage bottles to supplement the normal set of doubles on your back are used. After an hour's underwater commute, time and air become valuable commodities, so the team's efficiency needs to be high. One approach we used with some success was to restrict the rate of exploration of the main trunk. It is fairly simple to determine the total volume of air required to travel to a chosen area and then return to the entrance. After allowing for necessary reserves for safety, the remaining air volume is available for exploration and mapping. We used no more than one-third of this for exploration, leaving the rest for surveying and drawing on the way back though the newly explored passage. Once that section of the main passage was completed, subsequent dives would investigate all offshoots in the area, before we extended the main passage again. The primary advantage of this technique was that an area in the cave was completely surveyed and sketched, with no offshoot passages overlooked, before the next area was tackled.

Surveying at some distance into the cave requires a high level of concentration. Each diver needs to be very conscious of his air supply and body-heat loss, to stay focused on the survey, and to be able to shrug off the mental haze that can sometimes settle in after so much concentration. If we even suspected that a survey might close a loop, extra care was taken in the survey to try to avoid losing hours of effort to a bad closure. As exploration continued and loops were closed, solo dives were made to draw details in those areas and check for possible additional leads. Due to the nature of Mayan Blue, this was an expedient means of creating the complete map. The time that was actually spent in drawing during these dives depended on the distance the sketcher was from the exit. This part of the entire system has well-defined boundaries, unlike the region south of this map, which is still being explored and drawn, and most areas of Mayan Blue are not too distant for very productive drawing dives.

Can you imagine the importance that the master vellum copy gains after six months of diving and drawing? During infrequent trips to the United States, I would duplicate the master copy. But in between those trips, I must confess, I had a few noteworthy moments of panic. Sleeping with my map tube in a hotel room in Coba during Hurricane Gilbert was bad enough, but when I temporarily misplaced that tube years later in the Cozumel airport . . . .

The actual conversion of the master draft into a Mylar presentation-grade copy was quite similar to any cave-map drafting. The real question was how to make the map useful to a diverse set of users. With this in mind, I incorporated a set of special symbols to show environmental features and hazards. Many cave divers plan their excursions by using a map. Symbols for restrictions, delicate areas, visibility warnings, and so on give a better idea of what to expect during a dive. Penetration distances also aid in planning. As there are seven entrances to this section of Sistema Naranjal, I attempted to distinguish penetration distances from different entrances by using distinct fonts. Although I would have preferred to use metric values for depths and penetrations, I decided that English measurements would be more useful to the majority of cave divers who use this map. Most of the underwater instruments today still read in English units.

The Cenote Mayan Blue section of Sistema Naranjal required a few years to survey and draw. During this time the survey discovered major extensions in all sections of the cave that eventually quadrupled its known length. Sistema Naranjal is currently surveyed at 19,996 meters, and it is still going. It is currently the fifth longest underwater cave in the world.

Many people deserve special mention. Excursiones Akumal, Dick Blanchard, and Gonzalo Arcila displayed endless patience with me during those many years of surveying. Lorie Conlin, Harve and Toni Thorn, and Tom Young put up with a ton of my above- and underwater antics. And Pat Kambesis has been very supportive of my cartographic efforts over the years.

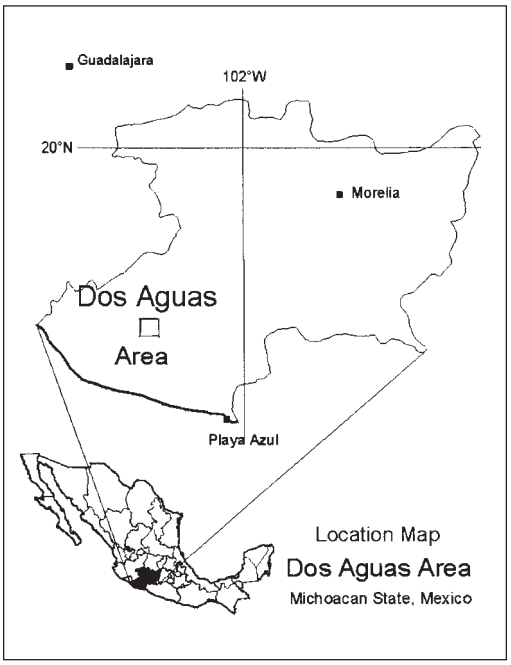
Topografía de cavernas subacuáticas

El autor describe las técnicas empleadas para elaborar mapas de cuevas sumergidas. Debido a las limitaciones temporales del buceo en cavernas, la topografía preliminar se realiza usando los anclajes de la línea de vida como estaciones, y en buceos posteriores se realiza el croquis. Las topografías mas exactas se realizan con cinta métrica y compás, aunque en la mayoría de los casos las distancias se miden contando los nudos en la línea de vida, previamente colocados cada 10 pies antes de entrar a la cueva. Los datos de elevación se obtienen mediante un profundímetro, por lo que no se usa clinómetro.

DOS AGUAS, MICHOACÁN, 1999

Chris Lloyd

In the winter of 1998–99, a small core group went to the Dos Aguas area. (An article on previous trips appears in *AMCS Activities Newsletter* 23.) We decided to move to a new doline located to the west of the town of Dos Aguas. It is 5 kilometers long and 3 to 4 wide, with many internal dolines and a flowing stream that sinks into a large entrance. The river cave, Cueva del Río Durazno, was pushed over a first sump bypass to the Boring Stompway, 10 meters high and wide for a kilometer, with ankle-deep water. With some effort, a climb bypassed a second sump, only to lead to a third. Above that, Humberto "Tachi" Tachiquin made good progress up a climb with wind in his face. We decided to leave the cave rigged, but wondered what the floods would do to our rope.



Our fourth Dos Aguas Expedition, over Christmas 1999, was the smallest yet, with only six people, one of whom stayed only half the time. Regulars Ramón Espinasa, Ruth Diamant, Chris Lloyd, and Vicente Loreto were joined by Sergio Nuno, on his second trip, and one Victor, who only stayed five days. Despite the small number and having to leave someone in camp, we still managed to field a mapping team each day.

After arriving on the twentieth, we started right in on one of Francisco "Curro" Ruiz's discoveries from the year before. It was hoped, eternal optimists that we are, that this would provide a quicker route into the bottom of Cueva del Río Durazno. Of course the cave had other plans. A series of three pit entrances is located on the north side of the road about 200 meters before it drops down to pass over the main entrance of Cueva del Río Durazno. We went to the first pit, which is located in the bottom of an obvious doline and is closest to the road. It started as a tall rift, blowing cold air, with its floor dropping down in a series of short vertical drops. We put ladders on the first two drops, of 5 meters each, which landed us in a sizable chamber. The right corner of the room led to a low alcove with a crawl at the back. Sergio pushed this into a small chamber with a smaller crawl leading off to the left and a tight climb up on the other side. No air movement was noted, so we left it "for the next generation."

From the main chamber, we then headed down to the left, where Vicente had been rigging a pitch while we were surveying the crawls. The pit dropped down about 8 meters to a small landing, from which another 8-meter drop was reached through a small window. The second pitch took us into a tall canyon passage that went off in both directions, one of which opened up into a chamber of sorts. The controlling fractures could be seen crossing the room. Two leads from the room pinched out, while the other lead started to trend up, after passing a hole in the floor through which we could hear the sound of running water. Unfortunately, the hole was a bit too small to enter, though it looked like some hammering would allow a small, flexible person to go down. The upward trend headed slowly back up, and, sure enough, after 70 meters or so was at the bottom of a 20-meter pitch up to daylight, the second of Curro's pits. After Sergio and I surveyed that, we caught up with Vicente and Victor, who were checking the other direction in the canyon. It soon became a stoop and, after passing thought a small room with a fossil section above, turned into a low crawl. Vicente went down it for about 40 meters, and it just got smaller and smaller, enough so that Vicente, who is not a big guy, didn't feel comfortable following the draft any farther. So that way on had to be left for the next generation as well. Our hoped-for easy way turned out to be about 175 meters of nice cave, but no easy way in.

The third pit was dropped by

Humberto "Tachi" Tachiquin leading the traverse above the second sump. *Chris Lloyd.*

Ruthy a few days later and found to be about 30 meters deep to a mud funnel. No way in there, either.

So off we went to push the end of Cueva del Río Durazno. Four of us headed in and found out that between Vicente and me we had managed to bring no more than two bolt hangers for the bolt climb Vicente was planning to do. These two hangers got used in the first sump-bypass pitch, while Vicente went out for more. The rest of us headed in to survey a lead Ruthy had found off the Boring Stompway last year. After managing to scale the 10-meter-high mudbank, we cruised along a passage 2 to 4 meters wide and 2 to 6 meters high, not bad for a cave that had been described by American cavers back in the eighties as having no side leads. Unfortunately it wasn't really heading away from the main river, and after 340 meters we started to hear water again. Vicente happened to be walking by in the stream below, and he helped connect the survey back to the river. We did pass two side passages that weren't pushed. They might go farther from the river. One was a low, but almost 3 meters wide crawl that was almost blocked by mud, but that trended upward somewhat. The other was a high inlet above a nice flowstone column just before Vicente's end of the loop. So there are things besides lots of nice stal for the next generation to check in the RV Overflow Passage.

United once again, we headed in to the end of the cave to see the climb Vicente was going to try to finish. This meant that we had to climb over the second sump, and when we got there we found that the rope we had left was not hanging down where we were hoping to find it. I had my trusty kayak-rescue throw bag with me, though, and proceeded to climb the big flowstone cascade across from the passage we needed to get into. Last year I had tried unsuccessfully to throw rope up from the sump side. This time I was able to get up almost level with the bypass passage, and thus my first throw went right over and down to the sump. With this we were able to pull over a proper rope, and Ruthy easily did the climb up and found our old rope lying beneath the bolts in the wall. Evidently the river had backed up almost 10 meters to the overflow route. The rope wasn't battered at all, just very muddy, so we used it to replace the fresh one and carried on up the additional rope that had been left on the big mud slope.

This was new territory for me, as they had pushed this after I had left to go to the beach last year. This had been a good effort, as it went about 80 meters, passing a couple of holes in the floor that went down to the third sump, and was slippery mud the whole way up. At the top was a level passage 2 to 8 meters wide and generally 8 to 12 meters high, but still wind enough to feel on your face. After a couple hundred meters it started to close down somewhat, and I lost the airflow in a chamber with some stooping passage going off. Not wanting to stoop, I waited for Ruthy, and she pointed out a window up in the wall of the chamber with a piece of flagging tape blowing in the wind. To give an idea of how big that section of the cave is, Ruth and Sergio managed, on the way in on our derigging trip later, to do a U-turn and find themselves back at the mud slope without having realized they were headed back out.

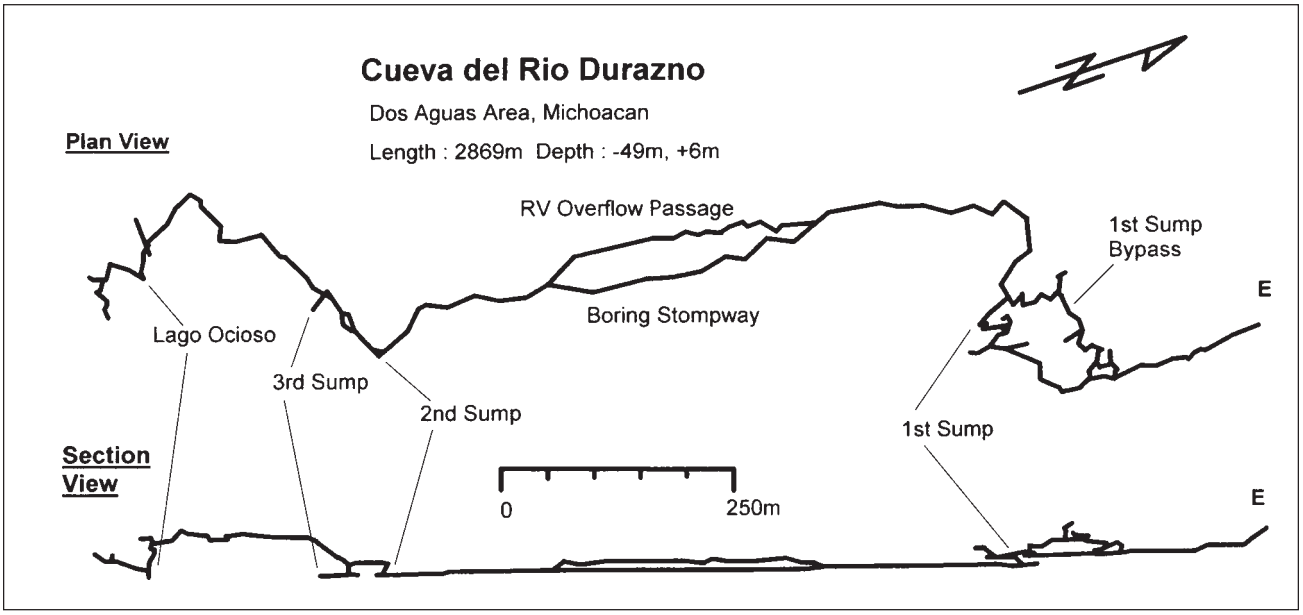
We had to re-climb the climb up to the Windy Window, and we decided to leave a rope rigged there, because the climb was sure to become muddy. There was a 7-meter drop immediately on the other side of the window that dropped into the Terminal Chamber. This large room is about 15 meters wide, 60 meters long, and more than 20 meters high, with very large breakdown blocks at the far end. The climb Tachi had begun the previous year went up an alcove at the far end. Ramón had dropped one of the holes in the floor last year looking for a way on. Now, while the rest of us sat and rested, Ruthy dropped another of the holes in the floor to

look for going passage. It looked promising, but it would require rigging another rope. We left all our gear and called it a day.

The next day, Vicente led Victor and Sergio in to have a go at Tachi's climb, which ended after two bolts in a blind aven, despite the apparent air flow last year. If you can't go up, go down. Vicente then continued past where Ruthi had gotten to and rigged a pitch that dropped into a large chamber sloping down in ever-thickening mud to the top of yet another pitch with a lake at the bottom. He left it at that, and it took Ramón and me one complete trip to tidy up the rigging and get Ramón down and across the lake. We were both so mud-covered that we just had enough time to survey back up the 50 meters and get out in time for Christmas Eve. The room was christened the Sala Chupabota for its ability to suck the boots right off your feet. Ramón was so impressed by the cold lake at the bottom that he christened it Lago Oscioso, which translates roughly as good-for-nothing, pain-in-the-ass lake. The rope landed in the middle of the cold water, requiring a swim across to the far shore.

We were now back to river level in a lake passage 5 to 8 meters wide and up to 20 or 30 meters high headed out of sight. Vicente and I were the only ones willing to brave the Chupabota and continue in the Chupalampara Passage, the Light Sucker. We had to rig a traverse high on a mud bank, and then we proceeded into shrinking passage. Fairly quickly the passage headed up as well, and we soon found ourselves in a room with two ways on. We left the smaller one with the red flowstone ramp for later and headed into what started as a nice stooping passage with pools of water and rimstone dams. The roof continued coming down, and the water turned to mud again. After a couple of survey shots through very yucky and slimy mud, I was standing crotch deep in mud with only 40 centimeters of air space. Fortunately this didn't last long, and we were soon in nice walking passage once again. This led to a small chamber with a sizable flowstone cascade at the end and a narrow slot up between boulders. Vicente popped up the slot and disappeared down an 8-meter pit on the other side that went to a room with a narrow crawl leading out from it. The airflow wasn't great, so he came back to try the flowstone cascade. After a couple of moves, he was able to lasso a horn to protect the climb for me. This put us up into another chamber, this time with three ways on. We surveyed the left one to a narrow rift mostly choked with mud, but with a tight squeeze going up and taking weak airflow. Straight above the entrance to this passage was another flowstone that was coming out of a 2-meter-diameter passage. This was a bit too steep and exposed to do without some aid, so we checked the third way, on the right. It was a narrow slot that dropped under a block and then went down what sounded like an 8-meter pitch. The largest amount of air seemed to be going down there, but it too would require a bolt, so we called it a day. Two-person surveying is not the fastest, and the amount of mud meant we would only have had another couple of shots anyway, before we couldn't read the instruments or even see the book.

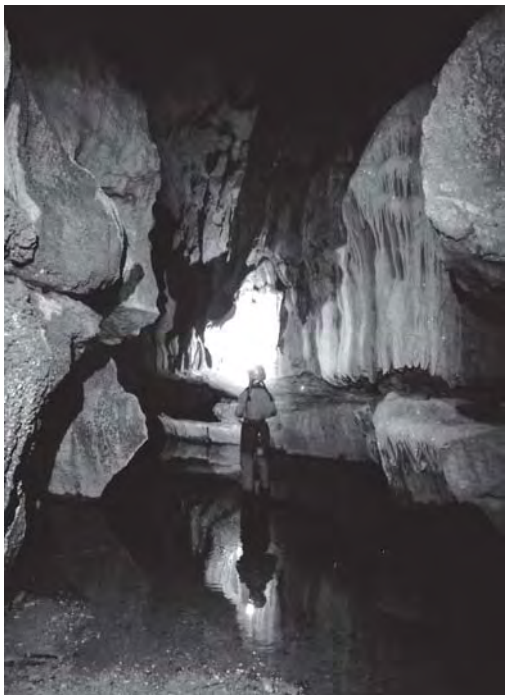
For some reason nobody wanted to return to the end of the cave, and it sat for a couple of days. On what should have been our last push day, we still couldn't get anyone into our peachiest of leads. Instead, I dragged Vicente along to go find a lead from Ruthi's scouting last year. It was a drafting hole located almost directly over where we were now pushing in Durazno. Down a few pits, we could have our sought-after shortcut. After thrashing around in head-high corn for a half hour, we went to get Ruthi and the GPS. While we were still attempting to find Ruthi's lead, Vicente went down into a largish amphitheater of rock. When he called us, we had a clue about why in the large echo. It was quite impressive how



an entrance 30 meters wide and 10 meters high could hide only 60 meters from the main road. If there had been Maya in this region, this is where they would have hung out. The entrance to Cueva de los Perdidos was almost twice as big as our main Río Durazno entrance, and it had a big roof just covered with roof pendants. The obvious, huge cleft in the back ended in a climb after 30 meters or so, and the only other way in was a climb down on the left-hand side. We were obviously not the first to climb down there, as shown by the notched log leaning against the wall. At the bottom, Vicente went to the left, while I stooped down and crawled to the right through a 10-meter-long low bit, through a strong wind. It opened up into nice walking passage 2 to 6 meters wide and 2 to 5 meters high, with clean walls and lots of formations. I strolled along for 100 meters or so and then started feeling guilty about scooping so much new stuff. But then Vicente caught up with me, and we figured there wasn't time to go back and get survey gear anyway, so we suffered on though passage that continued straight, flat, big, and clean. Eventually we came to a terminal room with big breakdown blocks forming the far wall. Poking into holes, I found an aven, and Vicente found the bottom of a pit with daylight at the top. This is probably the surface lead we had started out to find. Fortunately, there were also a couple of small holes in the floor that have the potential to get down to another level that may still provide our elusive shortcut.

Now we had only one day to push and derig Cueva del Río Durazno. Vicente and I went in ahead to the end to put in the bolt we knew was needed and see where it went. Ruthy and Sergio came in behind, enjoying the cold water, mud, and other diversions previously mentioned. They caught up with us just as Vicente came back up the 8-meter pit, which turned out to be blind. But while waiting for him, I could still feel air going into it. Sure enough, Vicente was able to spot a gallery heading off at just about the same level as the bolt, but off to one side and inaccessible without a bolted traverse to reach it. We decided to leave it for next year.

We have a going cave almost 3 kilometers long and a potential for a shortcut to get us to its end. Then there are the three other really good-looking entrances Ruthy has found, two taking streams, that are in a position to connect into the system lower down. Descriptions from the locals confirm that there is a big, walk-in entrance over the resurgence we have seen on the maps some 500 meters lower.



Claudia Ruiz in the stream passage just before the second-sump bypass. *Chris Lloyd.*

Vicente Loreto and others in the second-sump overflow passage, Cueva del Río Durazno. *Chris Lloyd.*

Dos Aguas, Michoacán

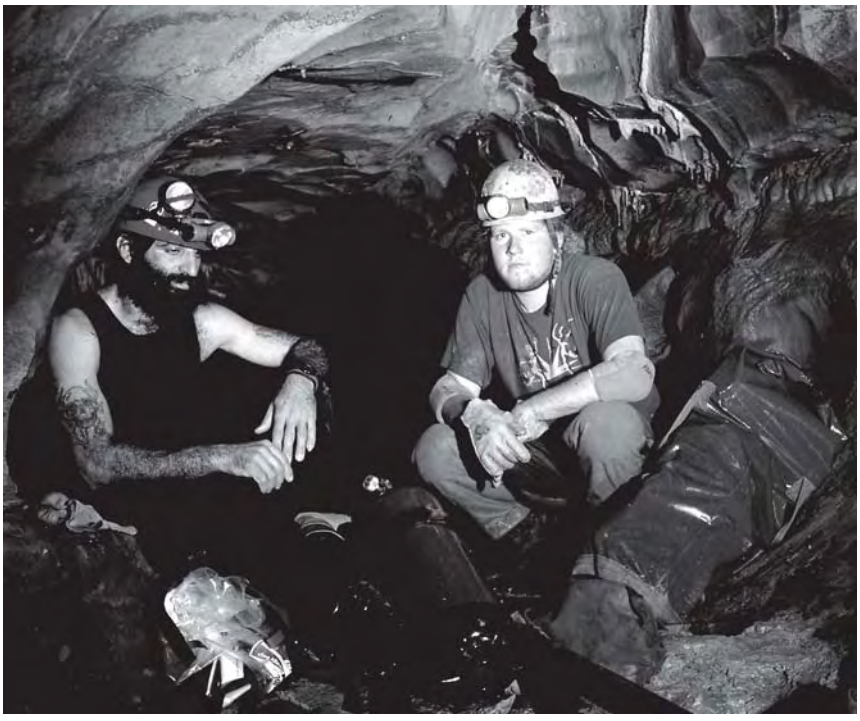
En la mas reciente expedición anual a Dos Aguas, se exploró la Cueva del Río Durazno hasta casi 3 km de longitud. Se piensa que la resurgencia está 500 metros mas abajo. También se exploraron una serie de cavidades menores, en busca de un acceso facil a la parte final de la Cueva.

RANCHO COLORADO, NUEVO LEÓN

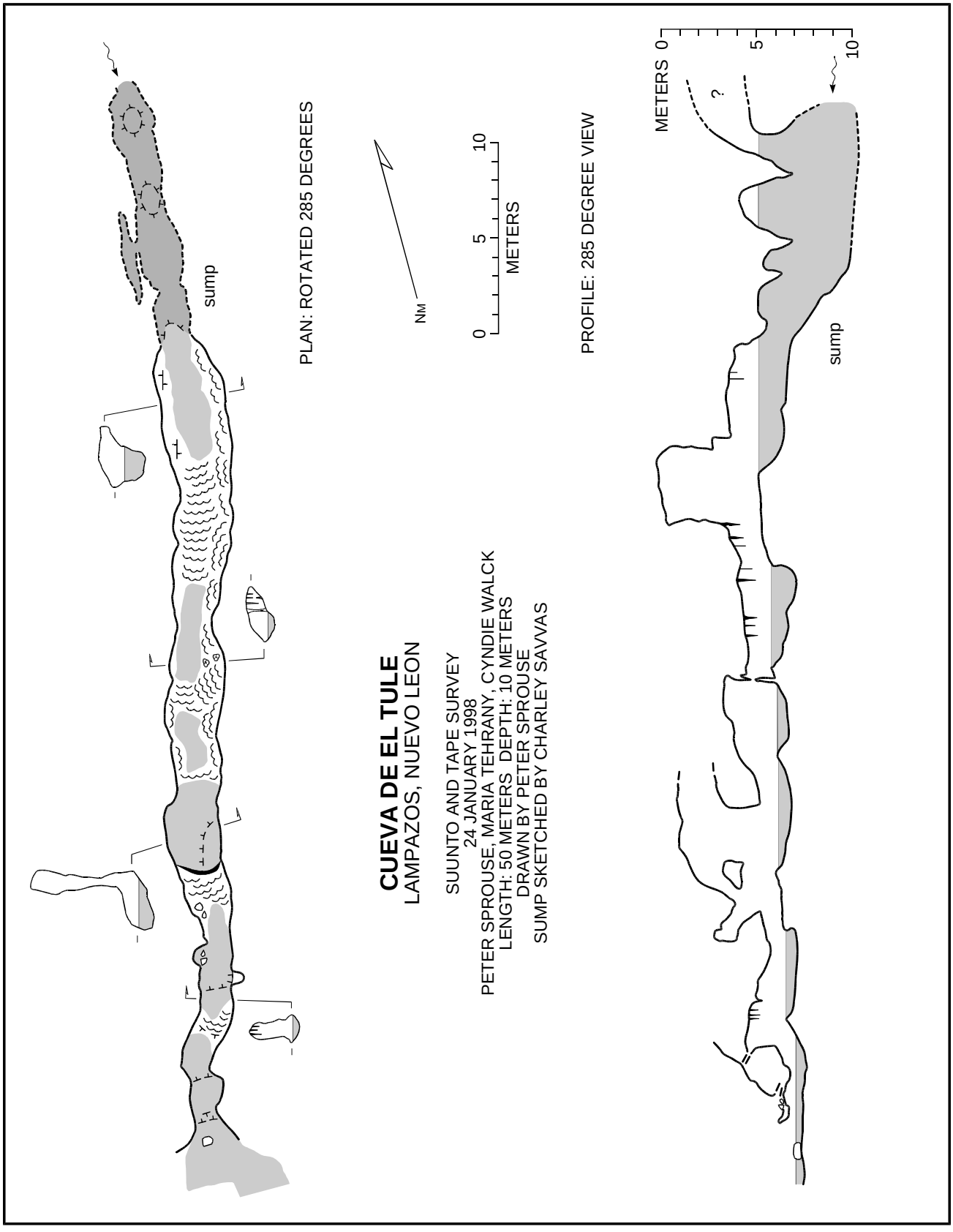
Peter Sprouse

The Minas Viejas area in the Sierra de Lampazos has over forty known caves, most notably Pozo de Montemayor, nearly 500 meters deep. The ranch where Minas Viejas is located is at the southern end of the mountain range, so it seemed likely that more caves could be found to the north. In November 1997, Mike Davis, Troy Lanier, Susie Lasko, Charley Savvas, and I were on the way back from El Potrero, south of Bustamante, and stopped at a ranch to the north of Minas to ask about caves and access. Rancho Colorado is named after Cerro Colorado, an igneous hill that protrudes out of the valley floor near the ranch house. We were fortunate to find the owner there, as he is normally at his house in Monterrey. We were able to arrange access, and the owner had his ranch hand guide us to a cave. We drove east toward the base of the sierra and parked the truck where the road ended near the entrance to Cañon el Tule. A short walk got us into the arroyo and to a nice spring pool. The water was coming out of a low-air-space cave entrance, where the rancher had placed plastic irrigation pipe for a water supply. Mike and Charley braved the numerous leeches and stripped down naked to crawl into the cave. They immediately popped up into a stooping stream leading to a sump. Since we were headed home at this point, we saved the mapping for the next trip. This seemed like an important find, since no resurgence caves were known in this area.

Charley Savvas and Kevin Stafford in Cueva de El Tule. *Peter Sprouse.*



Our return trip was organized for January 22, 1998. Eight of us loaded into my Power Wagon bus: Dale Chase, Susie Lasko, David McKenzie, Charley Savvas, Kevin Stafford, Maria Tehrany, Cyndie Walck, and me. We drove through the night and camped at the entrance to the ranch. We awoke the next morning and greeted Terry Sayther's pictograph crew, which included Maureen Cavanaugh, Allan Cobb, Marvin Rowe, and Chris Vail. At the ranch house we picked up the foreman, Alvaro, who guided us to Cañon la Espantosa to show us a cave and pictograph site. The pictographs were interesting, but we were after caves. We spotted an entrance in the south wall of the canyon, which Kevin climbed up to check, but it didn't go. The road ended, and we hiked up the canyon a short ways, past the Minas Viejas ranch fence. The cave entrance was not obvious, up a steep boulder pile to the base of the canyon wall. It was clear that water flowed at times out of Cueva la Espantosa. The entrance was walking-size and sloped down into a spacious chamber. Kevin and Charley explored ahead about 75 meters to a sump, while Dale, Maria, and I began the survey. At the bottom of the initial slope, we had to wade through a small pool that contained cirolanid isopods. These were of the smaller variety, like those found in Texas, and should prove to be a new


CUEVA DE EL TULE
LAMPAZOS, NUEVO LEON
SUUNTO AND TAPE SURVEY
24 JANUARY 1998
PETER SPROUSE, MARIA TEHRANY, CYNDIE WALCK
LENGTH: 50 METERS DEPTH: 10 METERS
DRAWN BY PETER SPROUSE
SUMP SKETCHED BY CHARLEY SAVVAS
PLAN: ROTATED 285 DEGREES
sump
NM
0
5
10
METERS
PROFILE: 285 DEGREE VIEW
METERS 0
5
10
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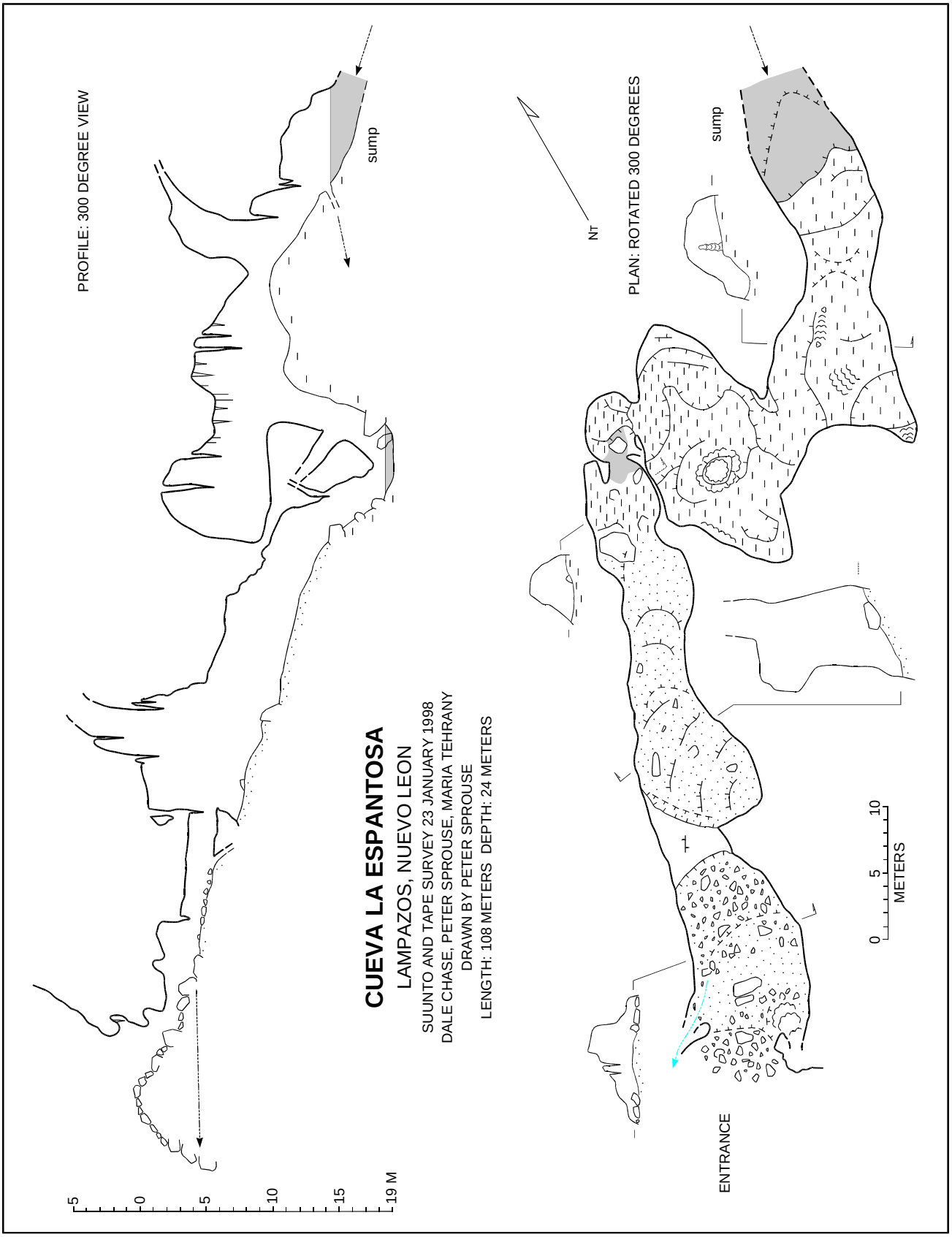
sump


PROFILE: 300 DEGREE VIEW
sump
5
0
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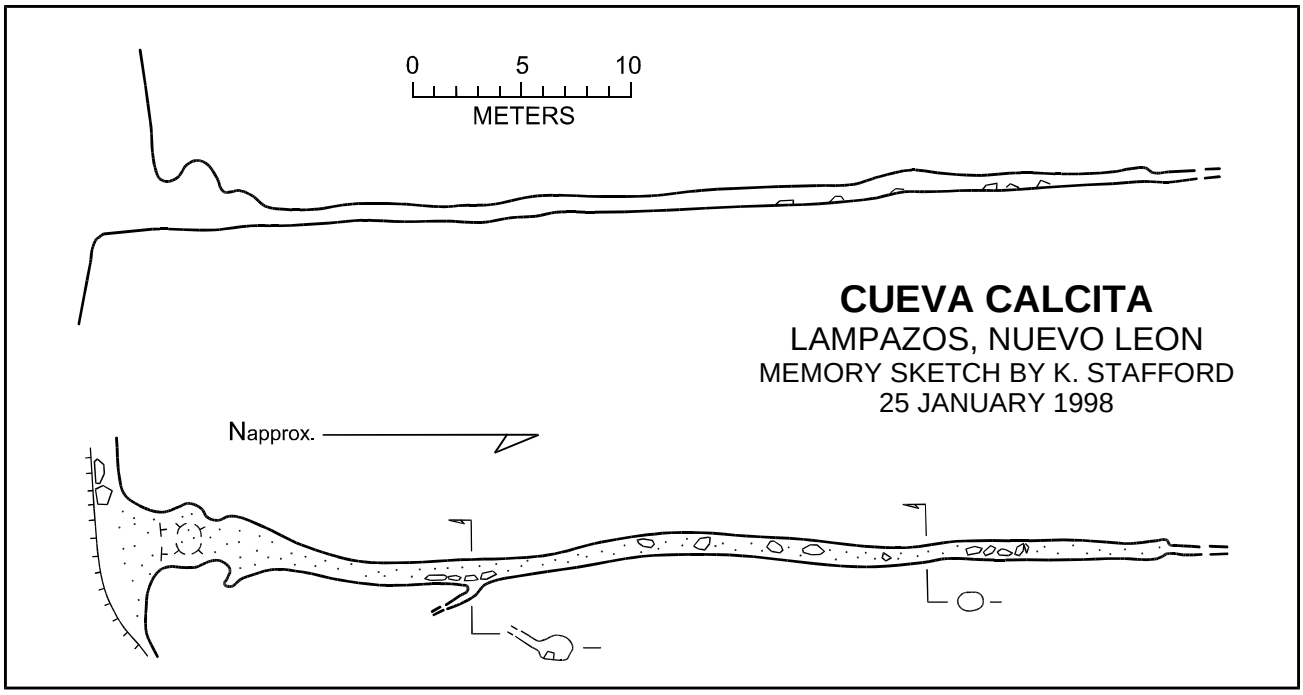
15
19 M
CUEVA LA ESPANTOSA
LAMPAZOS, NUEVO LEON
SUUNTO AND TAPE SURVEY 23 JANUARY 1998
DALE CHASE, PETER SPROUSE, MARIA TEHRANY
DRAWN BY PETER SPROUSE
LENGTH: 108 METERS DEPTH: 24 METERS
NT
PLAN: ROTATED 300 DEGREES
sump
ENTRANCE
0
5
10
METERS



Cañón la Espantosa. *Peter Sprouse.*

Maria Tehrany and Dale Chase in Cueva de El Tule. *Peter Sprouse.*

species. Beyond this pool we climbed into a large, muddy formation chamber, beyond which was a slope down into the sump. This was large and clear, a great diving prospect.

On our drive out of the canyon, Alvaro pointed out another entrance in the north wall. Kevin, Charley, and Dale set off up to it, while Susie, Maria, and I helped guide them from below. They angled across a talus slope to the base of an irregular cliff. We watched them traverse a ledge, pushing down a large cactus to get into the small entrance. Kevin explored about 50 meters into a very straight passage, which lowered to a crawl, but continued. It seemed to have been mined for calcite in the distant past, and contained the remains of stick torches. They named it Cueva Calcita. We drove back to Cañón el Tule to camp.

The next day Terry's crew drove off to look for more pictographs in nearby canyons, finding one more site. Dale and David set off to hike up to the top of the main ridge, north of Minas Viejas. The rest of us went to Cueva de El Tule. Charley and Kevin carried diving gear to the sump, while Cyndie, Maria, and I did the survey. We reached the sump as Charley was preparing to dive. He wasn't planning to go far, so Kevin belayed him with a lifeline to make sure he wouldn't. We watched him disappear into the sump, to return a few minutes later. He reported reaching an air bell 8 meters in, with a tight passage going out of it. He wasn't able to get up into it with his gear and belay. The sump could also continue underwater. He went back in for a second dive, but the water was murky. Charley and Kevin then left the cave, while we finished mapping and taking pictures. Once back at camp, several more folks set off on the hike up the ridge, and they all got back down before dark. Unfortunately they hadn't found any caves up there.

So the best leads left on this ranch seem to be for divers, but there is lots more territory there to check. I'm sure we will be back.

Rancho Colorado, Nuevo León

El Rancho Colorado está localizado al norte del bien conocido Minas Viejas, en la Sierra de Lampazos. En enero de 1998 se topografiaron tres pequeñas cuevas, dos de las cuales pudieran continuar buceando, y aun queda mucho terreno en el que buscar otras cavidades.

ACCIDENT REPORT: SÓTANO DEL AIRE

Joe Ivy

On Sunday, August 22, 1999, a group of cavers left San Luis Potosí to visit Sótano del Aire in the Sierra de Alvarez 50 kilometers east of the city. The group consisted of Miguel Angel Blanco, Rocío Medina, Christy Quintana, Cuauhtémoc Sánchez, Sergio Sánchez-Armáss, and Alfredo Silva. Christy, an avid Texas caver, had been in SLP for several weeks living with a local family to improve her Spanish. The Asociación Potosino de Montañismo y Expeleología is a very active caving organization, so it was natural for Christy to get together with them to enjoy visiting the many caves nearby.

The group left San Luis at about 10:00 A.M. and arrived at Sótano de Piedra Agujerada around 11:00. After parking the truck, they began the two-hour hike to Sótano del Aire. Once they arrived at the cave, the entrance was checked for loose rocks and then rigged so that the rope hung free of the edge. Miguel, Christy, Rocio, and Cuauhtémoc descended the 233-meter entrance pit. Alfredo and Sergio remained topside and left the entrance at about 4:00 P.M. to look for other entrances in the area. They returned at about 7:00. At about 10:30 P.M., Sergio and Alfredo heard a massive collapse from the entrance. When they approached the entrance, they saw that a large portion of the left side of the entrance had collapsed and fallen into the pit. Sergio and Alfredo immediately yelled down the pit to see if anyone had been injured.

Miguel and Christy had been on rope in the entrance drop, with Christy climbing first and Miguel climbing below her. They were about 40 meters below the entrance when the collapse occurred. Three large rocks struck Christy on the head and back. Miguel was on a flowstone ramp that placed him off to one side of the pit, so the rocks missed him as they fell. Some of the rocks came to rest on this ramp in an unstable position. Miguel ascended to Christy and found that she had been severely injured and was unable to ascend. He assessed her injuries and found that her legs were paralyzed. After doing his best to stabilize and comfort her, he realized that the only option was to haul her out of the cave. Miguel started climbing and reached the surface at about 11:30 P.M. The group then began rigging a haul system. Having no rescue equipment available, the group had to cannibalize their own gear and make do with a "Georgia haul," that is, simply haul on the rope with no mechanical advantage. Three large rocks that had been left very unstable at the lip by the collapse were secured using part of the original rigging and some of their clothing. They began hauling at about 12:30.

At about 2:30 A.M., Christy was about 4 meters below the lip. Miguel Angel rappelled down to help Christy negotiate the lip of the pit. At this time, he realized that Christy had succumbed to her injuries and had died while they had been hauling her out of the pit. The group decided to continue to bring her to the surface in order to be certain that she had died. However, when Christy was about 1.5 meters below the lip, they were unable to raise her any farther. Before giving up, the group checked again to be sure that she had died. Sergio then made the two-hour hike to the vehicle and drove back to San Luis to get help. He arrived in SLP at 7:00 A.M.

By 11:00 Monday morning, a rescue team had arrived at Sótano del Aire. The group consisted of Margarita Benavente, Miguel Angel Jones, Jorge Landeros, Luis Landeros, Gerardo Morrill, Ricardo Peralto, Antonio "Toño" Ramírez, David Solis, David Solis, Jr., and Gilberto Torres. The rescue team first removed the rocks that were loose at the lip and then proceeded with the recovery. At 2:00 P.M., Gerardo and Toño descended to the narrow spot about 55 meters below the entrance in order to remove the rocks that had come to rest there the night before. Once the rocks were cleared, Toño descended to take food and water to Rocio and Cuauhtémoc, who had been trapped at the bottom by the collapse. It was decided that the two would be given the news of what had transpired only after they were out of the cave. At 4:00 P.M., the authorities arrived to take initial statements and to take Christy to the morgue. By 5:00 P.M., Cuauhtémoc and Rocío had ascended out of the pit and learned of the magnitude of the accident of the night before. The group was back in SLP by 9:00 and gave official declarations to the authorities from 11:00 P.M. to 3:00 A.M.

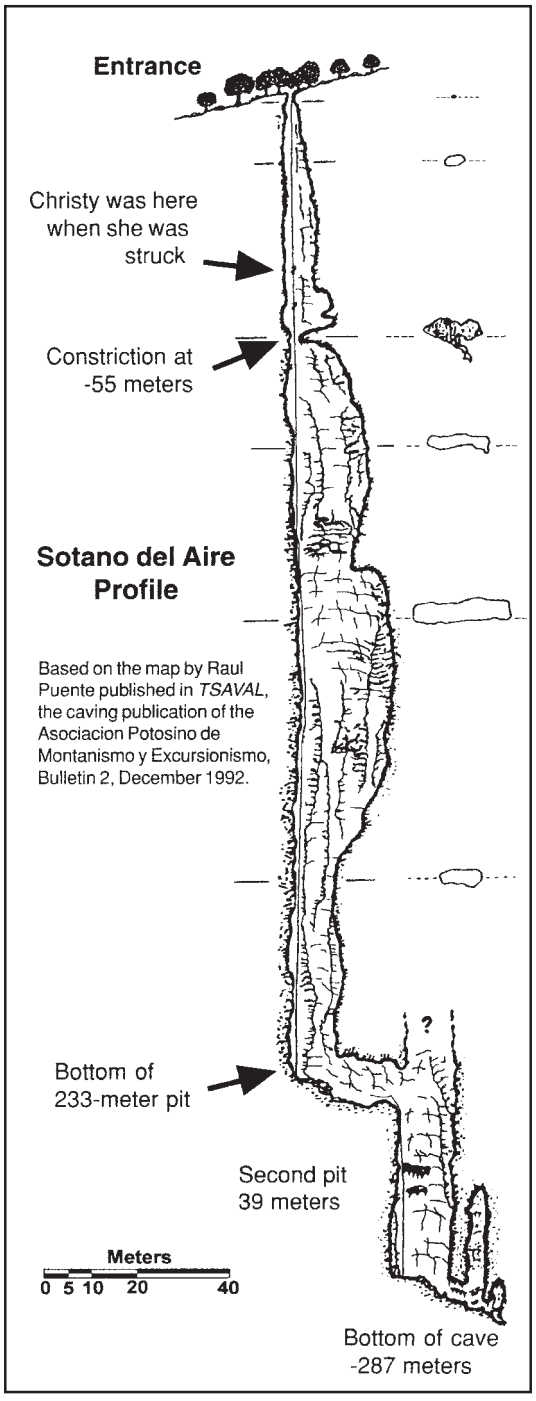
I believe that this accident was simply an "act of God" and that Christy was unfortunate enough to be exposed in the pit when a

Reprinted, slightly revised, from the *Texas Caver,* volume 44 number 5, September-October 1999.

natural collapse occurred. The cavers in the group were doing everything right, and a member of the group still got killed. Perhaps if they had chosen to go caving the day before or the day after, it would have been different. Why the rocks let go at just that moment is a mystery that no one can solve.

Once the collapse occurred and Christy was injured, the other members of the group were faced with an impossible rescue situation. Christy had been struck in the head, causing fractures of cervical vertebrae, and in the lower back, causing fractures of lumbar vertebrae. The cervical fractures were not life-threatening at the time, but the lumbar fractures immobilized her legs. Further, it is very likely that the lumbar impact had caused some serious internal injury with internal bleeding, but this is supposition on my part. The immobilization of Christy's legs was the primary threat to her life. Once the injury occurred, Christy needed to be in a trauma center within half an hour in order to survive. Given the location of the accident, this was impossible.

In addition, in situations where someone is hanging immobile on rope in a harness, a serious medical condition occurs when blood is trapped in the legs, unable to return to the heart. This is commonly known as harness-hang syndrome or, less commonly, compression avascularization/reperfusion syndrome. The body reacts as if there is serious bleeding going on, although no actual blood loss is occurring. That is, it starts to go into shock. As the amount of blood in the circulatory system decreases due to blood pooling in the legs, the body tries to maintain blood pressure by increasing the heart rate. This creates a vicious circle, because the increased heart rate and blood pressure increase the speed with which blood is getting trapped in the legs. Finally, the amount of blood remaining in the main part of the circulatory system is too small to continue to keep the brain, heart, and other vital organs perfused. Death occurs due to lack of oxygen in the brain and heart tissues. In testing done by a French caving group, it was found that healthy volunteers started having lots of trouble, such as dizziness and highly elevated heart rate, after as little as ten minutes of hanging immobile on rope. Loss of consciousness due to lack of oxygen in the brain occurred after as little as fifteen minutes, and no one maintained consciousness longer than thirty minutes. These were healthy subjects with no injuries. Even if she had had no other injuries, Christy needed to be off rope and on her back with her feet elevated within ten minutes of the actual impact. This was simply impossible.



Miguel was below Christy when the collapse occurred. Even in a perfect situation with an experienced, well-rested rescuer trained to handle such situations, it would have taken at least two or three minutes to get to Christy, assess her injuries, decide what to do, and then resume climbing. Miguel had already been caving for several hours and had no formal rescue training. Miguel had to climb another 40 meters before any attempt could be made to start a haul. Again, in a perfect situation, it would have taken a really fast climber at least ten to fifteen minutes to pass her and climb that distance. Miguel was already tired and stressed by the situation. Once Miguel reached the surface, the three-member team had to build a haul system and haul her out. During cliff exercises in Texas, it usually takes an experienced ten-member high-angle rescue team with pre-assembled equipment at least ten or fifteen minutes to assemble a haul system and then a minimum of another ten minutes to complete a 40-meter lift. And that's assuming that they have all the gear they need and that the rigging is perfect. This timing, compared to the length of time a patient can hang immobilized in a harness, is the reason the procedure usually recommended in such a case is to "pick off" the patient onto one's own descending gear and rappel with him to the bottom, but this can be done quickly and safely only with a considerable amount of training and practice, and in any case it could not have been done here because of the

unstable, freshly fallen rocks at the constriction in the pit.

Even if the team had somehow accomplished a miracle and gotten Christy to the surface in a short enough time, they were still a two-hour hike from the vehicle with a severely injured patient needing spinal immobilization and intensive care. Survival would have required a life-flight helicopter standing by very near the top of the pit and a state-of-the-art trauma center waiting for her at the end of a short flight. There was just no way that these unfortunate souls could have saved Christy's life.

In wilderness and cave rescue, the folks most frequently rescued are folks who did really stupid, thoughtless things and got hurt because of it. Accidents you read about are things like rescues of non-cavers who went caving while they were severely intoxicated and fell down a pit that they didn't notice or recoveries of people going into a cave that floods very severely when it's about to rain. But sometimes bad things happen to good people doing all the right things. And every so often, those bad things are fatal. In the seventeen years I've been caving, I've had some close calls and watched as others had close calls, but we were left with only amazing stories to tell, not serious injuries. In the past, I've gone back to a cave I hadn't been to in a while and seen that a big collapse had occurred in the interim that certainly would have killed or injured someone there at the time. Since a collapse like this happens so seldom underground, the chance of someone's being there when it happens is very slight. Unfortunately, Christy happened to be in Sótano del Aire at just the moment that a large collapse occurred. Statistically speaking, it is still far more dangerous to drive on highways than to go caving. There are some things that just cannot be foreseen or avoided. And the cavers with Christy had absolutely no chance of saving their injured friend, because even had they had all the necessary gear and manpower at their disposal, there would still have been no way to get her out of the pit in time. Miguel, Sergio, and Alfredo did the best they could, but all the cards were stacked against them and against Christy.

Accidente en el Sótano del Aire

Christy Quintana, espeleóloga de Austin, Texas, estaba pasando varias semanas en la ciudad de San Luis Potosí en agosto 1999. Visitó el Sótano del Aire con miembros de la APME. Al estar saliendo del tiro, grandes rocas se desprendiero de la boca y la golpearon. Sus heridas eran tan severas que murió en la cuerda. Su cuerpo no fue recobrado hasta el día siguiente. Otros dos espeleólogos quedaron atrapados en la base del tiro, ya que las rocas que cayeron bloquearon un punto estrecho del tiro. Salieron una vez que las rocas del borde del tiro fueron estabilizadas y que las rocas que bloqueaban el tiro fueron removidas.

SISTEMA PONDEROSA RESURVEY PROJECT

Steve Gerrard

It was July 6, 1990, and I was blindfolded and being driven north on Highway 307 from Aventuras Akumal in a beat-up old VW van. Tony and Nancy DeRosa had been telling me for days about a new cenote that they had dived a few weeks earlier. Their friends Bill and Joyce Matthews of Paalmu had told them about the cenote located on a friend's property. Bill and Joyce believed it had never been dived. With permission from the landowner, the DeRosas wanted to share their little secret with me, but they did not want me to know exactly where it was located. I could tell when we turned off onto a very bumpy road, and finally we came to a stop. The blindfold was removed. I could still hear trucks on Highway 307, so I knew we were not far into the jungle. We had to hike 150 meters from where we parked to the cenote. Standing at the edge, I gazed down 4 meters to water. It was gorgeous, with lush green aquatic plants, crystal-clear water, and an obvious entrance to an underwater cave.

The DeRosas wanted me to jump in and look at the cave they had found. I donned my wetsuit, a single tank with regulator, and all the other appropriate gear and entered the water. That was not easy, as you had to carefully lower everything from the rim down to a huge rock and negotiate several obstacles. Once in the water, I descended and swam around for a few moments getting myself oriented. The first thing I noticed was an incredible number of tropical fish. Toward the east side, the depth of the water increased to 9 meters. As my eyes adjusted, all I saw was a big dark void. Swimming under the ledge, I looked for the guideline that Tony and Nancy had placed on their initial dive, a traverse to another cenote. Finding their string, I casually swam along and immediately saw daylight in the distance. Reaching the other end, I was impressed by the enormous size of the passage. What a great cavern dive this would make. [Cave divers make a distinction between a real cave dive and a cavern dive. A cavern dive requires less training. This traverse is, perhaps stretching the definition a bit, considered a cavern dive because you are never really out of sight of daylight.—ed.]

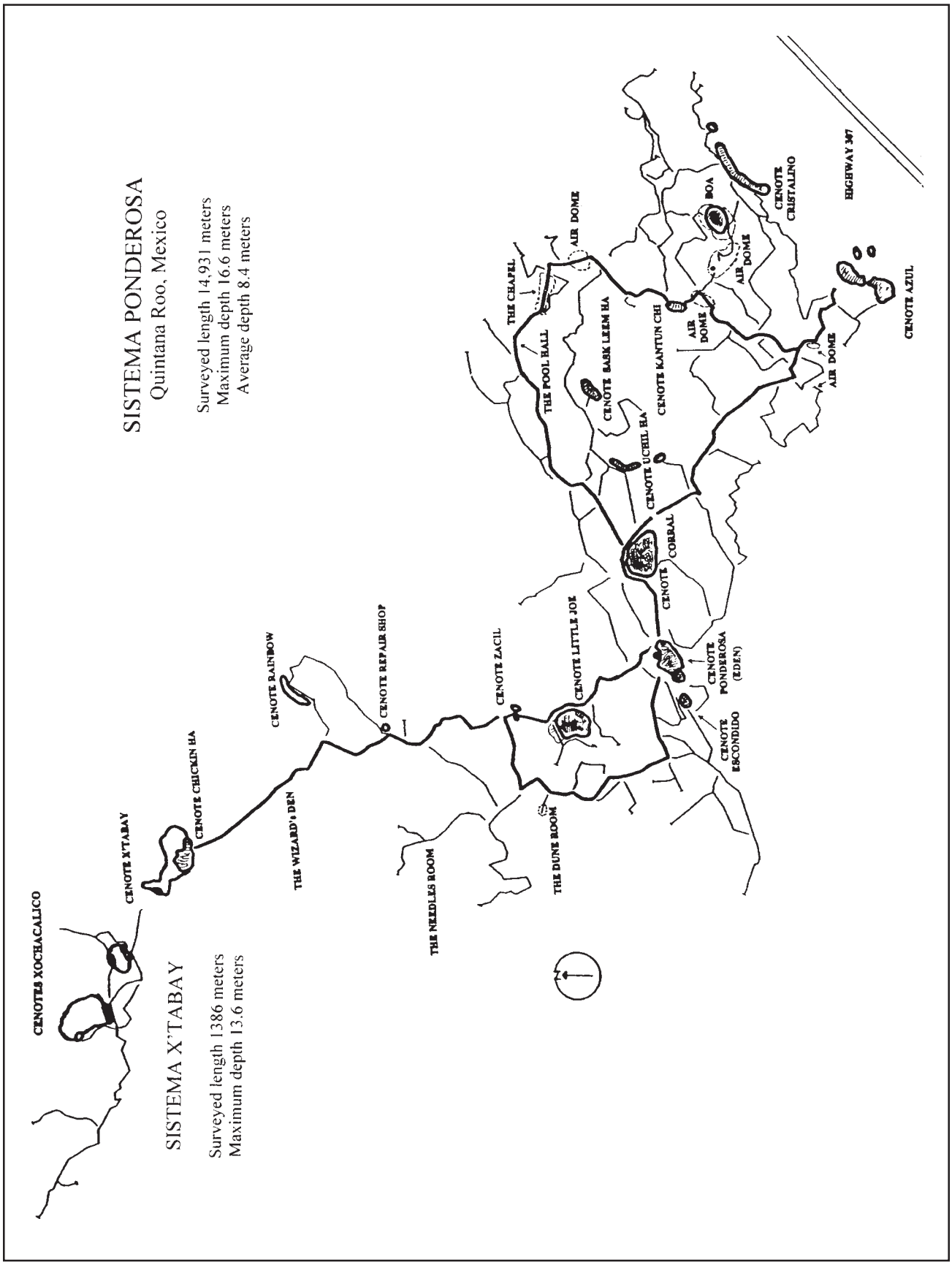
The line did not go much farther, and the potential for exploration was mind-boggling. Using my own reel, I poked around a bit. Surfacing back at the entrance cenote, I found Tony and Nancy anxiously waiting to hear my opinion. On the way home, the blindfold was not placed back on my face; it had been meant as a joke.

I had brought a group of cave divers to Quintana Roo from Florida and had been planning to stay an extra week, so we started plotting our strategy to explore this cave. The DeRosas and I spent four days exploring and laid over 2400 meters of line. We found the beginning of what is now known as the River Run, the passage to Cenote Little Joe, the passage to and beyond Cenote Alaina's Garden (Cenote Uchil Ha), named after the DeRosas' one-year-old daughter, the passage to the air bell named the Chapel, and all the passages around Cenote Corral.

We were having fun. On the second day, we were trying to decide what to call the cenote and the cave system. I suggested Ponderosa, the name of the ranch on the popular 1960s TV show Bonanza. That's where place names like Little Joe and the Corral came from. The last six letters were also the DeRosas' last name.

Since then, many cave divers have done much more exploration in Ponderosa. The DeRosas themselves had a hard time finding free time, because their commitment to building a hotel business in Aventuras Akumal took priority. They did arrange with the landowner Don Carlos Macias Acosta to conduct snorkeling and cavern tours. This has turned into a source of income for the owner. Wooden stairs were built for easy and safe entry to the water, and the road was extended all the way to the cenote. The site quickly became popular with all the local dive stores and snorkeling guides. Today, permanent stairs and platform of concrete are in place, public toilets have been built, and the area is landscaped with scenic paths around the cenotes. Don Carlos has built a small getaway home there.

Reprinted from *Underwater Speleology,* volume 27, number 1, 2000. A short article and earlier map appeared in *AMCS Activities Newsletter* 21, pp 95–96. A note about the map: Minor "offshoot" lines in the cave are not physically connected to the main lines to avoid confusion in line following. Divers wanting to follow those lines need to temporarily deploy a short line to bridge the gap. These line gaps are indicated by short gaps in the line plot. The passages actually connect.


SISTEMA PONDEROSA
Quintana Roo, Mexico
Surveyed length 14,931 meters
Maximum depth 16.6 meters
Average depth 8.4 meters
SISTEMA X'TABAY
Surveyed length 1386 meters
Maximum depth 13.6 meters
CENOTES XOCHACALICO
CENOTE X'TABAY
CENOTE CHICKIN HA
THE WIZARD'S DEN
CENOTE RAINBOW
CENOTE REPAIR SHOP
THE NEEDLES ROOM
CENOTE ZACIL
THE DUNE ROOM
CENOTE LITTLE JOE
CENOTE CORRAL
CENOTE PONDEROSA (EDEN)
CENOTE ESCONDIDO
THE CHAPEL
AIR DOME
THE POOL HALL
CENOTE BANK LEEM HA
CENOTE UCHIL HA
CENOTE KANTUN CHI
AIR DOME
BOA
AIR DOME
CENOTE CRISTALINO
AIR DOME
CENOTE AZUL
HIGHWAY 307

CENOTES CONNECTED TO SISTEMA PONDEROSA

Cenote Ponderosa (Eden)	20°29.496' N, 87°15.480' W
Cenote Corral	20°29.546' N, 87°15.404' W
Cenote Uchil Ha (Alaina's Garden)	20°29.561' N, 87°15.257' W
Cenote Chickin Ha	20°29.994' N, 87°15.666' W
Cenote Rainbow	not determined
Cenote Rainbow Shop	not determined
Cenote Zacil	20°29,561' N, 87°15.512' W
Cenote Little Joe	20°29.622' N, 87°15.506' W
Cenote Escondido (Hidden Cenote)	not determined
Cenote Sask Leem Ha	20°29.571' N, 87°15.243' W
Cenote Kantun Chi	20°29.477' N, 87°15.159' W
Cenote Boa	20°29.411' N, 87°15.062' W
Cenote Azul	20°29.337' N, 87°15.? W
Cenote Cristalino	20°29.403' N, 87°15.034' W

LINE DISTANCE FROM CENOTE PONDEROSA TO:

Cenote Little Joe	203 meters, 670 feet
The Chapel	753 meters, 2486 feet
Cenote Uchil Ha	367 meters, 1212 feet
Cenote Chickin Ha	979 meters, 3229 feet
Cenote Rainbow	865 meters, 2854 feet
Cenote Repair Shop	596 meters, 1966 feet
Cenote Zacil	332 meters, 1097 feet
Canote Sask Leem Ha	541 meters, 1785 feet
Cenote Kantun Chi	1096 meters, 3618 feet
Cenote Cristolino	1420 meters, 4687 feet
Cenote Azul (via Chapel)	1574 meters, 5195 feet
Cenote Azul (via Corral)	939 meters, 3099 feet

ORIGINAL EXPLORERS OF PONDEROSA
* principal explorers

Shelly Baker
Bernie Birnbach
Nancy DeRosa*
Tony DeRosa*
Fred Devos
Steve Gerrard*
Craig LaPorte
Gary Lemme
Dan Lins
Mike Madden
Harve Thorn*
Toni Thorn*
Gary Walten*
Kay Walten*
German Mendoza Yanez
members of the French Cave Diving Federation

ORIGINAL EXPLORERS OF X'TABAY

Bil Phillips
Danny Riordan

PONDEROSA RESURVEY TEAM

Butch Boggess
Bruce Campbell
Jose Cid
Tony DeRosa
Pablo Diaz
Don Ellerbrock
Hilary Foulkes
Ron Fraga
Steve Gerrard
Herve Gordon
Harry Hicks
James Hobbs
Kate Lewis
Dan Patterson
Benja Sacristin
Steve Serras
Greg Such
Charles Toth

In January 1993, I had just permanently moved down from Florida and was working at the same dive business as Gary Walten and Kay Pozda (since married). We realized that there was more potential for exploration in Sistema Ponderosa, and, after getting the blessing of the DeRosas as the original explorers, I suggested we try to push the cave farther. On two dives, Gary, Kay, and I pushed the River Run and found the Dune Room and the Needles Room. On a scooter dive, Kay and I laid 500 meters of line past Cenote Repair Shop toward Cenote X'tabay. Six months later, German Mendoza and I made the underground connection between the downstream and Cenote Zacil sides of Cenote Little Joe. That's basically when my exploration stopped, but Gary and Kay continued, finding such places as Cenote Rainbow and the Wizard's Den, a beautiful collapsed area 181 meters downstream from Cenote Chickin Ha.

During the research for my book *The Cenotes of the Riviera Maya* [see review elsewhere in this issue], one of the questions I had was how much cave passage had been found and surveyed in Sistema Ponderosa. The only information I had was an old line map with a total of 10,303 meters. I had a strong hunch that there was a lot more. I was fairly familiar with much of the system, but I wanted to learn more about what had been explored since 1994. I knew that Harve and Toni Thorn of Arkansas had explored and surveyed many passages in the Cenote Azul and Cenote Cristalino areas and that the Waltens had done more work in the Cristalino and Cenote Kantun Chi areas. I was too busy with my training and guiding business and writing the book to think about resurveying this cave system myself. But over several years, I'd had several cave divers ask me about learning to survey. I decided to try to organize a surveying project. The response to a notice in my monthly email newsletter far exceeded my expectations, and we ended up with nineteen people helping out, of whom eleven were the core cave divers. I did not know

whether that was too few or too many. As it turned out, we had just enough. Eight local cave divers participated, and most of the divers from out of the country stayed at Aquatech/Villas DeRosa.

The project officially began Saturday night, June 5, 1999, when we had an organizational meeting and our first lessons on properly surveying and recording data. Everyone had been asked to bring his own slate and compass. I was very impressed by many of the slates. The compass of choice was the Suunto M Series. A few years ago, my favorite was the M-3. Now, the M-5 is the hot choice, and you can get compasses from Suunto balanced and calibrated for specific areas around the world. We distributed a supply of pencils, survey record sheets, station markers, hundred-foot fiberglass tapes, and notebooks containing sketches of every line in the cave I knew. I had spent weeks before the project scouting areas I was not familiar with, so that everyone would know what to expect.

On Sunday, June 6, we gathered at Cenote Ponderosa, also known as Cenote Eden. We divided everyone into teams of two, and each team was given a survey assignment. Distances were measured with the fiberglass tapes on all gold lines and all other main lines. (Gold lines are distinctive main lines placed in the main routes used for tourist dives.) That helped a lot in making things close well on the computer. The first day went very smoothly, with each team completing two survey dives. We packed lunches each day, and I stayed topside coordinating, answering questions, and working on logistics. We had to make every minute count. We had two sets of tanks and stage bottles at the site each day for each member of the project. Some teams entered the system though other entrances.

By Wednesday, I was very surprised how much line had been surveyed. The hardest thing for me was entering all the data into the computer. Lesson learned: Have someone whose duty is specifically to enter the data. I should have known better, as I remembered how extremely valuable Rosemary Redgen had been during the Sistema Ejido Jacinto Pat project in 1996. I was getting exhausted coordinating during the day and "punching in" data at night. But I was able to get enough done that everyone could see the results.

The biggest mistake was not spending enough time in the classroom teaching survey techniques before people got into the water. It was hard to get everyone to record enough information and to properly identify the lines where two met. Some of the teams performed extremely well; others needed work and practice. But with time and persistence, by midweek I was confident of every team's ability. But some lines were surveyed three times before we were sure we had good data.

Butch Boggess and Dan Patterson handled the Cenote Zacil area and north. Kate Lewis and Donn Ellerbrock entered at Cenote Azul. Tony DeRosa and Charles Toth surveyed the River Run gold line and everything going west. Ron Fraga and Harry Hicks surveyed the cavern gold line and all lines around Cenote Corral and Cenote Ponderosa. Hilary Foulkes and Bruce Campbell surveyed the gold line to Cenote Little Joe and all lines around that cenote. Herve Gordon and Benja Sacristin surveyed the Chapel gold line. James Hobbs surveyed out from Cenote Kantun Chi and Cenote Cristalino. Nancy DeRosa and Pablo Diaz surveyed the line upstream from Cenote Azul. And it went on from there, with new assignments each day.

By Friday, our mission was accomplished except for an area around Cenote Cristalino. Everybody was happy, had learned much, and, most importantly, had had fun. The following week, Charles Toth helped me complete some lines and redo a few others. Steve Serras and Herve Gordon helped me over several days recheck a few lines and complete a few. There was more line than I had expected. Every time I thought we had finished, another line was found. Now I feel confident that 99.5 percent of all the lines in Sistema Ponderosa have been properly surveyed, but it would not surprise me if someone had a hidden line that we have not found.

(In 1993 and 1995, Brian Kakuk, Travis LoRe, and Pat Precin explored and surveyed approximately 600 meters of dry cave off of the air-bell The Chapel. See AMCS Activities Newsletter 23. This survey is not included on the map or in the total length stated on the map for the underwater cave.)

Did we do any new exploration or lay any new line? Not really. The cave system is so much like Swiss cheese that we thought it would be senseless to place new lines, as everywhere one could go he would eventually hit another line. We did not want to create any more of a navigational mess. We did not remove any lines, but in three places we straightened existing lines for better surveying or moved lines to an environmentally better location.

We also completely surveyed with fiberglass tape a new cave that had been explored by Bil Philips and Danny Riordan, mostly during the fall of 1998. Because of the major collapse around Cenote Chickin Ha and Cenote X'tabay, it appears impossible to make an underwater connection between this cave, called Sistema X'tabay by landowner Don Silvano Ku Chuc, and Ponderosa, although it is obviously the same water.

We present to the cave-diving community our stick map of the lines in Sistema Ponderosa. This illustration of the relationship of all the lines and the many cenotes connected into this grand system will be a useful tool for dive planning.

Proyecto de Retopografía del Sistema Ponderosa

El Sistema Ponderosa, un sistema subacuático de cavernas en Quintana Roo, fue descubierto en 1990, pero no se realizó la topografía detallada de las líneas de vida. Un proyecto de una semana, en Junio de 1999, realizó la topografía de la mayor parte de las galerías previamente exploradas, y trabajo adicional se llevó a cabo en las siguientes semanas. El mapa final muestra casi 15 km de pasajes. Los ramales conectan con la cueva principal, pero en el mapa se muestran separados para indicar a los buceadores que las líneas de vida no son continuas.

Rio La Venta: Treasure of Chiapas. Edited by Giovanni Badino, Alvise Belotti, Tullio Bernabei, Antonio De Vivo, Davide Domenici, and Italo Giulivo. Associazione Culturale Esplorazioni Geografiche La Venta, Treviso, Italy; 1999. 8.5 by 12 inches, 319 pp, hardbound.

The Río La Venta flows through central Chiapas, and much of its length is in an impressive canyon through a limestone karst. The Italian project there began when a group descended the canyon in 1990 and decided that the area warranted systematic and multidisciplinary investigation. This heavily illustrated book is the result. Caving was a major part of the project, and in fact at one point the river itself passes through a natural tunnel 500 meters long and 100 meters high. The river runs through part of the famous Ocote forest preserve, and long chops there and elsewhere led to some impressive caves. There are also a number of small caves of archaeological interest along the canyon. The longest cave explored is Cueva del Río La Venta, 11 kilometers. The most difficult goal was the Ombligo del Mundo, the Umbilicus of the World, an enormous black hole in the jungle first reached, after a couple of unsuccessful attempts at chopping trails, by rope descent from a helicopter. During the 1998 expedition, twenty men in twenty days finally managed to make a trail to the pit, which is still only partly explored. The book contains only a very small-scale area map of the caves. A foldout, but still much reduced, map of Cueva del Río La Venta appears in *AMCS Activities Newsletter* 23. Approximately half of the book deals with caves or cave archaeology. The rest deals with other aspects of the natural history of the area.

There is also a multi-media CD-ROM of supplementary information. I usually don't even think about trying such a thing, especially when it wants me to add some software to my system. But since it is about caving and I was preparing this review, I tried it. Sure enough, it didn't work on my Windows 2000 system. It is advertised as working on Windows 95/98 or Mac 7.5 or later, with QuickTime 3 (supplied). It did get far enough to offer me a choice of Italian, Spanish, or English languages. In *Descent,* Chris Howes has written: "The presentation of text, film, and photograph offers a slick alternative record of the expeditions. This is not a retelling of the book. The multimedia disk presents further data. To take a single example, a satellite image of the area is accompanied by a scrolling list of sites. Hover over any and a flashing marker appears on the map; click on it and basic data of location and references appears; select 'survey' and one flips to the fore."

This book is unfortunately not available in normal book-selling channels. Recently, Peter Taylor has begun offering it to credit-card purchasers on his web site, www.scienceattheextreme.com, for $75 plus $8.95 shipping within the U. S. Speleo Projects in Europe has it in its catalog for about the same price. There are also Spanish and Italian editions.—*Bill Mixon*

THE PIT IN DOS OJOS

Hazel Barton

Brrr. In my naked state, the 77-degree bath water was cold. I ducked back under the surface to wash the remaining suds from my hair, as the piranha-like tetras finished their job of picking out the debris that washed away. "Ow!" A tetra pecked at my big toe, and as I looked down for my attacker, I saw the warning glow of a returning diver's light. This, after all, was no ordinary bathtub. At 21 meters wide, 47 meters long, and over 100 meters deep, it was huge. With the bottom as yet undiscovered, Steve Bogaerts, Dan Lins, and Buddy Quattlebaum had mounted an expedition to unlock the mysteries that lay deep below the surface of the Mayan jungle in the state of Quintana Roo.

In November 1994, Dan Lins and Kay Walten entered the submerged cave system of Dos Ojos at a cenote called Tikim Ich, their goal a downstream maze that could be the key to a connection with the nearby Nohoch Nah Chich system. Using scooters and two sets of stage tanks, at a penetration of 1500 meters they found a narrow restriction with a significant amount of flow. By bumping and grinding their way through, they entered a highly decorated passage and then saw blackness below. In the distance, blue shafts of light danced on a huge debris slope, revealing the existence of another cenote entrance that would provide crucial access for further exploration. They named it The Pit. Dan and Kay continued looking for a route south, toward Nohoch. They picked a 10-meter-wide hole in the floor, partially concealed from view by a hydrogen-sulfide layer. This lead continued to descend, finally ending in breakdown at 75 meters, an incredible depth for the Dos Ojos system, which in its 55 kilometers averaged a tame 10 meters.

Shortly after this initial exploration, Hurricane Roxanne hit the Yucatan, destroying the trails through the jungle, including the one from Far Point Station at Nohoch Na Chich to the new cenote, and this halted further exploration until it could be rebuilt. Meanwhile, news of the find in the jungle spread to Florida, seducing other cave divers with hints of depth potential in the shallow caves of the Yucatan Peninsula.

In April 1997, Kay Walton returned with Gary Walton and Jill and Paul Heinerth. Diving in The Pit, the team found a hole obscured by an overhanging cliff and a breakdown pile that led to an impressive passage 12 meters high and over 20 meters wide. The end of this passage, named Cardea, was reached at 90 meters depth at a boulder collapse. Paul wiggled through a small, contorted restriction to discover another immense chamber, the Wakulla Room. Most exciting to the local cave-diving community was not the size of this room, but the fact that the line laid through it was heading due south, toward the Blue Abyss, a 70-meter-deep chasm in Nohoch Nah Chich, with the prospect of connecting Dos Ojos to that 61-kilometer cave. (See *AMCS Activities Newsletter* 20, page 86.)

This excitement propelled other explorers, and over the next few years trips continued to push the line south out of the Wakulla Room. In October 1997, Dan Lins returned with Andreas Matthes and Mike Madden and found a bypass to the restriction at 90 meters. This allowed them to reach the Wakulla Room at a relatively shallow 85 meters. They continued laying line south, adding another 44 meters toward Nohoch. The character of the cave was beginning to change, however. From the huge passage, the explorers now found themselves in an ominous tube, 1 meter high and 2.5 wide. The rock was heavily corroded, and exhaust bubbles hitting the ceiling created a rain of clay-like silt, threatening to reduce visibility to a few inches.

The dives at The Pit were becoming extreme, and Buddy Quattlebaum, long a facilitator of and participant in exploration of the caves deep in the jungle, decided that things had to change if dives at The Pit were to continue safely. Owner of the Hidden Worlds Dive Ship and perhaps the only person in the area capable of providing the needed logistics support, Buddy built a road directly to The Pit's entrance cenote. He established a new camp with a *palapa* for sleeping, a kitchen, and an electric generator for lights and charging batteries. The camp also came supplied with an array of creepy-crawlies that have a propensity for hiding in wetsuit booties and sleeping bags.

In addition to the relatively luxurious camp, one more item was needed to increase diver safety, a decompression habitat. The habitat was an inverted *tinaco,* the large black water-storage tank more commonly seen right side up on the roofs of Mexican buildings. When the *tinaco* was filled with air, tons

Much of this article appeared in *Underwater Speleology*, volume 27 number 2, June 2000.

of positive buoyancy jammed the structure against the ceiling of the cave at a depth of 6 meters. A wooden platform between the top of the tank and the ceiling protected against punctures. The opening at the bottom of the tank had been enlarged so that divers could climb in and sit on wooden seats to decompress in dry luxury. There was no vent for excess air, and it would belch out of the entrance hole, usually when an entering driver was least expecting it, making the whole contraption shudder. It looked dubious, but a swift kick convinced even the most ardent skeptic that it was stable.

A fresh assault on The Pit took place in January 2000, beginning with huge piles of equipment being transported out to camp. Transport was by means of an old, battered jeep, carrying the equipment out on a road that qualified only for the loosest use of the term. On the first trip, carrying nineteen tanks, its leaf springs broke on both sides. Buddy immediately rebuilt the suspension with ingenuity and a three-pound sledge hammer, and the expedition could continue.

Among the many divers involved were Steve Bogaerts and Dan Lins, who, along with Buddy, composed the exploration team. Both brought expertise to the team. Steve, an ex-rugby player from Britain and a strong and competent cave diver, is an instructor on the system that would be used to explore The Pit, the British-made A. P. Valves Buddy Inspiration closed-circuit rebreather. Steve could strip, repair, and reassemble the rebreather practically anywhere. Dan, a veteran cave explorer, had laid tens of miles of line in cave of the Yucatan Peninsula and brought an intimate knowledge of The Pit and the demands of diving there.

Despite the rebreathers, it was decided that open-circuit bail-out bottles would be staged throughout the cave in case of emergency. Forty or so stage and associated tanks were delivered to the edge of The Pit, where oxygen concentrations were analyzed and maximum operating depths calculated. They were labeled and sent down into the water. The second-stage regulator attached to each tank was bagged in biodegradable detergent to prevent nasties from growing during its prolonged stay in the water. During the dives, each diver wore a rebreather containing a diluent of trimix with 12 percent oxygen, 60 percent helium, and the rest nitrogen, and also two open-circuit bail-out tanks of trimix. Double ascent lines were rigged down to 40 meters, with loops for attaching stage tanks. Air was staged at 60 meters to be used, if not needed for bail-out, to flush the rebreathers at this stop and accelerate helium outgassing. In the end, the rebreathers functioned flawlessly, despite the daily demands and abuse.

A diver prepares equipment in the camp at The Pit. The dive plan is written on the white-board at left. *Jill Heinerth.*

On the first push dive, Buddy Quattlebaum and Steve Bogaerts traveled south out of the Wakulla Room through the BMB Passage and toward the elusive connection with Nohoch. At the end of the line, the cave remained ominously small and tight. The slightest movement brought down clouds of fine, corroded limestone from the ceiling and walls. Then their reel of exploration line jammed. The divers had decompression tables based on only twenty minutes: seven minutes of travel time into the Wakulla Room, five minutes to the end of the old line, and only eight minutes for exploration. Mindful of the time constraints, they made several attempts to clear the reel. The movements of both divers at the same point in the tunnel reduced visibility further. When Steve could no longer see the readings on the rebreather's computer when he pressed it against his mask, he turned the dive.

This early retreat gave the divers extra time to examine the Wakulla Room. While Buddy navigated, Steve checked the other leads heading south, but nothing went. As they were leaving, they noticed that the floor just before the Bypass seemed to have slumped and left a gap against the wall. There was no time left to explore, and they could only speculate about this lead as they began their slow ascent toward the surface.

Though the lead divers explored, it was the support team that allowed things to happen. Prior to the dive, the plan, penetration times, and decompression schedules were discussed. A white-board was then hung at the entrance to the cenote with the dive plan as a series of timed steps. As soon as the lead divers submerged, the support team set their watches and used the white-board as a reference so that they could be in the right place at

An Incident at The Pit

Jill Heinerth

In March 2000, Paul Heinerth and I made the trip to The Pit during which Paul discovered the extension he named Jill's Chamber. During our first dive in The Pit, I had trouble with my left sinus and was forced to call the dive at 95 meters depth.

The next day, March 11, our dive had a great start. I intended to follow Paul only if everything felt perfect with my sinuses. As we motored through the Big Room toward the Cardea Passage and the Bypass, I felt great. We headed off to Paul's Rock and down to the end of the line in small, crumbling passage. Paul tied on a reel and added a short stretch to the survey. Where we cut the line, the visibility was minimal. The floor had very interesting downstream ripples in the sand, but as we turned the dive, we could barely detect a current. We beat a hasty retreat through the tunnel, which was at 107 meters depth. On our way out, my sinus was a little finicky, but I was able to control it. The previous day's dive might actually have improved a long-troublesome nasal passage.

Hours into the dive, during our slow ascent, at –18 meters I became aware of the snug fit of the garments under my dry suit. I inflated my suit and tried to readjust them but they still seemed to pinch. When I reached my 6-meter decompression stop, with two hours left, I climbed into the *tinaco* for dry decompression. To pull my rebreather in behind me, I had to squat to lift the weight of about 55 kilograms. I opened up my suit to readjust my clothing. All this took a lot of exertion when I should have been resting. After the dive, I spent some time resting on the surface before climbing the ladder out of the cenote.

As I climbed the ladder, I was extremely fatigued and realized that I was bent. When a diver descends below the surface, he experiences an additional atmosphere of pressure for every 10 meters of depth. The breathing equipment must supply gas at this higher pressure. Under pressure, the diver's tissues soak up the gas like a sponge soaks up water. Oxygen is used up to fuel the body, so it isn't a problem, but the nitrogen in compressed air or the nitrogen and helium in mixtures used for deep diving must be discarded again on the way up. If the diver ascends too fast for the gas to be eliminated gracefully, tiny bubbles can form, which grow larger as the diver ascends. It is difficult to predict what constitutes too fast, and many factors affect one's susceptibility. Our bodies do not tolerate bubbles well, and they cause a variety of problems. My case of decompression sickness was mainly the sort called skin bends.

I stripped and got into bed. I drank gallons of water to stay hydrated and breathed a gas with 70 percent oxygen at intervals. At one point, a large scorpion inside my mosquito netting prompted me to move to a chair by the fire. I had muscle aches, and I started getting a blotchy rash.

The next morning, I called out on the base-camp radio to report that I was too tired to walk the five kilometers out, but would do so the next day after some in-water recompression. I hesitated to admit that I'd made a mistake, and was worried about how the information would be relayed to the States. Sure enough, Internet messages to the diving community soon had me "unable to walk" and even "paralyzed in a hospital."

Paul prepared my rebreather, and I slipped into the water for two hours at about –13 meters. This helps by squeezing the offending bubbles back into the tissues and shrinking them to manageable size. If the diver breathes pure oxygen, then the absence of inert gases in the breathing mixture helps flush inert gases from the body. Normally we do not expose ourselves to pure oxygen at that depth, but in this case the potential gains far outweighed any risks. By noon, I was feeling a lot better.

The following morning, I urged Paul to go ahead and dive in The Pit. Gabriel Rif and Buddy Quattlebaum arrived at camp in the old jeep. They offered me a ride, but I thought that the bouncing around would be worse than the walk, and Gabriel walked out with me. I was advised by a call to the Divers Alert Network to go to the hyperbaric facility in Playa del Carmen, where over the next days I had three treatments.

In the end, I believe that my DCS hit was a result of several factors. Physical exertion before, during, and after the dive, slight suit-squeeze, and repeating deep dives two days in a row contributed. I must admit that I was swept up in expedition fever, doing too much too quickly, with not enough support on hand. Although I am now, statistically, subject to a greater likelihood of getting bent again, I hope I have learned enough from my experience to be a safer, smarter diver. Initially I was demoralized, feeling that the facts and rumors would dishonor me and hurt my diving career. Strangely enough, I discovered that I had joined a sort of club by getting bent. Dear friends that I had known for years suddenly told stories about their times in the treatment chamber. If we continue to chastise individuals for getting bent, then we will do nothing to further honest reporting and increasing knowledge. I have made it a bit of a crusade to share my experiences with as many divers as possible.

The Pit

Sistema Dos Ojos

Quintana Roo, Mexico

A knotted-line survey by

Steve Bogaerts, Paul Heinerth, Jill Heinerth,
Dan Lins, Mike Madden, Andreas Matthes,
Buddy Quattlebaum, Gary Walten
and Kay Walten

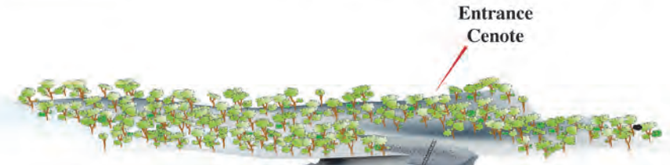
October 1996 - March 2000

Cartography by Hazel A. Barton

Regional Map

Local Map

Cave Map



History

The Pit was originally discovered in September 1994 by Dan Lins and Kay Walten during a 4800 foot penetration dive from Cenote Tikim Ich; their goal was a connection between the 34 mile Sistema Dos Ojos and the near-by, 38 mile-long cave, Nohoch Nah Chich. Following the initial discovery, Jill and Paul Heinerth explored The Pit, along with Kay and Gary Walten. This team discovered a descending borehole, The Cardea Passage. At the end of this passage, at a depth of 330 feet, a significant boulder collapse was encountered. Squeezing a route between these boulders, Paul went on to discover the Wakulla Room.

In 1997, Dan Lins returned with Andreas Matthes and Mike Madden. These divers discovered a bypass to the squeeze at the bottom of the Cardea Passage, The Bypass, and subsequently went on to discover the BMB Passage at the far end of the Wakulla Room. Due to the huge amount of equipment needed for these dives and the remoteness of the site, these were the last open-circuit exploration dives at The Pit.

Finally, Buddy Quattlebaum constructed a road to the entrance cenote. This improved access allowed two rebreather expeditions to take place at The Pit in early 2000. In January, Steve Bogaerts, Dan Lins and Buddy Quattlebaum carried out a series of dives, to discover the Alph Passage and Skid Row. Unfortunately, both of these leads closed down. In March 2000, Jill and Paul Heinerth returned to extend the cave beyond the BMB Passage. Once again, passing through a tight constriction, Paul discovered Jill's Chamber and, the as yet unexplored, Next Generation Passage.

exactly the right time. Even the cook had warm food ready to be given to the divers when they entered the habitat, and a hot meal was ready when they crawled from the water. Support divers were waiting for Buddy and Steve at 15 meters to remove any superfluous equipment to make entering the habitat easier. They removed stage bottles, lights, and slates no longer needed. The divers continued their decompression past 10 meters and were escorted over to the habitat. A whip hanging from the *tinaco* provided oxygen temporarily while the support divers removed the rebreathers, which were passed into the habitat after the unencumbered divers had climbed in. The divers continued decompression in relative luxury.

When decompression was over, the procedure was repeated in reverse. After leaving the habitat and donning the rebreathers again, they slowly swam to the ladder that provided access to the jungle above and was a convenient place to hang for an additional 3-meter safety stop. Then they floated on the surface, while continuing to breath oxygen from the rebreathers. Finally, they were completely stripped of gear by the support team, until only a wetsuit-clad diver climbed the ladder from the cenote.

After a recovery day, Buddy and Steve returned to examine the lead in the floor of the Wakulla Room. Once again the divers entered the water silently with the rebreathers, no bubbles trailing behind to remind the support crew that they were below. In the Wakulla Room, they descended past 100 meters and 105 meters. At 110 meters, the shell of Steve's rebreather was scraping along the ceiling as he entered a lead. Ahead, the cave continued. He saw a rippled sand floor 6 meters below him, and to the left and right was blackness. Steve swam along the ceiling to stay within his depth limits and tied the line to projections, while Buddy followed, surveying. As they laid 60 meters of line, the survey indicated they were heading northeast, away from Nohoch. Although it was not heading in the direction they wanted, this passage did trend along a major joint seen in the shallower parts of the Dos Ojos system. Was it possible that this joint penetrated down through the limestone to the level where they were now diving? If so, they had stumbled on a significant discovery, because the joint in Dos Ojos runs for a thousand meters.

Steve continued, ducking under a projection from the ceiling, where his depth gauge read 361 feet (110 meters). Surveying behind, Buddy monitored his gauge closely. Calibrated more conservatively for fresh water, even though they were 90 meters below the halocline, Buddy's gauge read 365 feet. With their decompression tables calculated for 360 feet, they were pushing their margin too far. Buddy turned the dive.

Two exhausted divers began six hours of decompression. On the way up, to pass the time Steve began thinking of names for this new discovery. His mind wandering, he thought of the famous eighteenth-century poem by Samuel Taylor Coleridge, which begins

> In Xanadu did Kubla Khan
> A stately pleasure dome decree,
> Where Alph, the sacred river ran
> Through caverns measureless to man
> Down to a sunless sea.

After discussions back at camp, the new passageway was called Alph, as it ran through "caverns measureless to man." Of course Mr. Coleridge, even in the opium-induced haze during which he wrote this poem, never imagined rebreather technology.

The majority of caves are formed in limestone, often an ancient reef. Indeed, as you walk over the bedrock of the Yucatan, you only have to take a few steps before seeing the fossilized remains of some sponge-like animal. Occasionally, the growing reef traps sea water behind it in a natural basin, where evaporation concentrates magnesium salts. If the magnesium is incorporated in the reef as it slowly turns to rock, dolomite, a harder rock than limestone, is formed. The structure of the cave passages discovered at The Pit were beginning to suggest that the layers of limestone there were interspersed with layers of dolomite, which is more resistant to dissolution. The Pit may be located at a place where there is a rare weakness in the dolomite, which allowed cave to form and connect to the layers of limestone below. The Cardea appeared to have punched through the dolomite to reach the next layer of limestone, in which the Wakulla Room was formed.

The Pit. *Paul Heinerth.*

But what of Alph? During the last ice age, the sea level was 100 meters below its present level. Since the weight of the freshwater aquifer this far inland depresses the underlying saltwater a further 20 meters, this would put the halocline, where the major cave development in the Yucatan takes place, 120 meters below the present water level. This

suggests that the explorers were at or very close to the bottom of the cave. Could Alph be in a layer of limestone as significant for cave development as that in which the extensive shallower parts of the caves are found? Had they found the main drain of Dos Ojos? The explorers collected rock samples to help geologists determine whether this is the case.

New tables were computed for 120 meters, where the divers would either reach the bottom of the cave and prove the geological conjectures true, or the cave would continue to descend into caverns truly measureless to man. In addition to the new tables, there was a change in the exploration team. Running a dive shop is difficult from the middle of the jungle, and Buddy Quattlebaum was forced to return to civilization and support continued exploration only in a logistics role. Dan Lins took over as lead diver. Once again the dive plan was discussed with the support team, the white-board filled in, and watches set. After climbing into the water, Dan and Steve glided silently down, to be engulfed by the hydrogen-sulfide layer and lost from view. From the Wakulla Room they entered Alph.

Dan resurveyed the line as he followed Steve; there had been some confusion about the previous data. Ahead, Steve retrieved the reel from the ceiling projection where the line had been tied off. No stalactites or other formations lined the ceilings at this depth, confirming that this level had never been dry. With the deeper tables, the divers could drop below the undulations of the ceiling and look ahead into Alph. It looked black. They began swimming, Steve ahead unreeling the dive-line and Dan behind, making slight adjustments to the tie-offs to make the survey easier and more accurate. Dan saw Steve's light swing to the left, then to the right, and then stop. Steve tied off the line as Dan swam up to finish the distance measurements. The cave had ended at a blank wall. Steve swam off the line to check the wall, while Dan remained at the line, his light giving Steve a reference point to return to.

The cave had ended. Steve looked at his computer: 366 feet (112 meters). The cave could have gone deeper, but there was nothing, no holes in the floor, no change in the ceiling, just blank walls. As the time they could spend at such depth was rapidly approaching its end and they saw no obvious leads, they turned the dive. Both were frustrated by the way such huge cave had suddenly ended. On the way out, they both noticed that the left wall of Alph sloped down out of sight. Could it be that Alph really did continue south, toward Nohoch? With the time constraint weighing heavily on them, at 60 meters they began the tedious six hours of decompression, watching the light streaming in through the entrance cenote, where drinks, hot food, and hammocks awaited them. But after a dive to 112 meters, until decompression was complete it might as well have been the moon.

Enough time and CO_2 scrubber for the rebreathers remained for one final push south out of Alph toward Nohoch. For the last time, a dive plan was written on the white-board and the divers slipped into the water. They swam down to Alph, turning south. In the confines of the bedding plane there was darkness ahead. Dan led, paying out the line while Steve followed surveying. After a hundred meters, the patterns seen earlier in Alph began to repeat. The walls came around and the cave began to close down. Dan saw a small hole leading off at floor level. Renowned for his ability to squeeze through tight holes, he thought nothing of entering this lead, though he admits it wasn't the wisest decision to enter a two-foot-high, narrow restriction wearing a rebreather and two stage bottles. He wiggled forward, but it was hopeless. Visibility was almost zero, and his outstretched hand could feel the passage getting smaller ahead. His computer said 391 feet (119 meters). Dan had previously been on the longest penetration in Dos Ojos, and now he was on the deepest. He backed out with some difficulty, the stage bottles resisting backward movement.

Back in the larger passage, Dan followed the wall around to another narrow lead with blackness. He stuck his head through the foot-high hole and recognized features of the Wakulla Room. It would be a good end to the exploration to survey back up into the Wakulla Room and close these eastern leads, so he began to dig at the restriction. He immediately regretted this. As he removed debris from the restriction, he threw clouds of silt into the water, destroying visibility. Steve would not be able to close the survey, so he stopped digging. They were done, so he called the dive.

Sitting in the decompression habitat, Dan and Steve decided to call their latest discovery Skid Row, down in the depths of despair. Where did the cave go? Earlier, they had placed a flow meter for a British hydrologist who was attempting to measure the movement of saltwater in the Yucatan interior. These results could help determine if water in The Pit was directly connected to the ocean, depending on whether the flow responded to tides. The flow meter was retrieved and the data analyzed, but despite initial promising results, the device had failed to work correctly. Several hours spent below 60 meters had been wasted. The rock samples did seem to confirm the hypothesis that dolomitic layers influenced cave development in deep parts of the system, suggesting that more cave should be found at the level of the Wakulla Room.

A vision had led three explorers and their support team, including support divers Clare Thornberry, Pierre Turgen, and Gabriel Rif, into the depths of the Mayan jungle. Despite hordes of mosquitos, repeated downpours of rain, and almost complete isolation from the modern world, they had followed this vision to the bottom of The Pit at –119 meters. The results of these explorations answered many questions about the deep hydrology of the Yucatan Peninsula. However, many unanswered questions remain.

One lead remained, the BMB Passage, which, though forbidding and tight, had never completely

closed down. In addition to organizing the expedition described above, Buddy Quattlebaum had also invited Jill and Paul Heinerth to return and take advantage of the new road to The Pit. They returned with rebreathers, Cis-Lunar MK-5Ps. Considering the results of the previous expedition, they decided to concentrate on the BMB Passage lead.

At first the passage appeared to close down, but Paul discovered a concealed hole in the ceiling. Fighting his way into the hole, he broke through into the cave's third large chamber at a depth of 100 meters. The cave continued, just as the geology predicted. The passage continued south as a tunnel over 30 meters wide. Paul named it Jill's Chamber in honor of his wife, who had not been able to accompany him on this discovery dive. During his return, Paul retrieved water samples from –105 meters.

The discovery of Jill's Chamber caused great excitement, but unfortunately it came at the end of Paul and Jill's expedition. They had to leave a huge and going lead at the end of Jill's Chamber open and inviting. [Recent information received from Buddy Quattlebaum indicates that Steve Bogaerts has managed to negotiate the Hawk-Ming Restriction to enter Jill's Chamber. He found Paul's line tied off in wide-open tunnel and was able to lay an additional 300 meters of line. He said that the cave continues in dramatically beautiful passage. We're all thrilled that exploration continues in this significant and unique cave.—*Jill Heinerth*] Was it heading toward a Nohoch–Dos Ojos connection, toward the Blue Abyss, only 20 meters shallower in Nohoch? If there was indeed a connection, it would produce a cave with a total length of 117 kilometers, far surpassing recently discovered 70-kilometer Ox Bel Ha as the world's longest underwater cave. It would also be the longest cave in Mexico.

The water samples showed that the water deep in The Pit has the same chemistry as the nearby ocean. Is there a deep main drain below the caves in this area, connecting them together and to the ocean? Along the wall of the barrier reef, large holes have been seen at 100 meters depth. Could these be entrances to the elusive deep system?

The answers to these questions may well be found through further explorations at The Pit in Dos Ojos. Other explorers of similar vision will, in their way, continue the traditions of the Maya, sacrificing time, energy, and riches to the Cave Gods that guard the mysteries of the underworld in the depths of the Yucatan Peninsula.

El Pozo (The Pit) en Dos Ojos

Descubierto desde adentro durante un buceo desde otra entrada, El Pozo es un cenote que da entrada al Sistema Dos Ojos, Quintana Roo. Contiene pasajes muy profundos, lo que es raro en las cavernas subacuáticas de la zona de la Riviera Maya. La mayor profundidad alcanzada es de -119 metros. Recientemente, buceos adicionales han mostrado la existencia de pasajes que salen del Salón de Jill, a una profundidad aproximada de 100 metros. Jill Heinerth describe un incidente de descompresión tras un buceo en El Pozo.

MYRNA'S GIFT: NOHOCH KIIN, QUINTANA ROO

Dan Lins and Andreas Matthes

In February 1997, Myrna Bush gave me, Dan Lins, a plane ride over the jungles of Mexico for my birthday. We were exploring in the same way that her father had back in the 1950s. Don Pablo Bush had led a number of expeditions to this part of Mexico and had used small planes to find cenotes and remote Mayan villages. Our short flight led to what Mike Madden calls "one of the most significant finds since the discovery of Nohoch Nah Chich in 1987."

We were especially interested in the areas surrounding the Nohoch and Dos Ojos cave systems. We were flying low, but too fast to see much through the dense vegetation. Since we had not found any new cenotes, we continued south to the Tulum area to take some video of the beach and the ruins. On the return leg, we went inland again, and just as our flight time was running out I caught a glimpse of a major depression with a hint of blue water. With the video camera rolling, I made mental note of the location. We were confident that we could direct our jungle crew right to it. Although the depression was perfectly located for a major new cave discovery in the area, it wasn't until May that any attempt was made to find it on the ground.

Mike Madden, Andreas (Matt) Matthes, and I were talking about plans for future explorations when I mentioned the plane ride. Mike asked me if I could find the depression on the ground, and I confidently stated, "Absolutely, no problem, we can walk right to it." We had picked a perfect day for a jungle stroll, lots of sun, heat, humidity, and mosquitoes. A couple of the sons of Don Pedro, owner of Nohoch Nah Chich, have been providing us with surface support for years, and they were scouting out front. Mike and Matt were swinging machetes, and I cruised along in back. Leading from behind, I felt very confident about my memory and orienteering skills.

After about three hours, the rest of the team weren't exactly up to my level of confidence, and there were lots of questions about my age, my memory, and my ability to judge distance. We eventually found a small crack in the limestone with water at the bottom. Getting a chance to really feed the mosquitoes, Mike stripped down for a check-out dive. The boys carefully assembled Mike's gear, and he descended into the depth with a mask, a light, and a swimsuit. I knew this wasn't the cenote I had seen from the air, but it looked like it might yield some cave passage. I thought that if enough blood was sacrificed to the mosquitoes, the cave gods would be good to us and the disparaging comments about me would stop.

On his return, Mike did not exactly have a glowing report of having found the big one, but on the trip out of the jungle, I was able to satisfy the team that the depression really did exist. After all, I had video that showed it and the surrounding landmarks. We headed to Akumal to view the evidence. I had never watched the video before and of course was somewhat embarrassed to find that all I had gotten was great footage of the beach, the Tulúm ruins, and a couple of naked bodies. This kind of thing happens to me a lot, and my career as a cameraman was over. I began to feel better when the discussion turned to the wall dive we had planned for the following morning.

The next morning brought a leisurely breakfast, rough seas, and no wall diving, so, left with a free day, we were off to the airport. We loaded up cameras, compasses, slates, and the GPS. I was assigned the GPS and its owner's manual. Mike was going to handle the video this time. Mike made one last stop on the way to the airport and came up with a dozen rolls of toilet paper. I wondered whether his breakfast has been more intense than mine had been.

After thirty minutes of circling the area where I had seen the depression, we had not found it. We were a little depressed, and our flying funds were on empty. We were turning back, when there it was, exactly where I had seen it the first time and only a couple of kilometers from where we had been looking for it on the ground. The collapse area was huge, with bits of blue water showing around the sides. Since the depression was well hidden by the jungle, it could only be seen from one direction, and you had to be flying directly toward it. The cave gods had been good to us this time. Matt had the headings, Mike had the video, and of course I had nothing, because the GPS didn't work. The pilot had gotten into the spirit of discovery and performed a number of maneuvers so we could deploy the trail-flagging plan. After a number of toilet-paper bombing runs, we had a nicely

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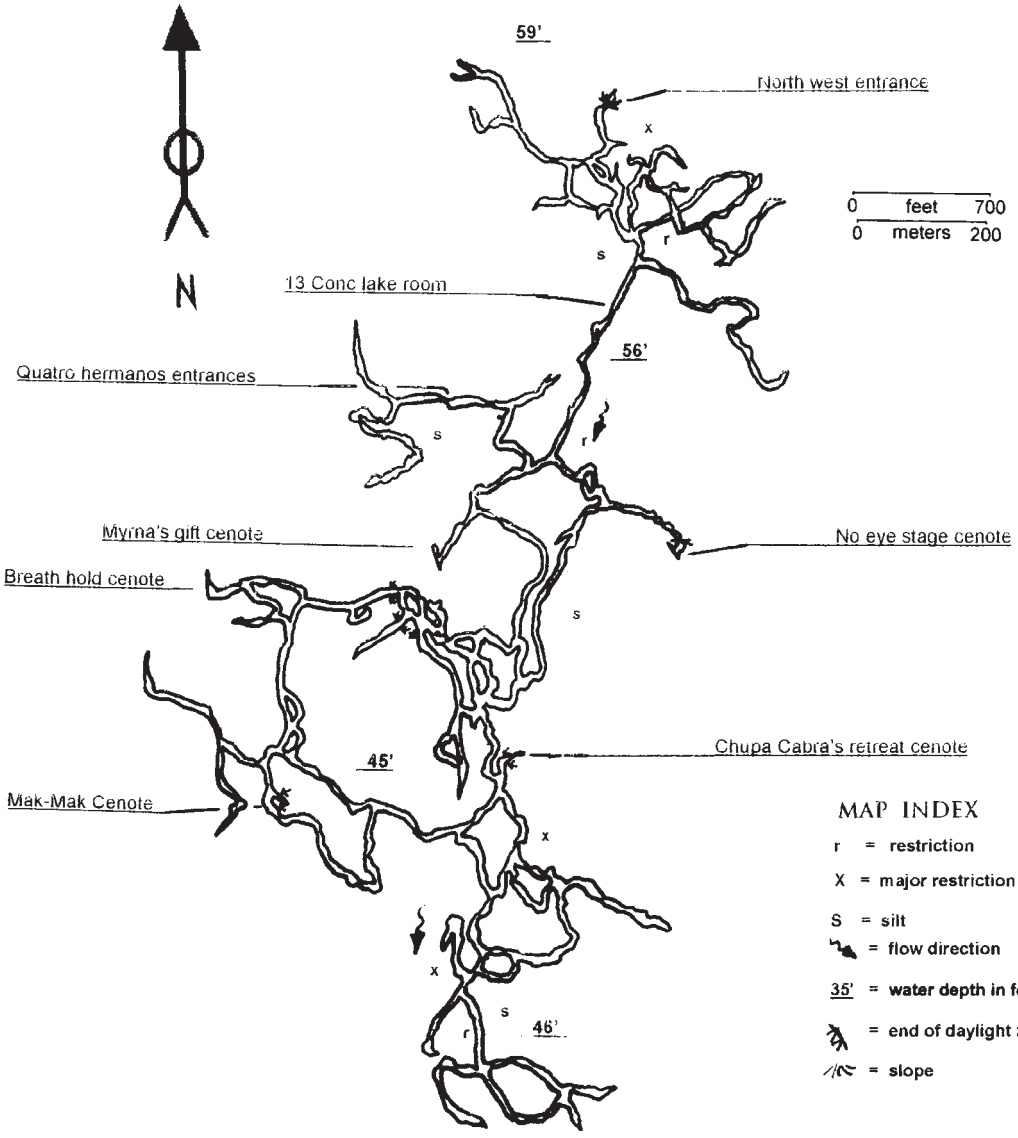
CENOTE - NOHOCH KIIN -

Q.ROO - MEXICO

Surveyed and Explored
May – November 1997 by Dan Lins, Mike Madden, Andreas W. Matthes



NOTES

This unique lime stone cave is entirely submerged at present time.
It drains fresh water from an inland Karst area through fracture controlled passages. Typical environmental conditions include white silt floor and a Halocline is usually encountered at a depth of 35 feet / 12 Meters.

Only individuals with the proper training and equipment should enter this fragile cave system.

A Freistein compass and knotted line were used to confirm all azimuth and distances. Wall distances are estimated.
A digital depth gauge was used to measure water depth. All distances have been corrected for plan view.

flagged trail to follow on the ground. As we headed home, both Mike and Matt feared that their leisurely breakfasts might be seen again, due to the acrobatics of the bombing runs.

Mike and I returned two days later with the boys, but without Matt, who unfortunately had to work that day. It had rained and the "flagging tape" was gone, but with proper directions the boys cut a kilometer-long path directly into the depression. We spent hours exploring the surface area and discovered a series of cenotes. We snorkeled each as we found it and located cave entrances. Two of the larger cenotes were separated by a land bridge of about 25 meters. Mike and I made the first breath-hold traverse from Myrna's Gift Cenote to the Breath Hold Cenote. We both made glowing reports to Matt that evening and went to bed thinking about the advantages of pressurized "snorkels" over breath holding.

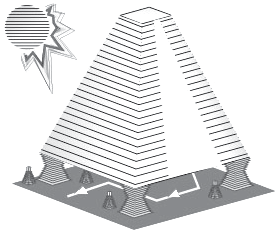
It took another two days to get diving gear transported into the depression. The morning air was hot and heavy, but everybody was smiling. We knew this was going to be a very big day. The boys knew it, too, and were as excited as we were. Mike took the lead, Matt and I followed, and the three of us made the breath-hold traverse on scuba for the first time. As we left daylight from the second cenote, it became very apparent that the cave gods had indeed been good to us. What lay ahead of us was borehole with good flow. While Mike was laying line, Matt and I were checking side passages. We got to a major junction room and went right. The passage went deep and closed down. We started the survey and backed up to the junction room. We took the smaller lead, to the left, it opened up, and we were rolling down major passage again. Since it was getting late in the day and we had quite a bit of surface survey to do before the hour of the mosquito, we tied off and surveyed out. The tale on the survey slate showed we had explored 915 meters of cave passage. Not a bad first day at all.

We returned four days later, on May 18. The boys had moved tanks, gear bags, and a lot of knotted diveline into the depression. Sidemounting four bottles apiece, the three of us headed for the end of our previous line. It turned out to be another very big day. In that four-hour dive we discovered three new entrance cenotes and surveyed 1398 meters of new cave passage. We had broken the ten-year-old 1987 record set in Nohoch of 1280 meters explored and surveyed on one dive.

Mike and I returned four days later for dive number three. We explored another 906 meters of passage, and the cave's length stood at more than 3 kilometers after three days of exploration. Matt and I have continued exploration and have expanded the system to over 15 kilometers of surveyed passage. Myrna's Gift continues, and Nohoch Nah Chich is "just inches away." All cave exploration starts from the surface. This time it paid to start above the surface.

Nohoch Kiin, Quintana Roo

El Cenote Regalo de Myrna, la primer entrada de este sistema, fue descubierta desde el aire en 1997. En los tres primeros días de buceo en el sitio, se exploraron y topografiaron 915, 1,398 y 906 metros de pasajes respectivamente. Hoy la cueva tiene mas de 15 kilómetros de galerías y la exploración no está terminada. Una conexión con el cercano Nohoch Nah Chich es posible.



THE QUINTANA ROO SPELEOLOGICAL SURVEY

Jim Coke

The Quintana Roo Speleological Survey supports the safe exploration, survey, and cartography of the underwater caves of Quintana Roo. Created in 1990, the QRSS maintains an extensive archive of cave-survey data for over sixty underwater caves and cave systems. Our database includes data and reports on 369.9 kilometers (229.9 miles) of underwater cave passage. Many reports include water-chemistry, biological, and environmental observations. This is a summary of painstaking research by numerous explorers, cartographers, and scientists who are concerned with the conservation and scientific documentation of this region's anchialine caves.

Our companion pursuit is to encourage the cartographic representation of these caves. Only ten underwater caves or cave systems in Quintana Roo have been completely portrayed by various types of cartography. Of these maps, four are outdated in view of more recent discoveries. We hope to stimulate cartographic endeavors to further an understanding and appreciation of all the underwater caves of Quintana Roo. We welcome all individuals who are interested in participating in QRSS mapping and science projects. Certified cave divers visiting the region may obtain information on underwater survey and cartography opportunities.

Sustaining a current survey database on the underwater caves in this region hinges on the generosity of our contributors. The QRSS archives this information in order to encourage conservation and awareness of the caves through collaboration and knowledge. We do not reveal cave locations or where going leads might be found. Should you be involved in credible speleological research in Quintana Roo and judge that our resources might be of assistance to your investigations, please contact us.

Since spring 2000, the Quintana Roo Speleological Survey has been an official project of the National Speleological Society. Directors are Hazel Barton, Jim Coke, Dan Lins, and Gary Walten. Its addresses are Hazel Barton, Department MCD Biology, Campus Box 347, University of Colorado, Boulder, Colorado 80309 and chac@lcc.net.

The geologic history of the Yucatan Platform is difficult to establish due to a paucity of deep-well data and exposed structures and the inaccessibility of the inland terrain. In a quest for oil reserves in the early 1970s, Petroleos Mexicanos drilled ten exploratory wells into this platform. Most were in the state of Yucatan, some deeper than 2000 meters. Data from the test wells describe the stratigraphy of the Mexican isthmian portion of the peninsula, a great limestone platform (Ward and Weidie, 1978; Weidie, 1985).

Paleozoic metasediments, at varying depths exceeding 2400 meters, form the basement strata. Early Mesozoic redbed sediments, the Todos Santos Formation, overlie the Paleozoic strata unconformably, with an average thickness of over 100 meters. The Cretaceous period saw the beginning of numerous marine transgressions that would submerge much of this isthmus under warm, shallow seas until the Pleistocene. During the Cretaceous, over 1300 meters of limestone strata were formed, and during the Tertiary period another 1000 meters of essentially pure carbonate sediments were deposited. This includes the uppermost Carrillo Puerto Formation (Miocene-Pliocene), a 15-meter-thick formation that holds the shallow portions of many cave systems.

Uplift in the south-central area of the isthmus began in the Oligocene, enabling the Carrillo Puerto Formation to be deposited in stages over the ever-expanding margins of the peninsula. This slow uplift continued until the Pleistocene. Quaternary deposits on the isthmus are mainly restricted to the present margins of the peninsula. These deposits are typically thin, extending 1 to 3 kilometers inland from the Caribbean. Most Pleistocene deposits are the result of marine transgressions over eastern Quintana Roo during the Illinois and Wisconsin ice ages. Unconsolidated Holocene deposits are restricted to the present shoreline. The study area is now a low-relief karst plain, elevation 3 to 16 meters, that sustains a shallow water table.

Although the geologic history of the study area is incompletely known, it has created a relatively stable karst platform predisposed to speleogenesis. The study area receives over 150 centimeters of rain per year (Ward and Weidie, 1978; Weidie, 1985). Atmospheric carbon dioxide lends a slight acidity to this

Material is from the web site of the Quintana Roo Speleological Survey, www.caves.org/project/qrss.

precipitation. Further carbon dioxide and tannic acids are absorbed from the upper, calichified zone of the Tertiary strata. Both the caliche and the parent strata are very porous, favoring rapid percolation toward a shallow aquifer of fresh water. Following a course to the Caribbean through bedding fractures, this acidified water has been dissolving caves in the parent limestone since it was initially uplifted above the ocean.

Sea-level fluctuations from the Sangamon interglacial through the Wisconsin post-glacial periods expedited developments within the cave systems. Receding sea levels during active glaciation resulted in a considerable drop in the water table, allowing free-surface streams to flow in the caves. Ceilings close to the surface, no longer supported by the buoyant force of water, collapsed, creating new karst windows at irregular intervals along the course of the conduits. Solution and stream erosion gradually broadened the existing caves, while also eroding new passages, currently explored to –100 meters, into deeper beds. About eighteen thousand years ago, as the Wisconsin glaciers waned, sea level began a slow rise from 125 meters below its present level (Ward and Weidie, 1978; Coke et al., 1991). As the layer of fresh water was elevated by a rising saltwater intrusion, deeper conduits were rapidly submerged. Upper-level passages were eventually flooded by the freshwater aquifer. Most of the cave systems came to possess both fresh and saltwater layers, with implications for future speleogenesis.

Holthius (1973) coined the term anchialine for certain inland, seemingly isolated pools. Many cave systems in eastern Quintana Roo contain anchialine pools. They contain salt or brackish waters that fluctuate with ocean tides, although there is no surface connection to the ocean. Anchialine caves in the study area contain an upper freshwater layer that flows toward the ocean over a near-static saltwater layer. A mixing zone, the halocline, occurs, stirred by water currents in cave passages, at a distinct density interface between the fresh and salt layers. The thickness of the freshwater layer, and hence the depth of the halocline, increases with distance from the ocean. Chloride concentration in the fresh water depends on the distance from the ocean, intensity of recent precipitation, and nearness to the halocline, but it is generally about 2 parts per thousand until cave passages reach the depth of the mixing zone. Salinity levels below the mixing zone rise abruptly to 14 to 35 parts per thousand, depending on depth and distance inland (Iliffe, 1992).

Investigators have concluded that preferential dissolution of limestone at the mixing zone (Back, et al., 1986), allied with ordinary fracture-zone speleogenesis, has contributed to the vast growth and passage complexity within these cave systems. Modern cave-diving techniques have allowed explorers to study these underwater conduits many kilometers from their entrances. These explorers have discovered a number of the longest underwater cave systems in the world. Cave diving has been a research tool for many scientific disciplines. Although many geological, hydrological, and archaeological discoveries have been made, perhaps the most numerous advancements have been in the field of biospeleology.

List of Long Underwater Caves in Quintana Roo, Mexico

	cave name	length m	depth m	#	reported by	date
1	Sistema Ox Bel Ha	70650	33.5	44	B. Phillips, GEO	2/2000
2	Nohoch Nah Chich	60985	71.6	(?)	Journal of CKS	12/1999
3	Sistema Dos Ojos	56037	119.1	18	D. Lins	01/2001
4	Sistema Naranjal	19996	34.7	8	J. Coke	01/2001
5	Sistema Sac Actun	17078	19.8	13	Lins, Phillips	8/2000
6	Sistema Ponderosa	15019	16.5	18	S. Gerrard	2/2000
7	Sistema Nohoch Kiin	13888	19.8	12	D. Lins	4/2000
8	Sistema Abejas	9743	12.8	4	D. Lins	4/2000
9	Chac-Mol	9193	28.3	9	A. Matthes	1/2000
10	Cueva Quebrada	9000	10.7	5(?)	S. Ormeroid	1993
11	Cueva Aerolito	6100	27.4	3(?)	S. Ormeroid	1993
12	Ayim Siphon	6001	23.5	3	F. Devos, GEO	1/2001
13	Sistema Actun Chen	5435	25.0	9	Birnbach, LeMaillot	1/2001
14	Sistema Actun Koh	5156	16.5	5	F. Devos	1/2001
15	Sistema Taj Hahal	5113	21.9	8	Birnbach, LeMaillot	1/2001
16	Nohoch Ha East End	4722	13.4	8	D. Lins	4/2000
17	Zapote	4604	24.4	2	G. Irvine	9/1992
18	Dzonot Took	4472	16.5	3	Lins, Matthes	8/2000
19	Esqueleto (TOD)	4164	18.3	2	J. Coke	4/1995
20	Burrodromo	3962	14.3	2	W. Skiles	9/1988
21	Sistema Dos Pies	3516	13.1	5	F. Devos	1/2001
22	Sistema Minotauro	3118	14.6	5	Birnbach, LeMaillot	1/2001
23	Mundo Escondido	2273	13.7	2	G., K. Walten	11/1994
24	Sistema Ek Be	2185	13.1	5	G., K. Walten	9/1994
25	Sistema Carrillo	2144	7.9	6	F. Devos	1/2001

= number of cenote entrances

The first serious attempts to study the cave fauna of the Yucatan Peninsula were made by expeditions in 1932 and 1936 from the Carnegie Institution of Washington, D. C. Of 306 species collected from cenotes and dry caves, only 28 were considered troglobitic (Pearse et al., 1936, 1938). Between 1973 and 1975, Texas Tech University fielded the first systematic search for troglobites that encompasses all the states in the peninsula, Yucatán, Campeche, and Quintana Roo. These expeditions documented a total of 34 troglobites, 11 of them aquatic (Reddell, 1977).

Cave-diving expeditions in Quintana Roo were initiated in the early 1980s. These investigations have unveiled 10 additional aquatic species. Six of these are known only from caves near the mainland coast near the town of Tulum Pueblo (Yager, 1987; Iliffe, 1992; with additions by Kallmeyer and Carpenter, 1996, and Escobar-Briones et al., 1997). There are now 21 described species of aquatic troglobites from the caves of Quin-tana Roo. These include 19 species of crustaceans from seven orders and two species of fish from two orders (the last four references, plus Navarro-Mendoza, 1988).

Obligate underwater cave species, stygobites, are inhabitants in anchialine caves all over the Caribbean area. But the geology, hydrology, and nutrient cycles are quite elaborate on the Yucatan Peninsula, perhaps more so than in other Caribbean regions. Many speleologists believe that additional stygobites will be reported in the near future. I know of two undescribed stygobites in two crustacean orders. At a meeting of the Texas Academy of Science in 1999, I discussed the first record of two species of the phylum Cnidaria, class Hydrozoa, *Hydra* spp. from an anchialine cave in Quintana Roo. Although common in many freshwater lakes and streams, *Hydra* species have never been reported to complete their life cycles in anchialine caves. It is doubtful that both species of *Hydra* are obligate cave species.

Javier Alcocer, Elva Escobar-Briones, Maria Elena Carmacho, Jerry Carpenter, Tom Iliffe, Jill Yager, and a host of others continue to investigate the fascinating subject of anchialine biology in the caves of Quintana Roo.

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List of Deep Underwater Caves in Quintana Roo, Mexico

	cave name	depth m	length m	#	reported by	date
1	Sistema Dos Ojos	119.1	56037	18	D. Lins	1/2001
2	Nohoch Nah Chich	73.6	60985	(?)	Journal of CKS	12/1999
3	Angelita	59.4	59	1	H. Hiler	3/1993
4	Sistema Naranjal	34.7	19996	8	J. Coke	1/2001
5	Sistema Ox Bel Ha	33.5	70650	44	Phillips, GEO	2/2000
6	Chac-Mol	28.3	9193	9	A. Matthes	1/2000
7	Cueva Aerolito	27.4	6100	3(?)	S. Ormeroid	1993
8	Cenote Tortuga	27.1	1361	1	S. Gerrard	7/1993
9	Carwash Siphon	26.5	1342	1	J. Coke	7/1999
10	Sistema Actun Chen	25.0	5435	9	Birnbach, LeMaillot	1/2001
11	Cenote Vaca-Ha	24.7	851	1	D. Lins	9/1993
12	Zapote	24.4	4604	2	G. Irvine	9/1992
12	Sistema Heder	24.4	1714	2	F. Devos	1/2001
14	Ayim Siphon	23.5	6001	3	F. Devos, GEO	1/2001
15	Calica	23.2	259	1	J. Coke	9/1992
16	Yaxchen	22.3	(?)	40	G., K. Walten	3/2000
16	Carwash Spring	22.3	1467	3	J. Coke	7/1999
18	Sistema Taj Mahal	21.9	5113	8	Birnbach, LeMaillot	1/2001
19	Ayim Upstream	21.3	1628	3	F. Devos, GEO	1/2001
20	Sistema Sac Actun	19.8	17078	13	Lins, Phillips	8/2000
20	Sistema Nohoch Kiin	19.8	13888	14	D. Lins	4/2000
22	Sacred Temple	19.5	734	1	B. Phillips	12/1996
23	X Dzonot	18.9	223	1	S. Gerrard	11/1993
24	Cenote Templo	18.6	596	1	S. Gerrard	3/1994
24	Cenote Hatzutz Actun	18.6	162	1	D. Riordan	2/2001

= number of cenote entrances

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Catastro Espeleológico de Quintana Roo

El Catastro Espeleológico de Quintana Roo (QRSS, por sus siglas en inglés) apoya la exploración, topografía y cartografía de las cavernas subacuáticas del estado de Quintana Roo. Su base de datos incluye más de 60 cavidades subacuáticas, con un total de 370 kilómetros de pasajes topografiados. Ha sido aceptado como un proyecto oficial de la National Speleological Society. Las formaciones estalagmíticas de estas cavernas crecieron durante períodos de bajo nivel del mar durante el Pleistoceno. Hoy en día están rellenas por agua dulce sobre una capa de agua de mar, y la interfase entre estas es escenario de altos niveles de disolución. Se conocen veintiuna especies de troglobios acuáticos, de los cuales diecinueve son crustáceos y dos son peces.

ISOTOPE EVIDENCE FOR CHEMOSYNTHETIC CONTRIBUTIONS TO AN ANCHIALINE CAVE ECOSYSTEM IN THE NORTHERN YUCATAN

John W. Pohlman

Ecological investigations in Mayan Blue Cenote, an anchialine cave system in Quintana Roo on the east coast of the Yucatan Peninsula, indicate that the energetic demands of the resident troglobites are partially satisfied by chemoautotrophically produced organic matter. Chemoautotrophs are microbes that obtain their energy from reduced compounds such as sulfides, ammonia, or methane and that can grow using carbon dioxide as their only source of carbon. It has been previously assumed that these ecosystems are based entirely on detritus. In other words, animals living in the dark recesses of anchialine caves were thought to depend completely on the transport into the cave system of photosynthetically produced organic food material from outside the cave. The data included in this report question that paradigm, and it is inferred that chemosynthetic productivity is a common anchialine phenomenon.

Anchialine caves are partially or totally submerged subterranean passages filled by a mixture of fresh and marine waters (Stock et al. 1986). Often the fresh and salt waters are stratified, separated by a relatively thin mixing zone, the halocline. These caves are prominent geological features of most tropical karst regions on coasts around the world (Iliffe 1992). Their importance in the Yucatan Peninsula is especially pronounced, because the caves serve as the major conduits of groundwater flow. Because the Yucatan lacks any significant rivers and streams, extensive cave systems are responsible for the drainage of the entire coastal plain. The groundwater in these caves serves as the primary water source for many Mexican citizens, a major attraction for the tourist industry, and, unfortunately, a sewage system for developing areas. Preserving and understanding this massive aquifer is of great importance to the many people who depend on it.

Prior to this project, biological investigations had been limited to taxonomic and biogeographic studies. These studies have revealed a surprisingly diverse community of organisms that includes twenty species of crustacea and two species of fish specifically adapted to the cave habitat. Typically, these organisms display regressive features, lacking functional eyes and pigmentation. This study represents the first significant data to explain how the biota in this region interact with and survive in this dark, nutrient-depleted environment.

Field work for this project began in July 1993. Dr. Thomas Iliffe and I collected crustaceans, fish, sediments, and particulate organic matter. All cave divers participating in the project were certified as full cave divers by the Cave Diving Section of the National Speleological Society. Stable-isotope mass-spectrometric analyses of these samples refuted the possibility that the organisms in the dark reaches of the cave relied on organic matter of photosynthetic origin. Instead, the data suggested that the principal food source is of chemosynthetic origin. In fact, the range of values recorded from the organisms almost exactly matches that reported by Kennicutt et al. (1992) from numerous hydrothermal-vent and hydrocarbon-seep communities. These communities are sustained by hydrogen sulfide and methane, which fuel the growth of chemoautotrophic bacteria living symbiotically in the tissues of tubeworms and the gills of mussels crowded around the seeps. This evidence led us to think that hydrogen sulfide, the compound utilized by sulfur-oxidizing bacteria, might be the source of energy for the anchialine community. Methane, ammonium ions, and reduced metals were not, however, ruled out as potential sources of energy.

With financial support from the Cave Research Foundation, we returned to Mexico in March 1994 to collect additional samples. Based on these additional studies, methane and hydrogen sulfide do not appear to be significant energy sources. The hydrogen sulfide concentrations in the water were below detection (<2μM), and the methane

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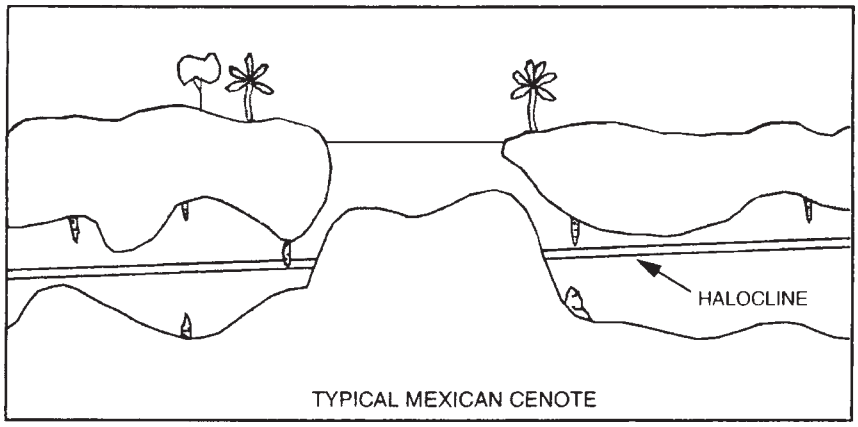
Revised by the author from a short article in the *Cave Research Foundation Annual Report 1994–1997.* A full description of this research has been published in Pohlman, et al., 1997.



Typical Mexican anchialine cave displaying open-water cenote and adjointing cave passages. The distinctive halocline is labeled; it becomes progressively deeper with distance from the coast.

concentrations were exceptionally low (73–180μM). We did, however, find the concentrations of ammonium (NH_4^+) and nitrate (NO_3^-) surprisingly interesting. The high nitrate (2.75–18.64μM) and low ammonium (0–0.01μM) concentrations suggest that nitrifying bacteria may be oxidizing all the available ammonium to nitrate and utilizing the energy from the reaction for biosynthetic purposes.

Synthesis of organic matter via nitrification is such an inefficient process that ecologists generally dismiss it as unimportant. Nitrification is a common and critical component of the global nitrogen cycle, but only for the turnover of ammonia to nitrate. The only other instance in which nitrification has been reported to make a significant contribution to the total pool of organic matter was within an ice core collected in Antarctica. Caves and cryptic ice communities are both organically starved environments where small contributions of organic material could constitute a significant trophic input. In anchialine caves, conditions for nitrification are optimum. Nitrification rates are highest in dark, hypoxic (<2mg/l) environments. The stable isotope composition of nitrifying bacteria is within the range of values we measured in the biomass of the larger organisms in Cenote Mayan Blue.

Holsinger (1989) and Yager (1994) reported on the occurrence of similar assemblages of troglobitic crustaceans, including amphipods (*Bahadzia* spp.), thermosbaenaceans (*Tulumella* spp.), and remipedes (*Speleonectes* spp.), at several sites in the Caribbean, including the Bahamian Archipelago and Cuba. Considering the parallels in habitat and community structure, it is not hard to hypothesize that similar processes may be occurring at these sites. In fact, measurements of dissolved oxygen, salinity, and temperature at Mayan Blue resemble those reported by Yager from an anchialine cave in Cuba.

Although we have made great advances in understanding the processes that control the anchialine cave ecosystem, numerous questions remain unresolved. As we think that the major bacterial activity is occurring along the halocline, we plan to characterize that environment chemically, physically, and biologically. We plan to identify the chemosynthetic bacteria and utilize immunofluorescence to quantify the bacterial populations. Samples from other Mexican anchialine caves and a lava tube on Lanzarote in the Canary Islands are being isotopically analyzed to expand our understanding of the phenomenon. Besides what is learned about the ecology of anchialine caves, knowledge from these investigations is applicable to other chemoautotrophic systems.

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Brett Dodson of Texas A&M University gathers water-quality data during our investigation of anchialine caves. *John Pohlman.*

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Evidencias de contribuciones bacterianas a los ecosistemas subacuáticos de Yucatán

Se colectaron muestras de vida animal y sus posibles fuentes de alimentos en el Cenote Mayan Blue, Quintana Roo. Los análisis de isótopos estables de carbono sugieren que los restos orgánicos provenientes de la superficie no son la principal fuente de nutrientes de los organismos hallados en el interior de la cavidad. Las bacterias que viven mediante la síntesis de amonia en nitratos pueden ser una importante fuente de material orgánicos en el agua, especialmente en la interfase entre agua dulce y agua de mar. Aun cuando en otros ambientes se conocen ecosistemas que incluyen bacterias que se alimentan de metano o sulfatos, estos organismos son muy escasos en el Cenote Mayan Blue.

Studies on the Cave and Endogean Fauna of North America. [*I*] 1986, 167 pp, hardbound. $18.50, *II*. 1992, 257 pp, hardbound. $28.50. *III*. 2001, 192 pp, softbound. $18.00. All are edited by James R. Reddell, are 8.5 by 11 inches, and are published by the Texas Memorial Museum, Austin, Texas. Speleological Monographs 1, 3, and 5 (ISSN 0980-9822). Order from the museum at 2400 Trinity Street, Austin, Texas 78705. Add $5.50 per book for postage and handling. Texans add sales tax.

This series of books is pretty much hard-core biology, of interest mainly to biologists of the butterfly-collecting sort, that is, taxonomy and distribution. Cave biology of Mexico is prominent in the volumes, especially the first and third. The majority of the articles in the first volume pertain specifically to Mexico, and the longest article in the third volume is on the cave fauna of the Xilitla area in Querétaro and San Luis Potosí.

—*Bill Mixon*

GHOULISH CAVING

Mitchell Ventana
Drawings by Jesús Moreno

Mexpeleo, the long-awaited international meeting, finally took place during the last part of December 1989, and although I have been quite busy translating and writing a fire-fighting manual, it was with great determination that all was set aside in order to get in shape for the Big One, Sótano de las Golondrinas, 333 meters deep. I even went so far as to clean my poor old truck.

Carlos Sánchez, a novice caver from Colima, and I arrived at Mano and Nani Ibarra's house in Guadalajara and were well received by their parents. However, I soon had the feeling that the Big One was not to see me as one of its visitors, because we heard that so-and-so was not bringing his rope, which meant that you-know-who was not going to bring his either. Some quick mental arithmetic soon told me that my hundred-meter rope would leave me dangling quite high above the floor. Despite this bad news, as Jesús Moreno would say if he spoke English, "Let's go for it." So off to the state of San Luis Potosí.

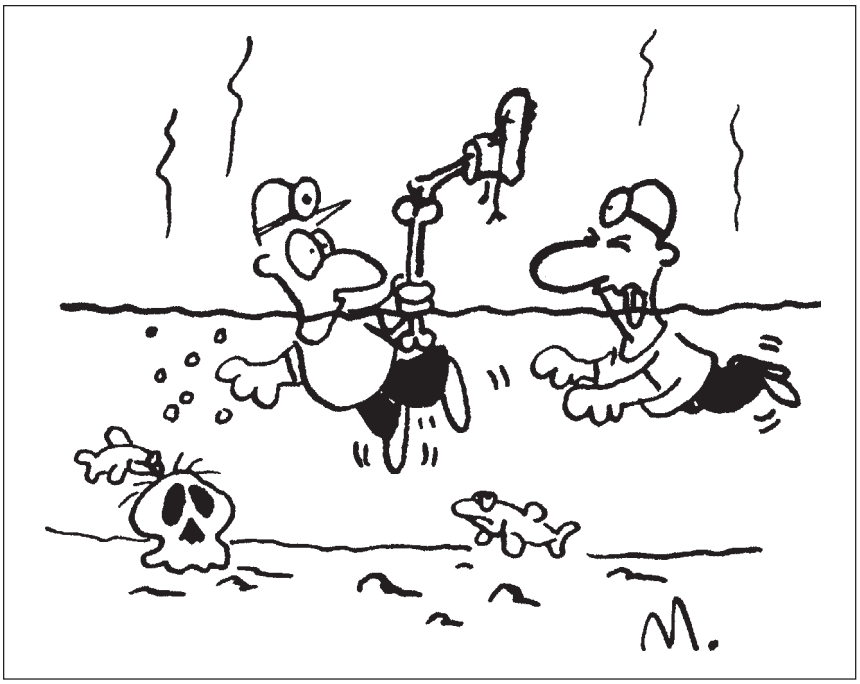
We were horribly surprised to discover, about four o'clock in the morning, that the area around Valles was suffering from an intense cold wave, for which we were not totally unprepared, which is to say we were not totally prepared, either. Please keep in mind, though, that thoughts of the Big One kept us going. In keeping with the friendly atmosphere of all Espeleoclub Zotz outings, we decided to visit a couple of horizontal caves in order for the novices to benefit, even though Jesús and I should have been doing pits to prepare for the Big One. On our second day, though, one of the convention organizers told us about the Nacimiento del Río Choy, which not only offered horizontal caving, but also a 50-meter rappel into a small lagoon. I won't go into detail since the reader will probably guess that we didn't find the cave easily, that the truck gave some trouble, that . . . .

We hiked up to a railroad track, then followed it to the top of the cave. We tossed in a couple of small rocks, until one of the group said that someone might be below, though we saw no ropes or any other way of getting to the bottom. We finally did find a trail, and since it was getting late decided not to rappel, but to just walk in through the dry part of the cave. What a surprise when we saw that at the bottom there was some sort of tourist area for paying visitors, though no one else was there. Also, we could see water everywhere, and that dry cave looked wetter with every passing minute. I was getting slightly miffed, because another of my Big One days was about shot. I took off most of my gear, except for coveralls, helmet, and lamp, and bravely waded across the stream. Then I thought that I must be getting shorter, since the water level was now past my eyes. I left the helmet and light on a wooden ramp and went in, using light from the openings in the roof. Near the entrance, there was a small but powerful waterfall over rocks and a horribly twisted iron rail from the track above.

I was trying to keep out of the water as much as possible, and was grasping small, sharp projections along the wall. I discovered an upper entrance to the cave and shouted to those below to go up there. When I was down in the water again, someone high above tossed in a rock that must have been the size of a small boulder. I shouted for he, she, or it to stop, but realized that he could not hear my calls. I hugged even closer to the wall and continued toward the end. A tall rock that resembled some sort of monolith attracted my attention, and I swam out to it. I could now see the end, divided by a conical rock. The right side seemed more interesting, as there was a twisting vertical passing leading up from it. After checking it out, I looked over to the other side of the rock and was surprised to see a pair of floating blue jeans.

The light was very low by now, and I was about to ignore the pants until I noticed what looked like part of a shirt still tucked in them. I suspected a body, but as I poked at it with a long stick, in order to keep my cut feet away from possible infection, there was no telltale odor. As I was hanging over the rock to try to identify the unidentified floating object, another boulder was tossed in. This coincided with Jesús's arrival down from the dry entrance, and as he saw me lying there, he naturally thought that I had been hit. I quietly let him know that I was alive, but someone else was not. As I swam over to him, he said that we should not mention anything about a corpse to Susy Pint, since she was nervous about such things. When I left the cave, the long way by swimming, I could

Reprinted from *Subterráneo* 6, May 1990.



tell from Susy's expression that her husband John, never one to mince words, had already told her, having been told himself by Jesús. We decided to return to the Mexpeleo site, south of Valles, before returning to town to report to the police. One of the convention organizers suggested we not say anything, because we might cause bad publicity or worse, but our plan was to report first to the fire department. When we told the story to the fire chief, who then called other authorities, I began to fear that I had not really seen a corpse, and that maybe I should have risked an infection to make sure and not look like a fool. It was decided that Jesús and I would be picked up by the fire department at seven in the morning the next day.

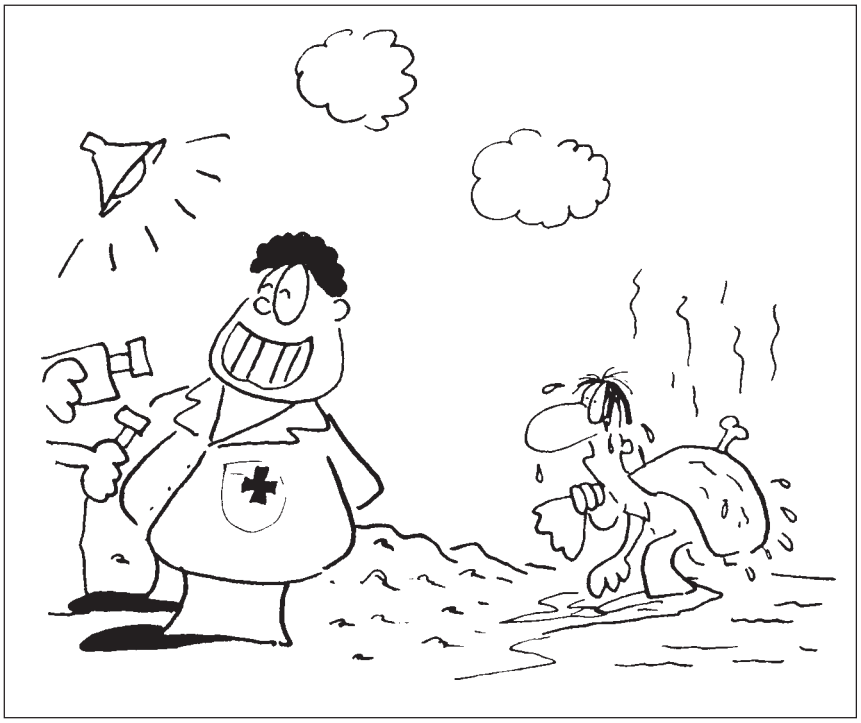
Back at Mexpeleo, I was asked to invite a leader of a certain rescue outfit in Mexico City. I hoped that the "expert" would do the recovery and leave me to do vertical caving, but even though he had founded a cave-rescue school, he declined the invitation, since this was only a body recovery. Fair enough. I would then have to go with Jesús and, you guessed it, miss one more practice day for the Big One.

Of course we did not get picked up on time, the fire department could not spare any men, the forensic doctor was asleep, and so on. When we did get to the Choy around noon, lo and behold if the expert from Mexico City wasn't there in all his glory with several helpers. I was furious, since it was obvious that he had declined to help as a ploy to get to the body first and so appear in the newspaper. I ordered his helpers out of the cave, and it turned out that they hadn't been anywhere near the body.

When Jesús and I were ready, I had the helpers stay behind us. As I leaned out over the rock, with the mid-day light shining down, I was so pleased to see that there actually was a body. There was a beautiful femur hanging from the pants. Proof at last! (Don't get me wrong. I'm sorry for the poor guy. But my reputation was at stake.)

Jesús and I swam slowly around the area so as not to disturb silt and make visibility worse. We hoped to find other parts of the body, which only consisted of the legs and the skin on the back, which I had thought was a shirt. We were handed a trash bag for a body bag, and the police suggested that I cut the body to pieces if it wouldn't fit. The only protections that we had were worthless polyethylene gloves, which lasted about a minute, and diving masks.

As I grabbed the corpse, three unsavory effects resulted. First, my fingers sank into the pelvic region. Second, the air was permeated with that special odor that even an outhouse cannot match. Jesús and I heard one of the rescue people, on the other side of the rock, begin to retch, while his friends told him to hang on. After all, they were the



experts and couldn't throw up in front of us. Third, the surface of the water became covered with various bits and pieces, which attracted tiny fish who made the water seem to boil as they gobbled away at the spoil. After one dive, I popped out of the water and handed Jesús a femur, which he took rather calmly for his first body recovery, and I knew I would never hesitate to take him along on such ventures. I was only able to find one other slimy bone and some more cloth material. The police said that I had found enough and that it was time to bring the remains out, which was good news, as I had cadaver slime in my hair and mouth (I didn't have a snorkel), and even though I have a reputation in Colima as a bit of a ghoul, I have my limits.

How had the body gotten there? Either accidentally or otherwise the victim had fallen through one of the openings in the cave ceiling. Locals do pass by while walking along the railroad tracks. The fall would have caused some fracturing, as seen in the bones. Enough branches and leaves were floating at the end of the cave room to show that objects do float over into that area and stay there. Since blue jeans to not decompose easily, the legs stayed relatively together, and the lake was big enough and deep enough to keep the other parts of the body hidden. The police were not particularly interested in finding everything, since there were too many murders and deaths in the area to solve already.

We made our way out, and, after we passed the safety rope that the experts had tied in the wrong place near the waterfall, the fearless leader, who never once got so much as a hair wet, began giving orders about how to take the bag out of the water. By now, a disgusting soup had filled the bag, some of which I had to dump out into the water. Fearless watched, and I think he actually touched a corner of the bag.

During the last day of Mexpeleo, during a talk on cave rescue, this same person actually had the gall to claim credit for the recovery in front of me. He later told me that he understood how I might misinterpret his actions, and as proof of his good intentions, he had told the newspaper not to mention my and Jesús's names because *we* weren't in the rescue business for publicity.

All of us from Zotz went to Cepillo the next day as a prelude to the Big One, but only I got to rappel down, and we got back at three in the morning. The trip to Golondrinas was set for four o'clock, and anyway the organizer of the trip did not care for our company. Could it have been the smell?

The trip to Mexpeleo was cold and somewhat expensive, the recovery was gross, and the truck gave me trouble all the way back to Colima, but it was all worthwhile because we learned new techniques and met interesting people. The only real problem was that we never did make it to the Big One.

Espeleología morbosa

Durante Mexpeleo 89 en Ciudad Valles, un cadaver fue descubierto flotando en el Nacimiento del Río Choy. Mitchell Ventana y Jesús Moreno del Espeleoclub Zotz encontraron el cuerpo y lo recuperaron al día siguiente.