# AMCS ACTIVITIES NEWSLETTER

Number 30 June 2007

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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 need to be high-resolutions scans or digital originals.

This issue was edited by Bill Mixon, with help from Katie Arens, Yvonne Droms, Rodolfo "Fofo" González, Mark Minton, Daniela Cipolla, and John "Solo" White.

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

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Front cover

Alejandro Álvarez during a scooter drive in SistemaYax Chen, Quintana Roo. Photo by Simon Richards

Back cover

The huge entrance to Cueva de las Golondrinas, La Solidad, San Luis Potosí. The photographer, Ben Kim, was 50 meters inside the drip line.

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The post office box used by the AMCS has been rented by Austin cavers continuously since December 1, 1953.

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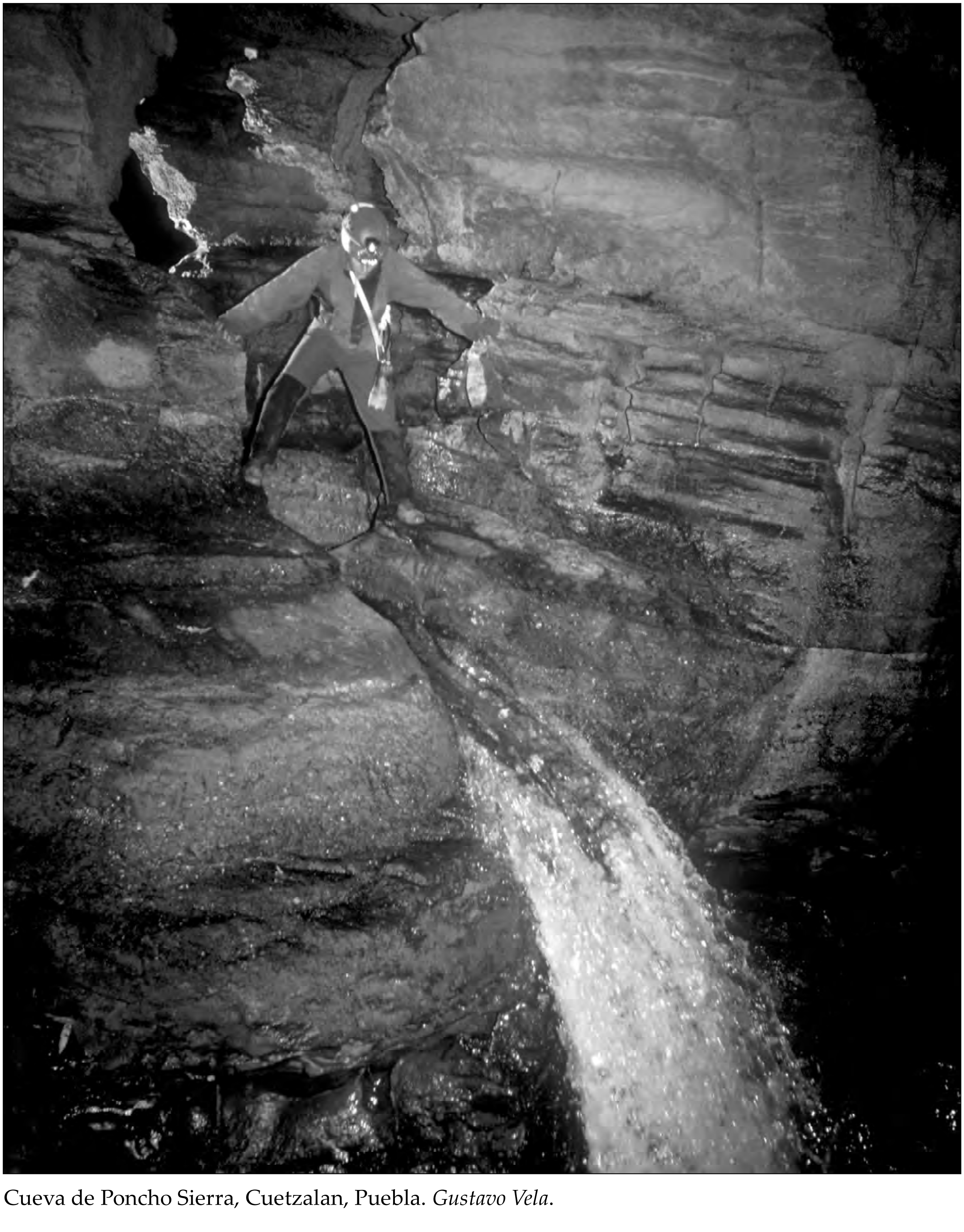
# MEXICO NEWS

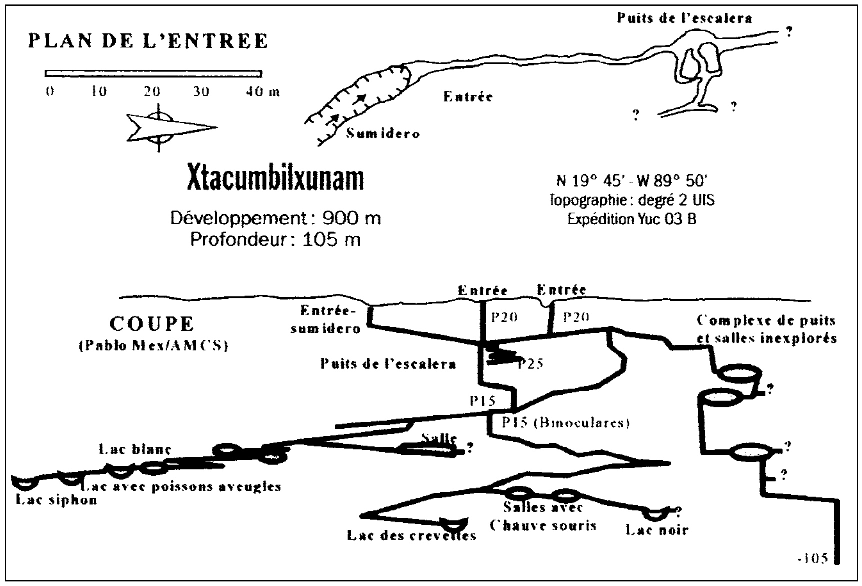
**Compiled by Bill Mixon**



Cueva de Poncho Sierra, Cuetzalan, Puebla. *Gustavo Vela*.

## CAMPECHE

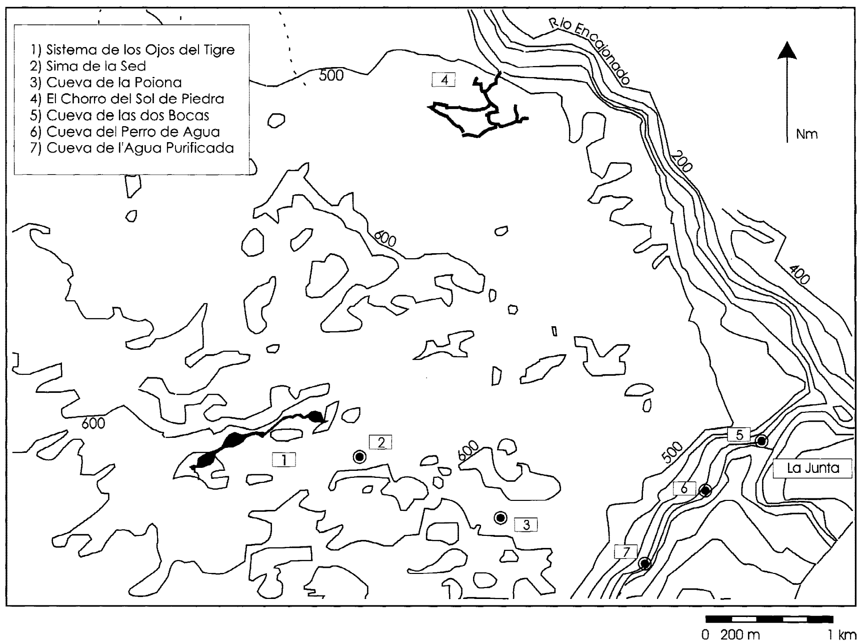
The sketch map of **Gruta de Xtacumbilxunam**, based on a survey by French cavers, is reprinted from *Spelunka* 98 (see also under Quintana Roo). This cave was famously described by Stephens in his 1843 *Incidents of Travel in Yucutan* and perhaps even more famously illustrated by Frederick Catherwood's drawing of Indians descending into it on a log stairway to fetch water.




## CHIAPAS

The Italian club Circolo Speleologica Romano has been visiting Chiapas periodically since the 1980s. Their "Malpaso '96" aimed to search for a sinkhole deep in the **Selva Mercadito** and to explore a resurgence on the slopes of the **Río Encajonado** canyon. The main activity turned out to be the exploration of the flood-prone resurgence cave, **Chorro del Sol de Piedra**.

In January 1998, most of their work was carried out in the *municipio* of **Ocozocoautla**, taking advantage of a new road connecting highway 190 to the Malpaso lake, Presa Nezahualcoyotl. The construction of the road had exposed some caves in the area's karst topography. They also located a resurgence on the **Río Grijalva** to the east of the lake.

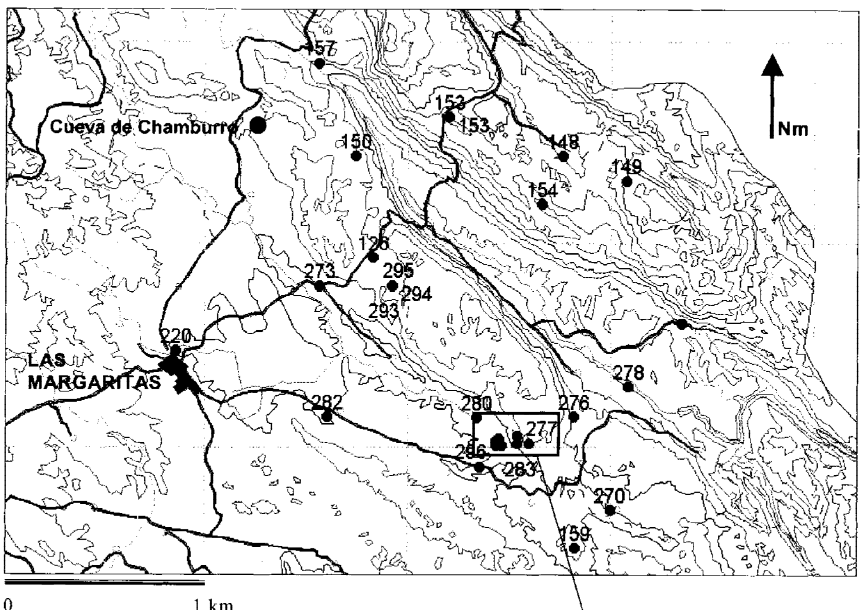



In March and April 1999, caves in the vicinity of the village of **Ocuilapa**, north of Ocozocoautla, were explored, confirming the good prospects found by the previous year's reconnaissance. A total of 2700 meters of caves were surveyed. In some cases, lack of time prevented finishing the caves.

In 2001, the Italians explored the area around **Las Margaritas**. An imposing resurgence spotted during an aerial survey turned out to be **Cueva Buena Vista Pachan**, main source of the **Río Santo Domingo**, explored by British cavers in 1982-83 (see *AMCS Activities Newsletter* 18, page 51). Following suggestions by a group of cavers in Comitán and Mauricio Nafate, a speleologist in Tuxtla Gutiérrez, the group explored the valley of the Río Santo Domingo and the area north of Las Margaritas. Also, a brief look at the area

Karst in the area explored by the Italians in 1999. *V. Sbordoni*.

The resurgence of the Río Santo Domingo in Chiapas. *V. Sbordoni.*




**ELENCO CAVITA'**

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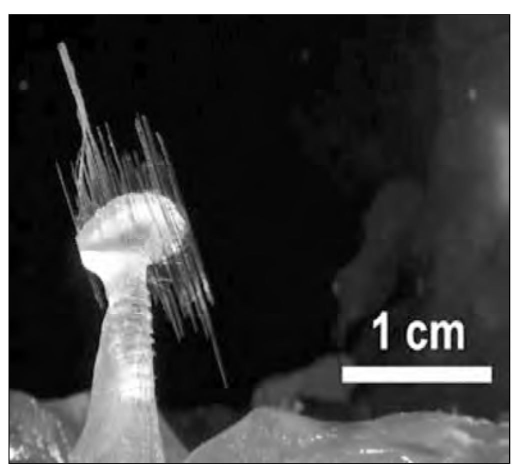
between San Cristobal de las Casas and the San Lucas resurgence, toward the valley of Río Grijalva along the recently opened road toward **Laguna Grande**, found a pit and a small cave.

See articles elsewhere in this issue for descriptions and maps of some of the caves the Italian group explored during these trips. *Source*: *Notiziario del Circolo Speleologico Romano*, new series number 16–19, 2001–2004.

## CHIHUAHUA

Abstract: The caves of **Naica** (Chihuahua, Mexico) are perhaps the most famous mine caves of the world due to the presence of gigantic gypsum crystals. Nevertheless, very little research has been carried out on this karst area until now. A multidisciplinary investigation started in 2006 with the aim not only to define the genesis and the age of the Naica gypsum crystals, but also on other scientific aspects of these caves.

This paper describes a completely new type of gypsum speleothem: the "sails," observed only inside the **Cueva de las Velas**, one of the caves of the Naica system. This speleothem consists of extremely thin, elongated skeleton crystals that have grown epitaxially only on the tips of the gypsum crystals pointing upward. The genesis of sails is strictly related to the environmental conditions set up inside the cave just after the artificial lowering of the groundwater by mine dewatering (less than 20 years ago). In a few years sail speleothems will disappear entirely, and therefore this study is fundamental to




A sail on a redissolved gypsum crystal. *Tullio Bernabei.*

Uncredited photo from the *Geology* paper.

preserve at least the memory of them. *Source*: Abstract of paper "Sails: a new gypsum speleothem from Naica, Chihuahua, Mexico," by Tullio Bernabei, Paolo Forti, and Roberto Villasuso, *International Journal of Speleology* 36(1), pages 23–30 (2007). The full article is available for PDF download at www.ijs.speleo.it.

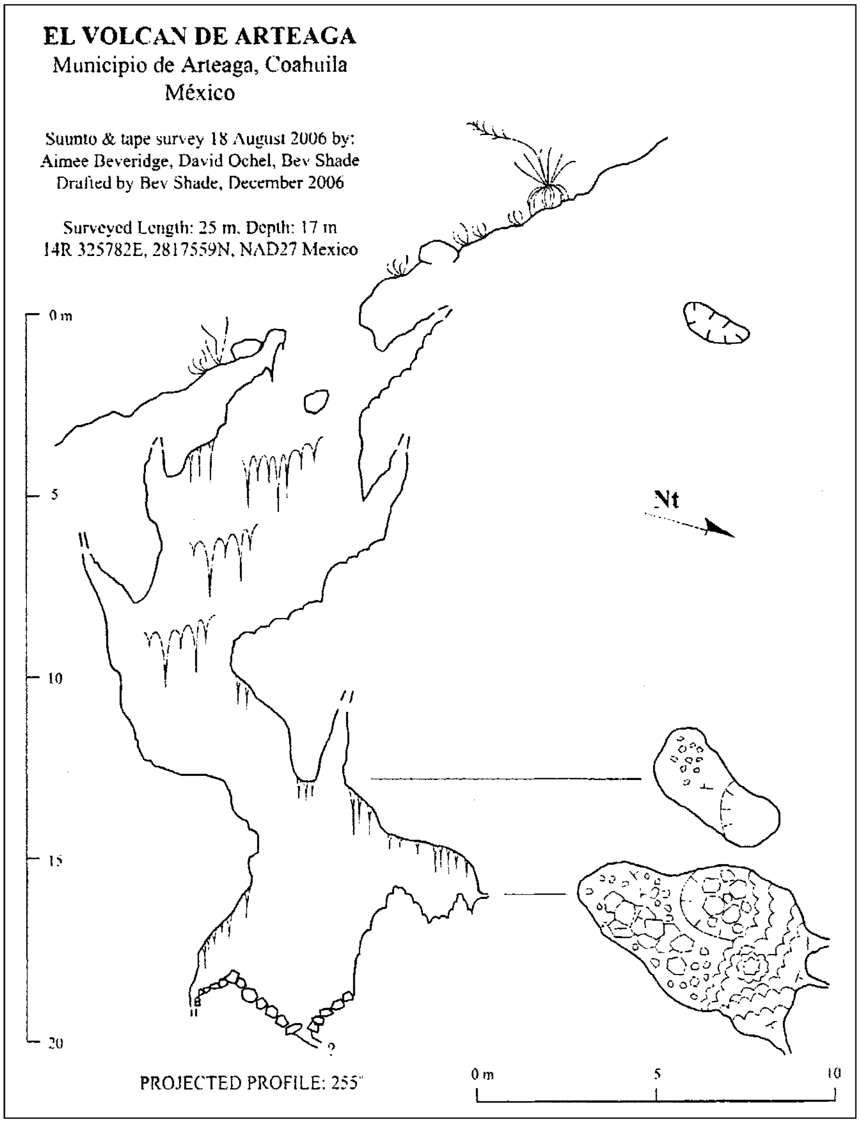
According to the article cited just above, mining activities in the **Naica** mine are expected to cease within the next five years. Once the dewatering of the mine, which involves pumping out about 1 cubic meter of water per second, ends, the **Cave of the Crystals** and other recently discovered natural rooms will return to being under 170 meters of water. Meanwhile, the research and media rights to the Cave of the Crystals apparently belong to Speleoresearch & Films of Mexico City and the La Venta group in Italy. See the article on Naica elsewhere in this issue.

Abstract: Exploration in the **Naica** mine (Chihuahua, Mexico) recently unveiled several caves containing giant, faceted, and transparent single crystals of gypsum ($CaSO_4 \cdot 2H_2O$) as long as 11 meters. These large crystals form at very low supersaturation. The problem is to explain how proper geochemical conditions can be sustained for a long time without large fluctuations that would trigger substantial nucleation. Fluid inclusion analyses show that the crystals grew from low-salinity solutions at a temperature of ~54°C, slightly below the one at which the solubility of anhydrite equals that of gypsum. Sulfur and oxygen isotopic compositions of gypsum crystals are compatible with growth from solutions resulting from dissolution of anhydrite previously precipitated during late hydrothermal mineralization, suggesting that these megacrystals formed by a self-feeding mechanism driven by a solution-mediated, anhydrite-gypsum phase transition. Nucleation kinetics calculations based on laboratory data show that this mechanism can account for the formation of these giant crystals, yet only when operating within the very narrow range of temperature identified by our fluid inclusion study. These singular conditions create a mineral wonderland, a site of scientific interest, and an extraordinary phenomenon worthy of preservation. *Source*: Abstact to article "Formation of natural gypsum megacrystals in Naica, Mexico," by Juan Manuel García-Ruiz, et al., *Geology*, volume 35, pages 327–330 (April 2007).

There are some photos of the giant **Naica** crystals at www.cellar.org/showthread.php?t=13631. Another good web site is www.canyonsworldwide.com/crystals/mainframe3.html. It contains photos and lengthy text from Richard Fisher's 2001 book on Copper Canyon (ISBN 0-9619170-6-7). *Source*: Mark Minton pointed out these links.

## COAHUILA

Abstract: The karst area of **Cuatro Ciénegas**, Coahuila, Mexico, represents an ideal site to study cave mineralogy, because it hosts caves of different age and genesis (karst, thermal, mine caves). Among the speleothems studied it is worth mentioning a nest of aragonite cave pearls found deep inside the Reforma mine characterized by the total absence of growth layers inside them. Despite only eight studied caves, some thirty-two different cave minerals have been detected, one of which is new for the cavern environment (kingsmontite) and another, still under study, will probably be new to science. Due to the scientific interest of their chemical deposits, it is very important to protect in the future the natural cavities of the karst systems of Cuatro Ciénegas in order to preserve a scientific partimony, actually only partly known. *Source*: Abstract to paper "Peculiar Minerogenetic Cave Environments of Mexico: Cuatro Ciénegas Area," by Paoli Forti, Ermanno Galli, and Antonio Rossi. *Acta Carsologica* 35(1)79–98 (2006).




EspeleoCoahuila 2006 was held in the city of Coahuila on August 19 and 20, organized by the Asociación Coahuilense de Espeleología, the Association for Mexican Cave Studies, and Protección Civil del Estado Coahuila. Following a day of talks on Saturday, there was a vertical-rescue training session on Sunday, conducted by Rebecca Jones, Rod Dennison, Patrick Lynott, and James Davis. The talks were:

EspeleoCoahuila, resultados de las Investigaciones, by Mónica Ponce.
Bat Conservation International en Coahuila, by Beverly Shade.
Expedición a la Biósfera "El Cielo," Tamps., by Aimee Beveridge.
30 años Explorando México, by Carlos Lascano.
Bat Conservation en Chihuahua y Sonora, by Peter Sprouse.
Salamandras en Cuevas, by Andy Glusenkamp.
Biografía del Agua, by Fernando Cabral.
Recorrido pol el Cañón del Infierno, by Maricio Pérezgómez.
Herramientas de Software para la Exploración Geográfica: La Interface 3D Google Eart, by Artura Betancourt.
Naica, by Carlos Lascano.
Cuevas y Grutas del Suroeste de Tamaulípas, by Jean Louis Lacaille.
Video Expedición al Sótano de las Golondrinas, by Asociación Coahuilense de Speleología.

On the way to EpeleoCoahuila 2006, cavers from Austin, Texas, explored and mapped **El Volcan de Arteaga**. A map of nearby **Grutas de Arteaga** appears in *AMCS Activities Newsletter* 19, page 6. *Source*: "Sierra de Arteaga," by Peter Sprouse, *Texas Caver*, first quarter 2007.

## MÉXICO

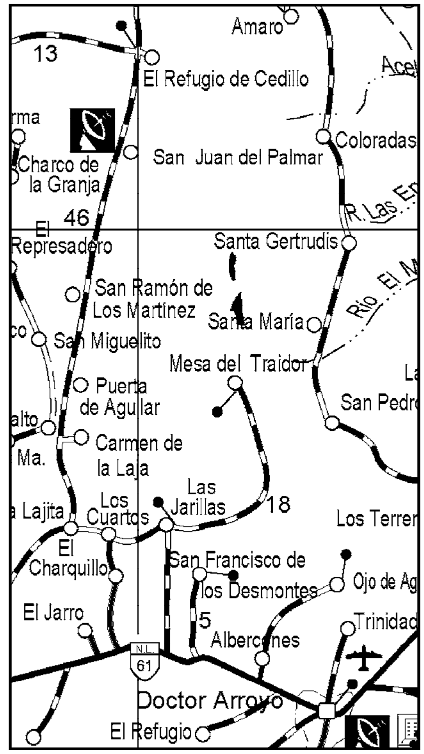
In November 2006, EspeleoRescate México and the Red Cross from San Luis Potosí recovered the body of a murdered 44-year-old woman from a mine shaft 270 meters deep. The Dos Estrellas mine is near El Oro, Estado de México, and has been out of operation since 1950. The recovery took seven hours. *Sources*: www.espeleorescatemexico.org/2estrellas/2estrellas.html, Antonio Aguirre Alvárez.

## NUEVO LEÓN

In a unique cross-border alliance, bat lovers have embarked on a multi-year effort to quantify the damage and replenish the bat population of northern Mexico. The project, being spearheaded by nonprofit Texas-based Bat Conservation International, includes detailed mapping of hundreds of present and former bat roosts, educational programs for farmers, and even purchases of land to protect the most vulnerable colonies. In late September, armed with BCI data, the Mexican environmental group Pronatura Noreste bought **Cueva de la Boca** for about $500,000. The acquisition, reported in the October 16, 2006, edition of the *Washington Post*, is believed to be the first purchase of a bat cave by Mexican conservationists. Access is now limited to researchers. Cueva de la Boca caught the attention of conservationists after researcher Arnulfo Moreno surveyed ten major publicly accessible caves in northern Mexico and found that the bat populations had fallen by 90 percent in five of them. At one time, Cueva de la Boca was home to an estimated twenty million free-tailed bats (*Tadarida brasiliensis*). By 2005, the colony had shrunk to six hundred thousand. *Source*: "In the Media" column, *NSS News*, January 2007.

Recent rains ended a long drought and filled up a reservoir in **San Ramón de los Martinéz**, an *ejido* in the *municipio* of Doctor Arroyo. The 1500 inhabitants were happy, because the reservoir had been full at the end of August only rarely, and they even had a party to celebrate. Although it has a capacity of only 60,000 cubic meters, it was the largest reservoir in the area, and it supplied water to neighboring towns San Juan del Palmar, Refugio de Cedillo, La Lajita, and others that had smaller local reservoirs.

However, in fifteen days, almost all the water disappeared down a hole that appeared in the middle of the resevoir, according to Isabel Garcia, the mayor of the *ejido*. "There is a very big crack underground that showed up in the dam as a hole, and the water went through it." The hole is about 1 meter in diameter, but its depth is unknown because it curves into what appears to be a cave.




The *ejidatarios* thought the dam was leaking when the water began to drop, so they reinforced the dam and built others within the reservoir. A small pool of water remained, thanks to the internal dams.

Martin Bremer, a geological investigator from Monterrey Tec, said, without having seen it, that the hole could have been caused by a fracture the cover to which was dissolved by the water or by a cavern that emerged in a similar way.

The four hundred families in the ejido have requested government assistance to build another "tank," because the reservoir would never fill up again, said the mayor. *Source*: based on October 2006 article in *El Norte*, translated for the AMCS by Nico Escamilla.

The mine recovery in progress.

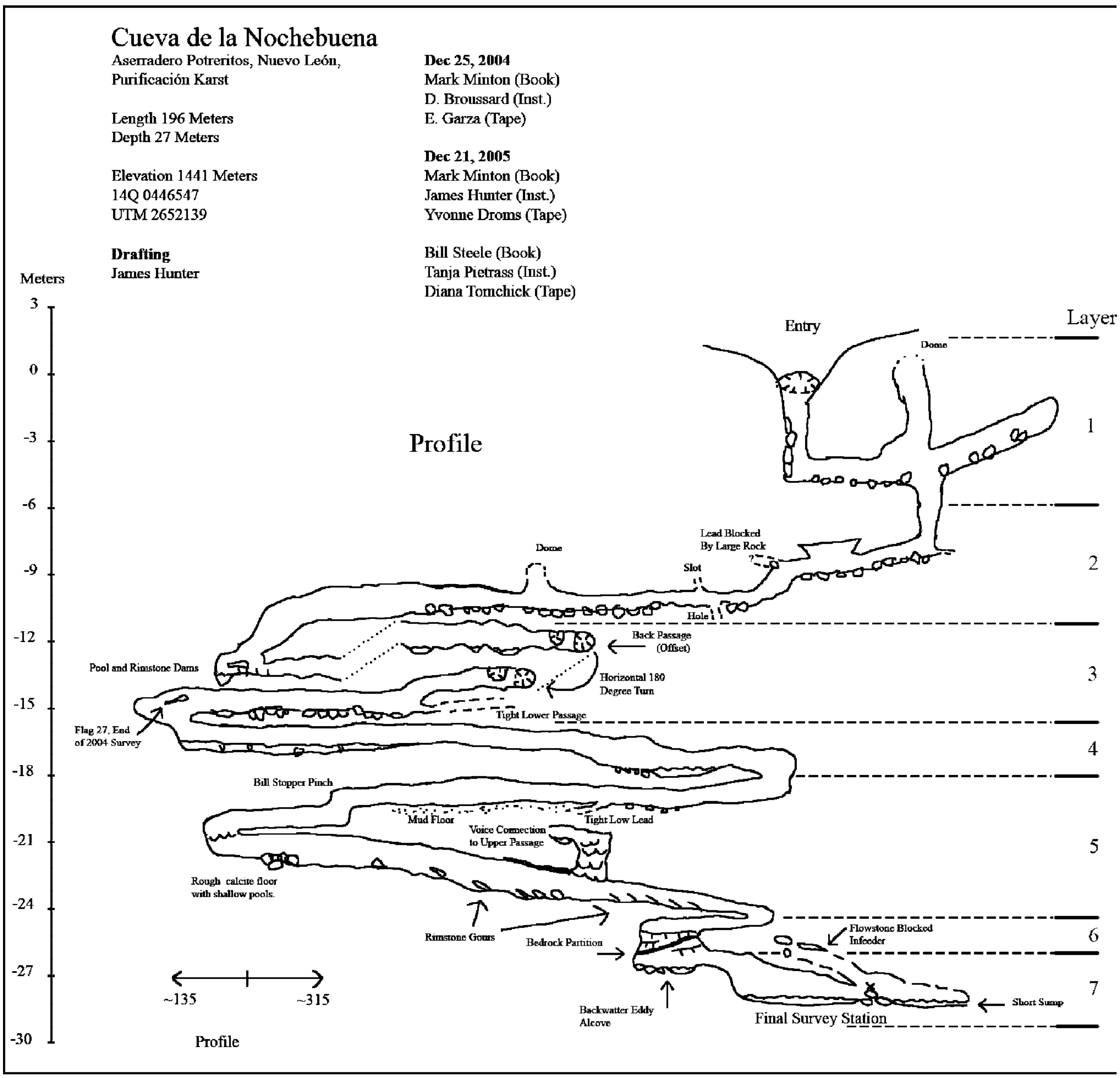
The exploration of **Cueva de la Nochebuena** was described on page 55 of *AMCS Activities Newsletter* 29.

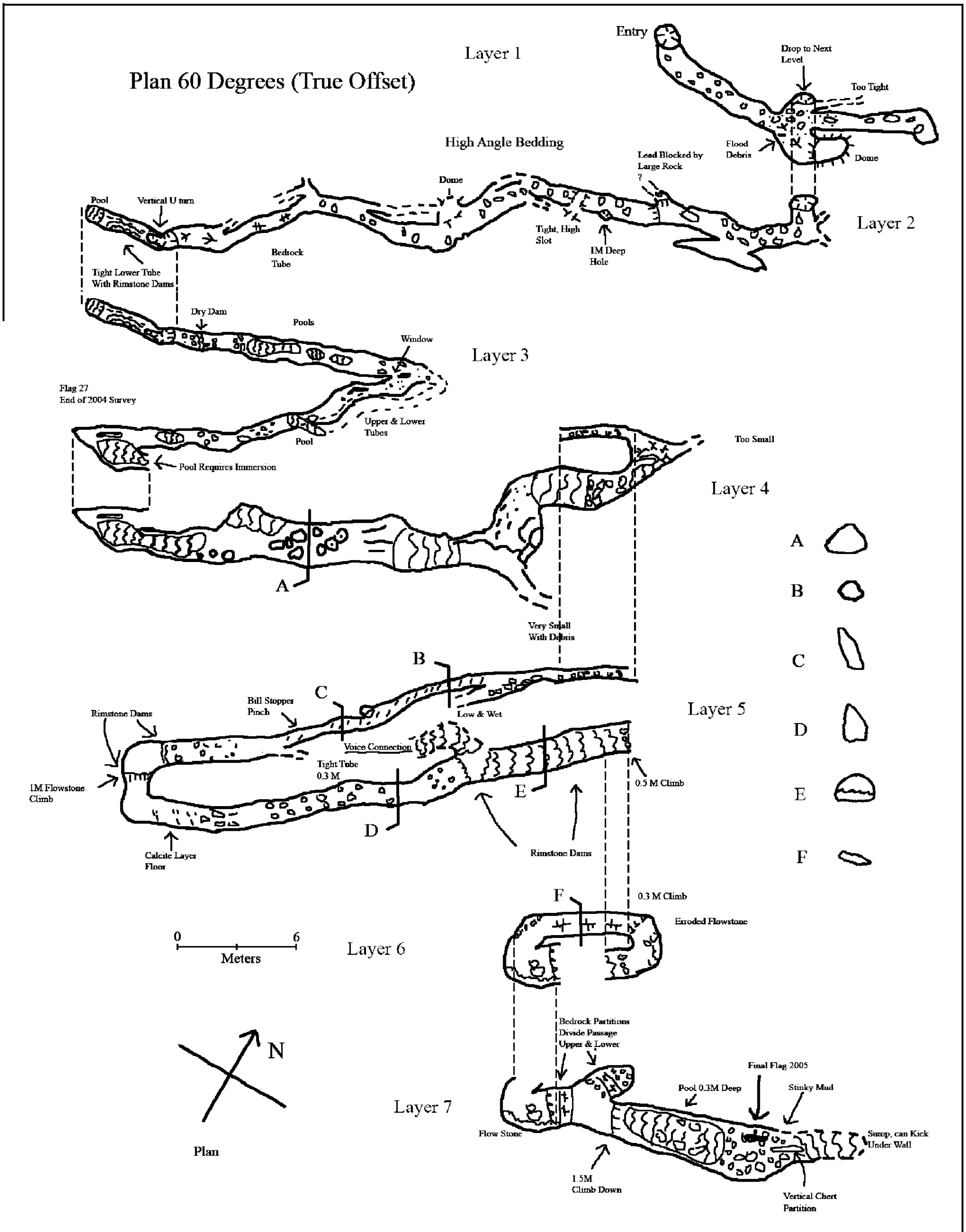
## OAXACA

On April 18, 2007, **Sótano del Río Iglesia** was connected to **Sistema Huautla**. (The word arrived hours before this “Mexico News” section was to be laid out.) A crew was sent to recheck a dig at the end of the Canadian’s 1967 map, and the alleged impenetrable mud choke turned out to be a crawlway with a howling wind. It was only 60 meters to the connection into the **Sótano de San Agustín** section of Huautla, where Matt Covington and Yuri Schwartz came out in the Fool’s Day Extension shaft series, about 60 meters above Tommy’s Borehole. The connection came during eight days of camping in Iglesia, both in the Penthouse and in the 1967 camp at –450 meters. Besides Matt and Yuri, Vickie Siegel, Bill Stone, and David Ochel were involved in the underground-camp push. The connection has increased the length of Sistema Huautla to over 61 kilometers; its depth is unchanged.

Higher in Sótano del Río Iglesia, about 1.5 kilometers of new passages were found by Jim Smith, Bill Steele, Diana Tomchick, Mark Minton, and Yvonne Droms, providing several alternate routes from the river entrance to the Penthouse, dropping in through domes in the ceiling of the huge room. The relatively small expedition has not so far found a way to follow the main Río Iglesia river deeper, though. *Sources*: Mark Minton, Bill Stone.

**J2** is the name of a cave with a high entrance that shows some promise of intersecting the so-far inaccesssible part of the **Sistema Cheve** underground watercourse between the breakdowns at the bottom of Cheve and the resurgence on the south side of the Río Santo Domingo canyon. See the area map on page 28 of *AMCS Activities Newsletter* 29. The 2006 J2 expedition, organized by John Kerr and Mark Minton, with Al Warild taking care of arrangements

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Layer 1
Entry
Drop to Next Level
Too Tight
Flood Debris
Dome
High Angle Bedding
Lead Blocked by Large Rock ?
Dome
Pool
Vertical U turn
Bedrock Tube
Tight, High Slot
1M Deep Hole
Layer 2
Tight Lower Tube With Rimstone Dams
Dry Dam
Pools
Window
Layer 3
Flag 27
End of 2004 Survey
Upper & Lower Tubes
Pool
Pool Requires Immersion
Too Small
Layer 4
A
Very Small With Debris
B
C
Bill Stopper Pinch
Rimstone Dams
Low & Wet
Layer 5
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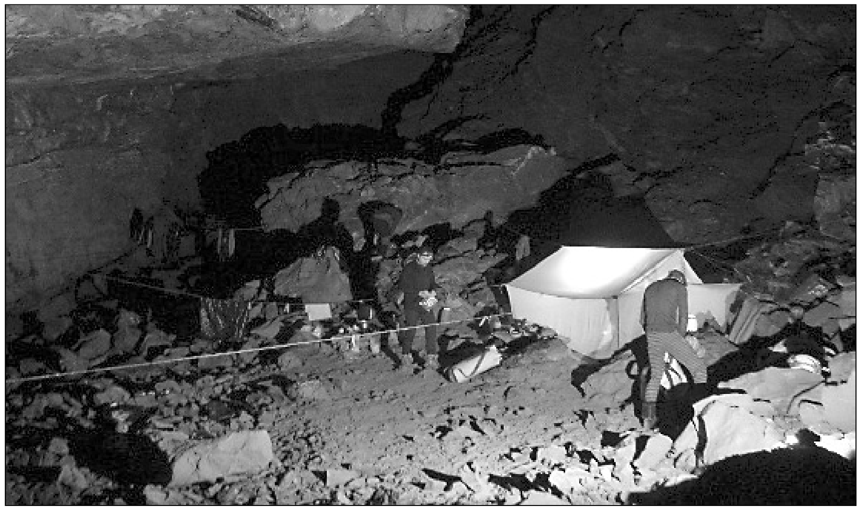
Plan
Bedrock Partitions Divide Passage Upper & Lower
Final Flag 2005
Pool 0.3M Deep
Stinky Mud
Layer 7
Flow Stone
Sump, can Kick Under Wall
1.5M Climb Down
Vertical Chert Partition



Camp in J2 during the 2006 expedition. *Al Warild*.

for group food, took place from April 3 to May 12. Almost forty cavers from nine countries participated.

The first project was to string 6 kilometers of communication wire from surface base camp to the previous end of exploration. This was very useful for coordinating activities and supply of the underground camps. A massive breakdown was found shortly beyond the previous end, but it was passed, and more large passage led to a deep sump at nearly –1200 meters. James Brown dove the sump, which proved to be about 150 meters long and 6 meters deep. Another deep sump was found only 6 or 7 meters beyond the exit from the first one. Much effort was spent checking climbing leads before the sumps. Several days were spent working from Camp 3, and then more climbs were done from Camp 2A. The source of Camp 2A's water was followed about 80 meters upward over waterfalls and some 100 meters westward, to the base of another waterfall. A strong air current flows down that series of shafts. With all the 2006 survey data processed, J2 was 9536 meters long and 1209 meters deep. *Sources*: Mark Minton, Sergio Zambrano, Bill Stone.

The 2006 issue, number 12, of *Furada: Revista dos espeleólogos galegos*, published by the Federación Galega de Espeleoloxia, in Galicia, contains a five-page article by Spanish caver Ignacio Rafael Ramos on the **Cheve** 2004 and 2005 expeditions.

There was a short article by Sergio Zambrano in the October 2006 issue of *Sale le foto*, a monthly photo supplement the the Mexico City newspaper *La Reforma*. It discusses exploration of the deep caves of Oaxaca and is accompanied by five photographs by Alan Warild. *Source*: Sergio Zambrano.

There is a video on the web in Google's Tech Talk series of Bill Stone giving an hour-long presentation "Journey toward the Center of the Earth," recorded at a conference on July 27, 2006. He describes the work in **Sistema Cheve** and **Cueva J2** and gives hints of things to come in the future, such as briefcase-size rebreathers. The link is video.google.com/videoplay?docidW9700150596185484 0&q?ving. *Source*: Don Hunter.

## PUEBLA

In April–May 2006, fourteen cavers (two from France, one Mexican, one from Alberta, and the others from Quebec) with the Mexpé group spent four weeks in the **Sierra Negra**. This expedition proved to be quite productive, with over 8 kilometers of new passages surveyed. Results include the discovery of the Amont des Galérics, an upstream extension of **Sistema Tepepa** that added 1151 meters to this already large system, bringing its length to 27.7 kilometers (and still 899 meters deep). That section was named, in a play on words meaning "Eric's upstream galeries," in honor of Eric Hamel, a previous Mexpé caver who passed away from cancer just a few days before the 2006 expedition got under way.

A new entrance got us very close to the area between **Gimnástica Selvática** and **Las Brumas** caves. Pushes by two teams connected to both caves on the same day. The connection to Gimnástica Selvática simply required dropping a pit, whereas connecting to Las Brumas made two cavers go through hell: tight, blowing, wet passages with unstable rocks that kept falling on them. This new system, **Sistema Las Brumas Selváticas**, is 7.9 kilometers long and 473 meters deep. Its proximity to Sistema Tepepa gives hope for a future connection between the two systems.

From the beginning of the expedition, we tried hard to connect **La Ciudad** to Gimnástica Selvática. We ended up connecting several new entrances to La Ciudad, but never got close to the nearby sections of Gimnástica Selvática. These finds, including just over 1 kilometer of large borehole some 20 meters in diameter explored and surveyed in just one day just before the end of the expedition, more than doubled the length of La Ciudad. The borehole continues for at least another 100 meters, to a large room. We'll be going back there in 2007. La Ciudad, which now has over seven entrances, is 6.7 kilometers in length and 299 meters deep.

On the last day of the expedition, **Tres Quimeras** cave, which had been discovered during the 2005 surface recon expedition, was descended to only –106 meters, but it continues with wind, water, and sizeable passages. This cave has great potential and is another priority for the 2007 expedition.

An area higher in altitude with a few known caves, such as **Sumidero del Año Nuevo**, was revisited, and going leads were left. This is located on the opposite side of a fault, so chances of connecting with Sistema Tepepa are slim, but there is still hope.

The year 2007 is the twentieth anniversary of the Mexpe project, and a new web site as been created at www.mexpe.ca. *Source*: Chris Chénier.

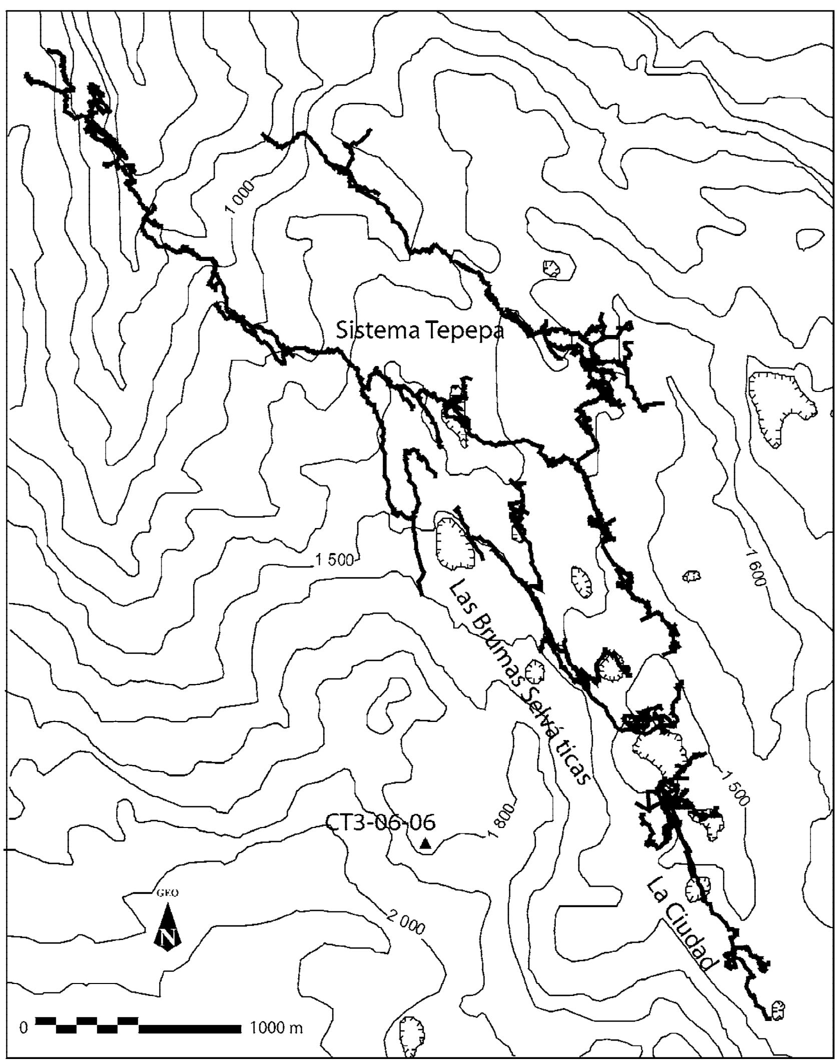
In March 2007, a multinational group camped in the municipality of Huixmaloc to push leads left in **Akamabis** by the Belgians of the Groupe Spéléo Alpin Belge. After some negotiations with the local landowner, we were given permission and started to rig a cave. The landowner showed us the entrance, and the bolts in the entrance series led us to believe we were in the right cave. After about a kilometer of cave, half of which was crawling between flat layers of black chert, we realized we were in the wrong cave. Convinced that we were in virgin passage, we continued on to find an eight-second pit. This monster pit, which we named El Santo Tiro, was measured at 245 meters of depth. The floor of the pit was breakdown, and, although we could hear water running below, no leads were found. The cave was surveyed at 1612 meters long and a respectable 588 meters deep. The cave was named **El Santo Cavernario**.

Still having some trouble finding the entrance of Akemabis, we decided to rig **Akemati**. This would be the fourth expedition to push Akemati and only the second to successfully put multiple teams into the bottom of the cave. The cave was first explored by the GSAB in 1988, to a depth of 1135 meters.

While Akemati was being derigged, the entrance to Akemabis was found. Ropes were put into Akemabis as fast as they came out of Akemati, and rigging was smooth sailing until about the –500-meter level. The top of the cave includes a very nice pit about 300 meters deep. After reaching the –700-meter level, we realized that we would not have time to push leads in the cave and began derigging, hoping to finish before it came time for most to fly home.

Our small group had cavers from England, Holland, Spain, Mexico, Australia, and the United States. Part of the success of our expedition was due to information and helpful hints from the Belgian GSAB cavers, who held their annual expedition during the same time-frame, based about a three-hour hike downhill from ours. *Sources*: Jon Lillestolen, Gustavo Vela.

Principal Caves Explored by Mexpé 2006




## QUINTANA ROO

Abstract: Extensive flooded cave systems are developed in a zone 8 to 12 kilometers inland of the east coast of the Yucatan Peninsula, Quintana Roo, Mexico. In plan, the systems comprise cross-linked anastomosing networks composed of horizontal elliptical tubes (which are actively developing where associated with the present fresh water/saline water mixing zone) and canyon-shaped passages. Both forms are heavily modified by sediment and speleothem infill and extensive collapse. The pattern of Quintana Roo caves differs both from the mixing-chamber form of flank-margin eogenetic caves and also the dendritic and rectilinear maze patterns of epigenetic continental (telogenetic) caves. Unlike the latter, Quintana Roo caves are formed by coastal-zone-fresh water/saline-water mixing processes. While mixing dissolution is also responsible for development of flank-margin caves, these may be typical of small islands and arid areas with limited coastal discharge, whereas Quintana Roo–type caves are formed when coastal discharge is greater.

In the Quintana Roo caves, multiple phases of cave development are associated with glacio-eustatic changes in sea level. Two critical conditions control cave development following lowstands: (1) if the passage remains occupied by the mixing zone and connected to underlying deep cave systems, and (2) for passages above the mixing zone, if active freshwater flow is maintained by tributaries. In the first case, inflow of saline water drives mixing dissolution, enabling removal of the lowstand carbonate fill and continued passage enlargement. In the second, despite limited dissolution in the fresh water, continued removal of uncemented sediments can maintain the cave void. Where neither of these conditions is met, enlargement will cease, and the cave void will become occluded

by collapse and sediment infill. *Source*: abstract to paper "Cave Development on the Caribbean coast of the Yucatan Peninsula, Quintana Roo, Mexico," by Peter L. Smart, Patricia A. Beddows, Jim Coke, Stefan Doerr, Samantha Smith, and Fiona F. Whitaker in *Perspectives on karst geomorphology, hydrology, and geochemistry—A tribute volume to Derek C. Ford and William B. White*, edited by R. S. Harmon and C. Wicks, Geological Society of America Special Paper 404, pages 105–128 (2006).

*Spelunka* 98 (2005), the magazine of the Fédération Française de Spélélogie, contains an article by Christian Thomas summarizing ten years of French expeditions to the Yucatan Peninsula, mainly cave-diving in Quintana Roo. Unfortunately, the many maps of underwater caves are printed much reduced and in color, and they resist reprinting. See also pages 10 and 11 in "Mexico News" in *AMCS Activities Newsletter* 28.

In addition to the report on surface explorations and cave diving that is summarized in the article on the **Sian Ka'an** underwater caves in this issue, the full report of the Ox Bel Ha Water Protection Project from November 2005 through June 2006 contains a preliminary report on detecting subsurface conduits and measuring halocline depth by electromagnetic surveys by Bibi Neuman (bibi.neuman@gmail.com) and Malene Rahbek malene.rahbek@gmail.com) of the Technical University of Denmark. It also contains a 28-page paper "Reporte Preliminar sobre la Hidrodinámica del Sistema de Cuevas de Caapechen en la Reserva de la Biosfera de Sian Ka'an," by Guadalupe Veláquez Oliman (gvogeoh@cicy.mx) and Rosa Maria Leal Bautista (rleal@cicy.mx) of the Centro para el Estudio del Agua. The paper reports results of the water data collected in caves of **Luguna Caapachen** during the project. The full report is a 12 MB PDF file at www.cindaq.org/reports/finalreport.pdf.

Diver Per Thomsen tows the Hydrolab in Entrada Caapechen. *Daniel Riordan*.

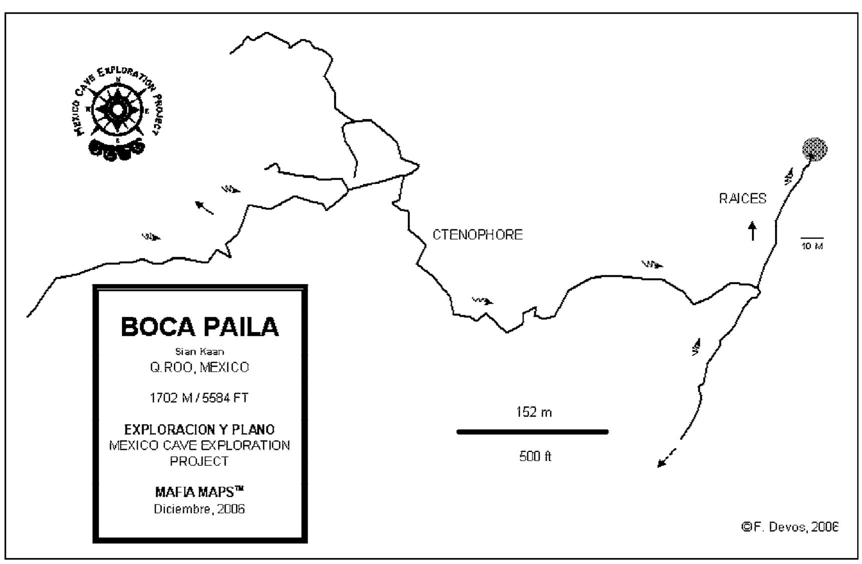
Some outline-form dive reports from the above project are at www.gue.com/Expeditions/Mexico/Reports. These duplicate information that is in the full project report, but there are also a few reports of other dives in the vicinity and some line maps of underwater caves.

Mexico City, April 10 (Xinhua)—Mexican archaeologists found remains of two women and a man that can be traced to more than 10,000 years ago in the Maya area of Tulum, Mexico's National Anthropology and History Institute said in a statement on Tuesday. The remains were being examined by laboratories in Britain, the United States, and Mexico, all of which had said that the remains were of people between 10,000 and 14,000 years ago, said Carmen Rojas, an archaeologist quoted in the statement. "This makes southeastern Mexico one of the few areas with a proven prehistoric presence in America," said Rojas.

The remains were found in **Las Palmas**, **El Templo**, and **Naharon** caves, in an area previously thought to be uninhabited. They are not Maya, because they do not have the classic Maya skull deformation.

The woman found in Naharon, 368 meters from its entrance and 22.6 meters underground, was 1.41 meter tall, weighed around 53 kilograms, and was between twenty and thirty years old when she died. The woman found in Las Palmas cave was between forty-four and fifty when she died. The body found in El Templo cave was a man aged between 25 and 30. His body was the least well preserved, because it had been eroded and most of its organic material was gone.

Archaeologists have worked since 2002 to exhume the bodies from underwater caverns, said the statement. In the past, the region was dry, but the caves were flooded in the last thaw of the Pleistocene ice age, it said. Archaeological finds showed the region was probably used as a refuge and a graveyard, said the institute. The archaeologists also found campfire remains. *Source*: April 11, 2007, dispatch from the Chinese new agency Xinhua at news.xinhuanet.com/english/2007-04/11/content_5962115.htm. Note that, as one expects from press reports, this may be misleading or inaccurate in part. It is not clear how recent all of these finds are. Some human remains and old



*Robbie Schmittner.*

campfires had been found in the underwater caves of Quintana Roo before 2002.

The owner of **Cenote Calimba**, one of the entrances to the original Sac Actun portion of **Sistema Sac Actun**, used a large excavator last December to unroof the cenote, where the water had previously been reached through a short section of dry cave. Evidently he wanted to create an open waterhole for tourist swimmers and snorkelers. The dry cave was heavily damaged by the project, and for a time the cenote was unusable by divers due to collapsed materials. Later word is that the big machine is gone and that rubble is being removed by hand excavation and smaller equipment. It is again possible to enter or leave the underwater cave at Calimba, although visibility there and at the main Sac Actun entrance, the Grand Cenote, is sometimes poor due to the rubble removal and perhaps the tourist activities. Mud from the work is being deposited on the cave floor downstream from Calimba. *Sources*: Quintana Roo Safety Officers, Jim Coke.

On March 21, 2007, a ceiling collapse took place in the upstream section of the cavern zone in **Sistema Chac Mool**. The line has been rerouted around the collapse, but the area around the collapse appears unstable, and no cavern tours should be conducted in the upstream area until the cave becomes more stable. The Kukulkan section and the Downstream area are not affected. *Source*: Quintana Roo Safety Officers.

The items above are examples of the sort of information circulated by the Quintana Roo Safety Officers Committee, which consists of at least NSS-CDS Safety Officer Steve Bogaerts, GUE Safety Officer Daniel Riordan, IANTD Safety Officer Michael Silva Neto, NACD Safety Officer Chuch Stevens, and NSS-CDS and NACD Safety Officer for Isla Cozumel Germán Yañez Mendoza. The goals of the committee are to maintain the permanent guidelines and line markers in the caves that are used for training and guided dives, inform the cave-diving community of any planned changes to lines and markers, install and maintain surface and underwater safety signs, and generally act as an information source about safety issues and site conditions. They have an e-mail newsletter that can be requested by sending an e-mail to qroocavesafety@hotmail.com with “subscribe” in the subject line and your full name in the message. *Source*: *Underwater Speleology*, July/August 2006. (The initializations stand for the National Speleological Society Cave Diving Section, Global Underwater Explorers, the International Association of Nitrox and Technical Divers, and the National Association of Cave Divers, organizations that offer training and certification in cave diving.)

QUINTANA ROO
SPELEOLOGICAL SURVEY

The Quintana Roo Speleological Survey notes that a connection has been made between **Sistema Toh Ha** and **Sistema Sac Ba Ha**. Also, a Czech team has made considerable progress in exploring and mapping **Sistema K’oox Baal**. Two new underwater caves, **Aktun Hu** and **Cenote Cueva Seca**, as well as two new dry caves, **Sistema Chemuyil** and **Cueva Powerline**, have been added to its database.

Connections between **Sistema Toh-Ha**, **Chumkopo Antigua**, and **Cenote Chan-hol** have made the enlarged Sistema Toh-Ha the thirteenth-longest cave in Mexico. Before the connection, Chan-hol had been the longest underwater cave in Quintana Roo with only one entrance. *Source*: www.caves.org/project/qrss/new.htm.

As of April 16, 2007, the longest underwater caves in Quintana Roo were

| | |
|---|---|
| Sistema Sac Actun* | 153,599 meters |
| Sistema Ox Bel Ha | 146,761 meters |
| Sistema Dos Ojos | 57,700 meters |
| Sistema Toh Ha | 22,171 meters |
| Sistema Naranjal | 21,558 meters |
| Sistema K’oox Baal | 19,178 meters |

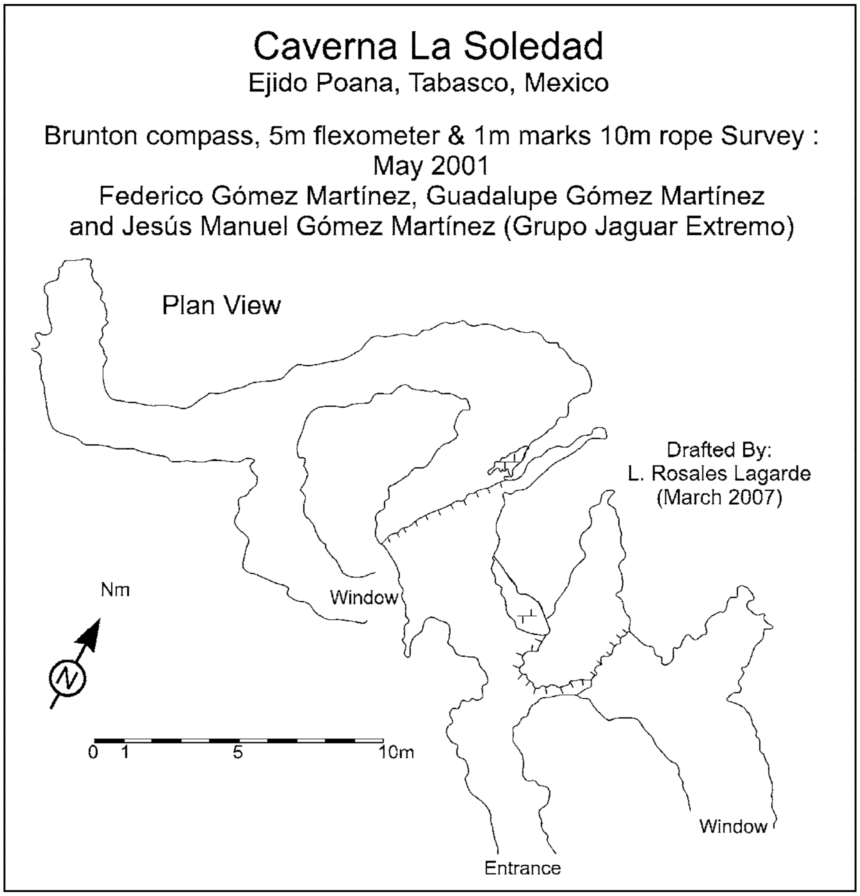
* Sistema Sac Actun also connects to dry cave Sistema Yax Muul, adding over 2 kilometers to its total length. See articles in this issue on the connection that made Sac Actun the new longest cave in Mexico and on Yax Muul. *Source*: www.caves.org/project/qrss/qrlong.htm.

The January 2007 issue of *México Desconocido* magazine contains an article by Sam Meacham on the underwater caves of the Caribbean coast of Quintana Roo on pages 56–63. It is heavily illustrated by large photographs by Mauricio Ramos.

## SAN LUIS POTOSÍ

The village of La Trinidad, located in the heart of the Sierra Gorda Biosphere Reserve not far from Jalpan and Xilitla, is eager to welcome cavers and provide food, shelter, and guides for those wishing to visit **Hoya de la Luz** and other remote pits and caves in the area. According to the map and description in *AMCS Activities Newsletter* 5 (where it is mistakenly placed in Querétaro), Luz has a 188-meter high-side drop and a 125-meter lower drop. The pit is about 125 by 200 meters across and has a nearly flat floor that is heavily forested. According to the locals in La Trinidad, it has been nearly ten years since anyone has visitied the pit. With a 4x4, it will soon be possible to drive to within a kilometer of the village.

This information is from Jim Conrad, who works with villages in the reserve to establish ecotourism projects. Jim has a web site www.backyardnature.net and can be reached at jim@backyardnature.net. *Source*: Bruce Morgan.



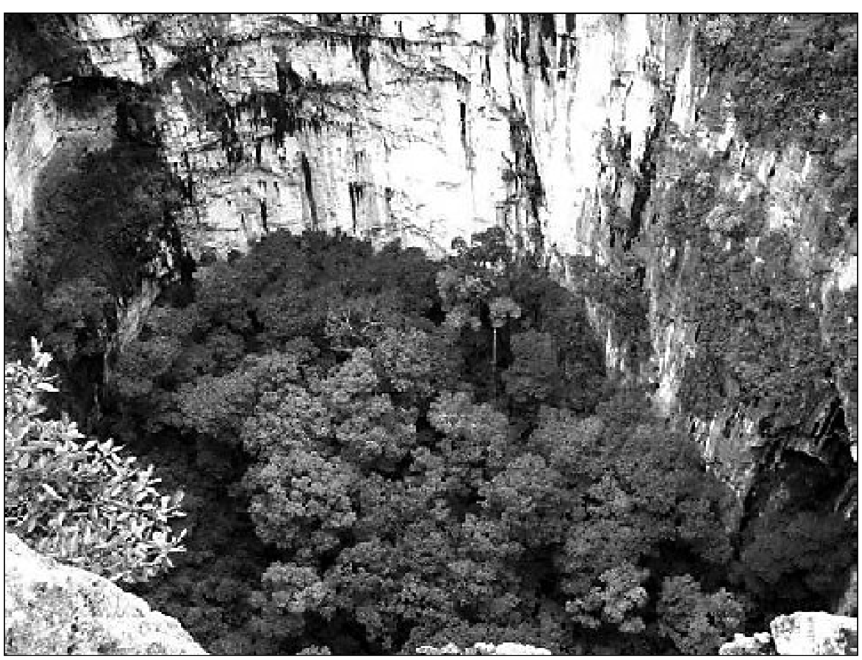

In early December 2006, a 41-year-old man fell to his death down the low side of the entrance drop in Hoya de las Guaguas, about 150 meters. He was part of a large group visited the cave for vertical practice. The cause of the accident, which happened at 1 a.m., is not known now, but a fuller report should eventually be posted at ermexico.tripod.com or www.espeleorescatemexico.org. *Source*: Antonio Aquirre Alvárez.

**Cueva del Tizar**, which has appeared on the deep pits of Mexico list and, in earlier years, the deep caves list, should be known by its original name **Cueva de las Murmullos**. The lists have been corrected accordingly. The map printed here is from *Tsaval* 5, magazine of the Asociación Potosina de Montañismo y Espeleología, April 1998. *Source*: Fernando Jalomo Mendoza.

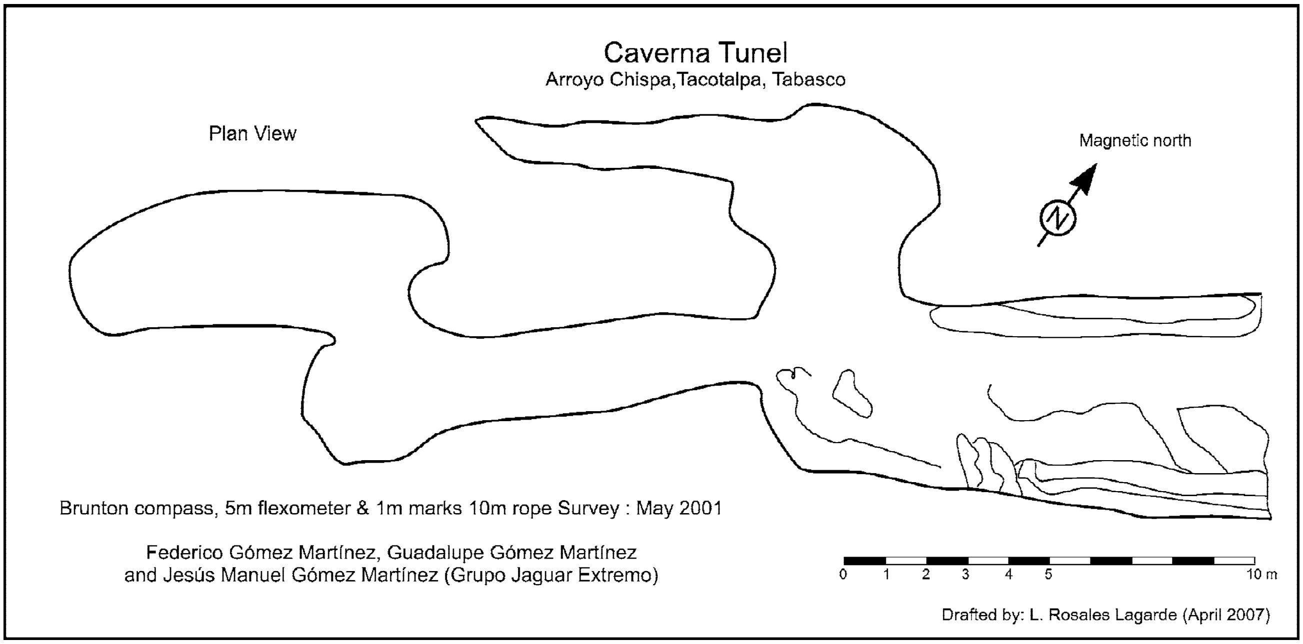
The area surrounding the **Nacimiento del Río Choy** was found to be occupied by a military training base when cavers attempted to visit it in January 2007. *Source*: Phillip Schuchardt.

## TABASCO

Federico Gómez Martínez, Guadalupe Gómez Martínez, and Jesús Manuel Gómez Matrínez started surveying caves to propose them as tourist destinations. In May 2001, these members of the Grupo Jaguar Extremo mapped seven caverns in **Ejido Arroyo Chispa** and two caverns at **Ejido Poana**, Tabasco, using a Brunton compass, a 5-meter tape, and a 10-meter



Hoya de la Luz. *Jim Conrad*.




rope with knots each meter. The members of this group provide adventure-tourist services in the Tacotalpa municipality, besides working in the Complejo Ecoturístico Villaluz in the same area. *Source*: jaguarextremo@hotmail.com, translated from Spanish by Laura Rosales Lagarde. Maps made by others of all but two of these caves have alredy been published by the AMCS.

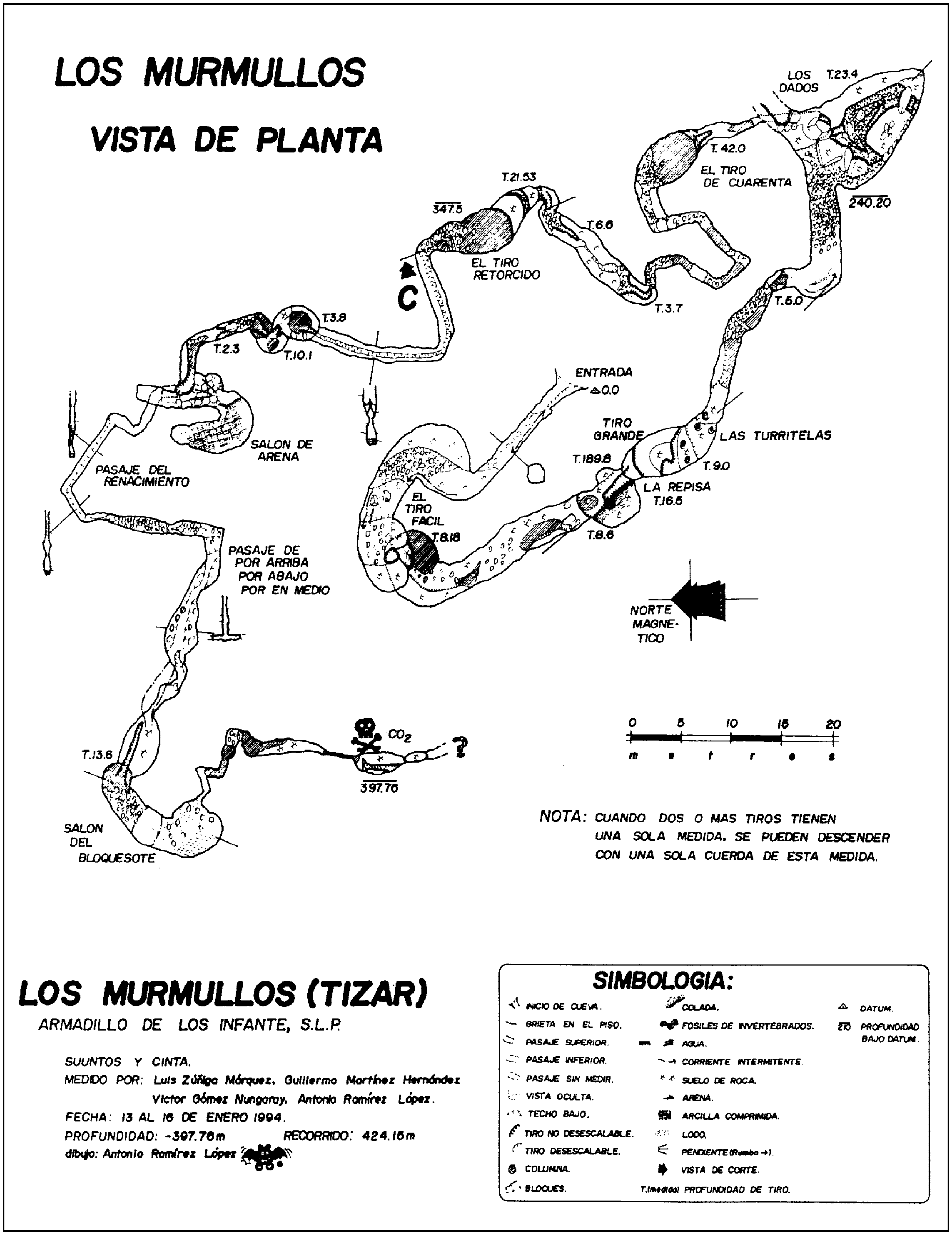
## TAMAULIPAS

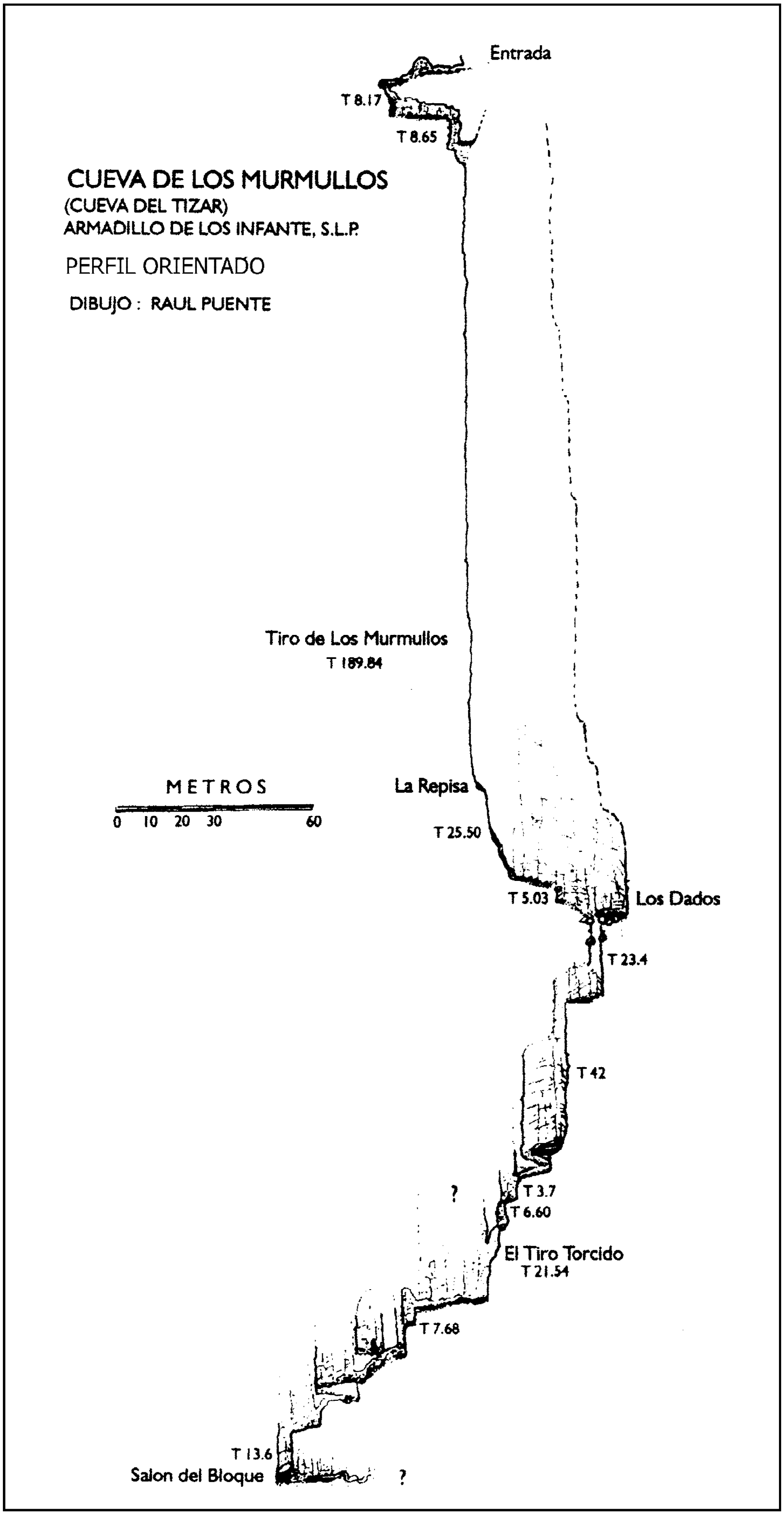
Abstract: Deep phreatic shafts and travertine-capped sinkholes characterize **Sistema Zacatón**, an isolated karst area in northeastern Mexico. At a depth of at least 329 meters, El Zacatón is the deepest known underwater pit in the world. Hypogenic karst development related to volcanism is proposed to have formed El Zacatón and is though to have diminished since the late Quaternary peak activity. The resulting geomorphic overpint of Zacatón displays features similar to hydrothermal groundwater systems throughout the world. Other karst areas in northeastern Mexico are known for deep pits and high-flow springs rising from great depths, but differ from Zacatón in the speleogenetic processes that developed the caves. Sótano de las Golondrinas (378 meters), 200 kilometers southwest of Zacatón, is among the deepest air-filled shafts in the world. The Nacimiento del Río Mante, 100 kilometers to the west, is a large artesian spring that extends a minimum of 270 meters below the water table. Although these three world-class systems all formed in Cretaceous limestone and are located relatively close together, there are significant differences in lithology, tectonic setting, and geomorphic features. Geochemical, microbiological, and geomorphologic data for Zacatón indicate that cave formation processes are similar to those observed in other volcanically influenced systems. *Source*: abstract of paper "Volcanogenic Karstification of Sistema Zacatón, Mexico," by Marcos Gary and John Sharp, Jr., in *Perspective on Karst Geomorphology, Hydrology, and Geochemistry—A Tribute Volume to Derek C. Ford and William B. White*, edited by R. S. Harmon and C. Wicks, Geological Society of American Special Paper 404, pages 79–89 (2006).

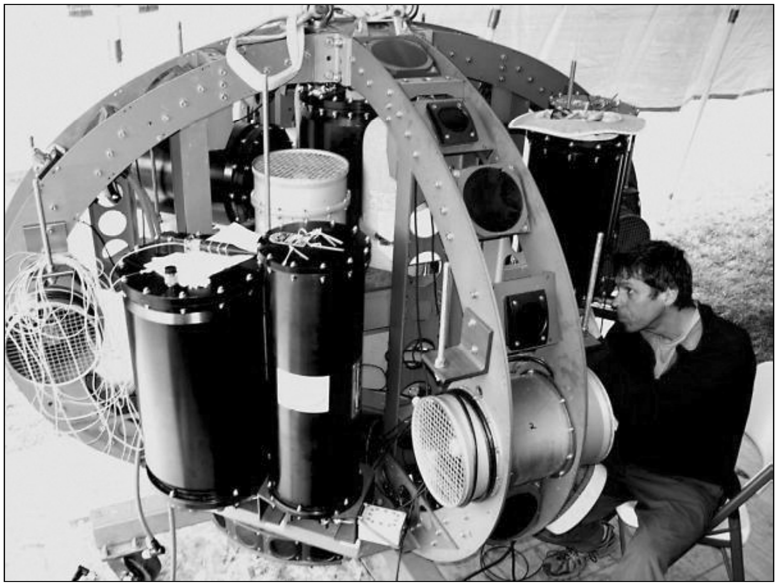
NASA's DEPTHX project to demonstrate autonomous underwater vehicle operation in the deep water-filled sinks at Rancho Azufrosa began with two visits to the site, one January 25 through February 10 and the second March 7 through March 14, 2007. During those missions, operations were restricted to relatively shallow **La Pilita**. During the project's final visit in May, the robot is to explore the so-far inaccessible depths of **Zacatón**. (For an overview of the area, see Marcus Gary's article in *AMCS Activities Newsletter* 24.) Following assembly and testing of the device, it made its first significant exploration of La Pilita on February 5, disclosing for the first time the full shape of the cenote. It is shallow enough to be accessible by scuba divers, but limited visibility had prevented getting a good idea of its extent. Most of the dives were made with a fiber-optic tether on the device, allowing surface monitoring of its behavior. The first untethered dive was on February 9. The March expedition was devoted mainly to testing the science package, which can take water and wall samples and photographs of the environment. The official web sites for the two missions are www.stoneaerospace.com/news-/news-zacaton-mission1.php and /news-zacaton-2nd-mission1.php, with additional pages accessible by clicking on dates at the top of those pages. The May 2007 mission site will probably be like those, but with *3rd* for *2nd*.The information can also be gotten to indirectly from www.geo.utexas.edu/zacaton/depthx.

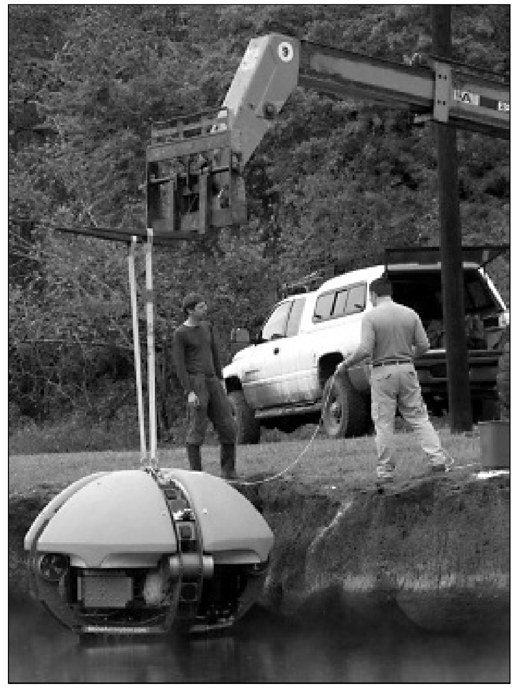
The DEPTHX project is also getting a lot of publicity elsewhere. A few samples are:

www.chron.com/disp/story.mpl/metropolitan/4315216.html
news.scotsman.com/scitech.cfm?id=581272007
www.news.com.au/heraldsun/story/0,21985,21561498-663,00.html
www.brisbanetimes.com.au/news/world/thinking-robot-tested-for-jupiter-mission/2007/04/15/

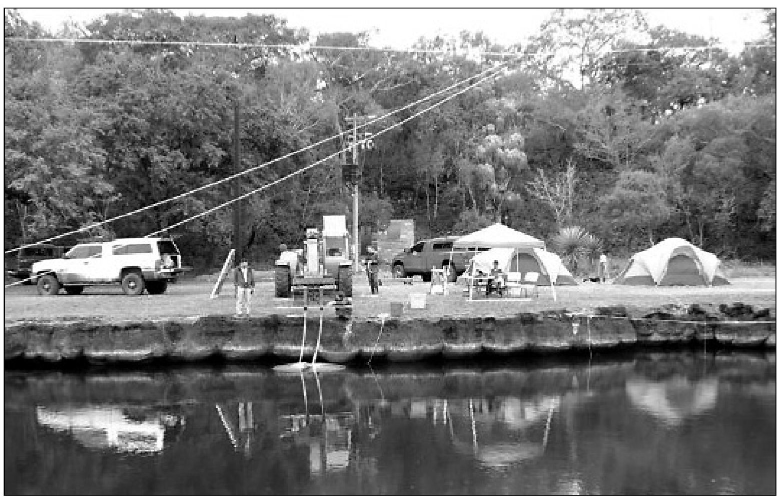

LOS MURMULLOS
VISTA DE PLANTA
LOS DADOS
T.23.4
T. 42.0
EL TIRO DE CUARENTA
240.20
T.21.53
347.5
T.6.6
EL TIRO RETORCIDO
C
T.3.7
T.5.0
T.3.8
T.2.3
T.10.1
ENTRADA
0.0
TIRO GRANDE
LAS TURRITELAS
SALON DE ARENA
T.189.8
T. 9.0
PASAJE DEL RENACIMIENTO
LA REPISA
T.16.5
EL TIRO FACIL
T.8.18
T.8.6
PASAJE DE POR ARRIBA POR ABAJO POR EN MEDIO
NORTE MAGNE-TICO
0 5 10 15 20
m e t r e s
$CO_2$
?
T.13.6
397.76
SALON DEL BLOQUESOTE
NOTA: CUANDO DOS O MAS TIROS TIENEN UNA SOLA MEDIDA, SE PUEDEN DESCENDER CON UNA SOLA CUERDA DE ESTA MEDIDA.
LOS MURMULLOS (TIZAR)
ARMADILLO DE LOS INFANTE, S.L.P.
SUUNTOS Y CINTA.
MEDIDO POR: Luis Zúñiga Márquez, Guillermo Martínez Hernández Victor Gómez Nungaray, Antonio Ramírez López.
FECHA: 13 AL 16 DE ENERO 1994.
PROFUNDIDAD: -397.76m
RECORRIDO: 424.15m
dibujo: Antonio Ramírez López
SIMBOLOGIA:
INICIO DE CUEVA.
GRIETA EN EL PISO.
PASAJE SUPERIOR.
PASAJE INFERIOR.
PASAJE SIN MEDIR.
VISTA OCULTA.
TECHO BAJO.
TIRO NO DESESCALABLE.
TIRO DESESCALABLE.
COLUMNA.
BLOQUES.
COLADA.
FOSILES DE INVERTEBRADOS.
AGUA.
CORRIENTE INTERMITENTE.
SUELO DE ROCA.
ARENA.
ARCILLA COMPRIMIDA.
LODO.
PENDIENTE (Rumbo →).
VISTA DE CORTE.
T.(medida) PROFUNDIDAD DE TIRO.
DATUM.
PROFUNDIDAD BAJO DATUM.


Entrada
T 8.17
T 8.65
CUEVA DE LOS MURMULLOS
(CUEVA DEL TIZAR)
ARMADILLO DE LOS INFANTE, S.L.P.
PERFIL ORIENTADO
DIBUJO : RAUL PUENTE
Tiro de Los Murmullos
T 189.84
METROS
0 10 20 30 60
La Repisa
T 25.50
T 5.03
Los Dados
T 23.4
T 42
?
T 3.7
T 6.60
El Tiro Torcido
T 21.54
T 7.68
T 13.6
Salon del Bloque
?

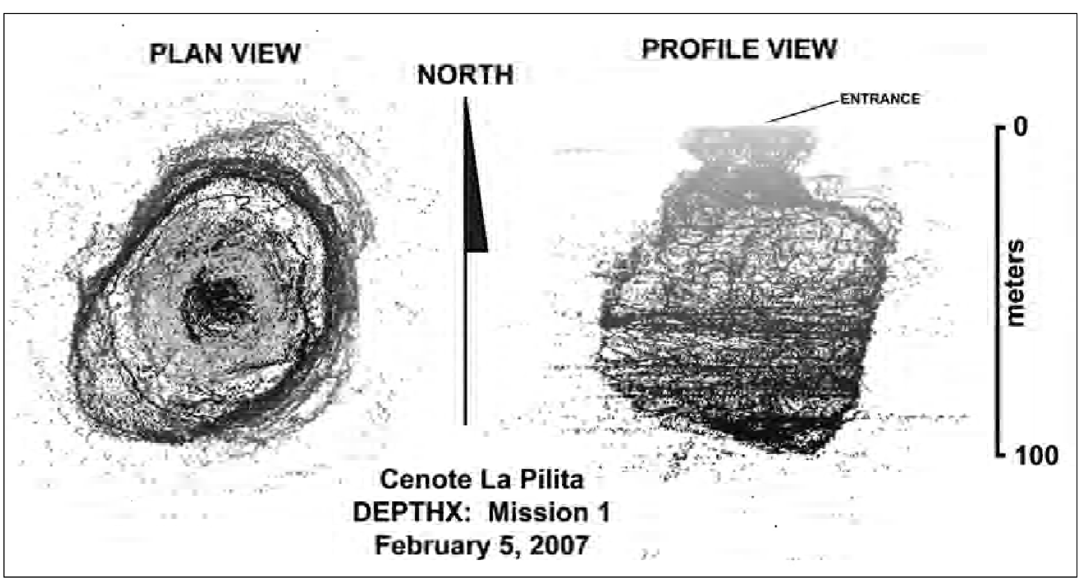




# DEPTHX



Above left: John Kerr installs computer boxes in the DEPTHX frame on February 1.
Above right: The robot being lowered into Cenote La Pilita on February 5.
Left: The “mission control” camp at the edge of La Pilita, photographed on February 6.
Below: Data from the first true exploratory dive by the robot, showing the configuration of La Pilita based on 340,000 sonor echoes.



1176575664502.html.

Magazine articles on the project include one in *Popular Science*, February 2007, pages 50–57, 84, and one in *Science*, 19 January 2007, pages 322–324.

On June 10, 2006, a group of cavers from Mexico, Texas, Tennessee, Minnesota, Poland, and Canada headed off for some caving and surveying in the **Infiernillo** entrance area of **Sistema Purificación**. Participants were Alex Alvárez, Paul Bryant, Marlena Cobb, Dan Green, Nick Johnson, Chris Krejca, Jon Lillestolen, David Ochel, Marcela Ramírez, Philip Rykwalder, Bev Shade, Vickie Siegel, Pawel Skoworodko, and Franco Attolini. The trip was a success, despite a broken ankle, a few cases of poison ivy, and some stomach problems, with many known leads in the western Confusion Tubes found and surveyed. New leads were found in abundance. A total of 969 meters of new passage was surveyed and fourteen smelly, sweaty cavers left the cave camp pleased with the results. *Source*: Marlena Cobb.

## VERACRUZ

In March 2007, twenty-two cavers from the US joined forces with Veracruz cavers to explore caves around Paraje Nuevo. A week was spent camped on the Río Atoyac, which emerges from **Cueva del Ojo de Agua Grande**, long known to contain a large river. A dry maze section leading in from the entrance rejoins the river at a whitewater cascade. This was explored upstream through swims and more whitewater to a sump. Less than a kilometer away was a higher cave, **Sótano del Resumbador**, which was also known to contain a river. This has a 60-meter entrance drop into a large chamber, where the roar of a river can be heard. The second drop, 40 meters, leads into a raging river that appears to have twice as much flow as that in Cueva del Ojo de Agua Grande. Resumbador also ends in a sump. Another large cave in this area is **Cueva el Encanto**, which has a drop leading into a very large chamber. Surveying was continued in an extensive cave 16 kilometers to the northeast, **Cueva del Cabrito**. This cave has a small stream in it and consists of large walking passage trending northwest. This cave has been explored for a considerable distance, so the survey has only just begun. Results of the trip are tabulated below. *Source*: Peter Sprouse.

| Name | Length | Depth |
|---|---|---|
| Sotano del Resumbador | 793 | 166 |
| Cueva del Ojo de Agua Grande (Gruta del Manatial) | 882 | 17 |
| Sotano de los Murcielagos | 20 | 11 |
| Cueva de los Cuatro Mujeres | 120 | 19 |
| Cueva de las Madres de Futbol Manejando Volvos | 200 | 35 |
| Cueva el Encanto | 500 | 57 |
| Cueva el Cuartel | 35 | |
| Cueva del Hongo | | 21 |
| Cueva Paisanos | 5 | |
| Cueva del Murcielago Solo | 30 | 7 |
| Cueva de David Sosa | 14 | 6 |
| Cueva del Nacimiento el Encanto | 15 | |
| Cueva del Cabrito | 1528 | 26 |

## MISCELLANEOUS

Abstract: Throughout the world caves are often important sacred landmarks whose dark zones tend to be restricted spaces reserved for religious rituals. The function and meaning of activities conducted within these spaces are categorically different than physically similar activities conducted at the surface. Archaeology has been slow to integrate this fact into the analysis of cave fetures. Recently discovered evidence of extractive activities within Maya caves allows us to reevaluate previous work on cave mines. We suggest that the extraction was always small in scale and that the material extracted was most likely used in ritual. We then examine several surface mines where tunnel mining was used to extract a relatively undifferentiated matrix. Evidence suggests that a prime concern in the excavation was the creation of an artificial cave. *Source*: abstract to paper "A Reappraisal of Ancient Maya Cave Mining," by James E. Brady and Dominique Rissolo, in *Journal of Anthropological Research*, volume 62, pages 471–490 (2006).

The article in *AMCS Activities Newsletter* 29 on hydroleveling in Krubera Cave has attracted a lot of attention. An exact reprint appeared in *Compass and Tape*, magazine of the NSS's Survey and Cartography Section. Portions of it are expected to appear in *Spelelogy*, magazine of the British Cave Research Association, and *Compass Points*, the newsletter of the BCRA's surveying special interest group. The Russian original can be found on the web at www.rgo-speleo.ru/biblio/hydroniv.htm, and the AMCS English version is at www.rgo-speleo.ru/eng/biblio/hydroniv-e.htm, with links to the tables in PDF format at the end.

### Shafts over 400m

*Compiled by Duncan Collis*

Notes indicate whether the shaft is on the surface or underground, whether it is broken by ledges, and whether it consists of a free-fall hang (though in most instances this is unknown)

| *Cave Name* | *Vertical Range* | *Country* | *Notes* |
|---|---|---|---|
| Vrtiglavica | 643m+ | Slovenia | Surface shaft, ice ledges |
| Patkov Gust | 553m | Croatia | Surface shaft, ice ledges |
| Da Keng | 519m | China | Surface, ledges |
| Lukina jama | 516m | Croatia | Underground shaft |
| Velebita | 513m | Croatia | Underground shaft |
| Brezno pod Velbom | 501m | Slovenia | Surface shaft, ledges |
| Miao Keng | 491m | China | Underground, ledges* |
| Melkboden-Eishöhle | 451m | Austria | Surface shaft |
| Höllenhöhle Hades | 450m | Austria | Surface shaft, ledges |
| Baiyu Dong | 424m | China | Surface shaft, free-fall |
| Meduza (Bojim-Bojim) | 420m | Croatia | Unknown |
| Abisso di Monte Novegno | 418m | Italy | Underground, ledges |
| Minye | 417m | Papua New Guinea | Surface, free-fall |
| El Sótano de El Barro | 410m | Mexico | Surface, free-fall |
| Abatz | 410m | Georgia | Underground shaft |

+ Some references quote 603m. This shaft is possibly not quite vertical

* A rerig will produce a free-hang

Table from *Descent* 194, February/March 2007

# DEEP CAVES OF MEXICO

Mark Minton
April 2007
Depth in meters

| | | | |
|---|---|---|---|
| 1 | Sistema Cheve | Oaxaca | 1484 |
| 2 | Sistema Huautla | Oaxaca | 1475 |
| 3 | Cueva Charco | Oaxaca | 1278 |
| 4 | Akemati | Puebla | 1226 |
| 5 | Kijahe Xontjoa | Oaxaca | 1223 |
| 6 | J2 (Ozto Faustino, Ozto Barbie) | Oaxaca | 1209 |
| 7 | Sistema Ocotempa | Puebla | 1070 |
| 8 | Akemabis | Puebla | 1015 |
| 9 | Soncongá | Oaxaca | 1014 |
| 10 | Guixani N'dia Kijao | Oaxaca | 955 |
| 11 | Sistema Purificación | Tamaulipas | 953 |
| 12 | Sistema Perrito (Nia Quien Nita + Nia Nga'co Nita) | Oaxaca | 906 |
| 13 | Sistema Tepepa (Ehécatl+Niebla+Xalltégoxtli) | Puebla | 899 |
| 14 | Nita Chó | Oaxaca | 894 |
| 15 | Sótano de Agua de Carrizo | Oaxaca | 843 |
| 16 | Sótano de El Berro | Veracruz | 838 |
| 17 | Sótano de Trinidad | San Luis Potosí | 834 |
| 18 | Resumidero El Borbollón | San Luis Potosí | 821 |
| 19 | X'oy Tixa Nita | Oaxaca | 813 |
| 20 | Nita Ka | Oaxaca | 760 |
| 21 | Sistema H31-H32-H35 | Puebla | 753 |
| 22 | Sonyance | Oaxaca | 740 |
| 23 | Nita Xongá | Oaxaca | 739 |
| 24 | Yuá Nita | Oaxaca | 705 |
| 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 Nashi | Oaxaca | 641 |
| 31 | Cuaubtempa Superior | Puebla | 640 |
| 31 | Sistema Soconusco - Aire Fresco | Chiapas | 633 |
| 33 | Sistema Atlalaquía | Veracruz | 623 |
| 34 | Cueva de Diamante | Tamaulipas | 621 |
| 35 | Sistema Coyolatl | Puebla | 620 |
| 36 | Sistema de los Tres Amigos | Oaxaca | 611 |
| 37 | R'ja Man Kijao (Nita) | Oaxaca | 611 |
| 38 | Nita He | Oaxaca | 594 |
| 39 | El Santo Cavernario | Puebla | 588 |
| 40 | Meandro Que Cruce (H54) | Puebla | 588 |
| 41 | Yometa | Puebla | 582 |
| 42 | Sótano de las Coyotas | Guanajuato | 581 |
| 43 | Sótano Arriba Suyo | San Luis Potosí | 563 |
| 44 | Sistema Tepetlaxtli | Puebla | 535 |
| 45 | Sótano de Nogal | Querétaro | 529 |
| 46 | Resumidero de la Piedra Agujerada | San Luis Potosí | 521 |
| 47 | Grutas de Rancho Nuevo | Chiapas | 520 |
| 48 | Sótano de las Golondrinas | San Luis Potosí | 512 |
| 49 | Hoya de las Conchas | Querétaro | 508 |
| 50 | Sótano del Buque | Querétaro | 506 |

Updates and corrections:

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Mark Minton
April 2007
Length in meters

# LONG CAVES OF MEXICO

| | | | |
|---|---|---|---|
| 1 | Sistema Sac Actun | Quintana Roo | 155638 |
| 2 | Sistema Ox Bel Ha | Quintana Roo | 146761 |
| 3 | Sistema Purificación | Tamaulipas | 93755 |
| 4 | Sistema Huautla | Oaxaca | 62099 |
| 5 | Sistema Dos Ojos (Sistema Jacinto Pat) | Quintana Roo | 57700 |
| 6 | Cueva del Tecolote | Tamaulipas | 40475 |
| 7 | Sistema Cuetzalan | Puebla | 37676 |
| 8 | Kihaje Xontjoa | Oaxaca | 31373 |
| 9 | Sistema Soconusco - Aire Fresco | Chiapas | 27793 |
| 10 | Sistema Tepepa (Ehécatl+Niebla+Xalltégoxtli) | Puebla | 27789 |
| 11 | Sistema Cheve | Oaxaca | 26194 |
| 12 | Sistema Coyolatl | Puebla | 23000 |
| 13 | Sistema Toh Ha | Quintana Roo | 22171 |
| 14 | Sistema Naranjal (Najarón-Maya Blue) | Quintana Roo | 21558 |
| 15 | Sistema K’oox Baal | Quintana Roo | 19178 |
| 16 | Sistema Aerolito | Quintana Roo | 18000 |
| 17 | Cueva de Alpazat | Puebla | 15200 |
| 18 | Sistema PonDeRosa (Pondazul, Eden) | Quintana Roo | 15019 |
| 19 | Sistema Yaxchen East | Quintana Roo | 13090 |
| 20 | Cueva del Río La Venta | Chiapas | 13000 |
| 21 | Atlixicaya | Puebla | 13000 |
| 22 | Chjine Xjo | Oaxaca | 12400 |
| 23 | Cueva Pitch | Quintana Roo | 12000 |
| 24 | Sistema San Andrés | Puebla | 10988 |
| 25 | Cueva de la Mano | Oaxaca | 10841 |
| 26 | Sistema Taj Mahal - Minotauro | Quintana Roo | 10600 |
| 27 | Actun Káua | Yucatán | 10360 |
| 28 | Grutas de Rancho Nuevo (San Cristóbal) | Chiapas | 10218 |
| 29 | Cueva del Arroyo Grande | Chiapas | 10207 |
| 30 | El Chorro Grande | Chiapas | 9650 |
| 31 | Sistema Camilo | Quintana Roo | 9649 |
| 31 | Sistema Muul Three | Quintana Roo | 9630 |
| 33 | Sistema Tepetlaxtli | Puebla | 9600 |
| 34 | J2 (Ozto Faustino, Ozto Barbie) | Oaxaca | 9536 |
| 35 | Sistema Chac Mol - Mojarra | Quintana Roo | 9193 |
| 36 | Cueva Quebrada | Quintana Roo | 8921 |
| 37 | Sótano de Las Calenturas | Tamaulipas | 8308 |
| 38 | Gruta del Tigre | Quintana Roo | 8200 |
| 39 | Nohoch Aktun | Quintana Roo | 8200 |
| 40 | Sistema Las Brumas - Gimnástica Selvática | Puebla | 7900 |
| 41 | Sumidero Santa Elena | Puebla | 7884 |
| 42 | Cueva Yohualapa | Puebla | 7820 |
| 43 | Cueva de la Peña Colorada | Oaxaca | 7793 |
| 44 | Cueva de Comalapa | Veracruz | 7750 |
| 45 | Sistema Zapote (Toucha-Ha - Vaca Ha) | Quintana Roo | 7697 |
| 46 | Sistema Xunaan-Ha (María Isabella) | Quintana Roo | 7600 |
| 47 | Sótano del Arroyo | San Luis Potosí | 7200 |
| 48 | Sistema Perrito (Nia Quien Nita + Nia Nga’co Nita) | Oaxaca | 7148 |
| 49 | Cueva de la Puente | San Luis Potosí | 6978 |
| 50 | Sistema Huayateno (Guayateno) -Tecaltitlán | Puebla | 6911 |

# DEEP PITS OF MEXICO

Mark Minton
April 2007
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 la Culebra | Entrance drop | Querétaro | 336 |
| 4 | Sótano de Tomasa Kiahua | Entrance drop | Veracruz | 330 |
| 5 | Sótano de Alhuastle | P'tit Québec | Puebla | 329 |
| 6 | El Zacatón (underwater) | Entrance drop | Tamaulipas | 329 |
| 7 | Akemabis | | Puebla | 310 |
| 8 | Nita Xonga | Psycho Killer | Oaxaca | 310 |
| 9 | Sotanito de Ahuacatlán | Second drop | Querétaro | 288 |
| 10 | Sótano del Arroyo Grande | Entrance drop | Chiapas | 283 |
| 11 | Sima Don Juan | Entrance drop | Chiapas | 278 |
| 12 | Hálito de Oztotl | Entrance drop | Oaxaca | 250 |
| 13 | Sima Dos Puentes | La Ventana | Chiapas | 250 |
| 14 | El Santo Cavernario | El Santo Tiro | Puebla | 245 |
| 15 | Resumidero del Pozo Blanco | Entrance drop | Jalisco | 233 |
| 16 | Sótano del Aire | Entrance drop | San Luis Potosí | 233 |
| 17 | Sistema Ocotempa | Pozo Verde | Puebla | 221 |
| 18 | Sótano de los Planos | Puits Tannant | Puebla | 220 |
| 19 | Live in Busch | Entrance drop | Oaxaca | 220 |
| 20 | Sótano de Eladio Martínez | Entrance drop | Veracruz | 220 |
| 21 | Sistema Soconusco | Sima de la Pedrada | Chiapas | 220 |
| 22 | Sótano de Coatimundi | Entrance drop | San Luis Potosí | 219 |
| 23 | Sótano de Sendero | Entrance drop | San Luis Potosí | 217 |
| 24 | Resumidero el Borbollón | Tiro Grande | San Luis Potosí | 217 |
| 25 | Cueva de los Murmullos (Cueva del Tízar) | Tiro de los Murmullos | San Luis Potosí | 215 |
| 26 | Sima del Chikinibal | Entrance drop | Chiapas | 214 |
| 27 | Kijahe Xontjoa | Son On Jan | Oaxaca | 210 |
| 28 | Nacimiento del Río Mante (underwater) | Macho Pit | Tamaulipas | 206 |
| 29 | Hoya de las Guaguas | Entrance drop | San Luis Potosí | 202 |
| 30 | Kijahe Xontjoa | Lajao Se | Oaxaca | 200 |
| 31 | Fundillo de El Ocote | Entrance Drop | Chiapas | 200 |
| 32 | Nita Gatziguin | Entrance drop | Oaxaca | 200 |
| 33 | Sistema H3-H4 | | Puebla | 200 |
| 34 | Sistema de la Lucha | Entrance drop | Chiapas | 200 |
| 35 | Sima La Funda | Entrance drop | Chiapas | 198 |
| 36 | Sótano de Soyate | Entrance drop | San Luis Potosí | 195 |
| 37 | Sótano de Alpupuluca | Entrance drop | Veracruz | 190 |
| 38 | Cuaubtempa | Pozo con Carne | Puebla | 190 |
| 39 | Sótano de Tepetlaxtli No. 1 | Entrance drop | Puebla | 190 |
| 40 | Sótano de Puerto de los Lobos | Entrance drop | San Luis Potosí | 189 |
| 41 | Hoya de la Luz | Entrance drop | San Luis Potosí | 188 |
| 42 | Sótano de Hermanos Peligrosos | Second drop | Veracruz | 186 |
| 43 | Ahuihuitzcapa | Entrance drop | Veracruz | 180 |
| 44 | Sima de Veinte Casas | Entrance drop | Chiapas | 180 |
| 45 | Croz 2 | Entrance drop | Puebla | 180 |
| 46 | Sima del Cedro | Entrance drop | Chiapas | 175 |
| 47 | Sótano de la Cuesta | Entrance drop | San Luis Potosí | 174 |
| 48 | Sima Dos Puentes | Entrance drop | Chiapas | 172 |
| 49 | El Socavón | Entrance drop | Querétaro | 171 |
| 50 | Sótano de Otates | Third drop | Tamaulipas | 171 |
| 51 | Sótano de los Monos | Entrance drop | San Luis Potosí | 171 |

# THE SAGA OF CUEVA CHARCO, THIRD-DEEPEST CAVE IN MEXICO

Nancy Pistole

I can't believe this is the underground camp—it's so small. My idea of an underground camp is lots of room, big flat floor, nice stream off to one side. If it weren't for the fact that it took me twelve hours to get here and I'm utterly exhausted, I'd turn around right now and leave. And the minor detail that it was a grueling trip to get here. I had been familiar with the first part of the cave: the 33-Meter Drop, the belly crawls, the Ivy Filter. It always amazes me that no matter how much gravel I push out of the way in those belly crawls, it all falls back in for my next trip through. But the rest of the trip to camp was new to me. Charley Savvas said the passage opened up. I'll have to ask him to define his idea of "open." Yeah, I guess you could call a cheese grater "open." The passage stayed small almost the whole way. And it seemed to just go on and on, with very few memorable landmarks. There were long stretches where I could only measure my progress by the occasional survey station. For a brief time the passage did get bigger, but I was wallowing in mud. Now I'm in this camp, and every time I move I hit my head on the ceiling and dirt falls down the back of my neck; my legs are so bruised they look like they belong to a Dalmatian. Time to get some rest, but what a choice of sleeping spots. I guess I'll take the one with the big boulder pushing into my hip.

After some sleep and a hot meal, I feel better. I asked Mike Ficco about some of his worst underground camps, and he had some stories to tell of wet, cold, windy places. At least this camp is dry, and the temperature is quite pleasant. And there is virgin cave just waiting around the corner. Okay, maybe this camp isn't so bad after all. . . .

Cueva Charco, located in the state of Oaxaca, Mexico, was first found by Mark Minton, Noel Sloan, Pam Smith, and Bill Stone in 1989. The entrance is inviting, a 5-by-5-meter opening at the bottom of a sinkhole, with several short drops leading into darkness. The passage makes a hairpin turn to the left, and then the scene changes. Within several meters, the passage shrinks down to a belly crawl. The first group stopped shortly beyond this point at a water-filled passage with very little air space.

The cave was revisited in 1993 by Peter Bosted, Carol Vesely, and James Wells. When they looked at the entrance, they noticed airflow. They got to the same point as the previous group and found that the crawl through the water was short; it was just a puddle, hence the name of the cave (charco means puddle in Spanish). The air seemed to whistle through a mishmash of fractures and fissures, and sometimes it wasn't obvious which route was humanly passable. As the cave goes deeper, the passage becomes better defined, but not significantly larger. There are still plenty of chimneys and squeezes to negotiate. Several more survey trips were made that year, and with the help of Don Coons, Patty Kambesis, and Ed Sevcik, the survey reached 734 meters long and 267 meters deep. During the last survey trip, a shaft was discovered that was 33 meters deep. There were high hopes that this signaled the beginning of bigger passage.

Charco is located in an area referred to as the "middle karst." It is an area of limestone located between the main entrance to the Cheve system and the Cheve resurgence. The Cheve system must have infeeders, because the volume of water at the resurgence is greater than the river in Cueva Cheve. Geologically, the middle karst is the ideal place to look for these infeeders. [See the area map in *AMCS Activities Newsletter* 29, page 28.]

In 1994, twenty-four cavers rented an old schoolhouse for two weeks in the small village of La Hierbabuena for a systematic assault on the middle karst. Many cave entrances were located, and the ones with the most potential for a connection into the missing middle part of Cheve were explored and mapped. Charco was not high on the list for exploration, not because of its lack of potential for a connection, but because of its reputation for being tight, wet, and relatively cold. Charco hardly fit the idea of Mexican borehole. On the only significant trip into Charco that year, Harry Burgess, Nancy Pistole, "Long Bob" Riley, and Taco van Ieperen went down the 33-meter pit (imaginatively dubbed the 33-Meter Drop) and continued to the end of the survey. Disappointingly, the passage did not get any bigger. In fact, within a few meters, Nancy was squirming on her belly through a small stream, digging out gravel so she could get through the passage. Taco was cold, so he left the cave. When he returned to the base camp, he told such horror stories of the cave that

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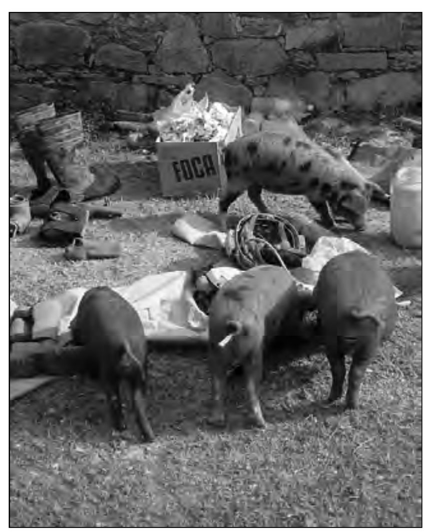
no one else wanted to check it out. The passage did open up a bit, but still had plenty of tight spots. Only about 200 meters were surveyed, adding less than 50 meters to the depth.

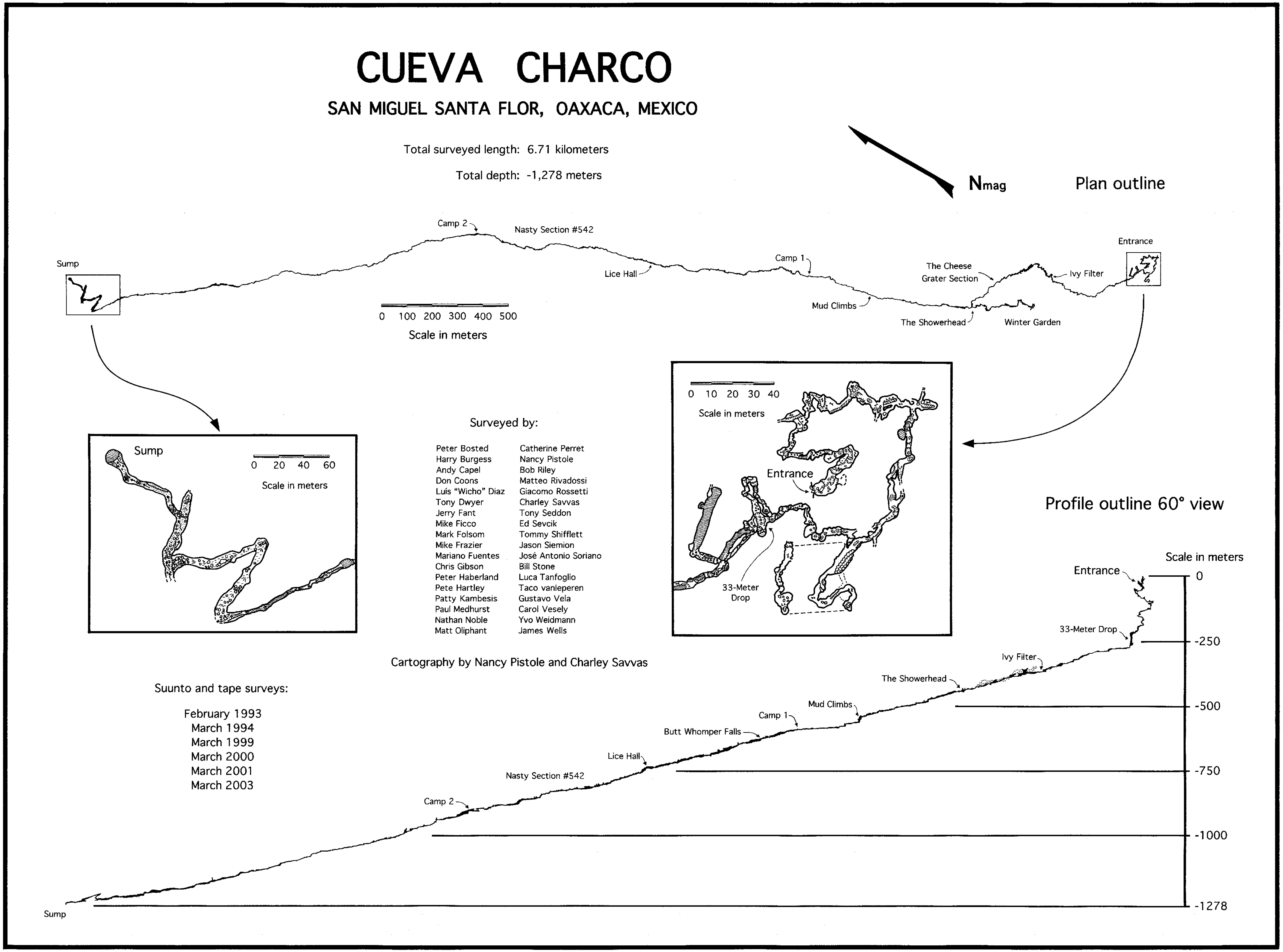
No one returned to the cave for five years. There are several major cave systems nearby, the main Cheve system, Huautla, and the caves of Cerro Rabón, all of which are much more inviting. Even in the close vicinity of Charco, there are many other cave entrances. However, during those five years cavers checked many of the surrounding caves, and the promising leads in the middle karst dwindled. Several attempts were made to get through the big pile of breakdown at the end of the main passage in Cueva Cheve, with no real success, so serious attention turned back to Charco.

In March 1999, Joe Ivy, Becky Jones, and José Soriano rented two small houses just above the Charco sinkhole. The accommodations were pleasant enough. There was enough room in one house to store gear, and the other building was turned into a kitchen. Both houses even had basic electricity. The primary mission was to explore Charco and determine if the cave had enough potential for a bigger expedition. This was supposed to be a small, informal trip, but over the course of two weeks, a total of sixteen cavers showed up, from the US, Mexico, Switzerland, Great Britain, and Italy.

Every day at least one survey team plunged into Charco, adding data to the survey. Sometimes another team would go in to rearrange rocks and widen parts of the passage to make the route less difficult. Progress was slow. Typically, a team would cave for one long day, then take two or three days to recover. Joe did a good job of "Ivy-sizing" the tight parts, but was finally stopped at the Ivy Filter, a tight, awkward squeeze over a calcite dam into a cold pool of water that inevitably forced a head-dunk. Yvo Weidmann, Catherine Perret, and Mike Frazier found several very small and sinuous side leads, one of which makes a loop connecting the top of the 33-Meter Drop to its bottom. Charley Savvas went on a survey trip with two Italian cavers, Luca Tanfoglio and Giacomo Rossetti. Even though they did not speak a common language, they had a successful survey trip. On the last survey trip, Matt Oliphant and Charley told Mark Folsom to be prepared for a twenty-four-plus–hour trip, but Mark thought they were kidding. The trip lasted twenty-nine hours, and Mark ran out of food. When they got to the surface, they ate a hot meal, and then Mark went to his tent. Becky checked on him a while later; he was lying there sound asleep, fully clothed, with his feet sticking out of his tent and his boots still on.

Upper left: The surface base camp. *Nancy Pistole*. Lower left: Inside the gear house. *Tommy Shifflett*. Below: Cleaning up after a cave trip. *Nancy Pistole*.




CUEVA CHARCO
SAN MIGUEL SANTA FLOR, OAXACA, MEXICO
Total surveyed length: 6.71 kilometers
Total depth: -1,278 meters
Nmag
Plan outline
Sump
Camp 2
Nasty Section #542
Lice Hall
Camp 1
Mud Climbs
The Cheese Grater Section
The Showerhead
Winter Garden
Ivy Filter
Entrance
0 100 200 300 400 500
Scale in meters
Sump
0 20 40 60
Scale in meters
Surveyed by:
Peter Bosted
Harry Burgess
Andy Capel
Don Coons
Luis "Wicho" Diaz
Tony Dwyer
Jerry Fant
Mike Ficco
Mark Folsom
Mike Frazier
Mariano Fuentes
Chris Gibson
Peter Haberland
Pete Hartley
Patty Kambesis
Paul Medhurst
Nathan Noble
Matt Oliphant
Catherine Perret
Nancy Pistole
Bob Riley
Matteo Rivadossi
Giacomo Rossetti
Charley Savvas
Tony Seddon
Ed Sevcik
Tommy Shifflett
Jason Siemion
José Antonio Soriano
Bill Stone
Luca Tanfoglio
Taco vanleperen
Gustavo Vela
Carol Vesely
Yvo Weidmann
James Wells
0 10 20 30 40
Scale in meters
Entrance
33-Meter Drop
Profile outline 60° view
Scale in meters
Entrance
0
33-Meter Drop
-250
Ivy Filter
The Showerhead
Mud Climbs
-500
Camp 1
Butt Whomper Falls
Lice Hall
-750
Nasty Section #542
Camp 2
-1000
Sump
-1278
Cartography by Nancy Pistole and Charley Savvas
Suunto and tape surveys:
February 1993
March 1994
March 1999
March 2000
March 2001
March 2003

Cozy in Camp 1. *Tommy Shifflett*.

From the line plot, the nature of the cave was becoming apparent. After a few spirals near the entrance, there is one passage that heads in a straight line north-northwest, towards the Cheve resurgence, with very few side leads. The profile shows a consistent gradient, also towards the resurgence. The cave was now 2.6 kilometers long and 588 meters deep and had good airflow and running water. Even though the passage continued to be a series of crawls, chimneys, squeezes, and short drops through loose, nasty, brittle chert layers, we decided the lead was worth pursuing.

The following year, in March 2000, twenty-one cavers returned, determined to find the connection between Charco and the Cheve system. The most efficient way to continue exploration was to set an underground camp, but where? Although the average passage near the bottom of the cave had become a bit bigger (roughly 1.5 meters wide by 1 to 3 meters tall), there was now a stream running along the floor, and the walls were covered with sharp, loose protrusions. The year before, Charley Savvas had noticed a small alcove above the stream when he was sketching. With a year to dim his memory, Charley, always the optimist, was sure that this alcove would make a great camp. After setting up the rental houses and making a few trips into the cave to rig and shuttle supplies, the first camp group was ready to go. Mike Frazier, Nathan Noble, and David Cole headed in with enough provisions for an overnight stay. However, they never found the alcove and ended up setting up a temporary camp. They came out of the cave the next day, very tired and beat-up. That was enough for David; the following day he left on a bus going down the mountain. Matt Oliphant, Gustavo Vela, Paul Medhurst, and Charley were the next ones in. Since they knew where the alcove was, they planned on a long rerig and gear-hauling trip. They found the alcove without any problem, but it wasn't exactly the great camp Charley had described. After several hours of hard digging and rock rearranging, three sleeping spots were excavated. These were not luxury accommodations. One of the "bunks" was in a slot less than half a meter high. Another bunk was long and narrow, with a big rock jutting in from the side. The crew slept for a few hours, then headed out.

After reevaluating the underground camping situation, a new plan was formulated. With some more digging, it would be possible to carve out another three sleeping spots, for a total of six. But there were more than six cavers who were getting psyched for the misery (and potential virgin cave). The plan was to send more than six cavers in to camp, and they would "hot-bed," using the camp in 12-hour shifts.

Ten cavers headed into camp over a two-day period. The bare minimum of camp gear was taken down to set up the camp, and even that had to be shuttled through the tight spots, since a normal-size camp duff would not fit. The first group, Mike Ficco, Nancy Pistole, and José Soriano, had the chore of carving out three more bunks. The entire camp space was so small that there was barely enough room for six people to be standing at the same time. Globs of mud kept falling from the ceiling. There was no place to dig a latrine without contaminating the stream, so garbage bags were rigged in a small rock alcove to make a porta-potty.

Peter Haberland, Pete Hartley, and Tony Seddon came down next. Because the end of the survey started close to the camp, the survey trips were quite efficient, with two survey teams leap-frogging. Then when Charley Savvas, Mike Frazier, Nathan Noble, and Gustavo Vela arrived in camp, the team divided into shifts. The way the plan was supposed to work, one shift would leave camp as the other shift arrived. That rarely happened, so at most of the shift changes, all ten cavers were in the tiny camp at once. It looked a lot like the old how-many-people-will-fit-into-a-VW-Beetle contests. Luckily, the cavers were in good spirits and tolerated each other well.

About a week later, some of the first cavers returned to the surface, and Matt Oliphant, Paul Medhurst, and Bill Stone joined the camp crew to continue surveying. Bill brought in some 7-millimeter heavy-duty dive line. The push team was short on rope, so they used the dive line to rig the many short nuisance drops.

On their last survey trip, the team broke the 1000-meter-depth mark, but the passage was still just as miserable. In one place, the passage was 8 meters high, but too narrow to continue. After drilling and hammering the bedrock wall and taking off their vertical gear, they were finally able to squeeze through. At that spot on the way back out, Charley tried to get through the squeeze with his vertical gear on. He wedged himself in the passage, but he formed a human dam, and the water in the stream started backing up and threatened to submerge his head. He backed out and reconsidered his tactics.

The underground camp was used for ten days, although no caver stayed for the entire time; five or six days was enough to get sufficiently trashed. The trip was very productive, and Charco was now 4.6 kilometers long and 1,019 meters deep. The line plot still looked the same, an almost straight line heading north-northwest toward the resurgence. And the passage continued to be tight, nasty, and loose.

The lure of a connection into the Cheve system overpowered the memories of the small passage and cramped camp. A smaller group returned in April 2001. The survey trips from the underground camp had become too long to be done in 12-hour shifts, so now there would only be room for one group of six cavers to stay in camp. At first, the surface crew was plagued by injuries. Pete Hartley was recovering from knee surgery, Tommy Shifflett showed up with a horrendous toothache that turned out to be an infection, and Gustavo Vela tripped in the middle of the night and badly bruised his foot while chasing a dog that was stealing food from the kitchen. Rest and medication cleared up most of the problems. After a few days of setting up the surface camp, organizing gear, and making some initial gear hauls into the cave, an underground group was ready to go. Tony Seddon, Charley Savvas, and José Soriano, all veterans of the underground camp, headed in first. Their job was to continue the gear shuttles and set up the underground camp. Matt Oliphant, Tommy, and Gustavo left for camp the next day. This was Tommy's first camp in Charco, but Tommy, with years of experience in some of West Virginia's most difficult caves, seemed to enjoy Charco's obstacles.

The cavers stayed underground for a week. Unfortunately, the end of the survey was so far away from the underground camp that most of the caving time was spent in transit, and not a lot of time was left for surveying. By the end of the week, they had managed three long survey trips, netting 661 meters of passage and adding 124 meters to the depth. The cave continued as it had been, narrow, straight passage, heading roughly north-northwest.

When the cavers headed out of the cave, they were in for a big surprise. The weather hadn't been great during the week they were underground, and it had been raining steadily for two days before they left for the surface. The stream level in the cave wasn't affected much, although they did notice a little more flow on the way out. But the tight belly-crawl in the entrance area was now filled with cold water. (Recall that when the cave was first discovered, this area had been sumped.) Soriano and Gustavo reached the sumped area first. They thought they had made a wrong turn and retraced their steps, but after searching the very few alternate crevices near the entrance, they reluctantly realized what had happened. After a grueling 12-hour trip from camp, now they had to start bailing. Charley soon joined them, but it still took about four hours to get through. It turned out there were three sumps at dips in the passage, and since the passage was a tube with no side leads, the only place to move the water was into the next lower dip. That meant when Tony, Matt, and Tommy came out, the sumps had been refilled, and they also had to bail them out. Tony had less patience than the rest and ended up free-diving one of the sumps.

Besides the disappointment of being so close to the surface and having this obstacle in the way, they had another adversity to contend with. Early in the year, a cow had died in the entrance. By the time we arrived in April, the cow was quite ripe and supported a thriving colony of maggots. Most of these maggots had been washed into the sumps. Matt and Tommy were the last ones through, and Matt recognized what all the white "floaters" were. In one spot, when Tommy was squeezing through one of the tight places with his head halfway submerged, Matt pointed out all of the maggots floating in front of his face. This gave Tommy an extra incentive to get through the spot and out of the water quickly. All six cavers gathered in the kitchen afterward to eat a warm meal, recount their adventures, and pick little flesh-eating beasties out of one another's hair.

Surveying the sump. *Tommy Shifflett.*

Matt and Tommy were not satisfied with the relatively small amount of depth that had been added to the survey and figured the other possibility for adding depth to Charco was to go up. With help from Nancy Pistole and Jerry Fant, they pushed every crack and crevice near the entrance. The payoff was small; they managed to gain about 27 meters above the datum at the entrance.

The other goal for this trip was to confirm the link between Charco and the Cheve system with a dye trace. The underground team carried fluorescein to the farthest point they reached and released it into the small stream. Meanwhile, Bev Shade was in the resurgence area, and she placed some dye bugs in several places in the water at the resurgence and along the Río Santo Domingo. After everyone left Charco, a handful of cavers went to the resurgence to collect the dye bugs. The hike down to the river is hideous from the south side, but is relatively easy from the north. The group drove through Huautla and on to San Simón. From there it is an afternoon jaunt to the resurgence, although it requires a river crossing that can be tricky if the river level isn't low. Dr. Nick Crawford at the Center for Cave and Karst Studies at Western Kentucky University generously offered to analyze the dye bugs, since very sensitive equipment was needed for detecting the highly diluted dye. Not surprisingly, the dye trace was positive, so the Charco-Cheve link was confirmed.

Two years later, in March 2003, many of the same people reconvened in Mexico for another push in Charco. After the initial gear shuttles and lots of planning, the first group went in for a seven-day stay. This hardy bunch consisted of Tony Dwyer, Mike Ficco, and Tony Seddon. They used the original underground camp, now called Camp 1, for one night, but Camp 1 was too far away from the end of the survey to use as a base. The next day they continued farther into the cave. At one point they had to climb up and traverse above the stream because the passage below was too narrow. Before they dropped back down into the streamway, they set up Camp 2. It was just wide enough that they could hang hammocks across the passage, although the hammock anchors were a bit shaky in the loose rock walls. The breakdown floor was made up of sharp rocks, so they cleared a flat spot for cooking. This was hardly an ideal camp spot. There were many holes in the floor, so if anything got dropped, it fell down into an inaccessible part of

Charley Savvas negotiating one of the many nuisance drops. *Tommy Shifflett.*

the stream below.

In two long push trips they surveyed over a kilometer of passage, to a sump. About 300 meters before a sump, the nature of the cave changes. While most caves tend to get bigger as they get deeper, the main stream passage in Charco remains straight, small, and narrow, best described as a cheese grater, with tight squeezes even below –1,000 meters. But just before the sump, the stream passage intersects a borehole almost 10 meters wide by 10 meters high in some places. The upstream section of the borehole is blocked by flowstone, and the downstream section leads to the sump.

The group briefly tried to find a bypass, but they were on a schedule and needed to leave to make room for the second team coming in. This group was Matt Oliphant, Charley Savvas, and Tommy Shifflett. The hammocks were not set up for a tall person like Matt, so he spent several hours rearranging rocks to make a bed. They spent five days underground and, in one very long push trip, checked every possible nook and cranny, but could not find a way around the sump. Matt swam around the sump pool looking for a way on. Finally, they packed up the camps and made the long and tortuous trip out of the cave for the last time. At each climb, squeeze, or generally hideous place Charley and Matt celebrated. "This is the last time we are ever doing THAT again!"

While the end of the cave was being explored, the cavers on the surface reviewed the map of the cave. There were almost no side leads, but there was one major infeeder a little way before Camp 1. Because the spray of water coming into the main passage couldn't be avoided, it was called The Showerhead. The surface crew figured that this might be the last chance to explore Charco, and this infeeder really needed to be checked out. Luis "Wicho" Díaz, Mariano Fuentes, Jason Siemion, and Nancy Pistole timed their trip so they could make one long push trip into the infeeder, spending two nights at Camp 1 when the deep teams weren't using it. After a rather hairy climb up a chimney to avoid the flow of water from the lead, they squeezed into a very low passage. This opened up, and the passage trended upward, varying between tight belly crawls and fair-sized rooms with high ceilings, for 350 meters. While most of Charco has no formations to speak of, this passage has alcoves choked with formations. The water cascades over pretty flowstone shelves and white, bulbous calcite. The team ran out of time and turned around at a nasty tight spot.

Tony Seddon, who had been out of the cave with the rest of the first camp team for less than 12 hours and had heard about the unfinished Showerhead lead, convinced Mariano and Nancy that it could be checked out on a long day-trip from the surface. So the three of them went back to the nasty tight spot at the end of the survey there and continued pushing. They managed to map another 52 meters before they came to a place where the water poured out of small holes that were definitely too tight. They checked out a short, dead-end side lead and admired some of the very pretty formations in the stream passage. This area was named the Winter Garden. Altogether, the Showerhead passage added over 400 meters to the length of Charco. The survey climbed almost 100 meters of elevation, but its end is still well below the surface, over 300 meters deep.

With all the data tallied, Cueva Charco is 1,278 meters deep and 6.71 kilometers long. This makes Charco the third-deepest cave in Mexico, behind Sistema Cheve (1,484 meters) and Sistema Huautla (1,475 meters). There are some features of this cave that make it quite different than the other deep systems in Mexico. Charco has one entrance and very few side passages. The length of the passage that must be traversed to get from the entrance to the sump pool is 6.08 kilometers, and the depth from the entrance to the sump pool is 1,243 meters, so the main route covers over 90 percent of the entire cave. The longest rope drop in the cave is 33 meters. There are dozens of short nuisance pitches, but most of the depth is obtained by climbing and scrambling. Most of the shorter drops were rigged with 7- or 8-millimeter rope; the longer drops and the ones nearer the entrance were rigged with 9- or 10-millimeter rope.

The line plot of Charco adds an important piece to the Sistema Cheve puzzle. The hope was that Charco would cut over toward Cueva Cheve and a connection would allow access to the lower part of Cheve, beyond the boulder choke that is currently preventing further exploration. But Charco, like other caves in the area, points in the direction of the resurgence. Charco drops to a sump kilometers away from the resurgence, so the conclusion is that there is a labyrinth of passages below the water table that eventually drain out to the resurgence. This knowledge significantly reduces the area of the middle karst that needs to be searched for caves that will connect into the Cheve system below the boulder choke and above this underwater labyrinth.

During the years that crews were working deep in Charco, groups on the surface were searching for other cave entrances nearby. Several pits were found, the deepest being 65 meters, but they all ended. Cueva Palomora was the most promising of the bunch. After squeezing through a very narrow crack, cavers found a slightly wider passage

Peter Haberland is glad to be out of the cave. *Monte Paulsen*.

for a short distance, but then it pinched back down and was too tight to follow. The depth of Palomora is 142 meters, and the length is 262 meters.

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We want to thank several sponsors who continued to support us throughout this endeavor: Cancord Inc., who generously made us nylon rope specifically for the trip, Richmond Area Speleological Society, Dogwood City Grotto, National Speleological Society, Gonzo Guano Gear, and Huntsville Grotto. We would also like to thank all the cavers involved for not getting injured in the cave, as any kind of serious rescue beyond the first kilometer would have been impossible.

## La Epopeya de la Cueva Charco

La Cueva Charco está en el carst intermedio entre la Cueva Cheve y su resurgencia en la Cueva de la Mano en Oaxaca. Fue descubierta en 1989. El primer kilómetro de cueva fue topografiado hacia 1994. En 1999 comenzó la exploración en forma para buscar una posible conexión con la sección hasta ahora inaccesible de la Cueva Cheve más allá del límite explorado actual. La mayor parte de la cueva es lineal y sus 1243 metros de profundidad se alcanzan después de una serie interminable de pequeños tiros y desescaladas. Casi todos sus 6.7 kilómetros de longitud están en el pasaje principal, que es pequeño y frecuentemente apretado, aunque cerca del final de la cueva, hacia el sifón terminal, es más grande. Se utilizaron dos campamentos subterraneos bastante incómodos durante la exploración.

## 40 Years Ago

# THE DISCOVERY AND DESCENT OF SÓTANO DE LAS GOLONDRINAS

T. R. Evans and Bill Deane

Sótano de las Golondrinas, San Luis Potosí, was discovered by cavers on December 27, 1966, and first descended on April 2, 1967, forty years ago. The announcement of its discovery was electrifying to American cavers, most of whom had previously heard of no pit deeper than 426-foot Surprise Pit in Fern Cave, Alabama. While no longer the deepest in the world or even in Mexico, Golondrinas is still often considered the grandest and most beautiful pit, due to its classic shape. For the subsequent history of the cave and a foldout map, see AMCS Bulletin 10, *Caves of the Golondrinas Area*. Here are reports from those times. All of the articles have been lightly re-edited.

*From a trip report by T. R. Evans that appeared in* Association for Mexican Cave Studies Newsletter*, volume 2, number 6, for December 1966 (published March 1968). Others on the trip were Charles Borland III and Ronald Stearns.*

An area west of Aquismón, SLP, shown on a Mexican topographic map contains many large *dolinas* and sinks occurring between 750 meters and 1000 meters above sea level and a few as high as 2000 meters. (The elevation of Aquismón is about 100 meters.) We decided to spend a few days hiking in the area to determine what exists in the way of caves and pits. Since our purpose was to reconnoiter the region, we did not burden ourselves with rope and climbing gear, but we did take carbide lamps, flashlights, and helmets so we could briefly explore any horizontal caves we happened to find.

Arriving in Aquismón around 5 p.m. on December 26, we ate supper and started the hike up to a village called Tamapatz, roughly 15 kilometers from Aquismón and 650 meters higher. By 7 p.m. we were plodding along in the moonlight and quite tired, so decided to camp. At this point we were already in Tlamaya-like karst. Continuing on the next morning, we arrived at a place called La Laja, where there is a small store where one can buy various *refrescos* and fruit. We were told of several caves that exist in the area, but visited none.

At La Laja the trail forks, the one to the left going to Tamapatz and the one to the right to a ranch and other trails that lead to Tansosob, Rancho Nuevo, and eventually to Tamapatz, too. A house is located at this junction, and the owner informed us of several caves and pits in that area. He described one large cave off to the left of the trail leading to the ranch, and we decided to have a go at finding it. The gentleman was unable to go with us because he had injured his ankle. Leaving our packs at his house, we set off. It was evident from the beginning that we had little hope of finding the cave, and finally we came across some lads clearing brush from under the coffee trees. Yes, they knew of caves and would show us some, and they took us to a couple of small shelter caves. What about sótanos? Sure, there was a big one on down the trail off to the right, only a half-hour's walk away. Being truly desperate to find something other than shelter caves (got to keep up the image, you know), we bombed off to find the pit, again with no guide, as the youths had to remain working. We eventually arrived at another house and stopped to inquire if anyone there knew of the pit. Oh yes. Half-hour's walk away, really big and very *profundo* . . . and birds, too—lots and lots of birds, especially in the morning and in the evening. Called the Sótano de las Golondrinas. A guide was provided, and, filled with enthusiasm, we departed. A half-hour later we were dripping with sweat and on the verge of exhaustion. We had to stop and rest—we the gringos, that is. Stopping and resting while walking is apparently a Yankee habit that the locals don't practice. From then on, it was willpower that forced us onward and upward until we finally reached the sótano.

A wooden gate is encountered on the right side of the trail, and from there a trail leads past a hut to a *milpa* and the pit. The pit is on the side of a hill and one walks up to it. No water appears to drain from the surface into the pit, which is 150 to 200 feet across. On the side of the sótano opposite the trail, the walls are about 100 feet higher. This pit is deceptively large, and when we first looked down, all we could see was the opposite wall until we got close enough to lean over the edge and have a better look . . . and then we could see nothing but inky black. The pit is completely overhung at the point the trail intersects it, although it might be possible to rig it so the rope would be near a wall for a good part of the way.

After a while, the vague form of a

bottom could be seen, and it looked a good 300 feet deep. Now it was time for that special event most pit cavers enjoy, rock dropping. The hectic search for rocks was on, and none could be found near the edge of the pit. Finally some were found 50 feet away or so, and a watch was made ready. Leaning over the edge, I dropped the first rock, which was 6 to 8 inches in diameter. Down it went. In five or six seconds the great crashing sound would be heard . . . not a sound. Eight seconds, nine seconds . . . nothing. Finally, after 9.5 to 10 seconds, the roar of the rock falling through the air could be heard, and after 10.5 to 11 seconds the sound of the rock hitting bottom was heard. Some pits look deep and others don't. This one just didn't look 10.5 seconds deep, and naturally we dropped another rock. Same story. The rocks were all about the same size, and they could be seen for about 8.5 seconds, after which there was not sufficient light, although, as I said, the vague form of a bottom could be seen. And it took between 10.5 and 11 seconds for the sound of the rocks hitting bottom to be heard after the rocks were dropped. Convinced the pit was pretty deep, we headed back down the trail to our packs. Even though there appears to be no surface drainage into the pit, it should prove interesting upon further investigation.

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*From a trip report by T. R. Evans in* Association for Mexican Cave Studies Newsletter*, volume 3, number 1, for February 1967 (published September 1968). Some of the party continued on from Golondrinas to Hoya de las Guaguas.*

Immediately after returning to Ft. Detrick, Maryland, after the December 1966 trip to the Aquismón region, we began making plans to return in order to investigate Sótano de las Golondrinas, which we had been shown. Chuck Borland and Ronald Stearns, who were along on the first trip to the area, decided that they would be unable to return in April, coincident with the University of Texas spring break, but there were several other members of the FTA Grotto who could go at that time. We wished to return as early as possible to avoid the rainy season. Thus four of us planned to go, Bob Hugill, Jon Morse, Sid West, and I. We were to be joined by John and Sandy Cole, Bill Cuddington, and Dan Hale from Huntsville, Alabama. Bill Deane planned to go from Austin. Cuddington had heard about the pit and offered the use of his rope. The trip would have hardly been possible without it, as all the other Austin cavers were planning a big push in the Sótano de San Agustín at Huautla, Oaxaca, that would require every foot of rope they could lay their hands on.

Having timed rocks falling down the pit, I was interested in predicting a depth for the pit. Solving a differential equation and running the solution on a computer, I found that the pit could not be less than 800 feet deep. We had timed rocks at 10.5 to 11 seconds free fall, no bouncing, and allowed 9.5 seconds for the fall and one second for the sound to reach the top. All concerned waited for the trip with great anticipation.

Bob and Jon had begun caving since arriving at Ft. Detrick, while Sid had been in several caves in California. Sid had done some vertical work, but the others from the FTA had not, and I hadn't done much recently. Upon receiving our order from Recreational Equipment, we began practicing. Weekends found us at Hell Hole in West Virginia or going off the cliff at Harper's Ferry. During the week, we practiced on a 300-foot rope run over a tree limb and were able to Jumar 300 feet at a time in that manner. I saw to it that Bob, Jon, and Sid became proficient at prusik knots as well. I figured if they could make it to the top, they could haul me up. The Huntsville group and Bill Deane were all well versed in vertical work.

Prepared and ready, we of the FTA got a military hop from Washington, D.C., to San Antonio, Texas, courtesy of the Air Force. My father met us there and drove us on to Austin for supper and a repacking session. Later that same night, March 29, I borrowed one of the family cars, and we set out for Laredo. Arriving in the wee hours of the thirtieth, we parked the car and hiked across the bridge to the Mexican customs house and got our tourist cards, then went directly to a bus station and got a bus to Monterrey. In Monterrey we made immediate connections for Valles. Around 2 p.m., while the bus was stopped in Cd. Victoria for a break, we noticed the group from Huntsville driving by and hailed them down. We agreed to meet for supper in Valles and also found out that Squire and Nancy were coming down from the east and picking up Bill Deane in Austin on the way. Later that evening we all rendezvoused at one of the hotels in Valles and planned to meet again the next morning to go on to Aquismón.

The Huntsville group went down to Xilitla in order to get a friend of John Cole's, Sandino Techo, who came along and helped us translate. Squire took the rest of us directly to Aquismón, where we talked with the *presidente* and inquired about getting some mules to haul some of the packs and rope up to the pit. We found that no mules would be available until the following morning. Squire, Nancy, and those of us from Ft. Detrick had planned to hike up with our packs, so gave 500 feet of our rope to the others, who were hiking up the next morning with the mules. Squire and Nancy carried the remaining 300 feet of our rope. Bill's "python" and another 1000 feet of rope went on the mules.

Having hiked in the area before and realizing how hot daytime hiking gets, I suggested that we start up that evening around 6 p.m. or so. After purchasing several liters of *caña*, an alcoholic liquid distilled from sugar cane that serves as a beverage-maker or fire-starter (it burns with a smokeless blue flame), we started up the trail. By the time we reached La Laja, roughly half way to the pit, we had been joined by a couple of locals and stopped to have a few relaxing drinks of a *caña-refresco* variety before retiring for the night in a small hut there that serves as a refreshment stand. In fact, the few drinks developed into quite a party. The following morning we completed the hike to the pit after collecting millipedes near La Laja and having breakfast there.

We arrived in the vicinity of the pit in the early afternoon and arranged to stay at a house about a mile below the pit. We had the woman of the house cook our food for us and prepare the odd pot of coffee. Several chickens, a dog or two, and the odd pig shared the hut with us. There is a small hut at the pit, but it was not large enough to accommodate our entire group.

The remainder of the party arrived with the mules and the rest of the gear a few hours later. All had a look at the pit, and no one was disappointed. Squire produced his timepiece and we timed several rocks. He got consistent times of 11 to 11.5 seconds. Since we were all tired from the hike, we sacked out rather early that evening in preparation for the rigging and descending of the pit the next day.

The following morning, April 2, we rigged the pit with Cuddington's Samson 2-in-1, and I, being the only one along on this trip who was a member of the discovery group, went down first. Assisted over the edge by several people, I began the descent on a single brakebar rappel. After five feet of virtual free-fall, I let my prusik safety catch and, again with assistance, added another carabiner and brakebar and continued on down. With a double brakebar rig, I had no trouble at all, but, as Bob Hugill found out, two brakebars for a lightweight person can cause feeding problems. Bob had to feed the rope for several hundred feet. The best answer is the rappel rack designed by John Cole. These racks worked very well.

Reaching the bottom after a half-hour, I talked with the group on top via walkie-talkie (excellent items to have along) and headed out across the floor of the pit, which is all well lighted by daylight from the top of the shaft. After ten minutes or so, the top called and asked me to return to the foot of the rope to safety Bill Cuddington down. I turned around and couldn't see the rope, and after a couple of minutes of looking, still couldn't see it and told the people topside the trouble I was having. Finally I got the wise idea of retracing my footprints back across the dry bird guano and did just that. The immensity of the pit finally dawned upon me. Bob Hugill and Dan Hale followed Bill Cuddington in. With some difficulty a second rope was rigged, giving us one for rappelling and one for prusiking or Jumaring. The second rope consisted of three tied together. Bob and I went out the same day, while Bill Deane rappelled in to spend the night with Bill Cuddington and Dan Hale. We threw in their down sleeping bags after untying them, and they were quite a sight as they drifted down the shaft. It took more than a minute for them to reach the bottom. The following morning John Cole, Sid West, and Jon Morse made the descent. Sandy Cole was busy, along with Sandino, keeping watch over things topside. Sandy also occupied a lot of her time trying to undo two 500-foot ravels of parachute cord that were to be used in measuring the pit. Squire and Nancy, having helped carry gear up and having assisted during the first day, returned to Aquismón.

By the evening of the third day at the pit, April 3, we were all safely back on top and out of what is certainly quite an awesome pit. The morning of April 4 found us packing and getting ready to hit the trail. The pit had been derigged the previous evening and the ropes fed directly into duffle bags as they were pulled up. The mule driver and mules arrived at 8 a.m. and were loaded up. We from the FTA gathered our gear and headed on to Tamapatz for some more caving. We hired a local Huastecan to carry our 500 feet of rope and draped the 300-foot chain across our shoulders. The others headed back towards Aquismón and thence to Austin and Huntsville.

The depth of the pit from our rigging point turned out to be 1094 feet. The pit is roughly 200 feet in diameter at the top, belling out on all sides until at the bottom the pit is 1000 feet long and 440 feet wide, containing 10 acres. There is 246 feet of relief on the floor of the pit alone. Virtually the entire floor of the pit is lighted by daylight, and a person on the bottom can be seen from the top . . . as a speck. The tremendous size and depth, the hundreds of green parrots, and the thousands of swallows all contribute in making a trip to the pit worthwhile. One's clearest impression of the size is gained on the way out. No cave passages were found at the bottom.

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*Article by Bill Deane, reprinted from the* NSS News*, volume 26, number 3, March 1968.*

In December 1966, T. R. Evans, Randy Sterns, and Charles Borland hiked up into the mountains west of the small town of Aquismón in Mexico to investigate the area for its caving potential. They followed a well-traveled mule trail leading to the town of Tamapatz. Along the way, Indians told them of a deep pit with many birds living in it. It was called the Sótano de las Golondrinas.

Arriving at the awesome entrance, the three cavers were stunned when they found that a rock dropped into the pit took more than ten seconds to reach bottom. This indicated a depth of over 800 feet. The pit was not entered at this time due to the lack of a long-enough rope.

The morning of March 31, 1967, found twelve of us arriving in Aquismón. Squire Lewis and Nancy Walters had come down from Pennsylvania and had given me a ride from Austin. T. R. Evans, Jon Morse, Sid West, and Bob Hugill had come from Maryland, Bill Cuddington, John and Sandy Cole, and Dan Hale had come from Alabama. Sandino Techo, a friend of the Coles, had come up from Xilitla, Mexico.

By chance our arrival occurred just as the elementary school began its morning recess. We soon found ourselves surrounded by fifty curious children, while an equal number of just as curious adults discreetly eyed us from a distance. Our first act was to inform the *presidente* of our intentions and ask him for aid in locating a mule team to carry our equipment. Soon the police chief was escorting T. R. around the town, but to no avail. After two hours of talking, we learned that all of the mule drivers were already gone for the day. We had arrived too late in the morning. By noon we had become rather discouraged. Then our luck changed. A mule driver who had come down from Tamapatz agreed to carry our equipment up the next morning. Squire and Nancy were eager to see the countryside, so they, T. R., Bob, Sid, and Jon decided to hike part way to the sótano that afternoon. The rest of us would hike up with the mules the next morning.

Early the next morning the remaining six of us were back in Aquismón. Again our arrival coincided with a school recess. We began to feel that these recesses were spontaneous in nature. We assumed that T. R. and his group had traveled two-thirds of the way the previous day and would arrive at the sótano by 1:00 p.m. Traveling much faster with the mules, we expected to arrive at the pit only three hours after they did. While our mule driver loaded the equipment, John and Sandino amazed the children with a

# THE ASSOCIATION FOR MEXICAN CAVE STUDIES

P. O. BOX 7672 UNIVERSITY STATION AUSTIN, TEXAS 78712

17 April 1967

Dear AMCS Member:

During December, 1966, T. R. Evans, accompanied by Charles Borland and Randy Sterns, was led to Sótano de las Golondrinas, located in the Sierra Madre Oriental, south of Ciudad Valles, San Luis Potosí. Having no equipment, they were unable to enter the pit but noted that a rock required more than ten seconds to reach the bottom.

Then, on 5 April 1967, several members of the Association for Mexican Cave Studies led by T. R. Evans made the initial descent and exploration of Sótano de las Golondrinas. In addition to T. R., those entering the pit included Bill Cuddington, Bob Hugill, Dan Hale, William Deane, John Cole, Jon Morse, and Sid West.

Briefly described, Sótano de las Golondrinas is a tremendous pit about 125 by 175 feet (38 by 53 meters) at the entrance. From this point it continually enlarges until the floor is reached, which was estimated to be 400 by 800 feet (122 by 244 meters). The free-fall drop from the rigging point, which was on the lowest side of the entrance, to the floor was 1070 feet (326 meters). No passages were found leading from the bottom of the pit. When completely surveyed, the total depth of the cave will be about 1300 feet (396 meters).

Complete details of the exploration of this cave, and all others visited by AMCS members, will appear in future AMCS publications.

Sincerely,

Terry Raines

Terry W. Raines
Editor

demonstration of our walkie-talkies. Soon we were packed and began the hike. It is only 15 kilometers from Aquismón to the sótano, but we found the going slow due to the heat. We questioned several Indians we met on the trail and learned of two other caves. One was a pit called the Hoya de Guaguas. T. R., Bob, Sid, and Jon later found it was a 400- to 500-foot drop to a sloping platform and then a 500- to 700-foot drop. This pit is still unexplored. The other cave is visible from the trail. Its entrance is about 20 by 75 feet, but it is only 100 feet long.

That evening the twelve of us gathered together at the edge of the sótano. Words cannot fully describe the impressive entrance. It is an immense hole descending into nothingness, surrounded by jungle. A plane-table survey conducted later, in June, measured it to be 160 feet by 205 feet. The western edge is 100 feet higher than the eastern. Squire took out his railroad watch and began timing the large rocks we were dropping into the pit. It was amazing to watch them fall and fall and fall. Then you would hear a distant boom as they hit bottom, and Squire would announce "11.5 seconds." This was rather amusing, since T. R. had told us it was a 10-second drop. This extra 1.5 seconds meant that the pit was 200 to 300 feet deeper than the 800 feet we had expected.

Adding to the beauty of the sótano are the thousands of green parrots and tens of thousands of swallows, or *golondrinas*, that nest in it. At sunset the swallows return from the jungle and fly in a great circle above the pit. To enter the pit they fold their wings and dive into it at speeds estimated to be 50 to 60 miles per hour. They dive for several hundred feet before opening their wings to slow themselves. The parrots try to imitate the dive-bomb tactics of the swallows. However, they are not very graceful, and it was not unusual to see a tangled blob of green falling into the pit, screeching its head off.

Arising early the next morning, we began our preparations for the descent. Our main task was to rig the rope into the pit. Bill Cuddington had brought his 1180-foot section of half-inch diameter Samson 2-in-1 nylon braid rope. Exhaustive tests have shown this to be the finest known rope for use in vertical caving. Its main characteristics are that it doesn't spin, has very little stretch, and tests at 7500 pounds tensile strength. To prevent the rope from snarling with itself, Bill had braided it in eighths rather than coiling it, as is normally done. Braided, the rope was about 40 feet long and 7 inches in diameter. It looked like a giant white python. We carefully unbraided it and laid it around the edge of the pit. Then we slowly lowered one end into the pit and secured the other end to a 70-foot rope wrapped twice around a limestone outcropping. The operation required most of the morning. We could see that the rope touched bottom. We knew that 1165 feet of rope was actually hanging in the pit.

Since it was the efforts of T. R. that led to the discovery, he had the honor of being the first down. T. R. put on his rappelling equipment and sat by the edge. Bill and John pulled up several feet of rope to create slack so he could rig on and ease over the edge. Great care was needed, since the weight of the rope, 65 pounds, made it very awkward to handle. Once over the edge, T. R. arranged his pack and began the rappel. He carried one of the walkie-talkies with him, but we had agreed beforehand that, except for emergencies, there would be no radio contact until he was on bottom. About 20 feet down he pushed aside a small tree limb. This was the last thing he was to touch besides the rope for the rest of the rappel. From there on, the walls continually recede away as you go down. When you land on bottom, the nearest wall is 200 feet away.

Our proceedings had been watched very quietly by about twenty Indians. The sótano had been a common feature of their lives, and I doubt if they had ever considered that someday someone would go down it. The minutes passed slowly. I kept myself busy photographing the descent. It was fantastic watching T. R. disappear into the blackness below. Finally, after 30 minutes, we could see that he had reached bottom. A few more minutes passed while he derigged. Then came the radio call we were waiting for. A very astonished T. R. informed us, "You won't believe the size of this place!" After giving us a brief description of the bottom, he began walking around looking for leads.

Bill Cuddington rigged onto the rope and began his rappel. The Indians couldn't believe their eyes. It was bad enough to see one man disappear into the immense sótano, but to see a second man go in was simply too much. From then on our audience stayed with us constantly and grew in numbers. After Bill was down, Bob rigged on and became the third person down.

To speed things up we decided to rig a second rope. We tied John Cole's 869-foot section to his 267-foot section. After the rope was let out, Sandy asked over the walkie-talkie how much was laying on bottom. Bill replied, "The rope is still 70 feet off the floor, let some more slack out." She laughed and told him we had let all the rope out. We estimated that 1030 feet of that rope was hanging in the pit, and yet it wasn't enough to reach bottom.

(In June, a second AMCS team conducted the plane-table survey mentioned earlier. They found that the minimum possible drop happened to be where we had rigged the second rope and was 1094 feet. It was a 1098-foot drop where we had rigged the first rope. This broke by 64 feet the existing world's record held by the Lépineux entrance of the Réseau de la Pierre Saint Martin in Spain. Mexico had produced her first world's record.)

Dan rappelled in next, carrying a 300-foot section of Goldline rope. After Dan reached bottom, T. R. began the prusik out carrying the same rope. He climbed about 80 feet and stopped. Bob, Dan, and Bill pulled the rope he was on over to where he could reach the dangling end of the second main line. He tied the 300-foot rope onto the end, giving us a second complete rope to the bottom. Using Jumars, Bob prusiked up to T. R., and together they continued up the rope. It took them 2.5 hours to reach the top. T. R. was grinning like a Cheshire Cat as he came over the edge. Three days later he was still grinning.

Meanwhile, Dan and Bill had decided to spend the night on the bottom. I agreed to bring down the necessary camping equipment and join them for the night. By this time it was sunset, and the birds had returned. I decided to let them finish entering the pit before I rappelled in. Following Bill's suggestion, we opened up the sleeping bags and threw them into the pit. They floated down like big leaves, taking over a minute to reach bottom.

My rappel was fantastic! Night had begun, and by the time I was 200 feet down I couldn't see my hand in front of my face. The entrance was faintly visible against a starry background. I purposely hadn't turned my carbide light on because of the danger of burning the rope. The only way I could tell I was moving was the motion of the rope slowly passing through my hand. I was using a rappel device designed by John Cole called a rack. It is the finest rappelling device yet designed. The ability to add more brake bars as you descend is a must on a long drop such as this.

Touching down, I was given an interesting welcome by Bill Cuddington. He said, "Hi, Bill. Hope the bugs don't get worse. Sit down and rest." Turning my light on, I was soon enveloped in a cloud of insects. I hastily turned it off. After I rested, we set off across a brown desert of bird guano. It covers 95 percent of the bottom. We spread a plastic tarp over the guano and put our equipment and sleeping bags on top. I should mention that the guano is odorless, dry, and looks like peat moss. It makes a tremendous mattress. We ate and talked for a while and then went to sleep. The night was uneventful, except that around midnight an animal the size of a cat visited us. I should add that the birds never shut up.

I woke at 7 o'clock the next morning. Rolling over, I looked out onto a bizarre and awesome sight, the bottom of Golondrinas illuminated by daylight. The bottom measures 440 feet wide by 995 feet long and changes nearly 150 feet in elevation. The lowest point is a mud sump 1306 feet below the high side of the entrance. The guano is the dominant feature of the bottom. In places it is over 6 feet thick. Numerous green plants and mushrooms grow in it. Insects, salamanders, and centipedes make up the small animals that live in it. Most of the small animals live in the center of the pit, where debris falling from outside adds to the food supply. Dark-brown salamanders were observed near the spring in the northwest cornet of the bottom. The animal that visited us during the night probably lives off of the birds.

The sótano is developed along a major fault. From the bottom you can see where several old stream passages used to pour into the pit. They are all now plugged with fill. The fault must have occurred millions of years ago. Underground streams and surface drainage began pouring into cracks, continually enlarging them. The pit began to slowly cave in on itself. As the debris collapsed, much of it fell below the water table. This debris was dissolved away, and more debris replaced it as the pit continued collapsing. Finally the pit broke the surface. The original floor, if you can call it that, is probably several hundred feet below the present existing floor.

After the birds had finished their morning exodus, John rappelled in. He was soon followed by Sid and then Jon. There were now six of us on bottom.

At noon I started the prusik out. Dan rigged onto the same rope 30 minutes later and came up after me. We maintained a 250- to 300-foot separation. The prusik was the highlight of the entire trip. You are nearly in the center of the pit. Now and then great coveys of parrots would break off from the walls and fly in vast circles around the rope. Below you, your friends become smaller and smaller, while the entrance creeps slowly towards you. It took 2.5 hours for both Dan and me to prusik out. On top we found Sandy busily unsnarling a 1000-foot-long nylon cord. It was a monumental effort that took her all day.

Jon and Sid started up the second rope around 2 p.m. The rope was dirty, and Jon, the top man, completely wore out his Jumars. John started up the first rope an hour later, and an hour after that Bill started up after him. Bill had the dubious privilege of prusiking the last 200 feet while the birds were diving into the pit. Just as he came over the edge, he was heard to mutter, "Damn, I'm going to take up checkers."

With Bill's arrival on top, our exploration of Sótano de las Golondrinas was over. We had successfully put eight men on the bottom of the world's deepest known pit. The next three hours were spent pulling the ropes up and stuffing them into duffle bags. It was a tired crew that ate a well-earned supper at midnight.

El Descubrimiento y Descenso al
Sótano de las Golondrinas

El Sótano de las Golondrinas fue descubierto por espeleólogos el 27 de diciembre de 1966 y el primer descenso fue el 2 de abril de 1967, hace cuarenta años. Estas reimpresiones de los reportes describen esos eventos.

*NEW LONGEST CAVE IN MEXICO*

# THE EXPLORATION OF SISTEMA SAC ACTUN 1987–2007

James G. Coke IV
with a contribution by Steve Bogaerts

During a 1987 aerial reconnaissance of the jungle surrounding Tulum, Steve DeCarlo and I spotted what is now the historic entrance to Sistema Sac Actun (White Cave). The Grand Cenote was difficult to locate by land, as it lay in the center of an old milpa overgrown by a thorny and dense coastal forest. After lowering our diving equipment from the rim by rope and pulley, we made our first dives, which erased all the pains of thistles and thorns. We were convinced that the strong flow of freshwater that coursed through white stalactites, stalagmites, cave pearls, and large flowstone formations would yield a cave unlike other underwater caves in Quintana Roo. By 1994, the upstream part of Sistema Sac Actun had grown to over 5100 meters in length. Later, explorations in the Calimba and Pabilany sections by Bil Phillips, Danny Riordan, Steve Gerrard, Kate Lewis, and Pablo Diaz produced a fascinating maze in the northwestern area of the cave.

When upstream exploration stalled, Dan Lins and Bil Phillips cracked the downstream sidemount restriction beyond the Snake Siphon Cenote. By 1999, Phillips and Lins were very close to connecting Sac Actun to surveyed passages in Nohoch Ha, which ran westward from Cenote Naval. Hilario Hiler had conducted the first exploration dives in this large cave system with Paul DeLoach in 1986. George Irvin, Bill Gavin, and, later, Chuck Stevens, Mike Madden, Dan Lins, and Andreas Matthes extended known passage in two separate Naval caves. One cave progressed west towards downstream Sac Actun, and the other, Naval East End, coursed southeast toward Sistema Abejas. Both Naval caves were separated by the large open-water expanse of Cenote Naval. By negotiating the Strangler Roots restriction, Lins connected the western Naval cave to downstream Sac Actun in 1999.

In 2003, Nadia Berni, Dave Sieff, Kim Davidsson, and Robbie Schmittner discovered Cenote Verde, south of Cenote Naval. Within a month, Verde was connected to both the Nohoch Ha part of Sistema Sac Actun west of Cenote Naval and the Naval East End cave, bypassing the open water in Naval and joining East End into the system. There was then only a 250-meter gap between the southern end of Sac Actun, in the Naval East End section, and the northern tunnels of Sistema Abejas. As imminent as the connection seemed between Sac Actun and Abejas, it would take over a year to find a connecting tunnel.

Cenote Ka'as is an ugly place. It is positioned on the edge of an active quarry, and the opening is low, which forces a diver to bend over or crawl for thirty meters while carrying his equipment. Once in the water, the finds a cave that is gnarly and highly unstable. For these and other reasons, Robbie Schmittner chose to call it Ka'as, meaning ugly in Maya. The GPS location placed Ka'as equidistant between Sac Actun and Abejas, but it seemed hopeless, as past mining activities created unstable conditions in the Ka'as cave. Huge blocks of limestone shifted at the slightest touch, stirring up silt that created an instant underwater whiteout. Nevertheless, Schmittner and Davidsson pushed a series of forbidding leads until Sac Actun and Abejas were finally connected in the fall of 2004. This important connection brought Sistema Sac Actun to 35.5 km in length.

Mike Madden, Dan Lins, and Andreas Matthes originally explored Sistema Nohoch Kiin (Big Sun) in 1997. The primary goal of this team was to connect Nohoch Kiin to Sistema Nohoch Nah Chich (Big Bird House). Hilario Hiler had found Cenote Nohoch Nah Chich in 1986. In six years, Mike Madden, Chuck Stevens, and dozens of other explorers had extended the length of Sistema Nohoch Nah Chich, which become the longest underwater cave in the world at the time. After its connection to Cenote Manati on the Caribbean Sea coast in 1995, exploration in Nohoch Nah Chich was largely abandoned. The 1997 team explored large, south-trending cave in Nohoch Kiin, but could not find a way through breakdown and small passages heading north or east towards Nohoch Nah Chich.

In spring 2004, I showed Schmittner Cueva Tancah, between Sistema Abejas and the large cave to the north, Nohoch Kiin. Tancah had been explored under the name of Altar Maya by Nic Toussaint, Philippe Brunet, and Christian Thomas. Exploration from Cenote Equinox in the southern end of Nohoch Kiin by Berni, Sieff, Davidsson, and Steve Bogaerts was also pushing southward toward Altar Maya. As Altar Maya would likely prove to be the key to reaching Nohoch Kiin from Abejas, it

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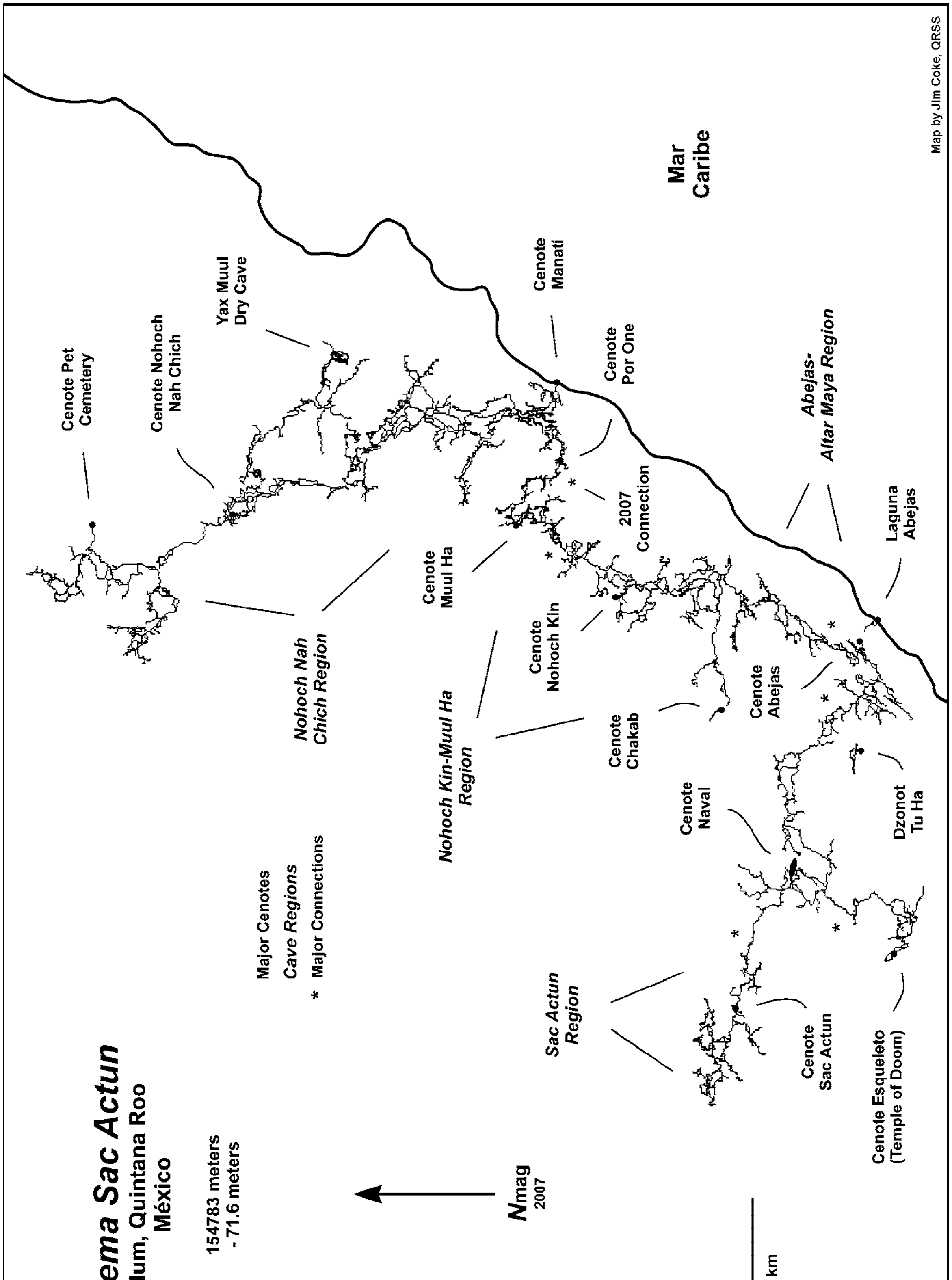
Sistema Sac Actun
Tulum, Quintana Roo
México
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Major Cenotes
Cave Regions
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Nmag
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Map by Jim Coke, QRSS
Cenote Pet
Cemetery
Cenote Nohoch
Nah Chich
Yax Muul
Dry Cave
Cenote
Manatí
Cenote
Por One
Abejas-
Altar Maya Region
2007
Connection
Laguna
Abejas
Cenote
Muul Ha
Nohoch Nah
Chich Region
Cenote
Nohoch Kin
Nohoch Kin-Muul Ha
Region
Cenote
Chakab
Cenote
Abejas
Cenote
Naval
Dzonot
Tu Ha
Sac Actun
Region
Cenote
Sac Actun
Cenote Esqueleto
(Temple of Doom)

was resurveyed during the summer of 2004. In late fall, Abejas was connected to Altar Maya; two weeks later a connection was made from Nohoch Kiin to Altar Maya. With the addition of Altar Maya and Nohoch Kiin, Sistema Sac Actun reached an overall length of 61.9 kilometers, stretching a straight-line distance of 5.3 kilometers from the Grand Cenote to Cenote Nohoch Kiin.

In the fall of 2004, Schmittner, Davidsson, and Bogaerts took up the challenge of connecting Nohoch Kiin and Nohoch Nah Chich. While cruising the jungle, they found a complex of large and small cenotes in the Muul Ha (Hill Water) area. Exploration in Muul Ha revealed cave leading south toward Nohoch Kiin and east toward the coastline and Nohoch Nah Chich. After months of difficult exploration, Bogaerts was able to connect the Nohoch Kiin part of Sac Actun to Muul Ha through a series of small, no-mount passages. Meanwhile, Schmittner was exploring the eastern part of Muul Ha, hoping that an easy connection could be made to Nohoch Nah Chich. By GPS, the caves were separated by 500 meters, which appeared to be an easy distance to traverse. Muul Ha was not being cooperative, though, and continued with a southeastern trend. The tunnels in this area became smaller, the restrictions became more frequent, the cave stayed shallow at the level of the halocline, and silt became finer and more easily disturbed. Solo diving, often in no-mount configuration, became normal operating procedure. With exploration at the limits of their equipment, a new cenote entrance was needed to leapfrog past this miserable section of Muul Ha.

They found one in April 2006, Cenote Por One. This entrance is midway between Cenote Manati and the southeast end of Muul Ha. It was not an inviting place; it too had very small and silty cave. Over the course of two months, Por One was explored west towards Muul Ha and east towards Manati. Meanwhile the two were also busy renewing exploration the southern complex of passages in the Manati area of Nohoch Nah Chich, this time to push small leads towards Muul Ha and Por One.

Less than 75 meters from the entrance to Cenote Manati, Schmittner discovered a tunnel concealed by breakdown that was pumping water out to Manati from the west. In four months, a connection from Manati was made to Por One, leaving 200 meters between the Por One section of Sistema Nohoch Nah Chich and the Muul Ha section of Sistema Sac Actun. This final connection tunnel was explored by Bogaerts and Schmittner in January 2007. I cannot help noting the remarkable fact that I discovered the historic entrance to Sac Actun almost twenty years to the day before the Nohoch Nah Chich–Sac Actun connection, which created a new longest cave in Mexico and longest underwater cave in the world.

Will the cave get longer. By all means. We'll see some interesting developments in the next year. There's still

## THE CONNECTION

On January 25, 2007, Robbie Schmittner and I were finally able to connect Sistema Sac Actun, formerly the second-longest underwater cave in the world, to Sistema Nohoch Nah Chich, formerly the third-longest underwater cave in the world. Sistema Sac Actun is now the longest underwater cave in the world, overtaking the previous record-holder, Sistema Ox Bel Ha. Sac is also the longest cave in Mexico and the ninth longest cave, wet or dry, in the world.

This accomplishment was four years in the making. It has been an incredible adventure and, at times, an emotional roller coaster, as we have been close on several occasions, but not able to make the final connection. At one point in 2004 we had promising leads from both sides and were confident that the connection would be easily made, but they never quite made it, and it ended up taking us another three years to achieve the connection.

The connection was made between the Muul Ha region in Sac Actun and the Cenote Manati (aka Casa Cenote) region in Nohoch Nah Chich. Cenote Por One, an extremely small and uninviting cave, is positioned between these two areas. On January 12, 2007, after eight months of sidemount and no-mount diving, Por One was connected to Nohoch Nah Chich. Seven more days of exploration dives led to the final connection between Sac Actun and Nohoch Nah Chich.

On the day of the connection, Robbie started his dive from Muul Ha in sidemount gear with five tanks, a DPV, and a bottle of Champagne. I began my dive from Manati wearing my sidemount harness over my no-mount rig, with three tanks, a DPV, and a digital camera. My sidemount harness was removed forty-five minutes into the dive, and another forty-five minutes of no-mount diving took me to the end of the line. We timed our dives to arrive at the connection point at the same time, and we placed the bottle of Champagne between our two lines and used it as the final tie-off between the two cave systems.

It is now possible to traverse from the Cenote Pabilany west of Cenote Calimba on the Coba road, around the Grand Cenote (Sac Actun), Cenote Esqueleto (Temple of Doom), Cenote Naval, Cenote Abejas, Cenote Nohoch Kiin, bypass Manati, press on to Balancanche, Cenote Nohoch Nah Chich, by Dinner Hole Cenote, and end up in the Dirty Dog or Pet Cemetery Cenotes. In straight-line distance, that's a bit over 10 kilometers, but there's 152,975 meters (95 miles) of underwater cave to look at along the way.

As Sac Actun was 14,300 meters longer than Nohoch Nah Chich at the time of the connection, following cave-naming conventions the entire cave will now be known as Sistema Sac Actun.

Robbie and I both hope that our work will be useful to scientists and conservationists seeking to learn more about this unique and fragile environment and help it get the protection is deserves. The last four years of exploration have had a radical impact on the appearance of the underground drainage patterns in the area, showing a lengthy connection path parallel to the coast. This may well require rethinking of the regional hydrology and the pollution risks.—*Steve Bogaerts* a lot to look at in Sac Actun, and there are nearby caves that will probably be connected.

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Some early diving in parts of Sac Actun are described in parts by San Meacham and Steve Gerrard ofan article in *AMCS Activities Newsletter* 22, pages 173–176.

A detailed foldout map of Sac Actun af the connection from the west to Cenote Naval is in an article by Bil Phillips, *AMCS Activities Newsletter* 25, pages 78–79.

There is an article about the exploration of Nohoch Kiin by Dan Lins and Andreas Matthes in *AMCS Activities Newsletter* 24, pages 92–94.

An article on the entrance room of Tancah is in *AMCS Activities Newsletter* 28, pages 78–82.

### Exploración del Sistema Sac Actún, 1987-2007

El Gran Cenote, la entrada principal a la parte original del Sistema Sac Actún, fue ubicado desde el aire en 1987. A partir de entonces, muchas conexiones han hecho de Sac Actún la cueva más larga de México. El 25 de enero de 2007, Steve Bogaerts ingresó al Sistema Nohoch Nah Chich por el Cenote Manatí y Robbie Schmittner ingresó al Sistema Sac Actún por el Cenote Muul Ha. Ambos bucearon por pasajes pequeños y difíciles, y al encontrarse unieron Sac Actún, previamente la segunda cueva subacuática en longitud, y Nohoch Nah Chich, previamente la tercera más larga. El sistema resultante tiene aproximadamente 153 kilómetros de pasajes subacuáticos y cerca de 2 kilómetros de pasajes secos. Además de ser la cueva más larga en México es también la cueva subacuática más larga del mundo y la novena cueva en longitud, seca o sumergida, en el mundo.

# SISTEMA YAX MUUL

James G. Coke IV

Sistema Yax Muul is the longest documented dry cave in Quintana Roo, Mexico. At over 1.8 kilometers in surveyed length, it is connected to the Nohoch Nah Chich region of Sistema Sac Actun through two sumps. The primary sump was discovered in 1997 during a series of underwater explorations in Nohoch Nah Chich. Entering through the Lunas y Sombras Cenote over a kilometer away, Eric Noftall observed a huge ceiling fracture that ascended beyond the reach of his primary light. No doubt his air reserves were urging his return back to a safe exit. Yet he ascended the fracture with a knotted guideline, surfacing in a small pool of water in the midst of an air-filled void. Most cave divers in Quintana Roo are reluctant to remove their kit and have a look at dry passage this far from their point of entry. Exploring a warm, dry cave in a thick wetsuit and booties while employing a single light source selected from underwater backup lamps is not an attractive proposal. There is also a small risk of damaging underwater life-support equipment when removing, securing, and then donning equipment in a dry cave. Eric elected to remain geared up in the water, and he surveyed from the water surface down to the survey line in the underwater tunnel. Noting this discovery as an emergency air-bell on Mario's Line in the Nohoch survey data, he had cracked what is now an important sump. It would be another nine years before the sump pool was explored again. The 2006 effort, though, would be from a mapped dry cave, down to the underwater tunnel.

Few cavers or publications have addressed dry-cave exploration or sump diving in Quintana Roo. Nearly all exploration continues to be focused on underwater caves and their cenotes. The physical conditions, such as horizontal topography and a shallow water table, in the usual caving areas near the coast inhibit extensive dry cave development. Exploration history and the resulting growth of the commercial caving business cause a strong emphasis on underwater activities in the area. Mythological and archaeological aspects of area caves can also burden dry-cave investigations. Legends of hidden Caste War bullion and chests of precious gems stockpiled within Quintana Roo caves are rife among the local populace. Also, Maya artifacts are frequently found in dry caves. Suspicious activities that could indicate treasure- or pot-hunting can bring harsh scrutiny by landowners and federal agencies. As dispiriting as circumstances may appear, a small group of cavers has started to explore and document dry-cave development in the area.

We have learned that most dry caves within two or three kilometers of the coast are strongly associated with an old Pleistocene ridge that parallels the general coastline trend. Many coastal caves are positioned under the ridge complex and are influenced by the local structural geology. Beyond an abrupt climb in elevation along the east flank of the ridge, rising from recent unconsolidated Holocene sediments to older Pleistocene and Tertiary limestones, a series of fractures appears below and some distance west from the ridge crest. Fractures may intersect at random locations or remain completely independent. However, most fractures meander in concert with the overall ridge development. Cave passages extend north and south from under the ridge, with occasional departures from the pattern. Thinning or descending strata restrict exploration to the east, toward the coast, of many caves, both wet and dry. Speleogenesis along the main axis of the ridge and, occasionally, to the west appears to be strongest. Past geological episodes of groundwater dissolution that created both dry and underwater caves introduce a unique aspect among coastal caves.

Yax Muul is certainly a result of past speleogenesis, perhaps influenced in part by the evolution of the underwater cave beneath the dry cave. Investigations in areas with both dry and underwater caves, such as Cueva Tancah (see Dominique Rissolo's article in *AMCS Activities Newsletter* 28) and dry Sistema Tishik Kuna, which is near underwater Sistema Templo, show that the dry caves are strongly correlated with their underwater counterparts. Yax Muul is not an exception to this trend. To understand cave development in this region, it's fortunate we were able to survey both the underwater and dry sections of Sistema Yax Muul.

After buying a 50-hectare parcel of land from Ejido San Jacinto Pat, in 2004 Donato Castro invited Robbie Schmittner and me to have a look at six or seven new cenotes on his property. Robbie and I suspected these cenotes were part of the Nohoch Nah Chich underwater cave, but turning down a landowner's invitation is not a productive option. After a morning's trip, GPS and underwater survey data confirmed that nearly all the cenotes were connected to the Nohoch Nah Chich cave. On the way out of the jungle, Donato's wife asked if we would like to see a *cueva seca* that contained a cenote. I agreed, envisioning a small shelter cave surrounding a pool of water. I was very surprised when we arrived at a 1.2-by-0.7-meter hole in the ground. I was

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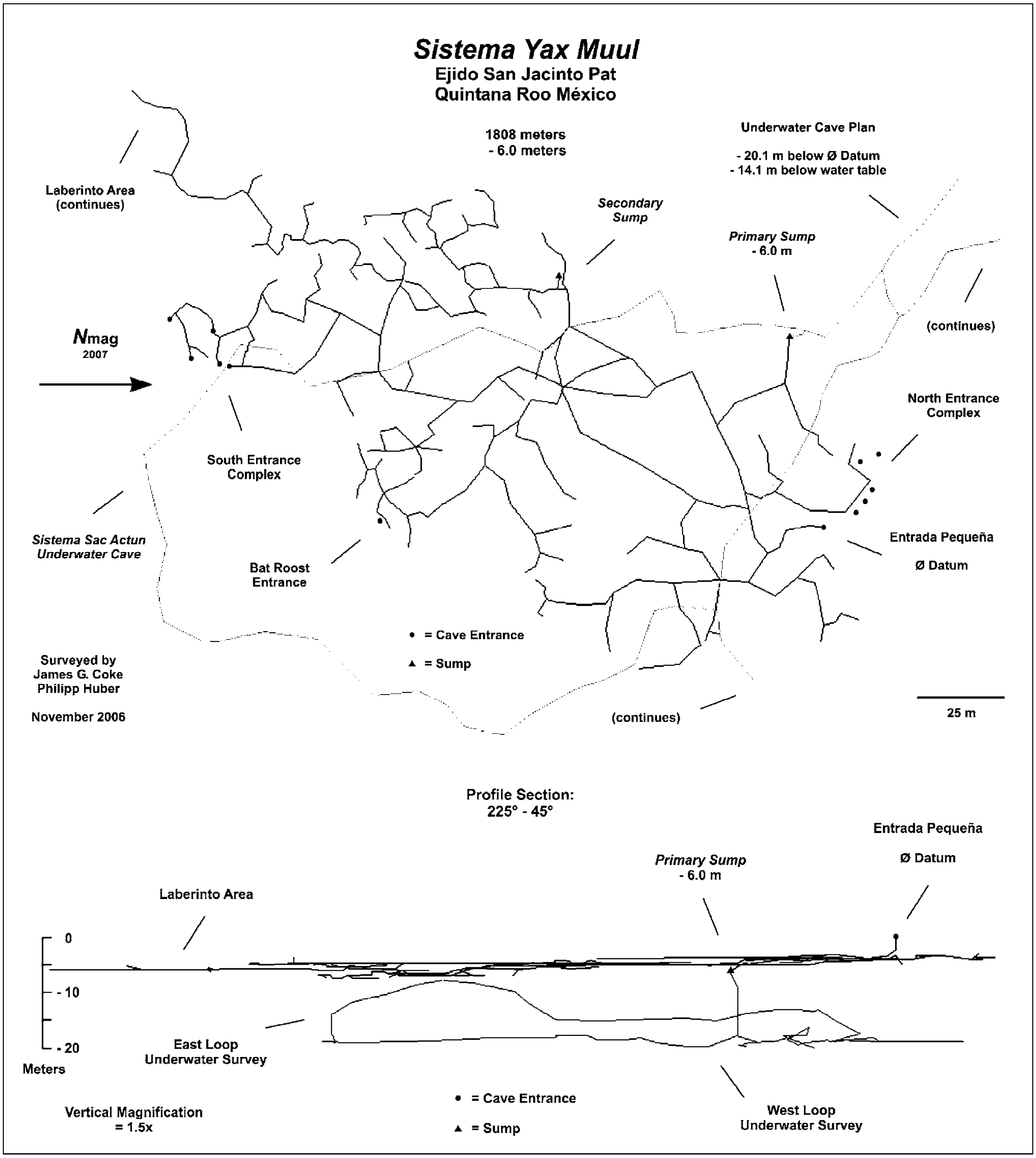
more excited by the steady draft blowing out of the entrance. As I collected a GPS waypoint, Robbie hopped down the 2-meter Entrada Pequeña drop and yelled up, "There's nylon line down here, and it's going all over the place. Are you coming down?"

Without helmets and kneepads and with only two small lights among the three of us, I left my principles on the surface and joined Robbie and the woman in a low sand and rubble crawlway. We followed a spider web of unknotted nylon lines to a decorated room and on into a sand-floored crawlway that eventually descended into a larger decorated room 65 meters from the entrance. Good-sized walking passage continued on, ending at a depressed basin in the floor in another 35 meters. Here was the "cenote," a very appealing sump, with crystal-clear water encircled by thick flowstone formations. The overhead stals, the flowstone, and the size of the sump were more than enough to entice any sump diver. From a black hole at the base of the sump funnel rose a knotted cave-diver's guideline, ascending from the depths. The guideline reached the water's surface at a small stal tie-off on the flowstone edge of the pool, but there was no identifying line marker. As we



Phillip Huber and Jim Coke in typical walking passage in Yax Muul. *Simon Richards*.

returned toward Entrada Pequeña through the walking passage, a large tunnel with nylon line branched off towards the south. I asked how far that part of the dry cave went. Although she didn't know, she suggested that the cave ended at Don Cupertino's Rancho Balancanché a few kilometers to the south. I was flabbergasted; could there be a dry cave in Quintana Roo of this length this close to the coastline?

Donato appeared interested when I offered to survey the dry cave. It was a simple contract based on a handshake. He would not charge an entry fee, and he could expect detailed map updates, in color, throughout the survey process. In return, I would get to do all of the work, while having as much fun as I possibly could. What could be a better proposition? I was at Yax Muul Ranch the next morning, this time prepared with survey gear and more suitable caving equipment. As I created the zero-datum station at Entrada Pequeña, an old feeling came back. It was one of pleasure to be surveying and exploring a new cave, yet a feeling mixed with "What in the world have I got myself into now?" Little did I suspect I would be working on dry and underwater exploration, survey, and cartography there for the next three years.

My initial plan was to survey the known trunk passage first, back-tracking to have a better look at any promising offshoot tunnels. Adopting a survey-as-you-go approach, I was beyond the primary sump room, surveying toward Don Cupertino's entrance, after two trips. Following an old nylon line, I saw in side passages small bits of discarded line that chronicled abandoned explorations. As the cordage was unfamiliar and knots were absent from all these old lines, I suspected that gringos had had nothing to do with the dry-cave exploration. This was confirmed two years later, when I spoke with a person who was part of the group that installed those old lines. He admitted that the guidelines had added a sense of security in case their old hunters' headlamps failed, which they did with annoying regularity. His face was pained when he recalled a "small problem" when both his and his companion's headlamps failed. Rather than ask about their escape, I asked if he enjoyed exploring the cave when their lights did work. Shrugging his shoulders, he confessed some disappointment that they never did find *algunas cosas de los Antiguos*.

Their southern line ended abruptly at the main south entrance, 250 meters from Entrada Pequeña by survey. It was disappointing to see the trunk passage end prematurely on the north rim of the complex South Entrance depression. But it came as no surprise; the few kilometers of rumored dry passage from Entrada Pequeña south to Rancho Balancanché had seemed a bit unlikely. But there were still a lot of offshoots to explore off the *Kaam Be* (String Way) tunnel. Confusing wind currents, remnants of strings, and bats flying off into side passages were indications there was quite a lot more to Yax Muul cave. I hoped that, perhaps, one or two leads might continue to other parallel fractures in the immediate area of the ridge. If this was the case, then a breakout from what appeared to be a central maze into unknown ground seemed possible.

By 2005, Yax Muul had grown into a complex maze cave. Irregular air drafts through low passages would occasionally lead to new sections of open crawlways or larger stoopways. Each new section was surveyed to its final constrictions before a new section was explored. It required a good reservoir of patience, though, as taping the survey stations was a four-step process. This included stretching the tape to the next station, recording the distance, returning to the previous station to collect the azimuth and inclination, drawing the cave, and then picking the tape up while crawling back to the forward station. This made progress slow, but proved to be ideal for sketching the cave. I yearned for a Disto. As the cave grew, so did the map. Seeing my drawing of data from the previous day's survey, a few of my cave-diving friends in Tulum became curious about why I would spend my time surveying and mapping a dry cave. A growing cave map is a great tool to lure innocents into a survey team. Philipp Huber was intrigued by the cave's complexity; his interest in having a better look at the cave resulted in a photography trip with Tanja Mueller, during which Philipp became hooked on dry caving. We explored a good amount of the western area together; some of it is quite narrow and low. Having Philipp along was a pleasure. As he grew accustomed to small crawlways, he also developed his "cave sense" and became a valuable partner.

One obvious dry lead, now called Laberinto, was still undone. I had surveyed its beginning in 2005 through a small decorated tunnel, but ran out of time in a low, drafty sand room. Two nice fracture-based leads wandering off into the wind would make a great beginning for the next year's effort. Philipp was keen to see the area and to observe the performance of a new Disto A3 I sported in my survey bag. I mentioned long crawls and sandy floors, which did not seem to bother him. Beginning as a meandering crawl through a series of small fault-directed passages, Laberinto appears to join a different fracture that skirts the South Entrance depression on its southwest perimeter. Straying from the general maze pattern, this could be a transition leading to a new area of fractures. Simon Richards and I made the last 2006 survey trip to Laberinto, checking a few side passages. Most were disappointments, while one or two tunnels continued farther south and west. Simon, a self-trained geologist and hydrologist, was amazed at the differences between the cave passages of the main parts of Yax Muul and the Laberinto area. His observations on variations of floor sediment composition, passage configuration, and degrees of speleothem development were enlightening. Variable air drafts and piles of outside detritus brought in by rats, common trogloxenes in Yax Muul, suggest we are near another entrance in this area. Donato was quite pleased with his steady supply of the promised maps, especially the 2006 updates. He was very surprised by the overall size of his cave, as we had made significant progress in many areas.

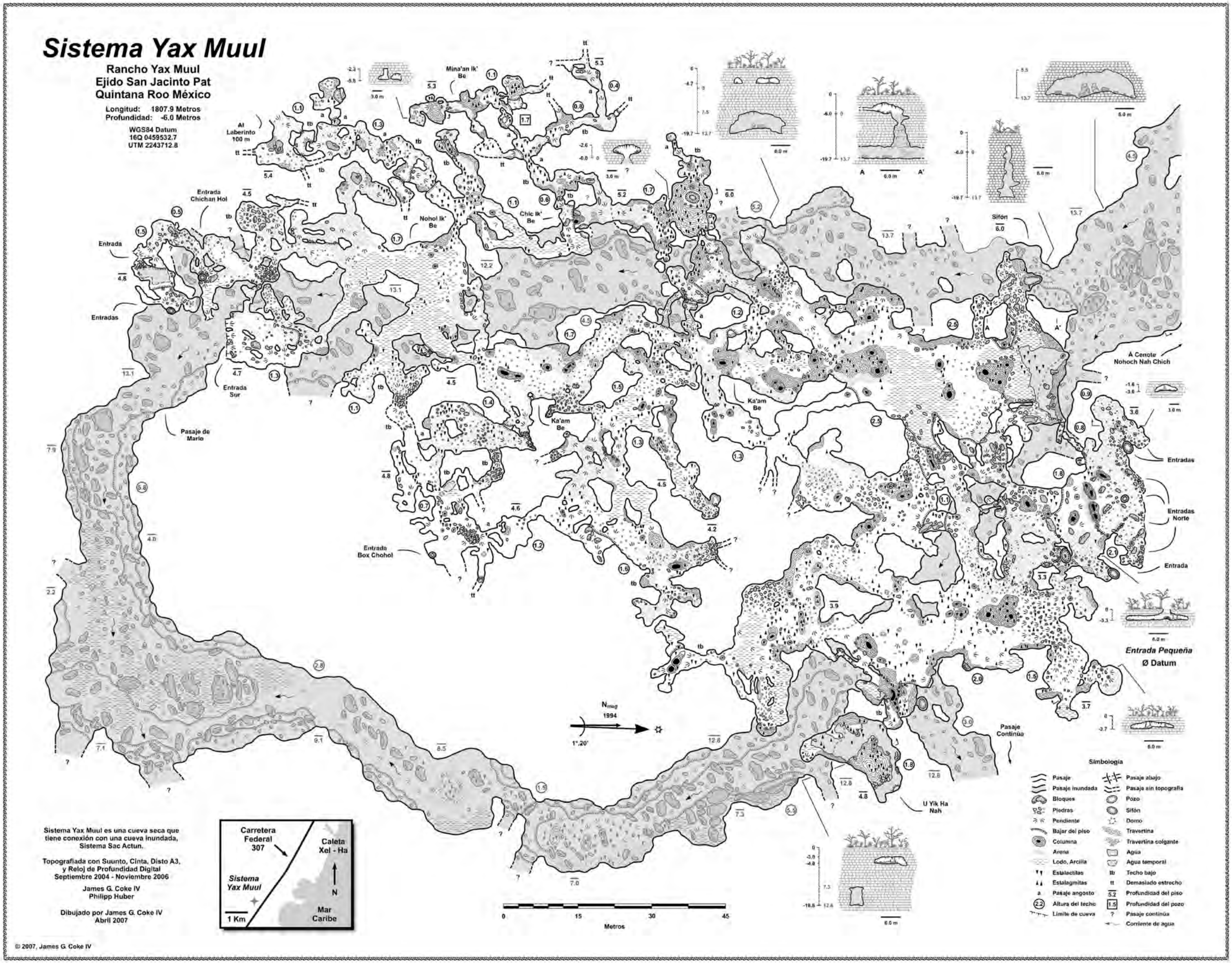
With the dry-cave survey nearly complete, investigating the underwater cave below the dry cave became a priority. Eric Noftall's survey data collected during the Nohoch Nah Chich 1997 project were invaluable as an elementary guide to the position of the wet cave in relation to the dry cave survey. But a resurvey of this section of Nohoch by fiberglass tape was the best approach, as Eric's data were based on knotted-line distances. Cartographically, it made sense to use the same survey methods in both parts to generate an accurate and detailed map. From a geological point of view, this was a unique opportunity to survey two companion parts of a cave that share common origins over geological time. A map could establish a foundation for further studies of how dry and wet episodes in local speleogenesis might relate. Finally, both wet and dry sections are situated on the isolated most eastern edge of the Nohoch Nah Chich system. These sections impinge on the east flank of the Pleistocene ridge structure as it descends to younger sediments. Since dry and wet cave growth in proximity to local ridge geology was not well documented, it seemed only logical to meet this challenge.

Phillip Huber passing a tank down the Entrada Pequeña. *Simon Richards*.

Transporting diving equipment through a dry cave can take a toll on cave sediments and formations. Fortunately there was an alternate, more direct route to the sump than that I took on my first visit. It avoided many delicate areas. Three hauling trips established a short-term base that would be used during a few weeks of diving. By leaving tarps, lighting, and most other diving equipment at the sump, a minimum amount of gear would have to be carried in for daily dives. Regulators, batteries, and expended tanks were removed at the end of each day. Only one trip was needed to replace these with fresh supplies for the next dive. I am very grateful to Donna Richards, Simon Richards, and Philipp Huber, who volunteered to haul gear back and forth on a few occasions. Simon, through his photographic talents, was also instrumental in documenting both underwater and dry caves.

The restricted base of the sump funnel at 3 meters below water table opens into a north-south oriented crevice, where a diver descends directly to –13.5 meters into large tunnel eroded by the interface between fresh and salt water, the halocline. The tunnel at the bottom of the crack, Mario's Line, extends north and south. Floor deposits consist of large breakdown, interspersed with carpets of sharp, irregularly shaped fragments of limestone ("boneyard") in deeper cave tunnels. Speleothems are generally not common; those that remain are highly corroded by the halocline, which is at –11.8 meters, unless they are positioned in upper freshwater sections of the cave. A strong southerly current of fresh water courses

Jim Coke ready to descend in the main sump. *Simon Richards*.


Sistema Yax Muul
Rancho Yax Muul
Ejido San Jacinto Pat
Quintana Roo México
Longitud: 1807.9 Metros
Profundidad: -6.0 Metros
WGS84 Datum
16Q 0459532.7
UTM 2243712.8
Al Laberinto 100 m
Entrada Chichan Hol
Entrada
Entradas
Entrada Sur
Pasaje de Mario
Mina'an Ik' Be
Nohol Ik' Be
Chic Ik' Be
Ka'am Be
Entrada Box Chohol
Sifón
A Cenote Nohoch Nah Chich
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Pasaje inundada
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Estalagmitas
Pasaje angosto
Altura del techo
Limite de cueva
Pasaje abajo
Pasaje sin topografía
Pozo
Sifón
Domo
Travertina
Travertina colgante
Agua
Agua temporal
Techo bajo
Demasiado estrecho
Profundidad del piso
Profundidad del pozo
Pasaje continúa
Corriente de agua
Sistema Yax Muul es una cueva seca que tiene conexión con una cueva inundada, Sistema Sac Actun.
Topografiada con Suunto, Cinta, Disto A3, y Reloj de Profundidad Digital
Septiembre 2004 - Noviembre 2006
James G. Coke IV
Philipp Huber
Dibujado por James G. Coke IV
Abril 2007
Carretera Federal 307
Caleta Xel - Ha
Sistema Yax Muul
1 Km
N
Mar Caribe
© 2007, James G. Coke IV

Jim Coke surveying in a large underwater breakdown room. *Simon Richards*.

throughout the cave.

Beginning the resurvey on the west leg of the loop (Mario's Line), it took me little time to judge the overall character of the cave. The underwater cave was much larger than anticipated, especially so close to the Pleistocene ridge. Most underwater caves that encounter the ridge contain much smaller passage, especially those that are able to pierce this structure into Holocene strata. Unexplored openings, probably room extensions, beckoned at either side of Eric's survey stations. With azimuths, tape, and trigonometry, wall and boulder positions began to fall into place along the base-line survey. Upon reaching a sharply ascending dome in the southeast room, I placed a pink personal line marker to mark the end of this survey leg. No one else uses pink line markers in Quintana Roo.

Managing air reserves is crucial in underwater cave explorations. To guarantee large safety reserves, my plan to survey the remaining east leg of the loop from the sump towards my west-leg line marker made perfect sense. It was half the distance to swim, and the exit to the sump was certain, so there would be no surprises. This new effort showed the cave to be just as unpredictable, and perhaps more complicated, than its parallel, western twin. Simon accompanied me on a memorable photographic dive as we followed the east leg line. We managed to survey a few stations, but a preview of what was to come was an eye-opener. Diverging leads were everywhere, unsurveyed tunnels were leading back toward the west leg, and others were plunging down breakdown slopes to the east. The fresh-water flow in this section of passage remained consistently to the south, a good indicator of where the underwater cave was actually heading.

Repeated survey dives eventually brought the survey loop to a close at a pink line marker in the midst of a large, shallow dome room. Black organic silts cover the breakdown floor of the dome; by depth gauge the dome crests at less than 2.0 meters below the water table. At this depth, tannic acids in the fresh water restrict visibility to just a few meters. The size of the dome and poor visibility make this section of cave very difficult to explore, much less draw to scale. An old exploration line in the dome lends some testimony to the environmental conditions, as it quickly loops back on itself. But by a stroke of dumb luck, I found going passage at the southeast corner of the dome. The return to the pink marker at the end of the west-leg survey from the east leg forced me to spend time on the closing station. While reconfirming the depth and azimuth, I gradually began to swing into alignment with the flow. With my fins pointing east, I slowly drifted backwards, off station and down a breakdown slope. Refocusing my eyes on suspended silt, I found that it was descending towards a tunnel opening at the bottom of the dome. I checked this tunnel during a further sketching dive to the dome, and it goes.

Although far from complete, the underwater survey suggests that the dry cave is "floating" on a wide underwater room in eroded limestone strata. This could explain fractured and shifted formations seen in many areas of the dry cave. It is likely that the rise due to breakdown seen on profile of the east leg coincides with a collision of dissolution paths against base strata of the Pleistocene ridge where it meets Holocene sediments. One surveyed tunnel breaches the ridge structure. In 2006, Robbie Schmittner followed this short fissure to an end 230 meters east-northeast from the main loop at massive breakdown. Water flow continued east beyond his exploration. From indications by water currents, a second breach may also continue some distance beyond the ridge. This remains to be seen.

A good amount of exploration remains in the Yax Muul area. Both dry and wet caves will continue to provide researchers and explorers with a special insight into coastal caves and their speleogenesis. It's doubtful that Yax Muul provides a complete model for these types of caves, but it does serve as one example of caves we know little about.

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The author must acknowledge Donato Castro and his family; Philipp Huber; Donna, Kat, and Simon Richards; Robbie Schmittner; and Kay and Gary Walten for their invaluable help and contributions during the explorations of Sistema Yax Muul.

Sistema Yax Muul

El Sistema Yax Muul, con 1.8 km de pasajes explorados, es la cueva seca más larga documentada en Quintana Roo. Está en una colina cercana a la playa y está conectado a la parte de Nohoch Nah Chich del Sistema Sac Actun, algunos de cuyos pasajes están debajo de la cueva. Esa parte sumergida fue topografiada de nuevo para completar un mapa que muestra la relación entre las partes secas y subacuáticas del sistema.

LA VENTA
EXPLORING TEAM

# THE INFERNAL SURVEY IN THE CRYSTAL PARADISE

Giovanni Badino

Naica is a small mining village on the slope of a modest mountain in Chihuahua, northern Mexico, 130 kilometers southeast of the state capital with the same name. According to local tradition, Naica means place without water, but the word probably has a Tarahumara origin. The Rarámuri roots would be *nai* (place) and *ka* (shade), leading to the meaning shady place, referring to the shade cast by the isolated mountain on the surrounding desert.

Aside from the Apaches who were attacking stagecoaches on the ancient *camino real* to Chihuahua during the eighteenth and nineteenth centuries, Naica's history is essentially that of mining, now successfully practiced by the Peñoles company and famous all over the world. The existence of valuable minerals at Naica was discovered in 1794, with the registration of "*una mina ubicada en tierra virgen con el nombre de San José del Sacramento, en la Cañada del Aguaje de la Sierra de Naica*." The exploitation of the sulfide deposits for silver, zinc, and lead started only in 1900 and continues. The Peñoles mine is one of the most productive in Mexico.

The Naica mine opens on the northwestern side of a dome-shaped feature 12 kilometers long and 7 kilometers wide that towers unexpectedly over the surrounding plain. It is oriented northwest-southeast and affected by erosion, faults, and secondary folds. Known as the Sierra de Naica, this structure has an average elevation of 1700 meters and is formed almost entirely of calcareous rocks that were deposited during the Albian (Lower Cretaceous), except for two small marl bands visible on the western side that show the domal structure of the mountain. The mountain contains a system of parallel faults and fractures that were formed before the mineralization; they are parallel to the longer axis of the dome, oriented northwest-southeast and dipping southwest to vertically. The main sulfide ore bodies and the four caves now known, Espadas (Swords), Ojo de la Reina (Eye of the Queen), Velas (Sails), and Cristales (Crystals), are located along this system of fractures. They have no natural entrances and are like deep geodes.

The plain surrounding the Sierra de Naica is about 1250 meters above sea level, while the main mine entrance, Rampa San Francisco, is at 1385 meters. The original water level in the mine was 120 meters below the entrance, more or less the level of the plain. Pumping required for mining has lowered that level to approximately 850 meters below the entrance, emptying the Cave of the Crystals, which was full of hot water until an estimated fifteen years ago. At the present time, water is pumped out at the rate of about 1 cubic meter per second. The water in the deepest levels has a temperature of 54°C.

In 1910, a cave about 80 meters long was discovered at a depth of 120 meters in the mine. Its walls were entirely covered with selenite crystals up to 2 meters long. For these blade-like crystals, the cave was named Cueva de las Espadas. [See history article in this issue.] The beauty of this cave excited even the miners, who closed it and protected it from destruction, equipping it with wooden ladders for visitors.

In April 2000, the brothers Eloy and Francisco Javier Delgado were digging an exploration tunnel at a depth of 300 meters when they intersected a small opening in the rock. Francisco went through, with difficulty, and came out in a geode-like cavern 8 meters wide that was full of selenite crystals similar to those in Cueva de las Espadas, but much larger and more impressive. This cave was named Ojo de la Reina. The

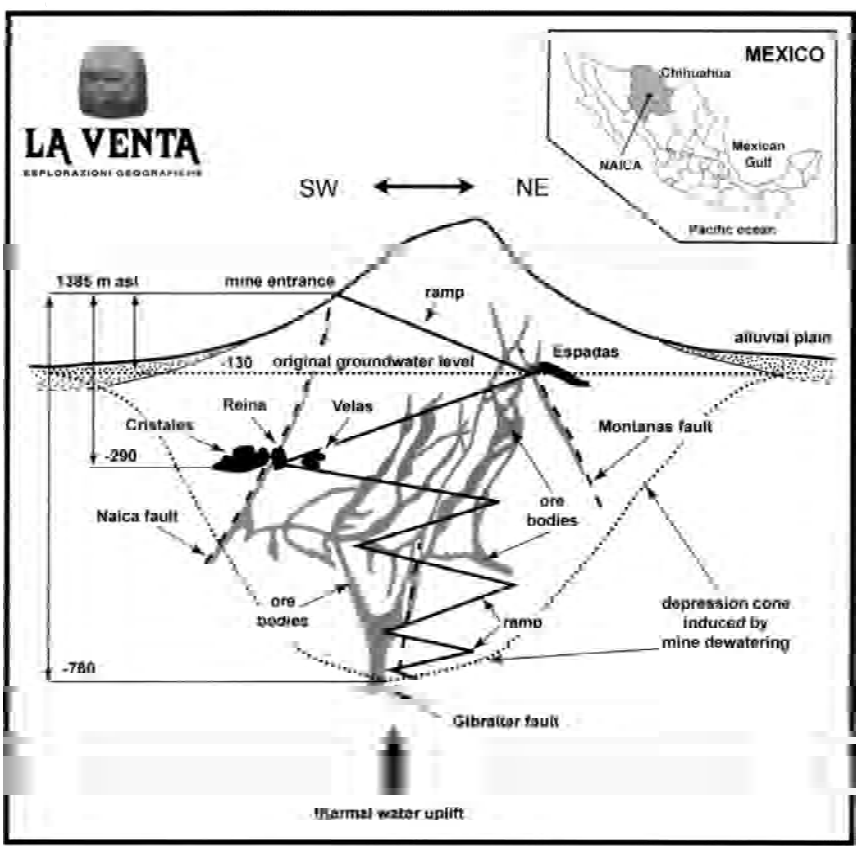
The entrance to the mine. *G. Badino*.


From *Speleologia* 55 (December 2006), pages 64–72, translated from Italian for the AMCS by Daniela Cipolla. Photographs courtesy of Archivo SR&F/La Venta. The geology figure is from a similar article in the *NSS News*, February 2007.

Tullio Bernabei in Cave of the Crystals. The rope is primarily to protect the crystals, but also to help prevent cuts on the hands. *G. Badino*.

brothers, fascinated by their discovery, suspended their digging and notified the mine director, Ing. Roberto González Rodríguez, who changed the direction of the tunnel to avoid damaging the crystals. A few days later, another room, about 30 meters wide, was discovered. It had huge selenite crystals more than 10 meters long and 1 meter thick. The miners could not finish exploring the cave because of the extreme environmental conditions. The temperature was close to 50°C, with humidity around 100 percent, a situation that can be deadly in a few minutes. Again the direction of the mining was changed, and the cave was locked with a steel gate to isolate it and prevent theft of the crystals.

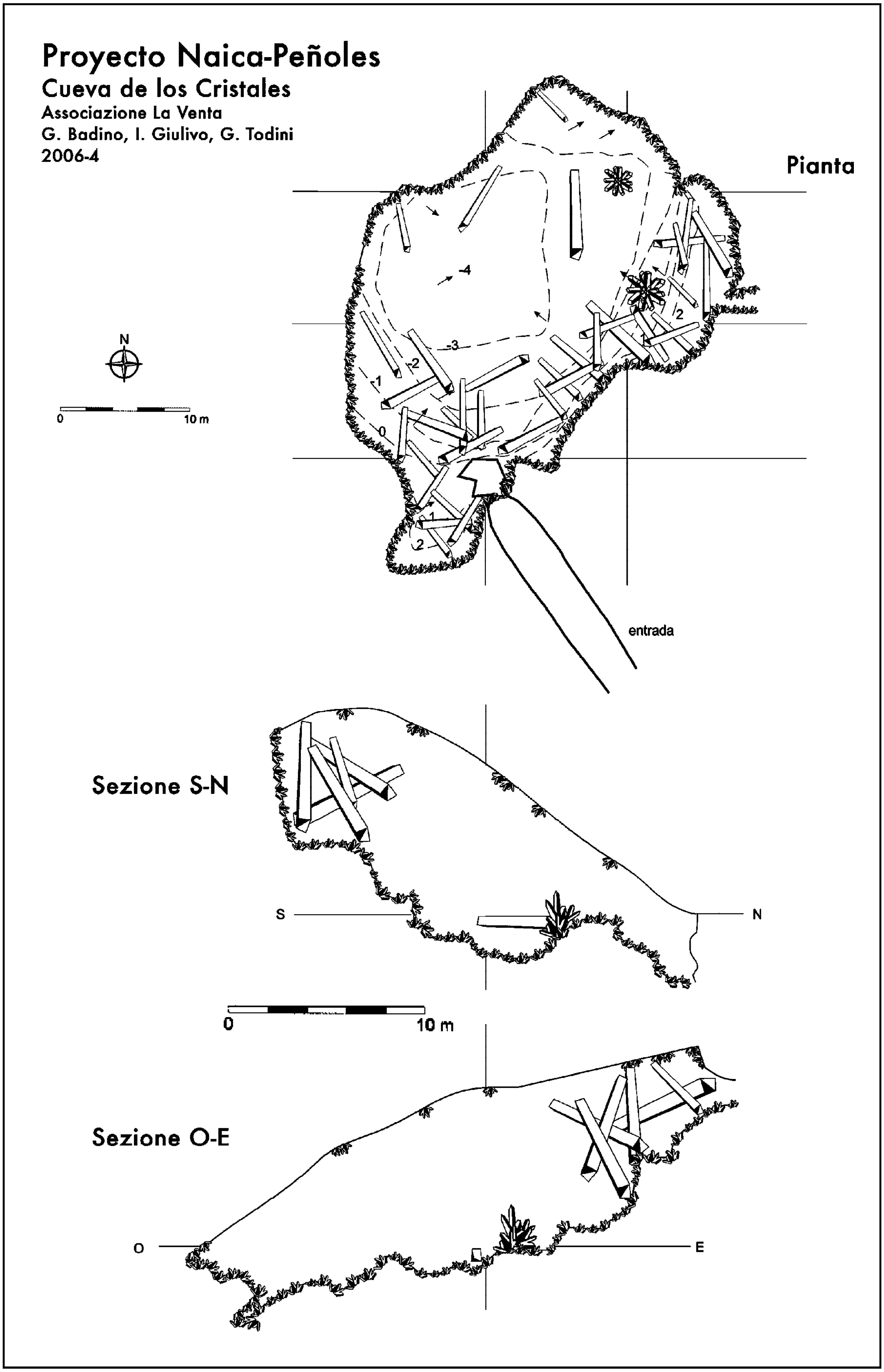
This cave was named Cueva de los Cristales, Cave of the Crystals, and the exceptional discovery soon became known to specialists around the world. In January 2001 it was visited for the first time by speleologists Carlos Lazcano, a veteran Mexican caver and La Venta partner, and Claude Chabert, a world-famous French speleologist. They were taken to the cave by Enrique Alejandro Escoto, security manager of the mine, and young guide Carlos Valles Carrillo. The few minutes they could spend inside, due to the hostile environment, were enough for them to recognize the uniqueness of this natural phenomenon and to make the first photographs of the giant crystals that had excited so much interest and curiosity among the experts around the world. [See *AMCS Activities Newsletter* 25, pages 72–77.] The difficult environment and the mine's desire to preserve the treasure prevented systematic research and even complete exploration and survey.




The first visit by the Associazione La Venta was by T. Bernabei, A. De Vivo, and I. Giulivo in May 2002, thanks to an invitation by Carlos Lazcano. They explored Cueva de las Espadas and Cueva de los Cristales in order to verify the extraordinary nature of the phenomenon and take a first few hasty photos and films, in spite of the considerable problem of condensation on the cameras' lenses. In October, a second visit was made, by G. Badino, P. Forti, C. Lazcano, and P. Petrignani. Better equipped to resist the extreme conditions, they made some measurements with precision thermometers. In Cave of the Crystals, 47.1°C was measured at the floor and 47.4°C at 2 meters height; the humidity was close to saturation.

The most important result of those first explorations was an understanding of the environment, because any survey in that situation is practically impossible without special precautions and suitable equipment. The experience gave useful information about the equipment that was necessary, and preparations were made possible thanks to a collaboration between the Physics Department at the University of Torino and the Ferrino company.

In January 2006, a new visit was made to test the refrigerated suits, called Tolomea, that allowed a longer stay in the cave and a first rough survey. On the same occasion, the La Venta Association signed an exclusive agreement with the Peñoles company, holder of the mine concession, for scientific study and photo-documentation of all


Proyecto Naica-Peñoles
Cueva de los Cristales
Associazione La Venta
G. Badino, I. Giulivo, G. Todini
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the caves in the mine. Research will continue for the next three years as the Naica-Peñoles Project of the La Venta Association and the Mexican companies Speleo-Research&Film and C/Producciones.

During a visit in April 2006, it was possible to draw up an accurate survey of the Cave of the Crystals. At that time, the temperature was 45.5°C, and the humidity was around 91 to 92 percent. There is evidence that the cave is cooling down at the rate of about 0.5°C per year. The map presented here was obtained by surveying around the whole perimeter of the cave to the north of the entrance, 72 meters, and then completing it later with a survey of the smaller, southern part. The total length of the survey around the perimeter is about 85 meters. The relief of the survey line from the zero point at the floor in the center of the entrance is –2.7 meters and +4.4 meters. To this must be added about 5 meters to the highest reachable point. So the cave's total height is about 12 meters.

During the last visit, at the end of June 2006, a quick check was done in the northeastern area by G. Badino and T. Bernabei. After approximately 15 meters of narrow and tortuous unmapped passages with walls studded with crystals, they found a new large room, but they had reached the duration limit of the Tolomea suits and could barely make it back to the entrance. So the cave continues.

The Cueva de los Cristales was discovered in 2000, and since then many people have been inspecting it, some of them of high stature in speleology. I was surprised that nevertheless there had been no survey, not even an approximate one. Why? Now I know, and I know well the answers to several other questions I had never thought about in many years of surveying experience. I want to explain the many reasons why it's so complicated and dangerous to explore the Cueva de los Cristales and why the final result is always less than ideal.

Speleologists usually survey caves by drawing a line made of many segments connecting a series of stations. Every segment is measured, and its orientation relative to north and horizontal is determined. Then, for each of these segments, more or less accurate sketches are made of the plan, the profile, and the cross-section. The result is a notebook full of information that will allow the reasonably accurate drawing that we call the map of the cave if it matches certain standards. But in the Cueva de los Cristales, this system doesn't work.

The main difficulty is the operating environment due to the climate in the room. We are there, awkward inside a cumbersome suit, with a short time-limit, and exposed skin is already burning hot. To talk ("five point six meters, Abney minus 40, compass three hundred twenty"), we must remove the mask and stand the hot steam that tries to enter our lungs, and discomfort increases very quickly. Every movement is difficult, causing overheating and breathlessness, control is gone, and exit becomes a fantasy. So we must prepare ourselves carefully before we enter. We have to plan what to do and how, and then we have to execute the plan under those conditions and in a short time. The process of gearing up in the anteroom is difficult and tense, and then the "descent" is hard, nerve-racking, and risky, even though I can't imagine anything better. So we tend to operate anxiously, hurriedly, and awkwardly; time flies, we must finish soon . . . . But this is precisely what we shouldn't do there. Instead, our movements should be slow and quiet, for otherwise we'll soon find ourselves breathless, hyperthermic, and mentally confused, perhaps seriously risking our lives. Because of this, we tend to lose accuracy and forget to note essential data. It's enough to miss one single number to keep the survey from closing with the desired accuracy, and it will be discovered too late . . . . And so the survey is born intrinsically imprecise,

R. Tedeschi.

son of the surveyor's physiological state.

Then there are the difficulties hidden in the details, first of all the accuracy we want to obtain. The cave is quite small, the largest possible circuit of the perimeters being only 85 meters, and under normal conditions, and if it were cold and undecorated, it would be surveyed by expert cavers with little investigation and only a few comments. Of course in Cristales it makes no sense to work that way, so mistakes that in normal caves would be acceptable are not at all acceptable here. We solved the problem of orientation with reasonable accuracy, and by the use of level curves in the room, produced a map that reports much information, even though the result is still far from satisfactory.

Then there's the problem, What shall we survey? Never as much as on this occasion have I realized that a cave survey is born in a certain cultural context. We see and note what we think is important, which differs greatly as time goes on. To see this we might compare surveys from throughout the twentieth century; we would discover incredible variety. Our problem is that in Cristales we don't know what's important. It is a *unicum*, a hidden window that suddenly opens on another world, a cave intrinsically outside our speleological culture, formed in caves that are made from the surface of the earth, not out of its depths. So the surveyors' hands would shake from doubt, if for no other reason. We have a few expensive minutes; what to do? We must take more information than usual, but without knowing just what that is or whether it is possible. It's crazy!

Another puzzle is what to draw. To understand this strange difficulty, let's try to answer the most simple question: Are the crystals something that fill the cave, or is the cave the part we can visit, that is, outside the crystals? Is a transparent wall of crystal tens of meters long the wall of the cave, or is it something to draw as a filling inside the cave? And are the huge crystals something we should sketch one by one, or, as we generally do with formations, should we indicate them with general symbols for a formation area? Depending on the choices we make, the map could be totally different. In this case, awaiting a detailed inventory of the big crystals, we decided to indicate the crystal zones, and when the area had so many crystals we could not penetrate them, we drew it as the cave's wall. OK? Of course not; it's clearly inadequate, but it was the most reasonable thing we could do.

There is a problem of limited time. I had never noticed before how a survey of a room is an operation that should not be interrupted. It should be finished on one trip, especially if someone wants an accurate job. But to do so while burning up is not easy. I think that's the reason there had been no survey for so long. It would be impossible to make a map of Cristales in a dozen visits of three minutes each. We solved that with the refrigerated suits that allowed us to stay for 50 minutes, although at the end of that time we were totally wiped out.

Then there is the problem of sketching. For some reason I don't understand, in there hands have big difficulties with precise movements. They literally shake, so that sketching is a nightmare. One can deal with it using large notebooks on a rigid support, but that doesn't much reduce the general problem. We recognized that problem almost immediately, and we found the solution: shoot pictures of every survey leg and then draw it "off line" at home. With some precautions to keep in mind (not easy when you are in an oven), the technique works pretty well, but the camera and its tripod, required because shaking hands make blurry pictures, isn't easy to deal with.

As one might expect, the instruments don't work properly. First, they, and even the notebook, have to be heated before entering the room, for otherwise condensation will prevent reading or note-taking. It soon becomes clear that the laser distance meter doesn't work on transparent crystals, so, after it has been baked, it must be pointed at another caver or one of those rare spots of rock that emerge from the crystal sea. It's easy to miss our aim, so we just try again and again; "225 meters" says the instrument that is burning our hands, while the clock ticks, discomfort becomes suffering, and we resist the urge to abandon the job. Resist? This is something we shouldn't do. By the time we decide it's time to leave because the situation has become unbearable, the time to leave has passed and the crisis has already come.

Through experience and many mistakes, we identified the problems and found solutions or ways around them. We made the survey in two phases with two different techniques. The first time, G. Todini and I used the technique of spray shots from a central point, where one of us stood with the laser distance meter while the other was circling the room as a target. To make the second survey, I. Giulivo and I risked, with too much self-confidence, to draw a traditional survey polygon along the perimeter, with the result that we present here. We even came out alive.

In short, surveying Cristales is difficult, trust me, really difficult. But it's worth it. Every meter of survey, every data point that comes out of there is a triumph and helps to transform that incredible place, that petrification of a crazy dream, into a real physical place. Facing up to the survey of Cueva de los Cristales as a geographical place taught us that what we present here is not *the* map of the cave, but one of its possible maps. That small cave can be interpreted in many ways, because it's much more complex than one can imagine. There's still a long way to go in absorbing its nature and bringing it among us. In the next few years, we would like to conduct great projects down there, using the most modern technologies, and I hope that soon this map will appear poor and miserable. But I know, as well, that even after decades we'll be tremendously proud to have been able to survey it that very first time.

## La Infernal Topografía del Paraíso de Cristal

La Cueva de los Cristales en la mina de Naica, Chihuahua, fue explorada y topografiada por espeleólogos italianos. El uso de trajes especiales con sistemas de refrigeración les permitió permanecer en el ambiente caliente y húmedo hasta por 50 minutos continuos para completar la topografía.

# SIAN KA'AN EXPLORATION EXPEDITION

## Ox Bel Ha Water Protection Project 2005–2006

Sam Meacham

*This article has been prepared from the final report* Ox Bel Ha Water Protection Project *for The Nature Conservancy that was compiled by Sam Meacham with the help of Fred Devos, Christophe Le Maillot, and Daniel Riordan. See the article on the Jade Pearl Exploration Project in* AMCS Activities Newsletter *28 for background material on the area and the water-pollution risks. The expedition log has been written by the editor based on information contained in outline form in the full report, which contains a lot of additional data, especially on observations of surface and underwater animals. The full report is available as a 12 MB PDF file at* http://www.cindaq.org/reports/finalreport.pdf.

The northern boundary area of the Sian Ka'an Biosphere Reserve is characterized by almost every habitat found in the reserve. The dominant feature is Laguna Chunyaxché to the west, one of the largest fresh-water bodies in the state of Quintana Roo. A series of canals, both man-made and natural, connect Laguna Chunyaxché to the coast. Two brackish coastal lagoons, Laguna Caapechen (known to INEGI as Campechen) to the north and Laguna Boca Paila to the south, are connected by a canal and buffered from the Caribbean Sea by a thin coastal dune that extends south to the settlement of Punta Allen. The lakes are generally shallow, with depths from just a few centimeters to an average of 2 to 3 meters. Fringing coral reefs of the Mesoamerican Barrier Reef run parallel to the coastline. Hundreds of hummocks dot the landscape, creating islands of dense vegetation in the middle of the otherwise flat topography of the savannas and mangroves. The northern boundary area is shared with the Ejido José María Pino Suárez, a collectively governed property of approximately 10,400 hectares. The archeological site of Muyil, though located approximately 16 kilometers inland, is considered to have been a port city because of the ability of ancient Maya coastal navigators to reach it by the canals connecting Laguna Chunyaxché to the coastline. Two small Maya temples can also be found in the area. The Temple of Xlapak is located at the eastern extremity of Laguna Chunyaxché and at the western terminus of the canal coming from Laguna Boca Paila. Another smaller temple can be found in Laguna Caapechen. Curiously, the doorway of this small temple is aligned almost perfectly with the principal cave entrance for this project, Entrada Caapechen. In total, six separate cave entrances were located, and five of them were explored during this project. All five entrances are located within the brackish lakes of Laguna Caapechen and Laguna Boca Paila.

The two main organizations participating in this project were El Centro Investigador del Sistema Acuífero de Quintana Roo AC and the Mexican Cave Exploration Project. While CINDAQ coordinated the funding, overall logistics, permissions, and surface exploration for this project, MCEP focused on all diving-related operations and documentation. Working together allowed us to gather and process a considerable amount of information that we present in this report. Both CINDAQ and MCEP share a common vision for the conservation of the region's cave systems through exploration, scientific study, and education. The work was accomplished with financial support from The Nature Conservancy, Alltournative SA de CV, and private contributions and the cooperation of the Comisión Nacional de Áreas Naturales Protegidas, Amigos de Sian Ka'an, Centro para el Estudio del Agua, and the Technical University of Denmark.

Cave diving is an extremely equipment-intensive endeavor that requires a very focused frame of mind for both the preparation and execution of dives. Normally, the preparation and execution of our projects are very time- and energy-consuming. In the case of diving in Sian Ka'an, we were very fortunate that the logistics are relatively simple. For all of the previous projects that we have undertaken, we have moved an average of two tons of equipment by manpower, horses, and in one case by helicopter, back into the jungle. By doing so we were able to establish a remote base camp that allowed us to work autonomously for weeks at a time. However, base-camp life can take its toll, and we generally have limited ourselves to two-week stints in the jungle. In the case of Sian Ka'an, we were fortunate that we were able to stay at the Centro de Visitantes de Sian Ka'an, a visitor center built expressly for researchers. As a result, we were able to spread the project out over five months, with an average of five days of exploration each outing. Another benefit was that the primary entrances to the northern and southern caves of Sian Ka'an are actually in

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lakes. Therefore, in order to get to the dive sites we merely loaded a boat with equipment and, in either case, had a ten-minute boat ride to the cave entrance.

Although in Sian Ka'an it is easy to reach the cave entrance, work in the caves presents significant challenges as soon as divers hit the water. One of the first things that divers encounter in Entrada Caapechen is extremely high water flow. In fact, the flow is so strong that a fully loaded diver has to kick to supplement the pull of a scooter in order to advance the first 100 meters into the cave. Although flow gradually dissipates as the divers travel farther back into the cave, it is still stronger, overall, than has been seen in any other cave in this area. This affected dive planning and safety measures.

The other challenge for the divers is that Entrada Caapechen, the main cave in Sian Ka'an, only has one entrance so far. The majority of cave systems in this area have multiple entrances; in fact, in order to be called a cave system, a cave usually must have been explored from at least two entrances. In the case of Ox Bel Ha, there are close to one hundred entrances spread over 147 kilometers of cave, meaning that on average you should find an entrance every 1.5 kilometers. Multiple entrances have two immediate benefits. First, they provide extra security as a 'bailout exit' should a diver experience equipment failure or any other type of problem. Psychologically it is very comforting to know that air is always nearby. Second, they provide points from which divers can enter to continue exploring, effectively allowing us to leapfrog from entrance to entrance, moving farther and farther back. Having only one entrance requires additional safety measures. In this case, additional scuba tanks were left inside the cave to insure that the dive team had additional bail-out supplies in addition to the air they carried with them. When one considers that the lead divers on this project were pushing more than 3 kilometers back in two different directions, the enormity of the dives being undertaken (over 6 kilometers round-trip) begins to sink in.

Despite all of the challenges, the divers and all of those who supported them at the surface for this project rose to the task at hand. In particular, Fred Devos, Christophe Le Maillot, Daniel Riordan, and Per Thomsen deserve much credit for the incredible effort they have put forth to explore and map the caves on this project.

Fred Devos surveying in Entrada Caapechen. *Daniel Riordan*.

The Mexico Cave Exploration Project is a Global Underwater Explorers affiliate and is supported by GUE training, diving logistics, and administrative support. We share a desire to safely explore and protect the underwater world and to improve the quality of education and research in all things aquatic. MCEP subscribes to a team approach in diving, and we work throughout the year training, practicing, and gaining experience. With years of local cave-exploration experience and access to an international base of highly skilled divers, we are able to line up the support needed to safely and efficiently conduct mission-specific dives in some of the most challenging underwater cave environments. The equipment we use is designed for quality and performance and is configured as a standardized system. This uniformity between divers is critical during team projects often located in remote areas. Breathing-gas choices and gas management are also standardized, with special emphasis placed on avoiding diving maladies such as oxygen toxicity.

The standardized procedures we use are based on prevention and efficient management during emergencies. In addition to these procedures and redundant underwater life-support equipment, we establish above-water support for dealing with emergencies. The environments we dive in are often pristine, and effort is made to minimize effects on that environment. Dive plans, equipment, procedures, and techniques all strive to leave the environment as it was found. It is the collective interest of CINDAQ and MCEP to survey and

The northern part of Laguna Caapechen, looking east toward the Caribbean Sea. *Sam Meacham.*

Roberto Chávez using the RECON unit in the field. *Sam Meacham.*

document new and existing underwater caves and to make this data available to groups legitimately trying to better understand caves and their related elements. For many years we have been shaping our survey methods in order to efficiently provide clear and concise data that is of optimal use to a wide range of end users, whether they be cartographers, landowners, scientists, or developers.

Surveying of the caves is conducted using knotted line, compass, and digital depth gauges. All information gathered underwater is recorded on underwater slates. Surveying during this project was conducted on the way into the cave in order to decrease time pressure and increase accuracy and safety. In addition, a standardized data sheet was filled out by divers during each dive to record passage width, passage height, passage shape, and observations on fauna, speleothems, sediment and other fills, and water characteristics. These, along with high-resolution photographs and video footage, provide a clear sense of the underwater cave. In addition to these general observations, we can tailor the data collection and our dive planning to include elements of interest to a specific end user.

On the surface, survey data were transferred to Microsoft Excel spreadsheets, and all dive slates were scanned so that a digital copy of the original slate exists. Data were then entered into Compass computer software, designed specifically for the mapping of caves. From Compass, line maps were exported as shapefiles into ArcView 3.1 GIS and overlaid on geo-referenced aerial and satellite images. In ArcView, both data collected underwater and on the surface can then be compared. To annotate the maps presented in this report, the particular areas being mapped were exported from either Compass or ArcView to Adobe Illustrator. CINDAQ thanks both Jim Coke and Fred Devos for their help in preparing survey data for this project. Fred Devos, Dr. Patricia Beddows, and Simon Richards developed the standardized data-collection sheets.

The surface work of this project saw our use of state-of-the-art GPS technology for the first time to help us effectively and efficiently locate and assess cenotes and navigate our way through the maze of channels and canals found in the northern boundary area of the SKBR. The Tripod Data Systems RECON uses a Pocket PC platform, proprietary software, and GPS integration that allows unequaled accuracy in the field for locating and then documenting whatever we come across. The Holux GM-270 GPS receiver provides 2- to 5-meter accuracy using an internal antenna. All data were recorded using WGS84 datum for zone 16. By uploading geo-referenced aerial and satellite imagery into the RECON, the guesswork is taken out of surface exploration, as we always know exactly where we are in relation to whatever we are looking for. In addition, the ability to create custom attribute menus in the SOLO Office proprietary software permits us record information in the field much more efficiently and to manage it better. Furthermore, by uploading shapefiles of explored cave passageways into the unit, we were able for the first time to accurately position ourselves above the cave on the surface. This came in useful when performing conductivity studies with the Technical University of Denmark. All data were exported directly from the RECON as shapefiles into ArcView 3.1. Specific areas of interest were exported from ArcView into Adobe Illustrator to produce the maps in the report.

From November 2005 to June 2006, teams of both surface and underwater explorers focused their efforts on the northern boundary area of the SKBR. Surface exploration was aided by the study of aerial and satellite imagery of the area, which was then uploaded into a highly sophisticated GPS device, allowing for pinpoint accuracy for locating and documenting surface features. As a result, seven potential cenote entrances were identified, located, and assessed for diving potential. Of these seven entrances, one was found to have cave passageway large enough to allow a diver to pass. As a byproduct of surface exploration, abundant wildlife was observed and recorded throughout the area. Of note were tracks of a puma adult and cub close to the northern shore of Laguna Caapechen. A healthy population of at least three, if not five, manatees was observed regularly at Entrada Caapechen. Marine fish species were observed well inland in seemingly landlocked cenotes. By combining local knowledge and information shared by divers from the Fédération Française de Spéléologie, we were able to locate and assess five cave entrances within Lagunas Caapechen and Boca Paila. One additional cave entrance was found through surface exploration; unfortunately it is too restricted for a diver to enter. A total of thirty-seven dives were performed between February and June 2006, resulting in the survey, exploration, and mapping of close to 7000 meters of cave within the SKBR. Two of the entrances, Entradas Caapechen and Boca Paila, revealed major flows of water and significant cave passageways that indicate that a massive cave system exists beneath the SKBR. The largest of the caves explored, Entrada Caapechen, now extends 2 kilometers west from its entrance and contains about 6000 meters of surveyed passageway.

Detailed observations were made both in the cave and on the surface to complement and enhance our understanding of the hydrological and biological dynamics of this sensitive area.

Surface conductivity studies were carried out by a team of scientists from the Technical Institute of Denmark, and data on water chemistry was collected by divers and interpreted by hydrologists working with the Centro para el Estudio del Agua, in Cancún. (Information on these studies is included in the full report.) Both studies allowed our team to improve the skills necessary for working with scientists both above and below water. Video and photographic documentation was made of the cave and surface features explored on this project. In March, CINDAQ was included by the municipal government in roundtable talks to discuss the future development plans of Tulum, and we were able to make a strong case for the protection of the submerged cave systems in this area. Preliminary indications are that the municipality is listening and is willing to consider low-density development on top of any cave system in the area of the Tulum Development Plan. While there is plenty of work still to be done, this is an encouraging sign.

There are four main areas in the northern boundary area of the Sian Ka'an Biosphere Reserve that warrant further investigation. Both Entradas Caapechen and Boca Paila show great promise for further exploration. There is still plenty of work to be done using open-circuit scuba at both of these entrances. However, future projects could benefit from the use of either fully closed-circuit or semi-closed-circuit rebreathers. This would extend the range of divers and greatly reduce the large number of tanks now required, making logistics much easier. Moreover, with their greater efficiency, rebreathers will cut costs in the long run, as fewer tanks need to be filled. As surface exploration revealed during this project, the Gem cenote group has one cenote with apparent cave-exploration potential. Due to its strategic position in line with the exploration lines heading west from Entrada Caapechen, it is a high priority for future exploration. Before committing to a base-camp project there, it is recommended that a reconnaissance dive be performed. Should it be deemed worthy of a full-blown expedition base camp, the only way possible to accomplish it will be with helicopter support. The last area of interest is a group of large cenotes located in the Zona Nucleo of the SKBR. They are located 7 kilometers west of Entrada Boca Paila. Before diving can take place there, they need to be thoroughly investigated from the surface. There is also limitless scientific work to be done, both underwater and on the surface. We are willing and very able to coordinate and facilitate through our projects further scientific study of this complex area.

## PROJECT LOG

*November 27, 2005, surface work.* Roberto Chávez, Sam Meacham, and Simon Richards went to the area of the Gem cenote group by way of the Chunyaxché–Boca Paila canal with the cooperation of the Camaal family. They were deposited at the northern tip of the canal near Cayo Venado. From this point it was a 1.5-kilometer hike through low mangrove, high water, and mud. They were able to reach the westernmost part of the collapse area. From the aerial photos it had appeared that there were two separate collapses, but in reality it is one big collapse area. Simon Richards donned scuba gear to perform a quick reconnaissance dive. Unfortunately, no obvious cave entrances were found. Access to the area is extremely difficult. If a base camp is needed here, helicopter support would be required. Water was flowing on the surface of the savanna from west to east, in some areas as much as 50 centimeters deep. This excessive water was attributed to heavy rainfall associated with Hurricane Wilma one month before.

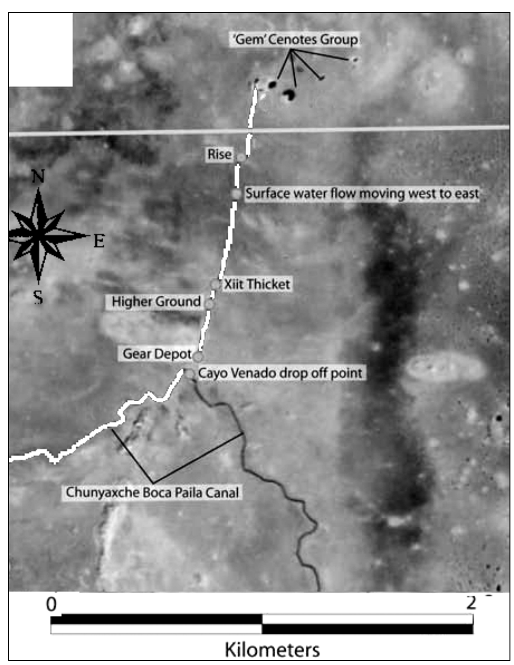
*February 7, 2006.* Fred Devos and Andrea Marassich dove in Entrada Camarón (WGS84 16Q 448230 2223-587). They found the old French lines buried in silt and replaced them. They surveyed 145 meters of the Shrimp Cocktail Line in flat-ceilinged passage 10 meters high and 2 meters high, observing lots of shrimp and amphipods and a halocline near the floor. Their second dive there went 35 meters on the Silt Clog Line in fresh-water passage 1 meter high and 7 wide. They then made a brief reconnaissance dive in Entrada Caapechen (WGS84 16Q 449018 22220411; also called Cenote Manati), finding very high flow at a depth of 8 meters. They determined that scooters would be needed for farther penetration.

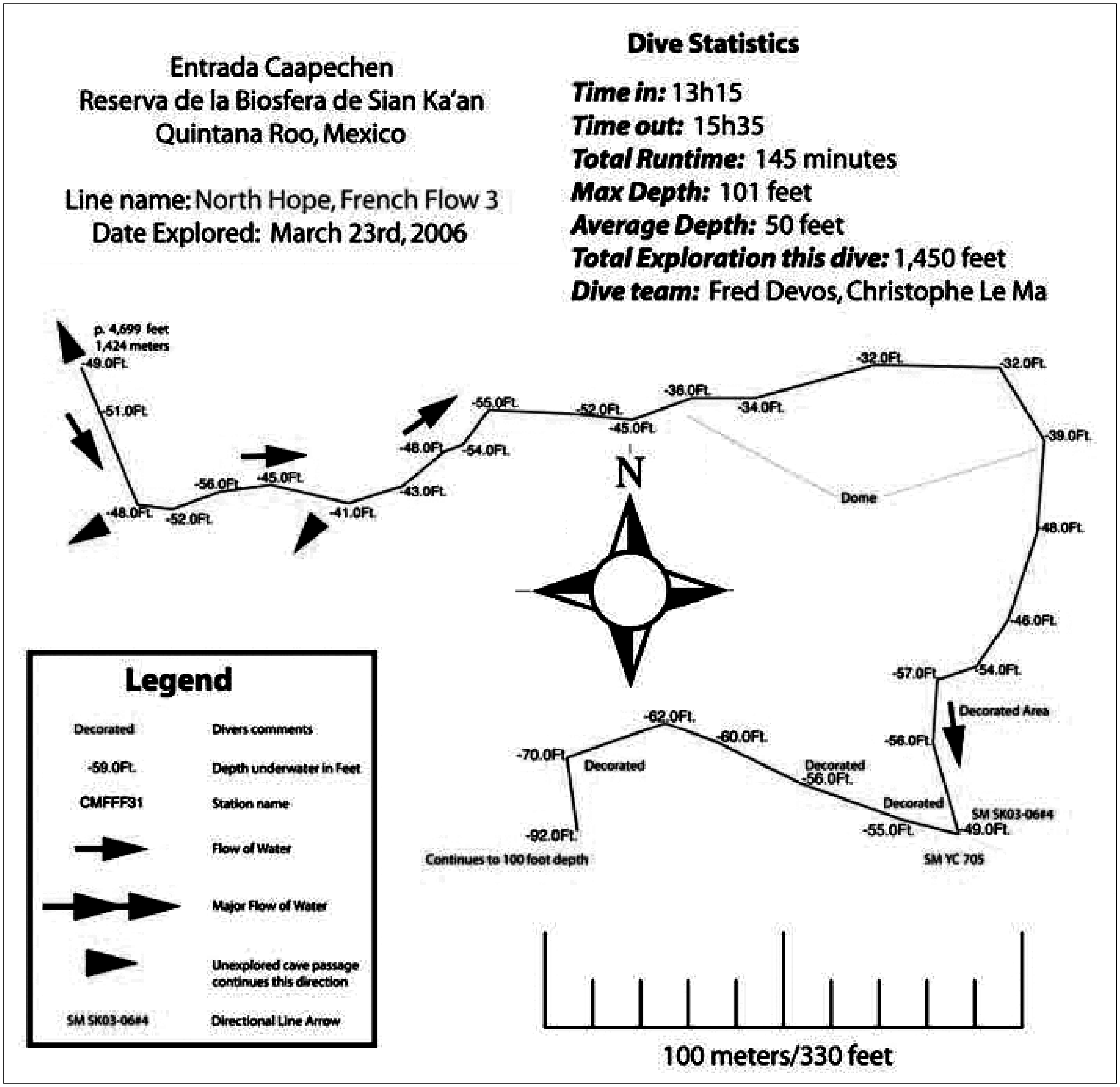
*February 8, 2006.* The same two divers returned to Entrada Camarón and established the Stag Ranch Line upstream for 84 meters in brackish water with strong flow at the entrance that dissipated when the cave got wider and deeper. It was a bedding-plane passage 7 meters wide and 1.5 meters high at an average depth of 8 meters. On another dive, they established the Stag Loop Line, also upstream, for 48 meters in similar passage. Two downstream dives checked leads; there is potential there, but it is risky and not promising.

*February 7–8, 2006, surface work.* Sam Meacham scouted the surface between Entrada Caapechen and the Ox Bel Ha system, by kayak from Entrada Camarón to the northern shore of Lake Caapechen and then on foot. Locations of three corner points on the northern boundary of the reserve were recorded by GPS, and puma tracks were seen in several areas. Except for areas of open rock, the terrain is difficult, with thick mud near the lake and thick vegetation inland.

*February 9, 2006.* Fred Devos, Jarrod Jablonski, and Per Thomsen dove in Entrada Caapechen using

Track of the November 27 surface recon .



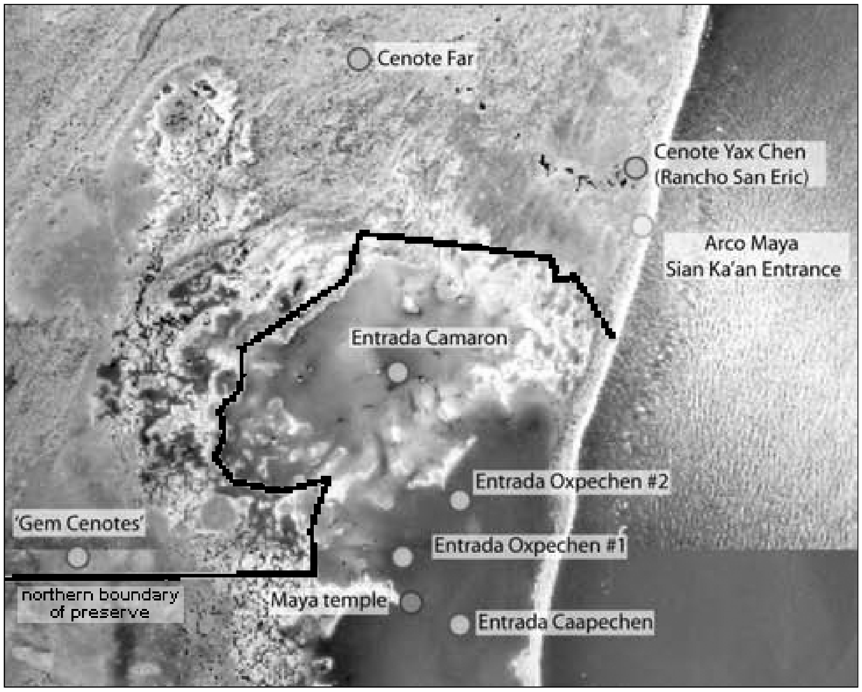



The result of a typical exploration and survey dive.

scooters. They laid new line over buried French lines in the French Flow 1 and Orange Pekoe passages, exploring a total of 437 meters. At 7 meters depth, visibility improved from the murky lagoon water to clear, with 30 meters or more visibility. The halocline is at a depth of 17 meters. The flow, which seems to come from the west, can be very substantial in the first 30 meters of the cave. There is heavy percolation of debris disturbed from the ceiling by the divers' bubbles, and this reduces the visibility for divers following the first. Strange bacterial growth covers a lot of the wall and hangs down to resemble speleothems. The passage is generally 10 to 20 meters wide and 5 meters high. The average depth of the 100-minute dive was 15 meters. A second dive by the same team was at Oxpechen 1 (WGS84 16Q 448288 2221179), where the Oxpechen 1 Main Line was established for 171 meters in passage typically 10 meters wide, 5 meters high, and 12 meters deep. Here also visibility was 30-plus meters, although again with heavy percolation in the deeper areas. Video was shot in both caves, and they reported lots of promise for further exploration in Caapechen.

*February 10, 2006*. The same three divers returned to Caapechen and placed the French Flow 2 Line for 660 meters in continuing large passage at an average depth of 16 meters. It took ten minutes to scooter to the start of exploration, out of a dive time of 120 minutes. Again, much further potential was noted. They also suggested that the French Flow 1 Line needed to be resurveyed when the flow was not as strong.

*March 23, 2006*. In two dives of durations 55 and 145 minutes, divers Fred Devos and Christophe La Maillot removed most of the old French dive line, much of which was buried in silt, from




Entrada Caapechen, extended the French Flow 2 Line with new French Flow 3 Line for 335 meters, and placed the North Hope Line for 107 meters in the first lead at the end of French Flow 2, which is interesting because it drops to –30 meters. The main passage continued large, typically 10 meters high and 4 meters wide, at an average depth of 15 meters. The end of the French Flow 3 Line was at a penetration of 1397 meters. The surface wind was from the east, and the lake was choppy. There was little flow at the entrance, leading them to wonder whether this was an effect of the wind direction. All surveying on these dives is done on the way in, so that there is no time pressure with the survey on the way out due to air constraints.

*March 24, 2006*. In Caapechen, Fred Devos and Christophe La Maillot added the 440-meter Silica Dome Line to the end of the North Hope Line in a dive of 165 minutes. Their new line ended in a huge chamber heading west or northwest with flow. The Silica Dome Line passage was typically 10 meters high and wide, with a flat ceiling and an average depth of 17 meters. The halocline was in mid-passage. The divers each used three stage tanks, in addition to their two back tanks, and two scooters. In a later dive that day, the two, together with Alex Álvarez, placed the 90-meter French North Line in a bedding-plane passage 10 meters wide and 6 high, with the halocline near the floor. The surface wind was from the north, and there was a strong flow at the cave entrance, but there was no flow in the Silica Dome area.

*March 25, 2006*. After a 35-minute scooter ride to the end of the North Hope Line of March 23, 398 meters of new Gandalf Line was laid in new canyon-shaped passage about 5 meters wide and 4 high. The end of that line is at –21 meters, but this is obviously not the main conduit. The duration of the dive, using equipment as the day before, was 205 minutes. Fred Devos and Christophe Le Maillot noted big leads along the new line going west and southwest that need to be investigated. Underneath the heavy layer of organic matter that covers the entire cave, the limestone is white and solid. It is seen where the divers' bubbles have hit the ceiling and cleared it of the organic sediment, leaving a white trail. A second dive was made later in the day, this time with additional diver Luca Magheli, to push a northward lead off the main line. The Broken Line of 137 meters was added here. Progress to the northeast is blocked by breakdown, and the passage swings to the southeast and will probably loop back to the main line. Elsewhere, the Russian Line was installed for 28 meters in a side passage only 3 meters wide and 1 meter high that was a twelve-minute scooter ride up the French Flow Lines.

*April 5, 2006*. Fred Devos and Chris Le Maillot explored 280 meters beyond the end of the Silica Dome Line, laying the Zigzag Line in a dive of 195 minutes. This is an area of large passages and steady flow from the southwest. Flow continued, and the cave is promising beyond the end of the line. The halocline was down to 20 meters deep here, 1800 meters from the entrance. During a second, shorter dive, joined by Alex Álvarez, they placed 119 meters of Reversal Line beyond the end of the old French line. This passage is high and narrow, with the halocline near the floor and a substantial northwestward flow of saltwater below it. They left a small lead two stations from the end of their line.

*April 6, 2006*. Per Thomsen and Christophe Le Maillot explored and laid the Shells Line for 367 meters beyond the end of the Zigzag Line. The cave was narrow just beyond a breakdown area, but opened up to the southwest, with a beautiful, well-defined passage with good flow leading to a canyon area. The halocline is at the ceiling at –19 meters, with the floor at –22. Large continuation beckoned. Their dive lasted 220 minutes. Also, in a dive of 90 minutes at an average depth of 13 meters, Alex Álvarez and Fred Devos laid the Dreadlock Line off of the French North Line through 41 meters of poor visibility. They also laid the Orange Farm Line at the end of the French North Line for 62 meters. Exploration was difficult there because of low visibility due to organic goo, but the cave seems to be continuing to the northeast. Both these passages are wide but only 2 meters high, with the halocline at mid-passage.

*April 7, 2006*. In a 205-minute dive, using four stage tanks and two scooters each, Fred Devos and Per Thomsen laid 430 meters of Artery Line in a lead off of the Gandalf Line. The line was laid to the southwest in impressively large passage averaging 5 meters wide and 6 meters high. The ceiling is at –12 meters. At the end of the line, the cave is wide open for more push to the southwest.

*April 6–7, 2006, surface work*. Sam Meacham and Christophe Le Maillot kayaked through canals in western Laguna Caapechen. The canals are intricate, but navigation was easy with the GPS-based RECON unit. From the westernmost point they reached by kayak, it was about 540 meters of difficult walking to the Gem Cenotes. One corner point on the reserve boundary was located and its position recorded. The three remaining cenotes in the Gem group were free-dived and assessed. Only one has cave-diving potential, where a massive crack was observed in the floor that had a large cave passage leading from it. A dive team needs to check that passage, which appears aligned with passages in Entrada Caapechen, to see whether a base-camp project there is needed. Marine fish were seen in the apparently landlocked cenotes.

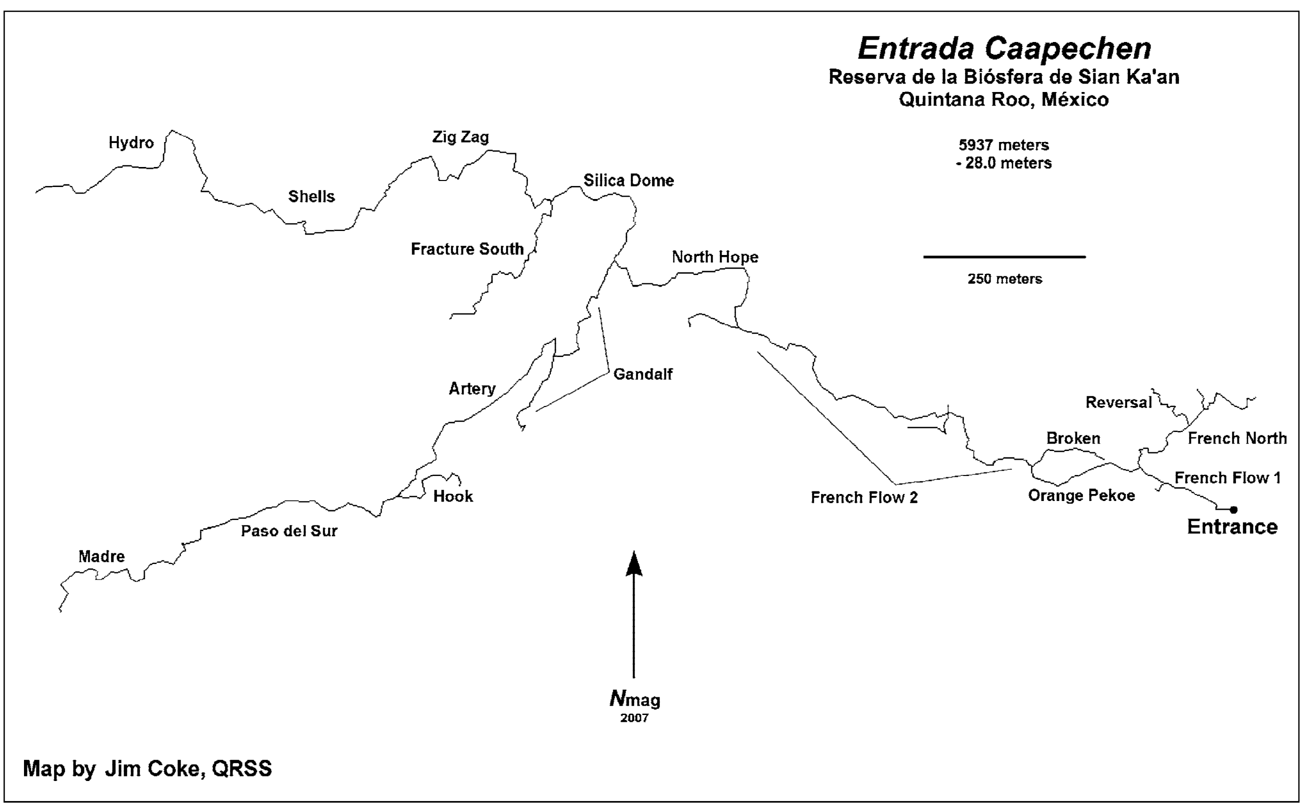
*April 8, 2006*. Fred Devos and Christophe Le Maillot added another 430 meters, the Paso del Sur Line, to the west-southwest, taking the end of the line to 2500 meters from the entrance. Their route was a well-defined tunnel, typically 12 meters wide and 4 meters high, with substantial flow following a big crack in the ceiling. Beyond the end of the line, the cave continues big toward the southwest, with good flow. Safety tanks will have to be placed at 2000 meters penetration because of the lack of entrances along the route. Per Thomsen and Alex Álvarez spent 150 minutes on a scouting dive in the first part of the cave. About 800 meters in, there's a mangrove ceiling that could have been an entrance in the past. There is going cave from there to the southeast.

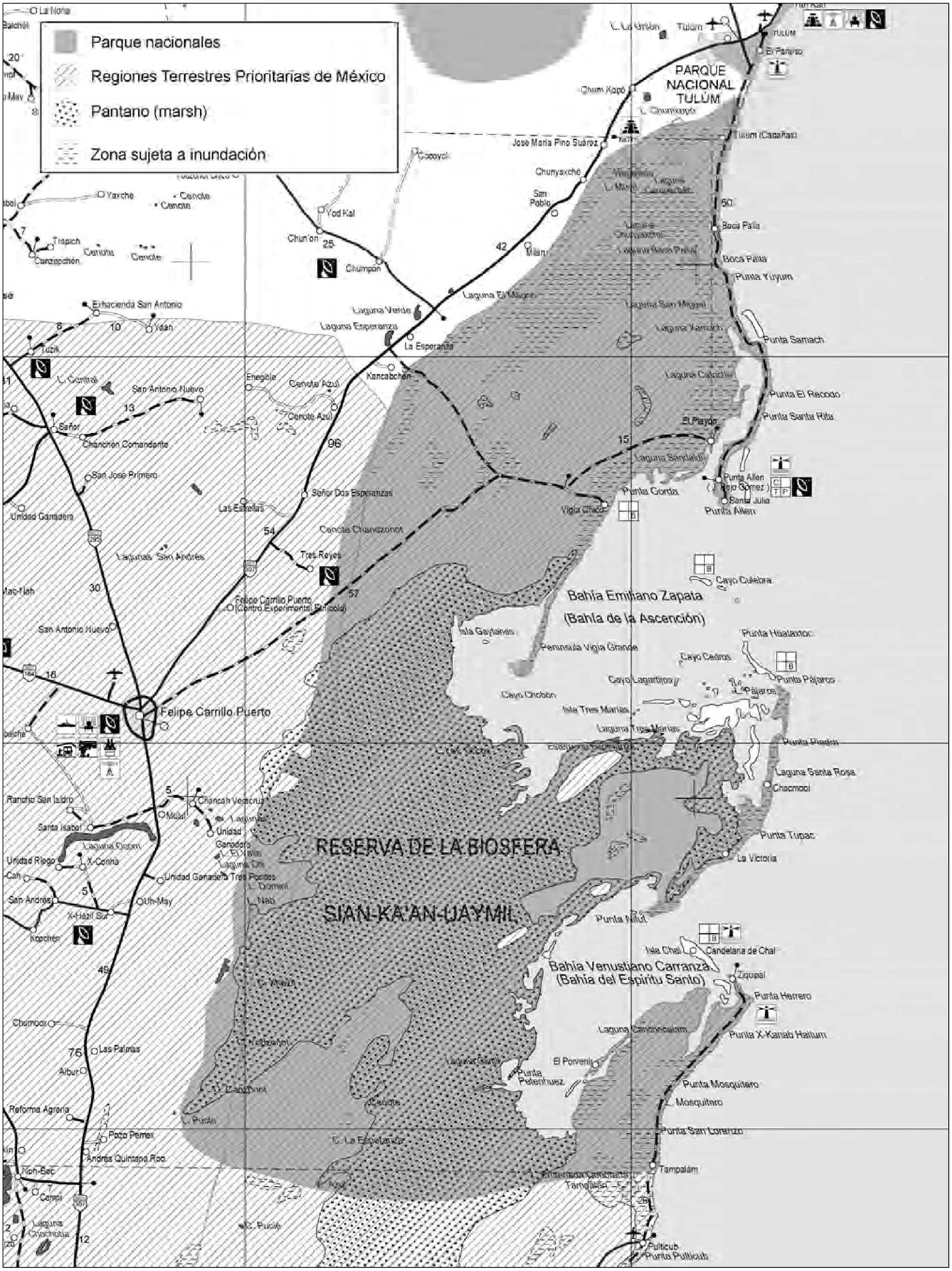
*May 9, 2006, surface work*. Sam Meacham, Mario Rebolledo-Vieyra, Robert Schmittner, and Jack Sherman went to the northern boundary area to investigate two open-water areas south of the Chunyaxché–Boca Paila canal and a raised area known of Cayo Venado. They went by boat from Muyil and then by foot, following overgrown canals all the way. The first area of open water is fed by a small canal and had a maximum depth of about 2 meters, but, despite appearing promising from the surface, it had no cave entrance. The second area turned out to be a dense stand of mangrove with standing water around the edges. Crossing the savanna to Cayo Venado was difficult due to dense, boggy areas, but once it is reached, the vegetation changes, due to the exposed rock that makes up the rise.

*May 16, 2006*. There was a north wind, but a strong flow at the entrance to Caapechen. Fred Devos and Christophe Le Maillot dove to place safety tanks at distances of 1200 and 2000 meters into the cave. Joined by Daniel Riordan for a second dive, they shot photos and video near the entrance. No new exploration was done.

*May 17, 2006*. In a 250-minute dive at an average depth of 18 meters, Fred Devos and Christophe Le Maillot added 335 meters of Madre Line going southwest from the previous end of exploration at the end of the Paso del Sur Line in bedding-plane passage 2 to 10 meters wide and 2 to 6 meters high. They followed the flow to a large, decorated room, then tried to continue past the room to the southwest, but the cave ended at a dome rich in fragile speleothems. The end of the line is now at 2857 meters penetration. There is still a good lead to the north-northwest near the end of the Madre Line. A second dive, by Devos, Maillot, and Franco Attolini, checked several leads near the entrance, with no luck.

*May 18, 2006*. Fred Devos and Christophe Le Maillot dove for 280 minutes, using four stage tanks and two scooters each. They laid 174 meters of Hook Line going northeast and then south from a point on the Paso del Sur Line. The passage is relatively small, only 2 meters wide and 3 high, in saltwater with a maximum depth of 22 meters. At the end of that line, the passage is tight, with no visibility. They also had a frustrating time checking






From state road map by Secretaría de Comunicaciones y Transportes.

other previously noted leads that did not go anywhere. On a second dive, they laid 145 meters of Mangrove Line around the area with the mangrove ceiling, which was at a depth of 11 meters. The lead looped back around to the main line in extremely poor visibility. There is no doubt that this was once a cenote entrance.

*May 17–18, 2006, surface work*. Sam Meacham and Pepe Sánchez spent two days and nights in the northern boundary area of the Sian Ka'an Reserve, traveling by foot and kayak. They checked something observed on aerial photographs that might have been an archaeological site, but it turned out to be a natural hummock. A new *ojo de agua* was seen. Although it is too small for a diver to enter, strong flow from it suggests that there might be cave passage below. Many wildlife observations were made, and an unusual sand beach visited. Most of the canals are banked by mud.

*May 19, 2006*. Fred Devos and Christophe Le Maillot checked out a lead going southwest from the Silica Dome Line and placed 353 meters of Fracture South Line there at an average depth of 20 meters. The passage was a canyon 4 meters wide and 3 meters high. The end of the line is wide open at the halocline, with noticeable flow. During a second dive, with Roberto Chávez as a third diver, they took photos of sediments near the entrance and did some resurvey of the main line near the mangroves.

*May 20, 2006*. Three relatively short dives were made, with the divers carrying only one stage tank each, in addition to their back tanks, at Entrada Oxpechen 1 and Entrada Oxpechen 2 (WGS84 16Q 448831 2221179). Flow in this cave dissipates once inside, and percolation and fine sediment make for poor visibility. It is necessary to push aside floor sediment to enter. Fred Devos and Franco Attolini laid and surveyed the 131-meter Snow Line going south from Entrada Oxpechen 2. From the entrance at –6 meters, the cave slopes down to –20 meters, with the halocline at –19. Mario Valotta participated in one of the other dives.

*June 13, 2006*. Fred Devos, Daniel Riordan, and Per Thomsen made a 269-minute dive from Entrada Caapechen to check the safety tanks at 1200 meters penetration and leave additional safety tanks at 2000 meters in anticipation of further dives beyond the end of the Shells Line. They also photographed the cave from 1200 meters to the Silica Dome and Gandalf areas, but heavy percolation made photography difficult. When they entered, the wind was from the north and there was strong flow from the entrance. Four hours later, with the wind from the southeast, there was no flow from the entrance, and visibility near the entrance was poor. Where does the flow from upstream go, if not out the entrance?

*June 14, 2006*. Daniel Riordan, Per Thomsen, and Fred Devos dove in Entrada Boca Paila (WGS84 16Q 448606 2212441). They resurveyed and replaced 113 meters of old French dive line and explored an additional 313 meters of passage, for a total of 426 meters of new Half Moon Line, going upstream to the southwest and west in large passage with strong water flow. The main tunnel is 10 meters wide and 5 meters wide, with lots of side leads. Average depth of the dive was 13 meters, with the halocline observed at –15 meters. Some jellyfish were observed below the halocline about 350 meters in, which suggests a fairly direct connection to the Caribbean Sea to the east. There is also French line in the smaller passage downstream from the entrance.

*June 15, 2006*. Fred Devos and Daniel Riordan returned to Entrada Caapechen, where the began a 275-minute dive with two scooters and five stage tanks each. They each dropped one stage tank as safety bailout gas 300 meters in. They laid and surveyed 470 meters of new Hydro Line beyond the end of the Shells Line. The passage was well-defined tunnel 10 meters wide and 5 meters high, going west at an average depth of 18 meters with substantial eastward water flow. The end of the line, 2953 meters from the entrance, was left wide open. A Hydrolab was carried all the way to the end to measure properties of the water column.

*June 16, 2006*. In the last dive of the project, Fred Devos, Daniel Riordan, and Per Thomsen dove Entrada Caapechen to take water measurements and samples, take photographs, and remove safety tanks. Water-column profiles were taken with the Hydrolab at the entrance, at the first T, at Silica Dome, and 120 meters to the left from the T. Water samples at various depths were taken at the same locations. Riordan took 160 photographs during the dive. They also resurveyed the line in the first 300 meters of the cave.

## THE SIAN KA'AN BIOSPHERE RESERVE

From the Web site of Centro Ecológico de Sian Ka'an, www.cesiak.org/aboutsiankaan.htm and www.cesiak.org/habitat.htm.

The Reserva de la Biosfera Sian Ka'an was established on January 20, 1986, by presidential decree (under President Miguel de la Madrid Hurtado) and became part of UNESCO's Man and the Biosphere program that same year. In 1987 the reserve was declared a UNESCO World Heritage Site. As part of the MAB program, Sian Ka'an faces the greatest challenge of conservation: to find a way to integrate human activities without compromising other forms of life contained within its boundaries.

Sian Ka'an is approximately 1.3 million acres in size and spans 120 kilometers from north to south, comprising almost one-third of the Caribbean coast of Mexico. In 1994 an area of over 200,000 acres to the south of the Reserve was named the Protected Area of Flora and Fauna of Uaymil, increasing the contiguous area of protected land.

The reserve contains three large core zones where human activity is limited by permission to scientific research. These areas, known as the Zonas Nucleares of Muyil, Cayo Culebras, and Uaymil, cover a total area of almost 700,000 acres. Low-impact human activities and sustainable development occur in the area of the reserve known as the buffer zone. The human population is estimated at 2000 inhabitants, the majority of whom are located in the coastal regions, especially in the fishing villages of Punta Allen and Punta Herrero. Approximately 1 percent of the land within the reserve is privately owned.

There are five entrances to the reserve, located at Pulticub, Santa Teresa, Chumpón, Chunyaxché, and Chac Mool. Guards employed by the governmental SEMARNAP organization are stationed at every entrance to enforce the reserve regulations.

Sian Ka'an is translated from Mayan

as "where the sky is born" or "gift from the sky." The reserve is thought to have been inhabited in the pre-Classic and Classic periods as part of the chieftainships of Cohuah and Uaymil. There are twenty-three known archeological sites inside the reserve. Discoveries of human remains, ceramic pieces, and other artifacts have been dated up to 2300 years old. The northernmost section of Sian Ka'an contains what is thought to be an ancient trade route through lagoons and mangrove channels between the cities of Tulum and Muyil. Parts of what is now the reserve were once areas of chicle production and trade through the middle of the twentieth century, and the fishing industry is still one of the most important economic activities of the reserve's population. Common species include spiny lobster, tarpon, grouper, permit, nurse shark, hammerhead, black-tipped shark, and snapper. Tourism is another source of income for fishermen in Sian Ka'an, who are hired to run boat trips to see the reefs and lagoon systems. Approximately 36,000 tourists entered the reserve in the year 2000, and those numbers are expected to increase significantly for the year 2001. There is a charge of $4 US per person per day as a fee for entrance to the reserve.

Habitats found in the Sian Ka'an Biosphere Reserve are:

*Coral Reef.* The boundaries of the Sian Ka'an Biosphere Reserve include 110 kilometers of the second largest barrier reef in the world, which extends onward past Belize and Honduras. The reef is home to many important and several endangered species. Uncontrolled development along the Caribbean coast of Mexico has placed the reef in grave danger, as it is easily damaged and not so easily restored.

*Beaches.* The beaches of Sian Ka'an constitute very important habitat and nesting grounds for many species of wildlife, as well as serving as an important transition between land and ocean. Most notably, during the months of May through August the beach is a nesting ground for four endangered sea-turtle species that have lost important nesting sites along many parts of the Caribbean coast.

*Dunes.* The coastal dune is an important protector of inland habitats, especially during storms. Coastal vegetation includes *Coccoloba uvifera*, *Tournefortia gnaphalodes*, *Suriana maritima*, *Sesuvium portulacastrum*, *Ambrosia hispida*, *Ipomoea*, and many other species.

*Wetlands.* Mangroves, savannas, swamps, and marshes are all included within the classification of "wetland." Water plays a vital role in the existence of each of these habitats, whether it be fresh, salty, or brackish. Wetlands line the coast of Sian Ka'an, playing an important protective role as a type of buffer between the ocean and the land that can absorb the impact of storms. Wetland areas contain immense biological diversity and are home to a number of endangered species. Evident in all inundated wetlands is a conglomeration of algae known as periphyton that is believed to play an important role in the dissolution of calciferous soils, as well as being an invaluable source of food for many species of fish, mollusks, and insects.

*Mangroves.* Four species of mangrove line the coastal areas of Sian Ka'an. The mangrove communities are critical for the survival of many species of fish, birds, insects, reptiles, and other plants. Many species of mangrove filter contaminated water and trap loosened sediment, making them protectors of the coral reef and other littoral habitats. The mangrove species found within Sian Ka'an are *Rhizophora mangle* (red mangrove), *Avicennia germinans* (black mangrove), *Laguncularia racemosa* (white mangrove), and *Conocarpus erectus* (buttonwood mangrove).

*Savannas.* Coastal savannas are large areas of low-lying land with sparse, oxygen-poor soil that is inundated throughout much of the year. As few tree species have adapted to these conditions, savannas are dominated by species of grass, reeds, and rushes that rarely exceed 3 meters in height. Inland savannas contain shrubs and occasional trees in addition to grass, are drier, and have a lower salinity. These environments are in danger of natural fires during the dry season.

*Cenotes or sinkholes.* Fresh water contained in the Yucatan's underground aquifer carves away at the limestone above, weakening it and eventually causing it to give way. The result of this phenomenon is a unique habitat known as a cenote or sinkhole. Many cenotes remain connected with the aquifer and with other cenotes through underground passageways. Occasionally, however, cenotes are found to be completely isolated from other bodies of water and may contain fish and other wildlife that have evolved over time into completely distinct species.

*Hummocks. Petenes*, or hummocks, are isolated areas of forest from several meters to several kilometers in diameter that are surrounded by swamps or inundated savanna land. These formations are found only in Cuba, the Florida Everglades, and the Yucatan Peninsula. There is often a cenote at the center of the hummock, which is surrounded by concentric circles of vegetation, from hardwood trees to grasses and rushes. Common species include cedar, mahogany, and zapote in the center ring, surrounded by various palm trees and the poisonwood tree, and eventually mangrove, rushes, and grasses. Many species of fauna live in hummocks, from insects to reptiles, mammals, and birds.

*Tasistales.* A *tasistal* is a concentrated strip found within savanna land that contains the tasiste palm (*Acoellorraphe wrightii*), the grass *Cladium jamaicensis*, and occasionally other plant species such as poisonwood (*Metopium brownei*), buttonwood mangrove (*Conocarpus erectus*), and cocoplum (*Chrysabalanus icaco*). The tasiste palm is extremely fire-resistant, and will survive natural fires that often strike savanna.

*Fresh-water lagoons.* The fresh-water lagoons of Sian Ka'an are supplied with fresh water from the subterranean aquifer by small springs or cenotes. Found mostly inland, the fresh water filters toward the ocean in channels or through the surrounding wetlands. The lagoons are home to a number of species of fish and vegetation not found in the coastal areas.

*Brackish-water lagoons.* Ocean water and fresh water from inland and the aquifer meet and mingle in the brackish-water lagoons along the coast of Sian Ka'an. These lagoons are lined with salt-tolerant mangrove and grass species that provide a home to fish and mollusk species and make the area an attractive nesting ground for wading birds and the residence of two crocodile species, *Crocodylus moreletii* and *C. acutus*.

*Low tropical forest.* Many of the mammal species found within Sian Ka'an reside within the low tropical forest land that is located in the western portions of the reserve. The forests contain many hardwood species, including chechem, chicozapote, mahogany, tsalam, and other valued hardwoods. The environmental importance of these areas is increased by the international demand for hardwood that is pressuring many countries in the neotropics.

## Cuevas Subacuáticas de Sian Ka'an

De noviembre 2005 a junio 2006, espeleobuzos del Centro Investigador del Sistema Acuífero de Quintana Roo y el Mexican Cave Exploration Project investigaron cuevas subacuáticas en el límite norte de la Reserva de la Biósfera Sian Ka'an, al sur de Tulum en Quintana Roo. Alrededor de 7 km de pasajes fueron explorados y topografiados, con 6 km de ellos en la Entrada Caapechen. Ya que, a diferencia de muchas de las cuevas subacuáticas largas de la zona, Caapechen tiene una sola entrada los buceos de mayor duración alcanzaron distancias de 3 km y requirieron que los buzos iniciaran la inmersión hasta con siete tanques. El proyecto también realizó algo de topografía en la superficie, revisando cenotes para encontrar posibles entradas.

La Reserva de la Biósfera Sian Ka'an, junto con la vecina área protegida Uaymil, cubre un área de 500,000 hectareas. Fue establecida en 1986 y contiene muchos distintos ecosistemas, como arrecifes de coral, pantanos, lagunas y cenotes.

# BAT CAVES OF CHIHUAHUA AND SONORA

## Philip Rykwalder

*"What did he say?"*
*"He asked if we were Christians. He says there are devils in the cave."*

Driving west out of Austin, Texas, Jean Krejca, Vickie Siegel, Peter Sprouse, and I cross into Mexico at Juárez, Chihuahua, and drive to the house of Gustavo Cortés, a Juárez caver and friend of Peter's. We four Americans are on a trip sponsored by Bat Conservation International in order to assess bat caves in Chihuahua and Sonora, Mexico. In the morning we have a somewhat novel but amazingly delicious breakfast of barbacoa and head south of Juárez. We are bound for the site of a large radar anomaly, assumed to be an enormous bat flight, that had been seen on the Las Cruces weather radar. We are to locate its source.

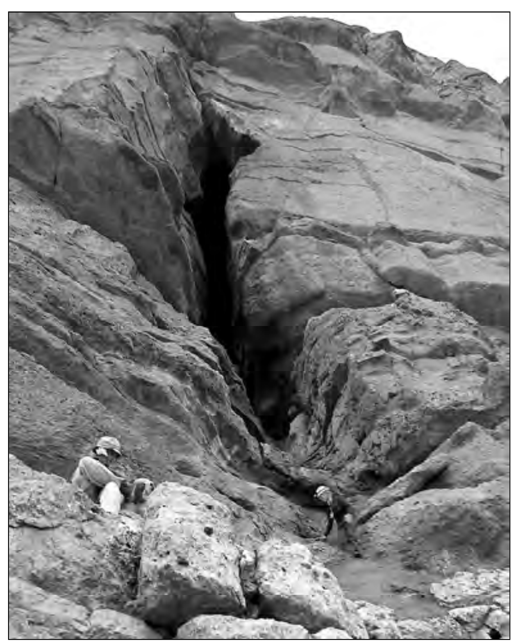
South of Ciudad Juárez, we drive past abandoned desert ranches, desolate ranches that any sane man would long ago have abandoned, rusted iron, faint runways, and no vegetation on the flatter-than-flat and hotter-than-hot white land of the playa. In this vast ancient lakebed, one of the most featureless yet mesmerizing bits of nature, we marvel at illusions, deception, and trickery on the horizon, as each of us looks off to the south and spots something, squinting with skeptical eyes. Soon we cautiously mention the optical illusion to each other in the same tentative and disbelieving voice as one might say, "Hey, do you suppose that's a UFO?," and then we are all out of the trucks with cameras in hand, staring off at floating mountains on the horizon in the distance.

We locate the bat caves in the Sierra la Nariz with the help of locals in Rancho las Norias and park the trucks some time in the afternoon, to find that a few kilometers of rolling cholla and ocotillo desert and a 600-meter-high talus slope separate us from two very tall tectonic cracks with huge mounds of guano pouring out of their entrances. Walking along through the desert of purples and browns, climbing, climbing, and finally scrambling, we find ourselves at the mouth of the first tall crack nested in dark, volcanic rock. The entrance is perhaps 60 meters high and 4 meters across. A giant mound of guano cascades out of its entrance at the angle of guano repose and spreads down the cliff below. We stand below the great entrance on the mound. Immediately below us is a cliff, and beyond it the guano cone extends down the mountainside. We see much evidence of guano mining up in the cave, and although bold guano miners have entered the cave, a small cliff, with loose footing in gooey guano and a lot of cliff exposure prevents our entry.

Peter, Jean, and I head off to the east and traverse along the base of the tall cliff to locate the second crack seen from the trucks. Another small headwall is at its entrance, along with walls covered by clumps of traction-sucking dry guano. Our entry is again denied, though I find a homemade grappling hook. Traversing farther east, I find a smaller fissure cave, and Peter, Jean, and I explore it. As it is the only bat cave in the vicinity that we are able to enter, we make sure to take bat population estimates and make a biological inventory of the cave. Squirming up a hole in overhead breakdown, I pop out higher on the cliff in time to watch a glorious desert sunset before the curtain of evening descends on the land. When the sun was up the trucks were glimmers of silver in the distance, but now a great sea of darkness separates us from our vehicles.

En route to the trucks I find some hundred meters of sun-rotted guano miners' rope and another surprise, a homemade mining pick welded from a truck's leaf spring and a bit of pipe, which very nicely complements my

Gustavo Córtez and Vickie Sielgel outside a tectonic crack used by bats. *Peter Sprouse*.



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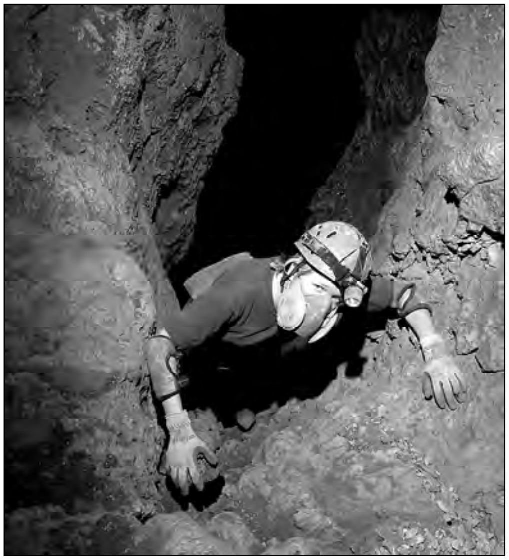
livetocave@hotmail.com
Photographs ©Peter Sprouse, Bat Conservation International



Jean Krejca climbs out of Cueva Vinata. *Peter Sprouse*.

grappling hook. As we continue through the dark toward the trucks, I slip it into my pack. Gustavo has elected to head back to Ciudad Juárez and has already retraced his tracks across the featureless playa in the dark, using the gentle glow of the large metropolis as a beacon.

In the morning, after briefly visiting a grassy desert oasis, La Amargosa, we spend a day driving across Mexico's largest state, Chihuahua. Hitting the pavement again at Ahumada, we continue to Ciudad Chihuahua. After passing scenic Cañón el Peguis, we continue northeast to Ojinaga for the night, where we eat a deliciously greasy dinner in the Burrito Bus, a school bus converted into a restaurant.

The next morning we head to a cave visible from *la frontera*. Asking directions in Barranca de Guadalupe, we receive guidance from an old man on a bicycle, who points us to Cañón de la Chiva and advises us that we had better be good Christians, as there were devils up in the cave. We kit up below the cave, head up a short scree slope to the entrance, and start our survey. Vickie and I scramble up a steep bedrock slope inside the entrance to survey, while Peter and Jean stick to surveying the main level. Peter named it Cueva del Plátano Malo. After the survey is complete we drive on, spending the night camped near Rancho el Murciélago.

The deserts in Chihuahua that we traverse to hunt for bat caves consist largely of volcanic rocks. Many of the caves we visit are in this dark-brown to purple rock, and are short, one-room shelter-type caves. While the caves come up a bit lacking, the deserts of Chihuahua more than make up for their shortcomings, with broad mesas, valleys hidden in shadow, landscapes strewn with strikingly colorful volcanic rocks, and a glorious display of desert life.

After visiting Plátano Malo, we drive through the open desert and camp on naked, thorn-studded ground near Rancho Socorro, where we look for scorpions with a blacklight. In the morning, before heading farther south toward the Río Conchos, we map two small volcanic shelter caves in El Murciélago, set in rock walls with finely painted characters in some past language.

Later we find ourselves driving south through the dark, bound for La Perla. We look for a camping spot, and look, and look, and then it is late—far too late. We eventually camp on a gravel road when weariness overtakes us to the point that the lump poking you in the back as you lie down is irrelevant. In the morning we drive into the nearby mining town of La Perla, a town reminiscent of a Steinbeck novel. We breakfast at the town restaurant and find that miners apparently aren't paid well enough to eat at the restaurant, whose cooks aren't well versed in their trade. Vickie and I order *huevos rancheros*, my favorite, and are served two eggs with a bad Mexican ketchup on them in lieu of the *ranchero* sauce. She slides her plate my way before it is fully put onto the table saying, "Help yourself," and I don't.

We are shown to a cave the locals refer to as *El Hundido,* meaning the sunken spot, and figure that with a name like that it has to be a good lead. After documenting guano mining activity inside the entrance, we explore a large borehole that descends nearly 100 meters vertically before ending in a breakdown room over 400 meters beyond the dripline. It is formed in variegated gypsum with strands of oranges, yellows and purples in it. It is the first time I have a good look at a most decidedly exotic-looking bat, this being the ghost-faced bat *Mormoops megalophylla*. I feel like I am reading a bat book featuring bats from around the world. Wending our way down through the breakdown, we find a lower, drain level, and after mapping a few hundred meters to the cave's end, we leave in the night and drive in a new direction, west.

Traversing more desert, we briefly skirt a dammed reservoir and make our way up into the low hills to a cave marked on Mexican topographic maps. Locating it just before sunset, we dine out in the open and then head up to the

Jean Krejca takes notes outside Cueva Murciélago 1. Cueva Murciélago 2 is at the left of the photo. *Peter Sprouse*.

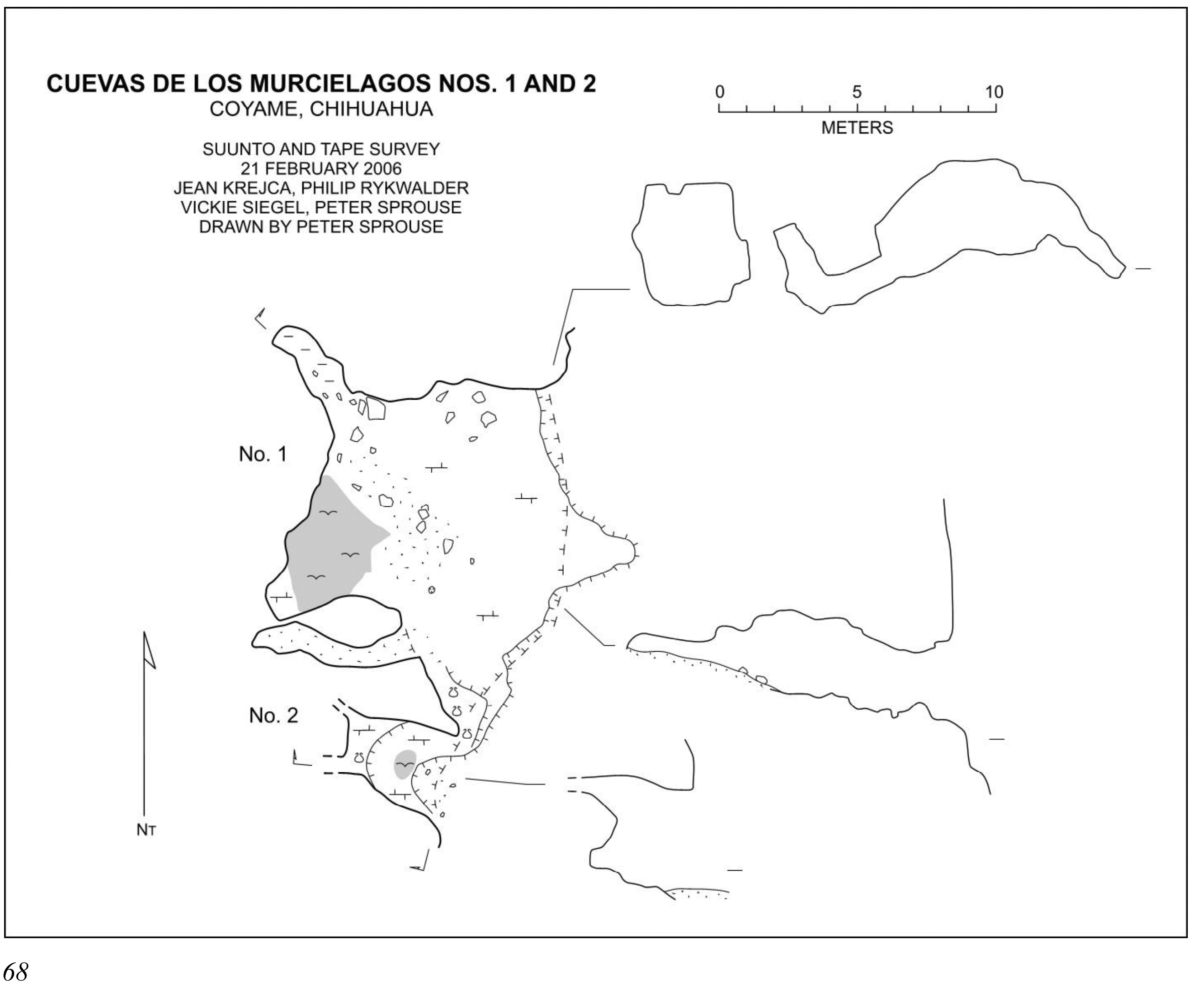
cave. We arrive to find bats leaving for their nightly dining experience, and we net a few of them while Vickie does a bat count. The cave itself, Cueva Vinata, reeks horribly—no, hideously—of ammonia. Breathing is difficult in this stifling, hot horror, and we hurry through the motions of surveying the cave. Outside afterwards, we gasp for air and settle in for a night under the open sky.

We meander our way through mountain roads for hours at a time in the Chihuahuan highlands just outside the glorious Copper Canyon, passing through Cuauhtémoc, Basaseachic, and into the state of Sonora. There we eat the hottest *enchiladas* around and spend the night at a tiny roadside town, Yécora. In the morning we are shown to Cueva El Salitre in Cañón Santa Rosa, another shelter cave in volcanic rock, although this one is fairly large. We spot multiple bat species in it, and the powdery yellow droppings of a nectar bat. After the map is made we continue our westward progress.

In Sonora we continue to the state's capitol, Hermosillo, and to the house of Ernesto Torres Picos, another friend of Peter's. Ernesto is beyond exhilarated when we arrive and excitedly shuttles us into his car and proceeds to tour us around the city at top clip in his sedan, a former Tucson police car. He has a way of driving without actually looking at the road. Perhaps sensing our agitation as he almost sideswipes every car we pass, or perhaps interpreting our agitation as dissatisfaction in his vehicle of choice, he herds us out of the cop car and into an SUV, and we proceed to the bar district at a sprint.

Mexican bands belt out tune after tune for a young crowd of *campesinos* and city girls in a gay, entertaining, and unequivocally festive atmosphere. The five us cram in around a tiny table, listen to the music over pitcher after pitcher of beer, and watch young couples dance in that close Mexican way. They take turns dancing in the spotlight as the featured couple, but the night's main event was when the two *gueras* from the States, Vickie and Jean, take to the floor. The music throbs to new heights and every camera phone in the house is raised up and photo after photo was taken of these two blondes dancing together while the crowd roars and roars with excitement. Half drunk on beer and half on pure energy, we return to our hotel room at the hand of Ernesto, and sleep soundly.

In the morning a day to beat all days begins with a trip to the *Protección Civil*—not a move that I'd typically make. Peter and Jean grab handfuls of papers from the truck and head in to talk to *Seguridad Pública* and *Protección Civil* personnel, leaving Vickie and I to wait at the truck. Though neither Peter nor Jean surface, we can tell they are causing serious commotion



Jean Krejca, Vickie Siegel, and Philip Rykwalder at camp in the desert. *Peter Sprouse*.

inside as car after car empties uniformed men into the station. Hours tick by and Vickie and I go for tacos and discover the fattest man in the world selling *chicharrones.* Soon, back at the station people pour out, and Peter comes back saying, “We’re in.”

Cueva de Santa Martha is a cave located in the city limits of Hermosillo. It is a bat cave, but it is also a local cave, that is, a cave visited by locals. Being escorted to the cave by no fewer than five police cars, we arrive to find that we were in the center of a *policía* and *prensa* mess. The newspaper and radio people are there, perhaps twenty policemen, and countless blaring radios and squawking CBs. Uniformed men do what they do: stand around and mill about in self-important military postures. Peter and Jean had convinced the police to let us visit the cave against their wishes, because typically the police visit the cave to rescue lost or trapped people from within. They had to be convinced that we weren’t going to get lost or eaten by some animal, and that nothing else bad was to happen. Claiming scientific reasons for access probably helped our cause, but the police don’t take any chances. They are out in full force and ready to help us in case anything happens.

Feeling a little intimidated by the crowd of uniformed men (and unable to find a private place to change into cave clothes), we eventually start the survey, but only after the assistant chief of police enters the cave with a three-foot mag light and makes sure it is safe for us. Peter and Jean head in to do bat counts, while Vickie and I start the survey at the cave’s entrance. We enter the cave, which is a badly trashed-out shell of a once-elegant cave. It is formed in marble, with those fascinating and quite unique passage shapes of splayed-out rock fins and pendants only found within this rock. But the smell of burned rubber fills our lungs, broken glass pokes at our knees, and trash is everywhere. The cave is nasty. Over the next few hours the two survey teams net over 200 meters of passage in an entirely unconfusing cave. I wonder how in the world people get lost in here. At one point I leave the cave to retrieve additional photographic gear, and a policeman escorts me the short distance from the cave to the truck and back. It is a police-state at Santa Martha this day, and Vickie and I name our survey the CC survey for the Crazy Circus going on around us. We all leave the cave near dusk, just in time to find the chief of police of Hermosillo pull up to greet us. I honestly would not be surprised to see helicopters circling overhead. Reporters from the local paper, *El Imparcial*, follow us to dinner and interview us over fish.

That night we drive north, staying in Carbó, and the following day we get directions to Cueva del Tigre. Jean and Peter map bat habitat in this cave, which has a very strong odor of ammonia in it, while Vickie and I map a small nearby mine that is also inhabited by bats. That night we drive north to Tucson and stay at Pete Shifflett’s house for the night, before driving back to Austin in the morning.

Vickie Siegel in the entrance to Plátano Malo. *Peter Sprouse*.

Vickie Siegel in Cueva de Santa Martha. *Peter Sprouse*.

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This trip was undertaken by Zara Environmental personnel under contract to Bat Conservation International for the purpose of assessing northern Mexico bat caves. Special thanks to BCI for allowing us this wonderful experience.

Cuevas de Murciélagos de Chihuahua y Sonora

Espeleólogos contratados por Bat Conservation International visitaron muchas cuevas que albergan murciélagos en los estados de Chihuahua y Sonora, incluyendo algunas cuevas en Chihuahua que tienen tal cantidad de murciélagos que son vistos en los radares metereológicos cuando salen de las cuevas. Una de las cuevas topografiadas está dentro de los límites de la ciudad de Hermosillo.

# PITS AND PARROTS
# THE 2006 LOS TOROS EXPEDITION

## Mark Minton

At the end of our 2005 annual Purificación trip (see *AMCS Activities Newsletter* 29, pages 55–59), we discovered a potentially significant new caving area around the village of Los Toros, Nuevo León. We were excited to get back and pursue the high, blowing cave Soplo de Los Toros, as well as the resurgence cave down in Arroyo Luna. But before we could do that, we wanted to rebuild the washed-out road to Los Toros so that we would not have to hike in every day.

Our team consisted of Yvonne Droms and Mark Minton from Virginia, James Hunter and Tanja Pietraß from New Mexico, Marion Smith from Tennessee, Bill Steele and Diana Tomchick from Texas, and Adam Zuber from Washington. We had come prepared with a full array of tools, including sledgehammers, pry bars, a come-along, a pick-mattock, shovels, and chisels. We used them all. Over the course of about six hours on December 18, 2006, we attacked the arroyo where the road had been, prying boulders loose and winching them out of the way. We filled holes and leveled out the rough spots. But the real challenge was an abrupt three- to four-foot rise at the end of the first arroyo-crossing, where the bank had been deeply eroded, leaving a vertical wall of bedrock. We used the same technique the locals use when building roads in such uneven terrain. We gathered flat rocks and stacked them into a wall leading down from the ledge to the floor of the arroyo. Then for an hour or more we tossed all manner of stream cobbles and stones into the void behind the wall until we had filled it in, leaving a ramp. James got the honors, while we all held our breaths. It worked! He drove across, and the ramp held. The other two trucks followed, and we were on our way. The remaining arroyo crossings required minor repairs, but were basically passable. Once up onto higher ground, the road was in perfect shape. We made camp at sundown just outside of Los Toros.

The following day, after some visitors from neighboring Potreritos, who were surprised to see trucks there, walked by, we hiked up the mountain and found the abandoned logging road we had seen previously, but had not followed back to town. We noted several good potential campsites and found the route down to Los Toros. We visited the home of the *jefe* and obtained permission from his wife Sofía to camp, explore, and even to use the local water trough. We drove up to a nice clearing and set our camp at about 1900 meters elevation, less than a kilometer down the ridge from Soplo. An added bonus of this camp was a small spring, shown to us by the *jefe*'s brother, a couple of hundred meters away, which would be important for washing the tremendous amounts of mud out of our gear after each trip. Large flocks of parrots flew over camp almost daily from the direction of Arroyo Luna.

The first trip into Soplo finally took place on December 20. We split into two teams: Adam, Bill, Diana, and Marion were the push team, while James, Tanja, Yvonne and I brought in additional rope, in the form of a huge 200-meter coil, and tweaked the rigging. The push team got down only three short drops beyond last year's end before encountering a near sump. Deep water blocked the passage, leaving a narrow slot at the far end as the only possible way on. Undaunted, Adam stripped naked, except for boots, and dropped into the pool, which was over his head. Bridging on small ledges, he dug at the slot overhead for over two hours, finally working his way up into wider passage a meter above the water. Our hero! This led shortly to a fairly deep drop with water at the bottom. This was the first, and so far only, significant water we have encountered in Soplo. As they were surveying out, our team caught up and passed through to check out Zuber's Bathtub. James chimneyed out over the pool and rigged a rope around a bridge. From there he was able to get up into the continuing passage without swimming. Then James and I, working from opposite sides, opened a larger hole in the roof over the pool, providing easier access. We rigged a second rope so that one could walk on the slack lower line while tethered at the waist to the taut upper one, completely avoiding the water. Yvonne came across, and we rigged, but did not descend, Adam's Pit. The rigging was difficult, because the walls were many centimeters deep in gooey corrosion residue. We had to dig through this layer to more solid rock underneath in order to set bolts. The floor was deep, sticky mud.

Every trip into Soplo was a test in operating in sticky mud. Although much of the cave does not look like it would be very muddy, nevertheless a coating

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Mark Minton entering Soplo.
*Yvonne Droms*.

Road work. Clockwise from upper left: *Adam Zuber, Diana Tomchick, Diana Tomchick, Yvonne Droms*.

Adam in Zuber's Bathtub. *Bill Steele.*

of mud gets on everything, and soon all of the ropes and all of one's vertical gear are covered. We probably weighed a few kilos extra on the way out each time. We all decided that Soplo has the dubious distinction of being the muddiest vertical cave we had ever done, surpassing our previous worst, Pinos (see *AMCS Activities Newsletter* 26, pages 46–50). It is a tribute to ascenders that they can function under such conditions. The spring near camp was a godsend for cleaning up between trips.

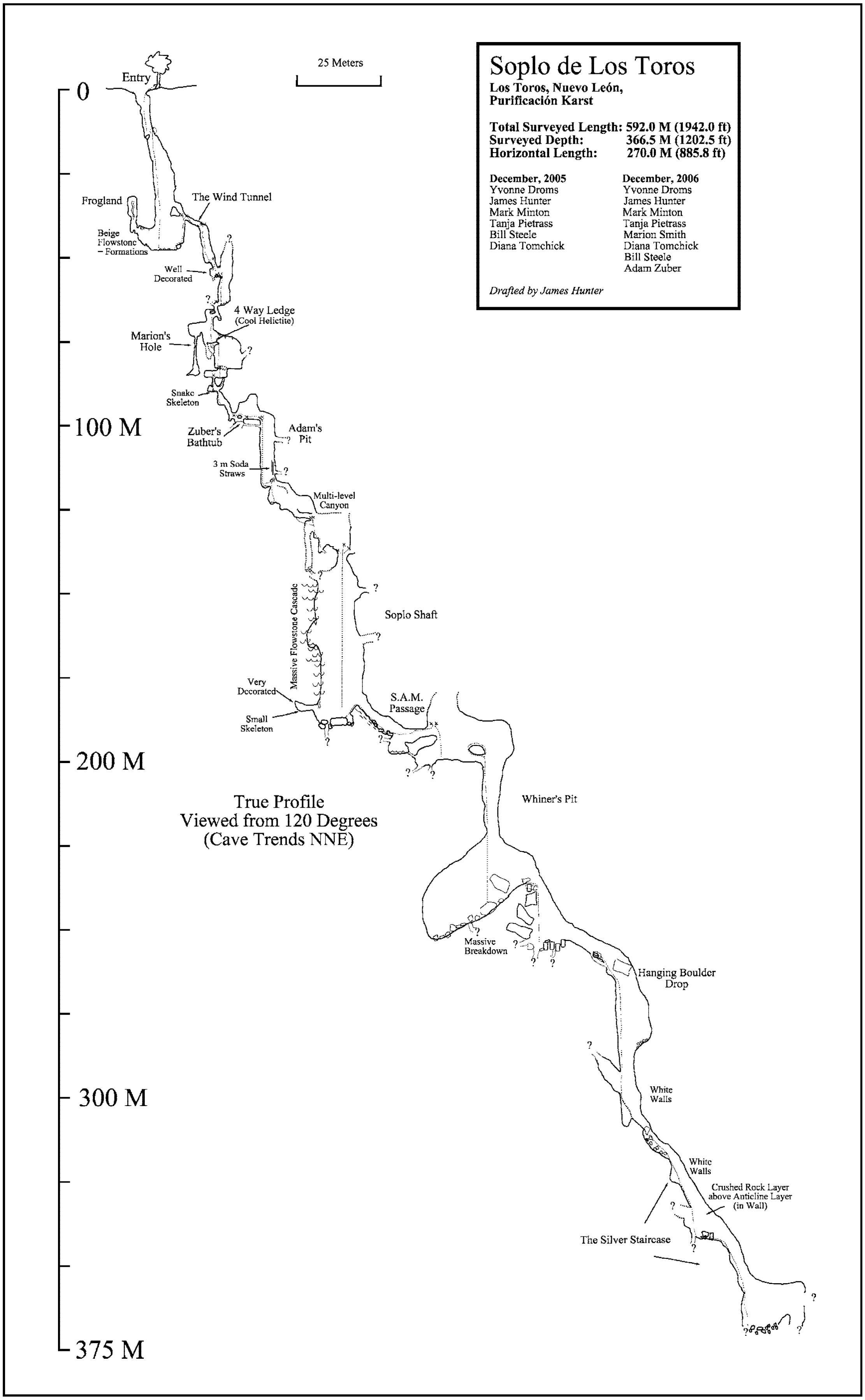
Two days later we were back in Soplo. Adam, Yvonne, and I descended Adam's Pit to a well-decorated, shallow pool at the lip of another drop. On one wall were three soda straw columns about 3 meters long. From there, narrow, braided canyons on three levels led to another drop, which split part way down into two routes. These were found to rejoin in the next pit, so the bigger route was chosen. (This behavior is common in Soplo. Often there are two or more parallel routes, the lower of which carries the trickle of stream and is more decorated. The routes repeatedly reconnect and then divide again.) A large canyon rounded a couple of corners and dropped away into a deep pit. Yvonne descended the 50-meter-deep Soplo Shaft, noting that the water rejoined and then disappeared again part way down and that there were a couple of possible leads near the bottom. We surveyed out from the top of the shaft, since we did not have a long tape. We had gained significant new depth, and the cave appeared to be going strong. The trip was 15 hours long.

Meanwhile Bill, Diana, and Marion checked an undescended pit above the Four-Way Ledge in Soplo. It was blind, but in getting to it Bill took a 3-meter fall, which fortunately produced no more than a spectacular bruise. Bill also set his grappling hook in a window in the second drop, but did not pull over and investigate the lead, which we think could bypass the muddy Wind Tunnel.

After another gonk day, we fielded two teams. Adam, James, Marion, and Tanja returned to Soplo to survey the Soplo Shaft and push on from the bottom. An easy climb to a muddy ledge led to descending canyon passage. Although the walls were almost pure white, the floor was covered with sticky, reddish mud. After a traverse and a short drop, a large 40-meter-deep drop, the Whiner's Pit, was encountered. This landed in a breakdown room that led to another drop, which they left for another day. An interesting discovery was made at the bottom of the Soplo Shaft. The complete skeleton of a small mammal, about the size of a squirrel, was in an alcove a couple of meters off the floor. How could so large a creature have gotten that far down the cave and still been able to climb into an alcove at the bottom of a 50-meter free drop? Is there a lower, more direct entrance we are unaware of?

While the others were in Soplo, Bill, Diana, Yvonne, and I geared up for the big hike to the resurgence. Last year we had only poked in a few meters, to where we could hear a waterfall beyond a deep pool, and we were excited to see where it went. We had full backpacks, with cave gear and wetsuits. The hike was as long and steep as we remembered it to be. It took about four hours, and we covered over 5 kilometers distance and about 1000 meters vertically each way. At the resurgence we suited up and jumped in. Around the corner from last year's poke was a small cascade over flowstone—so much for a waterfall. The passage beyond was good-sized, with deep water much of the way. After a hundred meters and a low air space, there was another cascade. This time we climbed up about a meter and a half. There were very nice white formations in an alcove to the left, probably fed by water from a surface arroyo nearby. Not far beyond the climb, the walls became very muddy and narrowed down to a tight slot over deep water. We hammered with a rock, but were unable to get through. It should yield to a hammer, but the lack of air flow was discouraging. We made a compass and pace estimate of the passage

On rappel! *Yvonne Droms.*

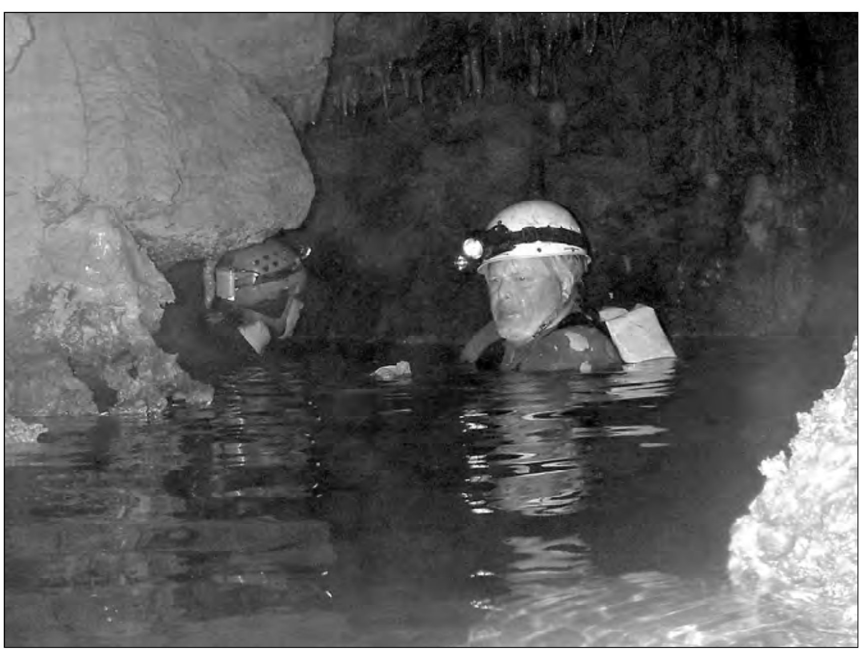

Soplo de Los Toros
Los Toros, Nuevo León,
Purificación Karst
Total Surveyed Length: 592.0 M (1942.0 ft)
Surveyed Depth: 366.5 M (1202.5 ft)
Horizontal Length: 270.0 M (885.8 ft)
December, 2005
Yvonne Droms
James Hunter
Mark Minton
Tanja Pietrass
Bill Steele
Diana Tomchick
December, 2006
Yvonne Droms
James Hunter
Mark Minton
Tanja Pietrass
Marion Smith
Diana Tomchick
Bill Steele
Adam Zuber
Drafted by James Hunter
25 Meters
0
100 M
200 M
300 M
375 M
Entry
Frogland
The Wind Tunnel
Beige Flowstone Formations
Well Decorated
4 Way Ledge
(Cool Helictite)
Marion's Hole
Snake Skeleton
Zuber's Bathtub
Adam's Pit
3 m Soda Straws
Multi-level Canyon
Massive Flowstone Cascade
Soplo Shaft
Very Decorated
Small Skeleton
S.A.M. Passage
Whiner's Pit
True Profile
Viewed from 120 Degrees
(Cave Trends NNE)
Massive Breakdown
Hanging Boulder Drop
White Walls
White Walls
Crushed Rock Layer above Anticline Layer (in Wall)
The Silver Staircase

Adam Zuber at the top of Whiner's Pit.
*James Hunter*.

Yvonne surveying in the Silver Staircase.
*Mark Minton*.

on the way out: roughly 150 meters. Our cave trip lasted only an hour and a quarter, because of the lateness of the day and the long hike back to camp. It's a good thing we had a GPS, because we got temporarily lost in the dark on the way back up. Further work at the resurgence will require a camp somewhere nearby, although suitable spots are scarce. (Since our previous visit, we had discovered that our Nacimiento de Los Toros was the same as the Nacimiento de Hervores that Charles Fromen had found from the bottom via Arroyo Luna back in 1993. Since Cañón los Hervores actually begins farther downstream and contains other rises, we decided to keep our name.)

After another gonk day, we took advantage of an offer by the *jefe*'s brother José to show us some pits on a neighboring ridge. After we had so painstakingly rebuilt the road to Los Toros, we were told that there was another way to drive to the village, from Dulces Nombres to the west. No wonder the locals had not rebuilt the other road. This road is not on the topo map and is essentially invisible from the main part of the village. Following our guide's lead, though, we found it, sure enough, on the far side of a field, looking like no more than a cow path at first. An interesting feature of the new road is a turn-around switchback, which I had not encountered before. The turn into it is too tight to make, and yet it is not a back-up switchback commonly used in such situations. In this case, a larger flat area has been prepared that one drives into at the corner to turn around to head on up the mountain. A few kilometers later we arrived at the top of a higher ridge, where José showed us four pits around 30 meters deep. I found another nearby, but none of



Bill and Diana swimming in the resurgence cave. *Yvonne Droms*.

Diana Tomchick in the entrance to the resurgence cave. *Yvonne Droms*.

them went anywhere. Curiously, one had the initials Y (J?) S and the date 30 Julio 1911 chipped into the flowstone at the bottom. It was likely put there by a mining prospector.

The year's final push in Soplo took place on December 27, the one-year anniversary of the day we dug it open. Adam, James, Marion, Yvonne and I headed to the bottom loaded for bear. We made good time and were soon descending the drop out of the room at the bottom of the Whiner's Pit. It went down 20 meters past huge breakdown blocks that formed the floor of the room above. A sloping passage soon led to the next pit, the Hanging Boulder Drop, so named because of a huge boulder perched precariously on the edge. This pit had an offset halfway down, where a shattered layer of rock was clearly visible in the wall, and the bedding in the lower half of the pit appeared to be nearly vertical. At the bottom, a steeply sloping breakdown room led down to a pinch where a boulder nearly blocked the route, but there was just enough room to slip past. The passage beyond dropped in a series of short pitches, The Silver Staircase, to a final 20-meter drop. At the top of the last pitch was a clearly defined anticline in one wall, with the shattered layer above it. There were at least two holes leading down in the floor of the final room, but we were out of time and nearly out of rope. On that 16-hour trip we added 125 meters of depth, bringing the cave to –366 meters. The length is only 592 meters. Soplo is well on its way to becoming the second-deepest cave in the


Old initials in José's Third Pit. *Adam Zuber*.

Purificación area, with only 100 meters more depth to go. It shows no sign of stopping its rapid descent, and we still have the wind.

After a last rest day to clean up gear and pack, we headed out of the mountains on December 29. As we left, we said goodbye to our friends in Los Toros and gave them much-appreciated gifts of rope and plastic water jugs. We took the new road we had been shown over the mountain to the west and through Dulces Nombres. Since we were already so far to the west, we continued in that direction, emerging from the mountains at Zaragoza. We can't wait to get back to see where Soplo goes.

Expedición Los Toros 2006

Espeleólogos regresaron al poblado de Los Toros en el área de Purificación, Nuevo León, para explorar Soplo de Los Toros, una cueva vertical con un gran potencial de profundidad. Alcanzaron -366 metros y la cueva continúa. También visitaron una cueva de resurgencia que nombraron Nacimiento de Los Toros. Está 900 metros por debajo de la entrada a Soplo.

# YAXCHEN AND OX BEL HA, QUINTANA ROO

Donna and Simon Richards

*It is 7:00 a.m. on a February morning in 2006. In a small fenced lot south of Tulum, a group of thirteen cave divers arrives in a succession of pickup trucks and vans, each loaded with up to a ton of diving equipment. Each diver has his own set of cave diving gear—double tanks, dry suits, regulators and lights—and all have brought as many additional tanks and electric diver propulsion vehicles (DPVs or scooters) as they own or can borrow. The divers have come from Mexico, the US, Italy, Canada, Spain, France, England, and Norway. Some of them have flown in especially for the diving this week, while others have relocated their families to Quintana Roo so that they can cave dive year-round. They have been meeting at this location for several weeks each year because it backs onto a cenote called Yaxchen. Yaxchen cenote is the main entrance to the Yaxchen underwater cave, a part of the Ox Bel Ha cave system, the second-longest longest cave in Mexico and the second-longest underwater cave in the world. To a cave diver, this is Mount Everest . . . before it was first summitted.*

Until the 1970s, no one knew Ox Bel Ha or the other underwater caves here existed. The ancient Maya used the cenotes for water for drinking and irrigation, but they also served a spiritual function; cenotes were believed to be direct links to the underworld. Friar Diego de Landa wrote in his *Account of the Things of the Yucatan* about the sacrifices at Chichén Itzá, "Into this well they were and still are accustomed to throw men alive as a sacrifice to the gods in times of drought; they held that they did not die, even though they were not seen again. They also threw in many other offerings of precious stones and things they valued greatly; so if there were gold in this country, this well would have received most of it, so devout were the Indians in this."

More recently the cenotes have been used for snorkelling and other tourist activities. With the growth of tourist scuba diving on the reefs along the coast, it was only a matter of time until divers would turn to the cenotes when the ocean was too rough for diving. What they found shocked and then astonished them, for in some areas, the walls of the cenotes gave way to the entrances to underwater cave systems. Initially dark and foreboding, when the divers returned to explore the caves with lights rigged for underwater use and proper cave diving equipment, the mythical underworld of the Maya was revealed as an enchanting world of crystal-clear water and beautifully fragile stalactites and stalagmites. Word spread among cave divers in Florida and elsewhere, and within a few years a small number of experienced cave explorers were living in the region, instructing and guiding tourist reef divers by day and exploring the underwater caves by night and on weekends.

In fact, those modern-day divers were not the earliest explorers of the Maya underworld. That honor goes to Edward Thompson, an archaeologist and the youngest American consul to Mexico. Thompson spent over forty years in the Yucatan, during which time he acquired the lost city of Chichén Itzá. Driven to prove that de Landa´s account was not fictitious, he undertook the first underwater cave-exploration project in the sacred cenote at Chichén Itzá. According to his book, he was told by his friends, "No person . . . can go down into the unknown depths of that great water pit and expect to come out alive. If you want to commit suicide, why not seek a less shocking way of doing it?"

After years of planning, in 1904 he prepared for the world's first cave dive. Thompson and one of two Greek divers he had hired each donned a dry suit, a thirty-pound hard hat, a lead necklace, and iron-soled shoes. As Thompson took his first step on the ladder, one of the Maya workers left his place to shake hands with Thompson, his face echoing the same concern as the other natives. None expected him to return.

Although Thompson had some idea of the objects he would find because he had been dredging artefacts for several months, he had little idea of how dark the pit would be or how the mud bottom would render his specially made underwater light useless. His diving technique would not impress modern-day cave divers, who are taught to glide smoothly through the water, avoiding the bottom. As Thompson and his companion descended, the water quickly turned from yellow to pitch black. Because the water filtered into the cracks and loosed some of the blocks above their heads, stones would frequently drop into the water, and the divers had to take care to avoid injury from the displaced rocks and, most especially, not allow them to sever their air lines. The divers scrounged on the thick bottom,

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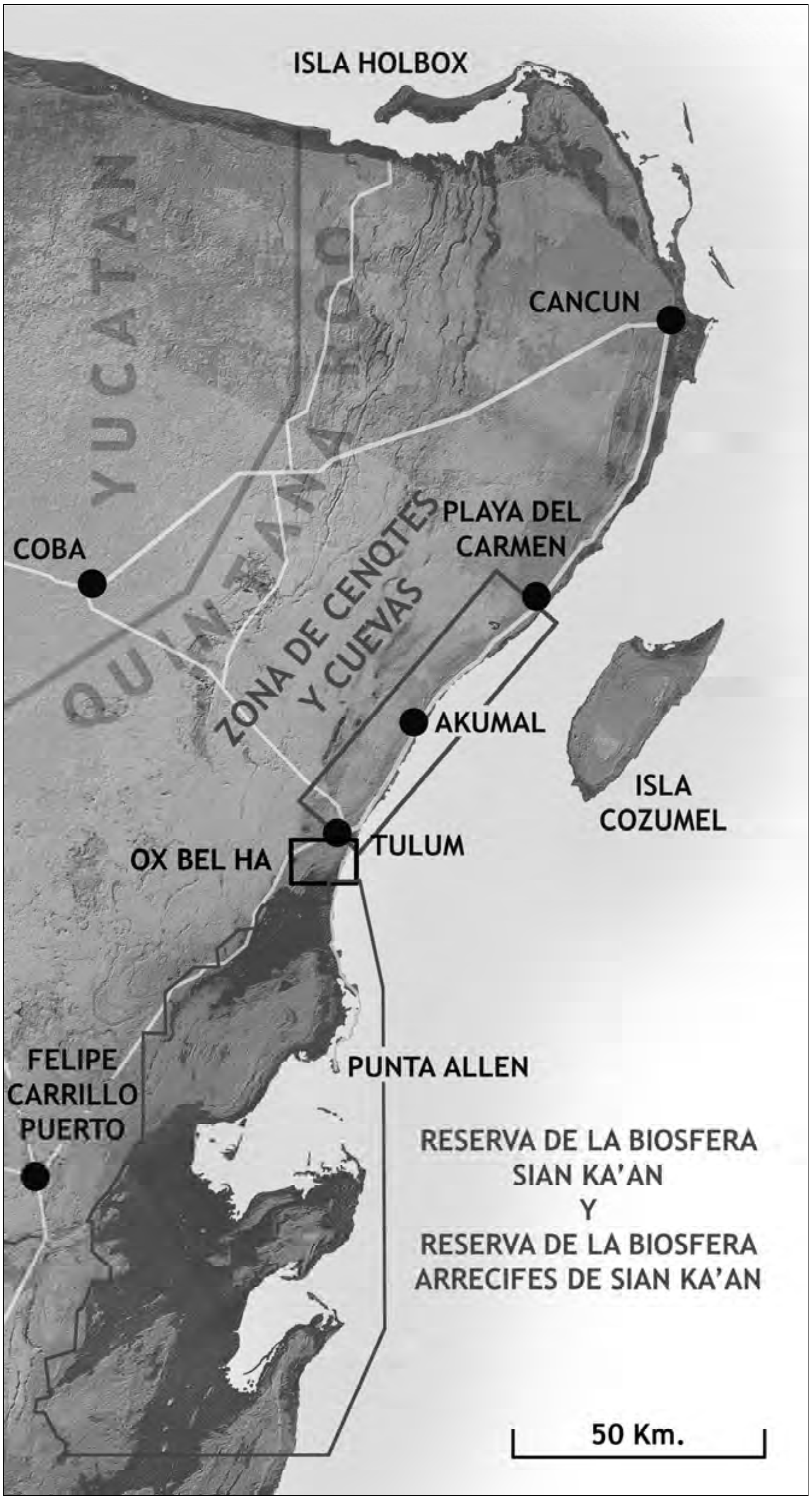
This article was written in appear, in a Spanish translation by Mauricio Domenge, in a popular outdoor magazine. That version is, however, so far unpublished. The English text has been updated to reflect the recent connection that made Sistema Sac Actun the longest cave in Mexico. [See elsewhere in this issue.]

creating plumes of silt and retrieving the objects the dredge couldn't gather.

Thompson accomplished his objective, proving that human sacrifices did occur among the ancient Maya. In spite of many health problems brought about by living and exploring in a harsh environment for so many years, Thompson had the heart of a true explorer. More than forty years after he first stepped foot in the Yucatan, he penned, "I have squandered my substance in riotous explorations and I am altogether satisfied. The reward of a labor of love lies in the performing of it, and I can look back upon a career as full of incident and adventure as any man has the right to expect."




The new generation of underwater-cave explorers that emerged in the 1970s and 80s had different objectives than Thompson. They were concerned less with retrieving ancient Maya objects in the cenotes and more with the underwater caves themselves. The first to arrive had learned the special cave-diving techniques in the underwater caves of Florida, which are not as extensive or as beautifully decorated with cave formations as the caves in Quintana Roo.

When divers first brought their specialized cave diving equipment to Quintana Roo some twenty-five years ago, many locals assumed that its purpose was to assist in harvesting black coral from the reefs offshore of Tulum and Akumal. However, when they were told that the objective was to explore inland cenotes, it was as if a dark cloud had descended. Some cautioned that there were serpents and spirits (the mysterious Chacs) in the caves; others believed there were jewels and gold hidden in the caves from the previous century's Caste Wars.

Soon the real treasure in Quintana Roo became known. By 1990, sophisticated maps of two caves had been published, while a third and fourth cave were being mapped to a high degree of detail. Over 60 kilometers of underwater passage had been explored in the Tulum area, and there remained no doubts that there was a whole network of caves under the jungle of Quintana Roo.

Although cave surveying techniques were well developed, there were few personal computers in Quintana Roo in the 70s and 80s, and so maps had to be drawn from survey data by hand. Caves were being found in excess of 10 kilometers in length, and the task of drawing the maps simply became too much for many explorers. There were dangers that survey data collected on exploration dives wouldn't be processed into maps and that when explorers left the area to pursue new challenges their survey data would go with them and be lost to others.

Claudia Höcher in the entrance to Cenote Chac Mool during a scooter dive. *Simon Richards*.

In 1990 two experienced cave explorers and surveyors, Lorie Conlin and Jim Coke, saw this problem and created the Quintana Roo Speleological Survey, which now acts as an archive for cave exploration in Quintana Roo and helps to produce maps from survey data collected by explorers. By 1995, the QRSS archive had grown to include over 180 kilometers of explored and surveyed cave passage. As of 2006, the QRSS database includes 636 kilometers of surveyed underwater caves. While preserving an account of the history of cave exploration in the area, it also acts as a central repository for information for scientists who are involved in legitimate research.

Persuading cave explorers to share their information with the QRSS was initially difficult. Everyone wanted to be the first to find and explore the longest caves, and so information on caves was often kept secret, and it was rare for competing groups of explorers to cooperate. In this context, the story of the exploration of Ox Bel Ha is remarkable. In 1996, a group of divers, comprising Sam Meacham, Bil Phillips, and two others, had made a short dive to check a cenote south of Tulum and found what appeared to be a massive cave system. Even though the cenote, Los Canales, was two hours into the jungle and the logistics of getting cave-diving gear to this location was confounding, they both dreamed of organizing a large-scale diving project there. Two years later, the pair returned to the area and dove another large cenote, named Esmeralda. It had taken the divers and four landowners several hours to reach Esmeralda with all the necessary cave-diving equipment, but the effort was worth it. They used all 550 meters of guideline they had brought with them, finding what appeared to be another large cave.

Meanwhile two divers, Bernd Birnbach and Christophe Le Maillot, were exploring another cenote south of Tulum, Cenote Del Mar, resurveying 1700 meters of lines laid by the initial explorers and exploring and surveying an additional 18 kilometers. Joined by Daniel Riordan, they made an important discovery: through three vents on the downstream side, the system flowed directly into the sea.

The two groups knew of each other's activities, and when they compared notes, it became apparent that Los Canales, Esmeralda, and Del Mar were probably connected underground; they were probably different entrances to one enormous underwater cave system. Although the situation could have become intensely competitive, the teams of explorers instead formed an alliance to work jointly on the exploration.

In May 1998, the group was joined by divers Sabine Schnittger and Fred Devos, and a large project was launched at Cenote Esmeralda. Horses were used to carry the divers' compressor and other heavy equipment. The compressor enabled divers to refill their tanks at the dive site rather than transport them back through the jungle every evening. Over six weeks, connections into Los Canales and four other cenotes were made. From this first project the divers also learned much about exploration in remote places. They had already chosen the location for the next project, and on that and subsequent projects their bases would include camping facilities.

In May 1999, the alliance was formalized and given the name Grupo Exploración Ox Bel Ha, or GEO for short. By that time, the group had already

Fred Devos and Chris Le Maillot connect a new line onto an existing guideline in Sistema Sac Actun. The arrow points to the exit. *Simon Richards*.

found the connection between cenotes Esmeralda and Del Mar, and they immediately launched a number of ambitious projects, cutting trails and establishing temporary camps that included generators for charging light and scooter batteries and compressors for filling tanks.

Despite some personnel changes resulting from differences in diving philosophies among its members, over the next three years GEO found and surveyed the underground connections between a number of caves and cenotes, and the combined cave system was named Ox Bel Ha, Mayan for Three Paths of Water. When the numbers were added, the divers realized that together they had found and explored the longest underwater cave in the world. [See Bil Phillips's article in *AMCS Activities Newsletter* 25, pages 40–46, for the history of exploration of Ox Bel Ha through 2001.]

One particularly challenging undertaking is known as the Jade Pearl Project, which took place in October/ November 2003 and which involved founding GEO members Meacham and Phillips, joined by Steve Bogaerts, Andres Labarthe, and Roberto Chávez. Cenote Jade Pearl was named for its round shape and clear water and was located in a new exploration area, far off into the jungle. As with the other projects, trails were cut and a compressor was moved to the dive camp, but for Jade Pearl a helicopter was used to ferry four loads of dive equipment and provisions to the remote site (attracting some attention from local and federal officials). During two weeks, twenty-nine exploration dives were made, and over 15 kilometers of new passage was explored and surveyed. Ten new cenotes were connected into the system. [See "The Jade Pearl Exploration Project," by Sam Meacham, in *AMCS Activities Newsletter* 28, pages 63–77.]

Major camp projects such as these made diving in logistically challenging areas possible, and as a result an amazing 77,280 meters of Ox Bel Ha was surveyed by the GEO group.

Jim Coke of the QRSS considers the GEO alliance a major achievement. Although it is relatively common for groups of dry cavers to combine efforts, cave diving groups had seldom, if ever, undertaken such cooperative ventures. This achievement would not have been possible without the help and support of a number of parties. Ejido José María Pino Suárez and Ejido Tulum provided access and assistance to the explorers, and non-profit organizations such as the Summit Foundation, The Nature Conservancy, the Steve Corey Memorial Fund, and Centro Investigador del Sistema Acuífero de Quintana Roo (CINDAQ) recognized the value of the exploration and supported it.

In January 1997, two American cave explorers, Kay and Gary Walten, were exploring caves in the Tulum area. Juan Tun, a member of Ejido Pino Suárez, showed them a number of the *ejido*'s cenotes. One of them, a 160-meter-long cenote originally known as Escondido, had briefly been dived in 1986, but had since been forgotten.

Gary Walten described their initial impressions. "We first snorkelled the cenote in February 1997, swimming to the west tip of the open water pool, breath-holding to peer into the blackness. The void looked very promising. We did our first dive a day or two later and emptied our 400-meter-plus reel discovering another large cenote, and then swimming through that to find the upstream cave continuation. After that dive we were excited. We had found an extensive mangrove cave system that showed promise of going a long distance, and we had high expectations." The Waltens named the cave Yaxchen, which is Mayan for Green Well.

Their instincts were correct, and they found themselves laying reel upon reel of line, extending the cave by thousands of meters. They launched a major project, Proyecto Yaxchen, which required what were some of the longest cave dives that had been done in Mexico or the world at that point. The significance of the project was apparent to people thousands of kilometers away. During 1997, the project qualified as an Explorers Club Project, joining the ranks of such historically notable expeditions as Hillary and Norgay's summit of Mount Everest and Aldrin and Armstrong's walk on the moon.

By the time their project ended in 2001, the Waltens had connected nine cenotes into Yaxchen and surveyed 18 kilometers of open-water and cave passage. Their longest dives were around 4 kilometers, with each diver using three scooters, the equivalent of eight standard scuba tanks of air, and a tank of pure oxygen for decompression. The Waltens also collected many hours of video footage to document the cave, and they involved a Canadian scientist, Samantha Smith, in obtaining water samples for analysis. Their accomplishments are even more impressive considering the limitations of the equipment they had been using a decade ago during their initial explorations. Since then, scooters have become significantly

Hervé Gorden during a photography dive in Sistema Sac Actun. *Simon Richards*.


Chris Le Maillot preparing for an exploration dive in Cenote Yaxchen. *Simon Richards*.

faster, and there have been advances with basic cave diving equipment, most notably in lighting.

The Waltens' explorations were blocked at the end of an enormous cave passage, the Río Grande Tunnel, by a large breakdown area where the surface rock had collapsed into the cave. They made several unsuccessful attempts to bypass this. Each attempt required three days of diving by the pair, a day to set up scooters and tanks halfway through the tunnel, then a push dive the next day during which they entered with fresh tanks and scooters and swapped equipment at the halfway point, and then a third day to retrieve the empty stage tanks and discharged stage scooters. Finally they reached a point where with the technology of the day they could go no farther.

When asked if they had any regrets about the end of their exploration, Gary Walten mentioned the obvious regret of not "walling-out" the system. But he also expressed the sentiments many cave-diving explorers feel, "the regret of compromising the purity and sanctity of an unexplored cave system, especially one as spectacular and unique as Yaxchen. Once 'discovered' by divers, a cave with easy access is seldom left undived and there is a sadness there for the explorers."

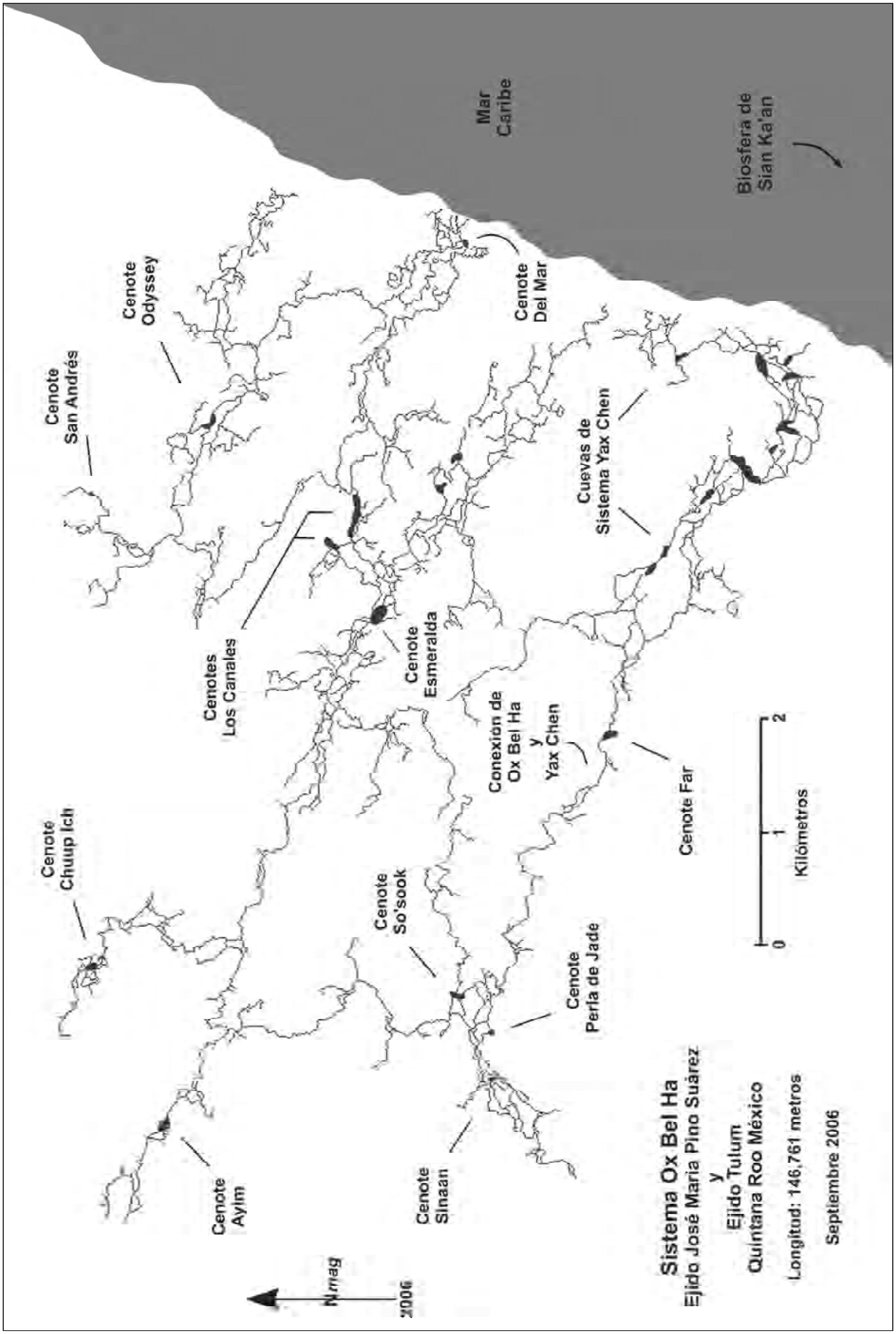
By 2003, two of the former GEO explorers, Riordan and Le Maillot, had formed an impressive team of divers that included Devos, Tulum resident Alejandro Álvarez, and Norwegian diver Per Thomsen. One of their aims was to find a route from Yaxchen up to Cenote Far, a large 120-by-70-meter cenote that could be seen on aerial photographs, but could not be reached on the ground through the dense mangroves above Yaxchen. To reach Cenote Far from underground, they would have to find a way round the breakdown that had blocked the Waltens at a distance of just over 4 kilometers from Cenote Yaxchen and then dive at least an additional 500 meters beyond that, in total farther than they or anyone else had dived in a cave in Mexico and close to the longest distance that had been dived in any cave anywhere in the world.

With this objective, they began with a series of dives in Yaxchen in 2003. Their first task was to familiarize themselves with the cave. They were helped in this by the Waltens' providing their meticulous dive logs and survey data, which had been drawn into a map by Jim Coke. Alejandro Alvarez described his first impressions of diving Yaxchen: "The first thing that struck me was the sheer size of the cave. The first dive consisted of mesmerizing long traverses through cenotes bathed in sunlight, alternating with stretches of enormous cave passage with water ranging from an emerald green to almost opaque hydrogen-sulphide clouds through which one could sometimes see less than a meter. As we progressed farther through the system, the cave passages became longer and deeper, and it was clear that the cave was not going to end soon."

By September 2003, the team had reached their first objective, the end of the Waltens' main line in the Río Grande Tunnel. Far Cenote lay slightly to the west, and so the Riordan/Le Maillot team conducted a series of dives, each time backtracking a little farther from the end of the Río Grande Tunnel and looking for alternative passages to the west. Their efforts were frustrated, as every new passage they tried either ended in more breakdown or looped back to the Rio Grande. Undeterred, they launched another project in December 2003, and this time they made the breakthrough, connecting first to Cenote Ma'Kai and then to Cenote Far, a distance of 4.8 kilometers from their entry point at Cenote Yaxchen. They then followed the cave passage for another 700 meters, to a total distance of 5.5 kilometers, before breathing-gas limitations forced them to begin their exit. Satisfied they had achieved their initial objective, the team retired to plan its next move, exploration at unprecedented distances beyond Cenote Far and the connection with Ox Bel Ha.

But while the Riordan/Le Maillot team was pushing Yaxchen northwards towards Ox Bel Ha, two other cave divers were working on plans to push Ox Bel Ha south towards Yaxchen. One of the finds of the Jade Pearl project was another cave passage, heading off from Jade Pearl straight in the direction of the farthest upstream reaches of Yaxchen. The primary objective of the Jade Pearl project had been to try to find an underwater route from Ox Bel Ha to the Sian Ka'an Biosphere Reserve to the southwest, and so the passage towards Yaxchen had been left unexplored.

Two former GEO members, Phillips and Bogaerts, were determined to go back and see where this passage led. In contrast to the Yaxchen team, they used a cenote-hopping approach, working


Mar
Caribe
Biosfera de
Sian Ka'an
Cenote
Odyssey
Cenote
San Andrés
Cenote
Del Mar
Cuevas de
Sistema Yax Chen
Cenotes
Los Canales
Cenote
Esmeralda
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Ox Bel Ha
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Kilómetros
Sistema Ox Bel Ha
Ejido José Maria Pino Suárez
y
Ejido Tulum
Quintana Roo México
Longitud: 146,761 metros
Septiembre 2006
Nmag
2006

coastward from Jade Pearl and moving their base camp every time they found a new cenote to enter from. The cave passage was initially so small that they used side-mounted tanks, rather than the back-mounted tanks more often used in the area. However, finally the cave opened up into large borehole passage with strong water flow that led them into Cenote Far, establishing the connection between Yaxchen and Ox Bel Ha.

Once the connection between Yaxchen and Ox Bel Ha had been found, Yaxchen became a victim of the particularly cruel convention for naming caves. When two caves are connected, they become a single cave with a single name, the name of whichever cave was the longer immediately before the connection. Although this area of Ox Bel Ha is still called Yaxchen for historical reasons, strictly the name for the entire interconnected system is Ox Bel Ha. (A number of small caves in the Yaxchen area have not been connected into the large cave yet, so they still retain independent names.)

The Sian Ka'an Biosphere Reserve was established in 1986 by presidential decree, and in 1987 became a UNESCO World Heritage Site. At approximately 1.3 million acres and extending about 120 kilometers along the coast, it is the largest protected area in Caribbean Mexico. In Mayan, Sian Ka'an means Where the Sky Is Born, and much of the area is a large, open wetland habitat unlike anywhere else in Mexico, with exuberant tropical forests and rich coral reefs. It is home to over one hundred known species of mammals and over three hundred species of birds, and its wetlands provide nesting sites for wading birds and two endangered species of sea turtles. Approximately two thousand inhabitants live within the reserve, and almost forty thousand tourists a year visit it, but large areas are set aside purely for scientific research.

Since 1986, the non-governmental organization Amigos de Sian Ka'an has been helping to understand and conserve this resource and educate the public about it. Gonzalo Merediz Alonso, ASK's Executive Director, explains the role of water like this: "Water issues have become one of our main conservation interests. Forests help water recharge into the underground, and so we need to conserve the forests. Water flows through the underground, and so we need to understand and conserve this too. Water from the underground feeds coastal wetlands, and takes nutrients from these wetlands out onto the coral reef. The coral reef and the fishing and tourism it supports sustain a significant portion of the economy of Quintana Roo. Therefore, to do conservation work in Quintana Roo, we need to address the underground water world." Privately, he explains the situation more directly. "We need to prevent Sian Ka'an from becoming the recipient of all of the contaminated water from Quintana Roo." As a result, ASK and The Nature Conservancy have been active in a number of recent projects, including helping to support the work of cave divers looking for the connection between Ox Bel Ha and Sian Ka'an.

It was the connection between Ox Bel Ha and Sian Ka'an that was the target of the divers assembled at Yaxchen cenote for the February 2006 project. The connection between Yaxchen and Ox Bel Ha had already been found, but no connection to Sian Ka'an had yet been discovered, and many areas of Ox Bel Ha remained to be explored.

There were two objectives for this week of diving in Yaxchen. One was to push an area of cave to the north that appears to be heading towards another connection with Ox Bel Ha. It would be useful to establish a second connection; furthermore this area of the cave is simply stunning, large passages up to 40 meters wide, clear water, and strong currents. The second objective was to explore some passages heading south from Yaxchen that are only a couple of kilometers from the *lagunas* of Sian Ka'an and seem to be heading directly towards some known cenotes in Sian Ka'an. But the project had another line of attack on the elusive Sian Ka'an connection. With help from governmental and non-governmental authorities and financial support from The Nature Conservancy, they had obtained permits to explore from within Sian Ka'an itself. One team would be walking the dry land between Sian Ka'an and Yaxchen with GPS equipment, looking for cenotes and other signs of caves, and a second team would be diving from the cenotes inside the Sian Ka'an Biosphere Reserve. Hopes were high that the week's diving would yield a connection between the world's longest underwater cave system and one of Mexico's largest protected nature reserves. [See the article "Underwater Caves of Sian Ka'an" elsewhere in this issue.]

One of the reasons behind this increase in exploration and scientific activity is the issues raised by the explosive growth in and around the village

Cenote Yaxchen. *Simon Richards*.

Alejandro Álvarez in Yaxchen. *Simon Richards*.

of Tulum, just to the north of Sian Ka'an and Ox Bel Ha. The Tulum development plans include a twenty- to forty-fold increase in the resident population over the next twenty years. Under Mexican law, the development plan must take into account the impact on the environment, and so it must contain a hydrological study. But the cave networks dominate the hydrology of the area, and this hydrological assessment will pose challenges beyond the scope of perhaps any other hydrological assessment ever undertaken in the world. Within the footprint of the expanded city of Tulum lies Ox Bel Ha in the south, which is the second-longest underwater cave system in the world with 147 kilometers of explored passage, while in the north is Sistema Sac Actun, with 154 kilometers of explored underwater passages, making it the longest underwater cave in the world. More than sixty other underwater caves are also being actively explored in the area, including Sistema Dos Ojos (57 kilometers), the third-longest underwater systems in the world.

The challenge is more than just knowing where the caves are. A recent study by Dr. Patricia A. Beddows, a hydrologist at McMaster University in Canada working in collaboration with researchers at the National Autonomous University of Mexico, has shown that the average fresh-water outflow at the coastal spring of Xel Ha just north of Tulum is about 7.3 cubic meters per second (a cubic meter is equivalent to a metric ton), or about 230 million cubic meters per year. A land area of 175 square kilometers would be required to collect the rainfall necessary for this outflow. However, some rainwater is always lost to evaporation and transpiration by the vegetation, and so the catchment area may be over 1000 square kilometers. Nobody knows where this catchment area lies—how far inland and up or down the coast the water for Xel Ha is coming from. Xel Ha is not even a particularly big cave, and it is only one of many large coastal springs along the coastline. The total outflow from Ox Bel Ha has not even been studied, and its catchment area remains a greater unknown.

How can the town planners of Tulum produce an assessment of the environmental impact without a hydrological study that covers much of the peninsula? The information on which to base such a study simply doesn't exist, and the increase in demand on water resources will not slow down while it is collected. Organizations such as Amigos de Sian Ka'an have recognized this, and they are working with national and international scientists on a broad regional study. The cave divers are also recognizing that their work is essential, and they are increasingly making their survey data available to municipal planners, organizations such as Amigos de Sian Ka'an, and resident and visiting scientists.

When cave divers began exploring the Three Paths of Water, the Ox Bel Ha system, they had no idea they might be playing a key role in the overall understanding of the region's water supply. They had no idea they might be in a position to assist conservation groups, scientific researchers, or towns such as Tulum. This is slowly changing, as explorers have realized that there are larger issues at stake.

## Yaxchen y Ox Bel Ha

Este artículo, originalmente escrito para una revista de actividades al aire libre, describe la exploracion de las cuevas subacuáticas de Ox Bel Ha y Yaxchen en Quintana Roo. Las dos cuevas fueron conectadas y el resultante Sistema Ox Bel Ha se convirtió en ese entonces en la cueva más larga de México, con 147 kilómetros (actualmente es la segunda en longitud en el país). Partes del sistema están cercanas a la Reserva de la Biósfera de Sian Ka'an, y el crecimiento futuro de la ciudad de Tulum amenaza la calidad del agua en las cuevas y en la reserva.

# CAVES OF TABASCO PROJECT 2007

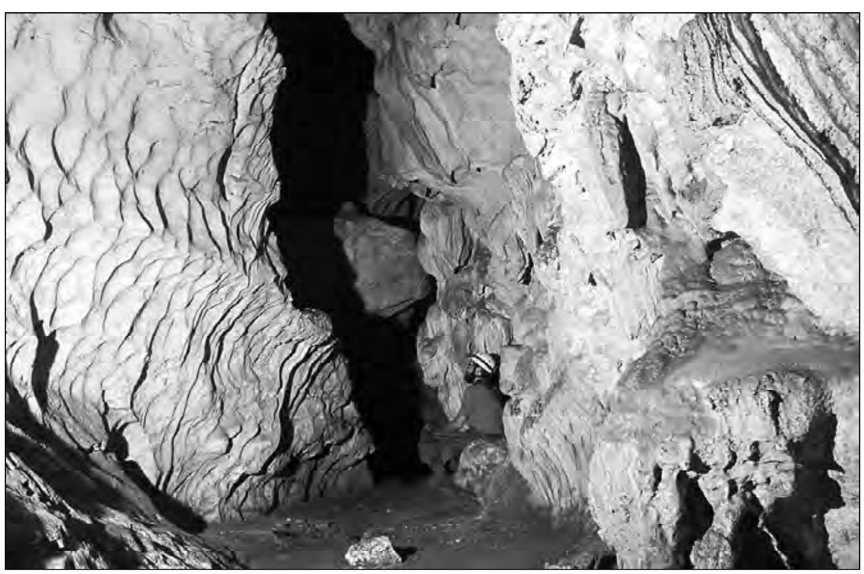
Erin Niedringhaus

In 2007, the Caves of Tabasco Project enjoyed its third major expedition in as many years. The project has benefited from a flurry of activity in the past few years, thanks primarily to the work of Jim Pisarowicz and Vickie Siegel, both of whom have led trips and done the majority of the planning, packing, and finagling. Even so, the karst regions of Tabasco are far from exhausted, and the area holds years' worth of projects for dedicated cavers. As in previous expeditions, this year's participants finished surveying, only to find additional leads and opportunities for next year and beyond. The Caves of Tabasco Project has only begun to scratch the surface of this beautiful and often surprising region.

This year's expedition began with a bang at the Stone Compound's New Year's Eve party. Replete with a hot tub, courtesy of Pete Strickland, and a seemingly endless supply of booze, the party was to be an incredible send-off from the United States, as Vickie Siegel, Seth Spoelman, and I intended to leave Austin the next morning after a hearty breakfast. Unfortunately, in the painful light of New Year's Day, these plans proved difficult to implement, and we decided to leave on January 2 instead. However, we soon made up for the delay. After crossing the border without a hitch, we drove all the way to the Emerald Coast for the night and continued to make good time afterward. On January 4 we arrived in Teapa, Tabasco, slightly ahead of schedule.

Here we met up with Laura Rosales and first laid eyes upon the incredible field house that Laura graciously allowed us to share; the entire group was immediately taken with the orange and pink two-story house and its electricity, flushing toilet, and lukewarm shower. The town of Teapa was similarly amenable, with an impressive central market and an excellent pizza place right down the street. Thus encouraged, we began our work in earnest. The first few days were mostly spent in preparation, talking to local officials and obtaining letters, testing Laura's spare-air tanks and gas meters, tagging a cave surveyed in previous years, and, of course, talking with Peter Lord, our favorite British ex-pat caver, who always wines and dines us in style. We also made sure to ridgewalk certain hotspots as we were passing by, and these ventures brought us a measure of success. When checking holes visible from the road outside the town of Poana, Seth located Cueva Tucán, which is approximately 20 meters long, and Vickie and I located two similar small caves right across the street. Ultimately, we chose to leave these caves unsurveyed and focus instead on a larger cave down the road, Cueva Safari.

Located by Chris Amidon and Vickie Siegel during last year's expedition, Cueva Safari typifies the caves found around the Sierra Poana. Formed within haystack karst, it features a relatively flat floor, rounded walking passage, numerous entrances, and considerable dripstone decoration. Not only was surveying this cave particularly comfortable, with very little stooping required, it was also an excellent place for Laura, Seth, and Vickie to hone their sketching skills and for the entire group to practice photography with equipment generously provided by Bill Stone. Safari is also a cave of considerable archaeological merit, and our archaeologist collaborator Eladio



Seth Spoelman in Cueva Safari. *Erin Niedringhaus*.

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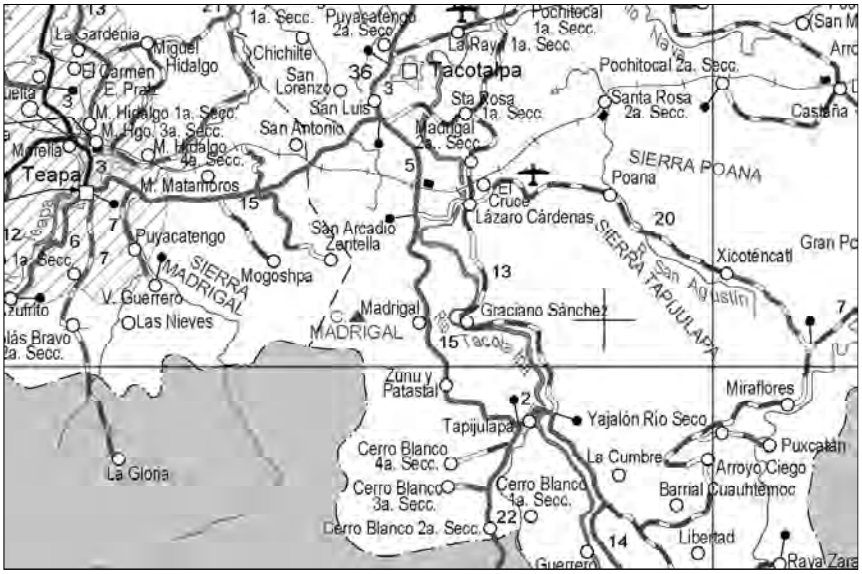


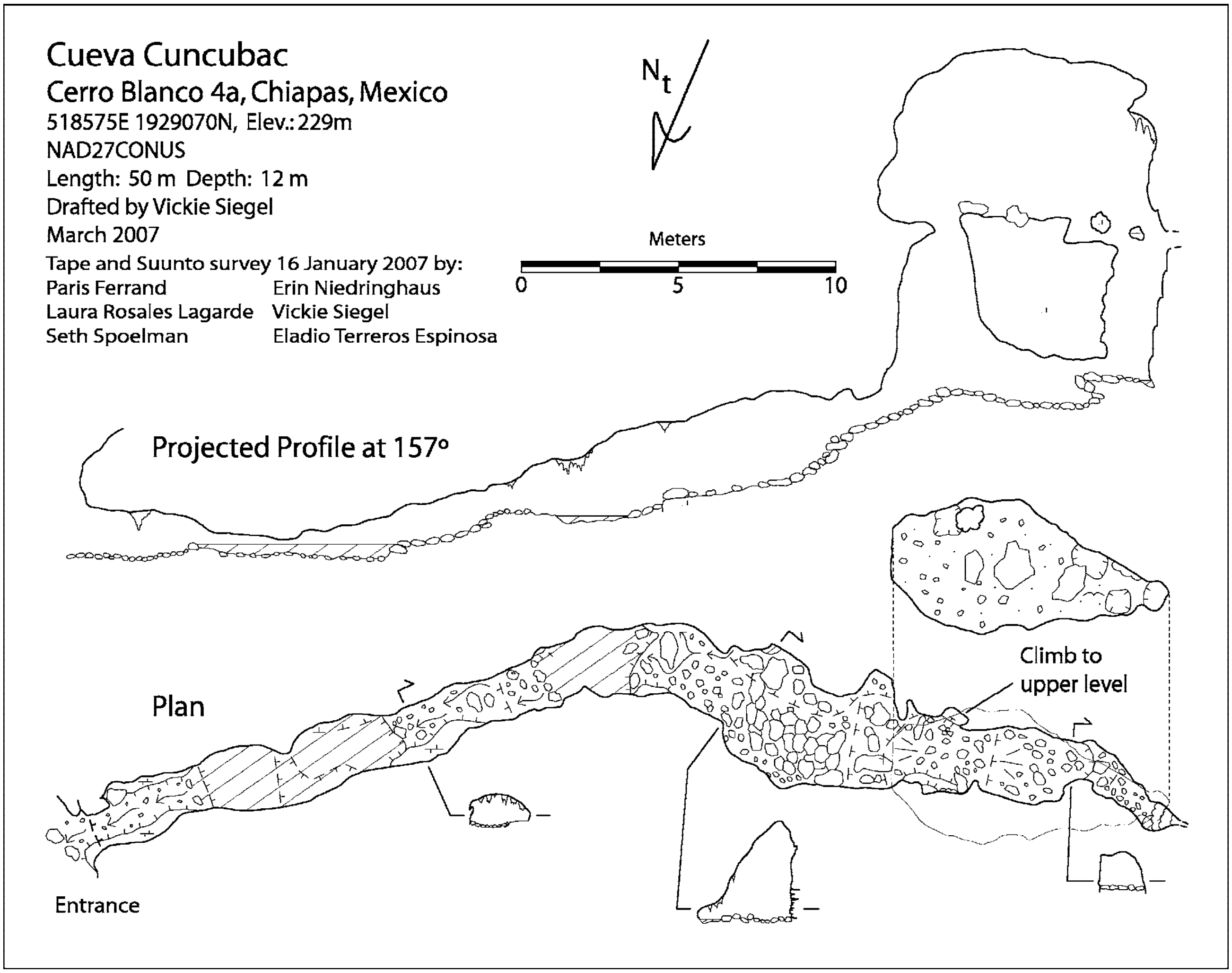

Terreros found it a good addition to his Tabasco database. Cueva Safari takes its name from its plethora of wildlife, which includes frogs, lizards, spiders, scorpions, pseudoscorpions, amblypygids, and at least two species of bats, and our group enjoyed observing all these creatures despite an (ultimately) comical interaction with a (dead) scorpion. When walking to and from Safari, we also made sure to pay attention to neighboring haystacks; on the last day of survey Vickie found a small cave in an adjacent hillside that merits future attention. Working in Safari became a cornerstone of the expedition. Though we would frequently suspend the survey to begin new projects with our collaborators, we would eventually return to enjoy the comfort of a familiar and beautiful place.

The Caves of Tabasco Project has always depended on collaboration and grants. The assistance of local guides has often proved invaluable, and plenty of Tabascans are willing to tell us about the caves they know and sometimes follow us into the tightest and most uncomfortable of spots. However, this year collaboration reached a new level. It began in the United States. Seth Spoelman, "on loan" from FEMA and resident high-tech map guru, wrote a grant proposal for software and received both ArcInfo and ArcPad from ESRI. Though these products arrived too late for Seth to implement during this year's expedition, he has big plans for GIS in Tabasco. He will bring GIS into the field with ArcPad, improving efficiency and accuracy and aiding in locating new caves, and he will continue to improve a shareable interactive map that uses ArcReader. Even without access to more advanced products, Seth still employed GIS and GPS to our advantage during this expedition. He used existing INEGI data with GIS and GPS (DNR Garmin software) to locate sinkholes and sinking streams, and he collected point and line GPS data to document our ridgewalking activities, which reduced accidental redundancy. In addition, Seth updated our cave database, which is designed to keep track of unchecked leads as well as any changes made. With a project as long-lived as Caves of Tabasco, this database literally keeps us from covering the same ground twice.

Laura Rosales is both a collaborator and member of Caves of Tabasco Project. She has participated in expeditions for several years now and contributes her invaluable language skills as a Mexican citizen as well as her considerable technical expertise. Laura is also a graduate student at New Mexico Tech and has made Tabasco and its unique sulfur springs the center of her research. Thus, Laura and the Caves of Tabasco Project have established a fine symbiotic relationship, in which Laura takes a break from her fieldwork to survey, ridgewalk, and network with the rest of us, and we Americans do our best to help Laura with her projects. This year, in particular, Vickie and Laura returned to an interesting sulfur spring in the Graciano Sánchez area, where they took photographs and squeezed into some uncomfortable cracks, and the entire group visited Grutas de Coconá, a show cave, to consider its geology and potential significance to Laura's research. During this visit, employees at the site provided information on other nearby caves, and we investigated a lead along the road; the area around Teapa and Coconá has considerable potential and certainly merits a return visit. We also spent some pleasant hours at Balneario Las Azufres testing sulfur-monitoring equipment, and we accompanied Eladio Terreros to a beautiful freshwater spring so Laura could record its location for more extensive water sampling. With a geology hammer as a constant accomplice, Laura took rock samples at various road cuts we passed; she also collected samples from cave-bearing limestone strata. It is her hope that these will provide her with a more comprehensive picture of Tabasco geology and hydrology.

Juan Pablo Bernal Uruchurtu and Ernesto Guerrero Sánchez paid the Caves of Tabasco Project a visit that

Seth Spoelman sketching in Cueva Safari. *Vickie Siegel*.




was short but sweet. The former is a researcher at the Geology Institute of UNAM and the latter a UNAM chemistry student. After spending some time at Cueva de Villa Luz with Laura, the two accompanied her to Cueva de Arroyo Azul, which was surveyed by the Project in 1999 (see *AMCS Activities Newsletter* 28, pp. 39, 44) and is located within shouting distance of Cueva Safari. The three took some stalagmite samples and photographs that could yield considerable information, including the rate of speleothem growth, the origin of an unusual iron oxide crust, and the verification of the presence of gypsum, aragonite, and moonmilk. This collaboration should prove beneficial both to Laura's graduate work and to the project by increasing scientific knowledge about Tabasco.

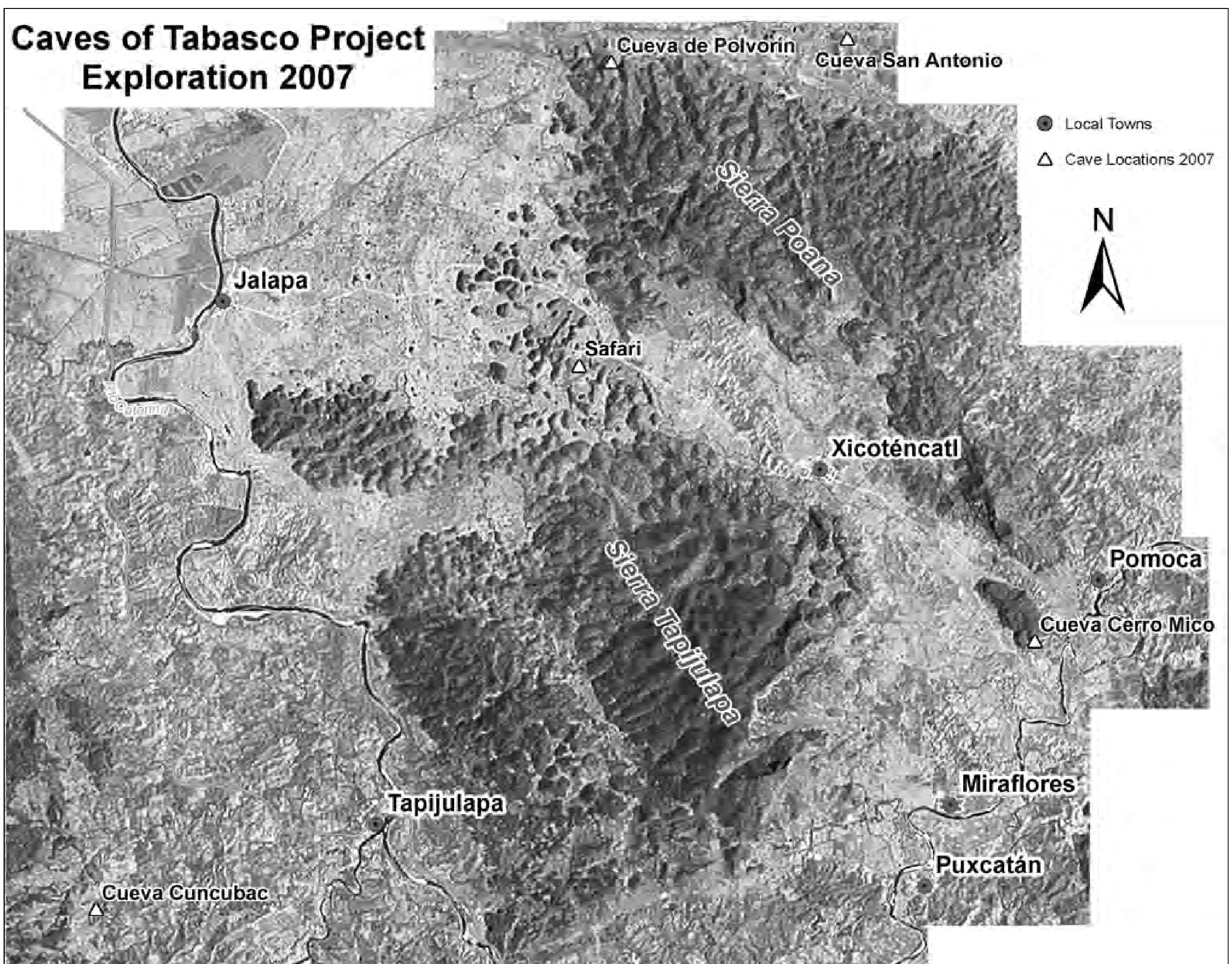
Our work with Eladio Terreros Espinosa and his student Paris Ferrand did much to increase our understanding of Tabasco. Eladio is a professor-researcher at Museo del Templo Mayor in Mexico City. After completing an undergraduate thesis on the archaeology of Tabasco caves, Eladio has continued to amass information on Tabasco cave archaeology for a master's degree from UNAM. Given his extensive knowledge of Tabasco caves (beginning in 1987), we decided to spend some time together, sharing relevant information and mapping caves with known archaeological merit. We introduced him to Cueva del Polvorín, documented in 2005 (see *AMCS Activities Newsletter* 28, pages 40–41, 47), and Cueva Safari, and he in turn shared Cueva Cuncubac, Cueva Cerro Mico, Cueva San Antonio, and a freshwater spring. We taught both Eladio and Paris the basics of cave surveying, and they generously assisted in our surveys of Safari, Cuncubac, Cerro Mico, and San Antonio. It is our hope that our finished maps will prove helpful to Eladio in future publications.

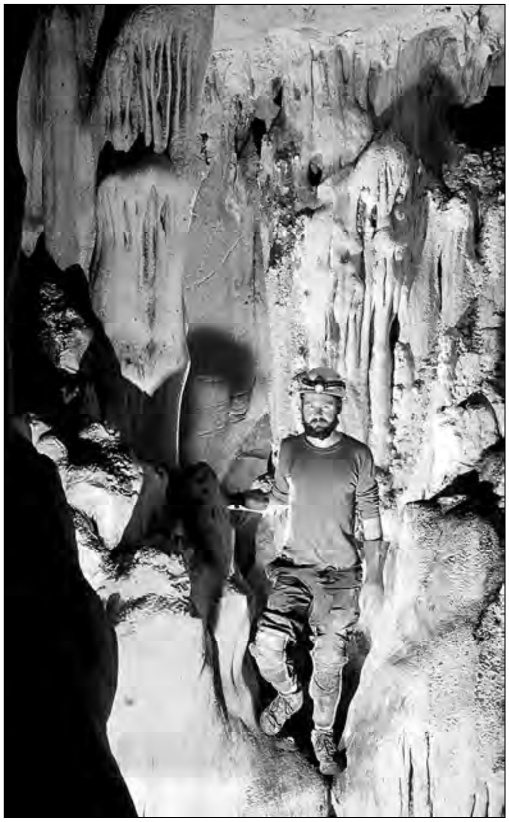
Located near Cerro Blanco Quinta, Cueva Cuncubac is, in the words of Seth Spoelman, a "small but sporting cave." Though short in length, this cave features both a low-air-space section and a challenging climb. As Paris's first (and kneepad-less) foray into caving, the group was quite impressed by his willingness to tackle both of these obstacles. The cave entrance is located at the base of a hill and features a stream that seems to receive its water from a sinkhole above. After leaving the cave, the stream collects momentarily in a pool filled with freshwater snails; our guides took home sacks full of these little creatures and insisted they were delicious in *salsa verde*. Cuncubac requires one to get wet. Though the entrance is not particularly low, the initial stoop soon becomes a crawl through the stream and then a belly crawl and ear-dip in the lowest and tightest spot. The water is also quite cold and produces a constant roar as it passes through the

Erin Niedringhaus in the “sporting” section of Cueva Cuncubac. *Seth Spoelman*.

steeper and narrower sections of the cave; these conditions made both surveying and communication difficult. Despite these circumstances, the group still enjoyed watching a species of freshwater shrimp dart to and fro, avoiding our attempts at photographing them. Beyond the ear-dip, though, the stream soon disappears underneath the left-hand wall, and the cave seemingly terminates in a larger and much drier chamber. Though it appeared we had reached the end of the cave, Seth decided to make a difficult free climb up the left-hand wall of this room, and his efforts were rewarded when he popped into a hole at the top and found an additional chamber. Despite the difficulty of reaching this room, Seth, Laura, and Paris found some graffiti from the 1960s. Eladio informed us that humans have been visiting this cave for centuries; perhaps we were not the only ones to leave with water in our ears.

Cerro Mico is a small cave that nonetheless contained some challenges. Located near El Paraíso, Mpo. Tacotalpa, Cerro Mico is conveniently situated near the base of a hill quite close to the road. Though machetes are optional, the cave has a deceptive and difficult entrance. After our guide



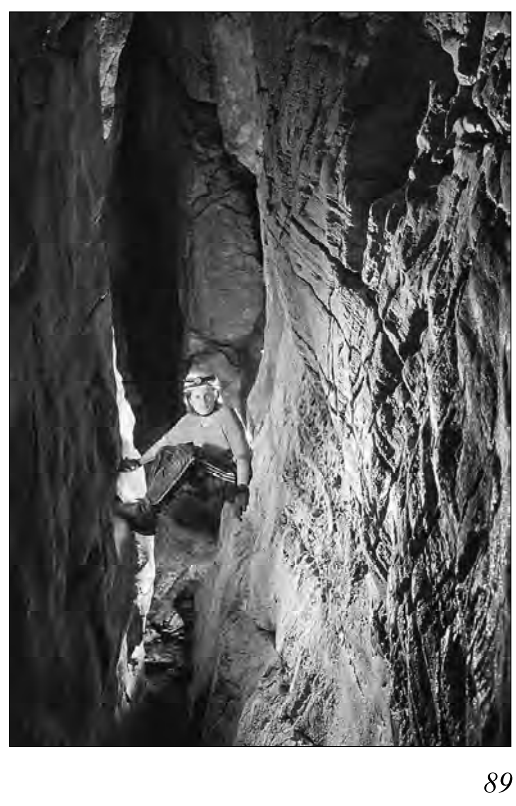


Seth Spoelman in Cueva Cerro Mico. *Vickie Siegel*.

scrambled up a short but steep cliff to the entrance, I attempted to follow. Unfortunately, the best handhold collapsed, and the route our guide had used became impassible. After assessing our options, we finally reached the top using a handline and some well-placed roots, but climbing to the entrance was never easy and required great care, especially after the best root gave out. In any case, Cerro Mico was worth the effort. The cave extended far back into the limestone from a large entrance and featured a series of rounded rooms with dramatic flowstone. Its floor was black with guano, and though we saw a number of bats, the piles of dung suggested a much larger bat population some time in the past. An owl also called this cave home, and a large population of small raptors outside the cave loudly objected to our presence there. In addition to this larger fauna, spiders in a variety of colors inhabited Cerro Mico, as did the occasional pseudoscorpion. The large entrance area and first few rooms were easy enough to map, but toward the back of the cave a challenging upclimb on slick limestone and a steep downclimb afterward definitely got the blood flowing. At the rear of the cave, stinky with vampire bats, a small unpromising pit required ropes, so the group decided to leave it for another day. Toward the end of our survey, Seth also pushed a small hole below Cerro Mico's entrance and found a small cave; christened Cerro Mico Bajo, this cave is at least 20 meters long. Given this new discovery and the pleasant interactions we had with the landowner, this area demands a return visit.

Outside a small *ejido* of the same name, Cueva San Antonio is in the northeastern Sierra Poana. The entrance is large, which is not unusual for caves in this area, but San Antonio soon proved atypical in a number of ways. First off, the cave followed a long, deep crack in the limestone and possessed a high ceiling and nearly vertical walls that narrowed sharply the farther they went in. Compared to the rounded, scalloped walking passage we normally encounter in the Sierra Poana, San Antonio seemed sharp, angular, and strange. The main crack was paralleled by a shorter, even narrower crack that went back nearly as far as the main passage. Toward the end of our first day of surveying, we also discovered another interesting feature. Vickie and I were climbing up a pile of breakdown toward a second entrance when a wide tunnel suddenly loomed on my right. Vickie and I investigated it further and were surprised to discover a phreatic tube more typical of the area. This tunnel later made a T-junction with another tunnel, and the passageway to the left opened up into a large, bat-filled chamber where we could detect sunlight. Cueva San Antonio is almost two caves in one. The rounded section does not follow the earlier trend of the cave and seems almost completely independent of it. Our first day of surveying went well, and we felt confident that we could probably complete the survey in one additional day. Unfortunately, our confidence proved ill-founded. Our next visit coincided with some rainy weather, and we soon discovered that San Antonio was poor shelter from the wet and cold. Water streamed steadily through the rock, and our phreatic tube, so pleasant to survey before, was breezy, cold, and wet. We plugged on for several hours, but San Antonio defied our expectations yet again. At the end of the main passage, Seth and Laura were working on several small crawling leads that didn't seem very promising. But then Laura popped out into a maze of tight passageways somewhere beneath Vickie and me. We could hear each other perfectly, but Laura never found a connection despite considerable calisthenics. Somewhere above, I was having a similar experience. Vickie and I had returned to the phreatic tube and had decided to survey to the right of the T-junction. This tunnel opened up into a room with a steady stream of water pouring out of a hole in the ceiling. After making my way into this room, I discovered tight passageways opening to both the left and right. Both

Erin Niedringhaus in Cueva San Antonio. *Vickie Siegel*.



leads showed potential, the latter immediately opening up into walking passage and the former connecting to a three-dimensional maze with no obvious end. I climbed up some water-slick rock in this area and glimpsed possible walking passage at the top of several steep climbing leads. In the end, we did not finish our survey, but it was certainly nice to find that San Antonio is bigger and more unusual than we first suspected.

The Sierra Tapijulapa has long interested Caves of Tabasco Project participants. At its center is an enormous sinkhole that seems to drain more than 10 square kilometers, and its remoteness could hide quite a few caves, pits, and other karst features. So, when the group had the opportunity to journey a little deeper into the area, we jumped at the chance. Our guide took us to several leads of interest. Cueva Gary is approximately 8 meters long and probably provides a habitat for a species of gigantic snail (10 centimeters and larger shells were found, but no live specimens), and two other small leads seemed to have potential, but required ropes for further exploration. We also heard much from local residents about other features in the area and noted a remote zone of rugged karst that needs ridgewalking. Needless to say, the Sierra Tapijulapa is high on our priority list for next year's effort.

Every expedition to Tabasco comes to the same fundamental conclusion: this beautiful corner of Mexico has a seemingly infinite number of caves. However, what actually lies within the jungle is difficult to anticipate. Apparently predictable caves are not always so predictable, and apparently simple caves are not always so simple. It pays to stay on your toes in Tabasco.

## Proyecto Cuevas de Tabasco 2007

El Proyecto Cuevas de Tabasco regresó al área al sureste de Teapa y Tacotalpa, donde exploraron cuevas en la Sierra Tapijulapa y la Sierra Poana. Ellos colaboraron con Laura Rosales, estudiante de posgrado que está investigando las cuevas sulfurosas de la zona, y con varios investigadores de la UNAM.

# DESCRIPTIONS OF CAVES EXPLORED BY CIRCOLO SPELEOLOGICO ROMANO IN CHIAPAS, 1996 AND 1998–2001

Anna Pedicone Cioffi and Mauricio Monteleone

## 1996

El Chorro del Sol de Piedra

*Location*: On the bank of Río Encajonado, Mpo. Tecpatán, Chiapas. 93°47′03″W, 17°00′39″N, elev. 400 m. Río Playas quad (E15C47). [Original said 95°W, probably a misprint.]
*Exploration and survey*: Circolo Speleologico Romano, April 1996.
*Size*: length 2790 m.
*Directions*: After crossing the Malpaso lake, you go upstream by boat on the Río Encajonado to a wide curve to the left where there is a high tufa-covered cliff that extends 200 meters above the river. To the left of this cliff, climb a steep path up the wall of the canyon almost to the top. Moving to the right at this level toward the cliff, you'll find the entrance above a series of ledges, covered with boulders by the floods from the resurgence entrance, that lead down to the top of the surface flowstone.

*Description*: The entrance has a rectangular shape 5 meters by 7 meters and opens into a roundish room. In the center of the ceiling is a "rose window" of formations arranged in concentric circles. Below it are large, square stone blocks. The room slopes downward to the first flooded passage, the widest in the cave. It is 20 meters wide and 90 meters long, leads to the south-southwest, and is characterized by some unusual perfectly rounded domes of various sizes. These forms look like the insides of thimbles 40 to 60 centimeters wide and 60 to 80 centimeters high. They are formed by the action of swirling water on areas of weakness and discontinuity along the fractures on which they are aligned.

The upstream end of this passage has a higher floor that separates that lake from the second one. Here is the first tributary, which alternates between dry and flooded parts. In some places, there is a curtain of formations just above the water level, testifying that the level has remained stable for a long time. Toward its end, there is a maze of branches, flooded and just partly explored. The survey data for this passage were lost.

Ahead on the main route, the second lake, smaller than the first, extends about 50 meters west-southwest to a narrowing and lowering where the floor surfaces again at the Saletta d'attesa, the Waiting Room. The third lake is 30 meters wide and goes through an S-bend under a sort of limestone balcony, El Falso Mirador, overlooking the water. After climbing over this obstacle, you reach another stretch of flooded passage that leads 40 meters to the Esquina Pútrida, the Putrid Corner. To the left, water flows from the main passage; to the right is a minor affluent. The latter, divided by turns into three parts, is about 190 meters long. The first 70 meters is oriented north-south, the second is a bit more than 50 meters long and oriented east-west, and the third starts out to the north and bends gradually toward the east for about 70 meters to a small sump. It is no more than 2 meters wide, and the floor is covered by a thick layer of mud under the water.

The main branch proceeds as flooded passage for about 100 meters to the southeast to a small waterfall 2 meters high. Above it, at a place marked by a large pointed stone, the Piedra Pulgada, the passage branches again, with an important tributary to the right. The first 70 meters of the tributary is flooded and about 3 meters wide. Then a slope upward for about 10 meters is climbed to a small room and a second lake, 60 meters long, beyond which the canyon continues dry through a series of curves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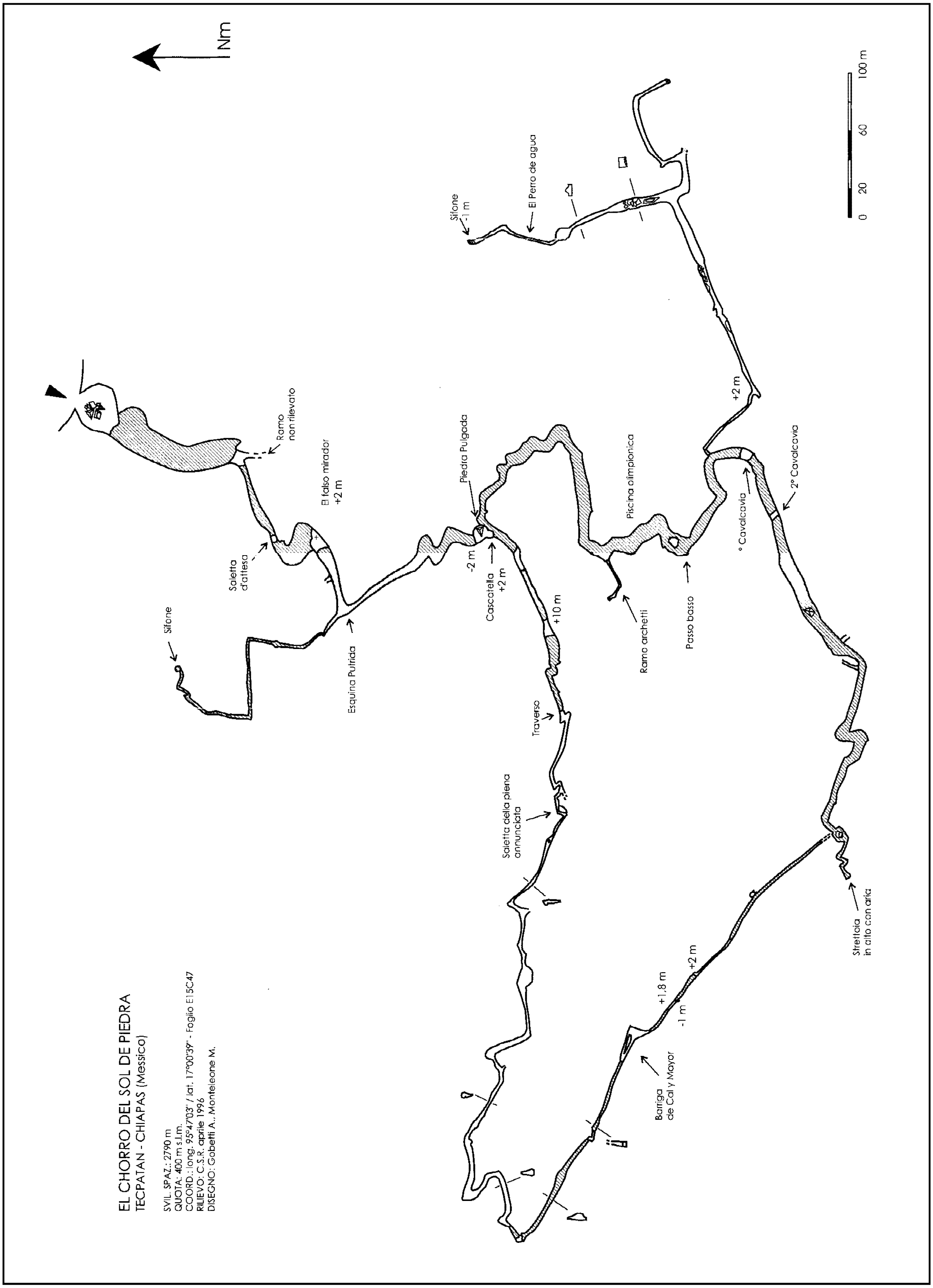
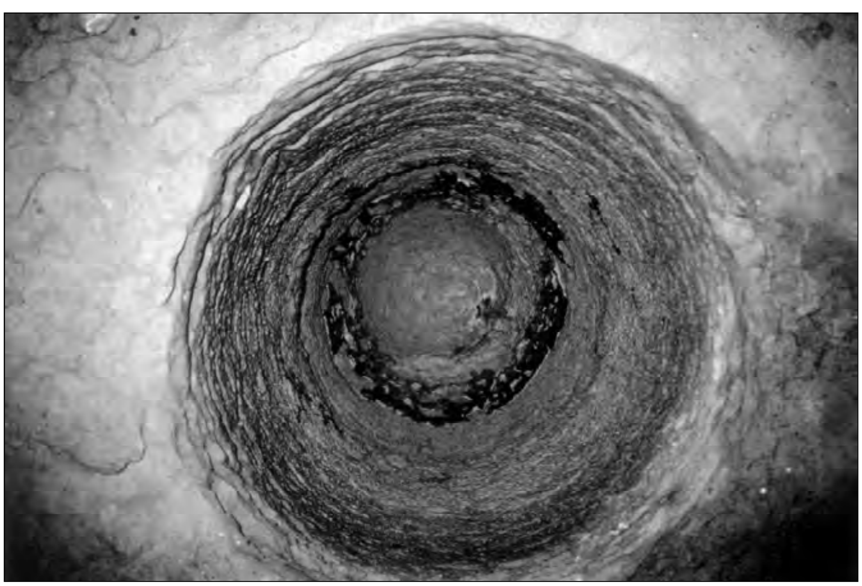

EL CHORRO DEL SOL DE PIEDRA
TECPATAN - CHIAPAS (Messico)
SVIL. SPAZ.: 2790 m
QUOTA: 400 m s.l.m.
COORD.: long. 95°47'03" / lat. 17°00'39" - Foglio E15C47
RILIEVO: C.S.R. aprile 1996
DISEGNO: Gobetti A., Monteleone M.
Nm
0 20 60 100 m
Sifone -1 m
El Perro de agua
Ramo non rilevato
El falso mirador +2 m
Saletta d'attesa
Sifone
Esquina Putrida
Piedra Pulgada
-2 m
Cascatella +2 m
+10 m
Traverso
Saletta della piena annunciata
Piscina olimpionica
Ramo archetti
Passo basso
+2 m
° Cavalcavia
2° Cavalcavia
Strettoia in alto con aria
+2 m
+1,8 m
-1 m
Barriga de Cal y Mayor

for over 400 meters to the west, until a wide curve back to the east-southeast leads to a series of phreatic conduits, partly flooded, that are about 1.5 meters in diameter. This crawl is about 340 meters long and ends at a sudden tight spot where exploration stopped. About 140 meters into the crawl, the passage briefly divides into two dry passages, the Barriga de Cal y Maior. This passage may connect back to the main passage at its upstream end, but the connection was not made.

From the Piedra Pulgada junction, you swim in the main branch, which is flooded almost everywhere. After 200 meters of passage with an average width of 10 meters, going first southwest and then east, you come to a small side passage to the right. This Ramo Degli Archetti (Branch of the Small Arches) is about 30 meters long. Ahead is the Piscina Olimpionica (Olympic Pool), 50 meters long and 15 wide, at the end of which the cave goes around an S-bend with a column in the middle, the Passo Basso (Low Passage).

After another 70 meters, there is passage to the right where it is possible to walk out of the water. The first section, 50 meters long and 2 meters wide, leads into a passage of similar size that goes straight to the east-northeast for 150 meters to a T. To the right, a bit more than 100 meters of passage goes east and then south to end at a blockage. To the left, a passage floored with breakdown leads to a room and then smaller passage to a sump about 150 meters from the T.

Continuing to swim up the main passage, you pass two dry spots, the 1º and 2º Cavalcavia (First and Second Overpasses), beyond which the cave continues flooded for about 300 meters, first to the southwest and then to the west-northwest. The final stretch is narrower and leads to a sump above which an impenetrable fissure could lead to a continuation.



Cueva de los Dos Hermanos

*Location*: Berriozábal, Mpo. Ocozocoautla, Chiapas. Approximate coordinates 93°16′00″W, 16°45′32″N, elev. 800 m. Chicoasén quad (E15C59).

*Exploration and survey*: Circolo Speleologico Romano, 31 March 1996.

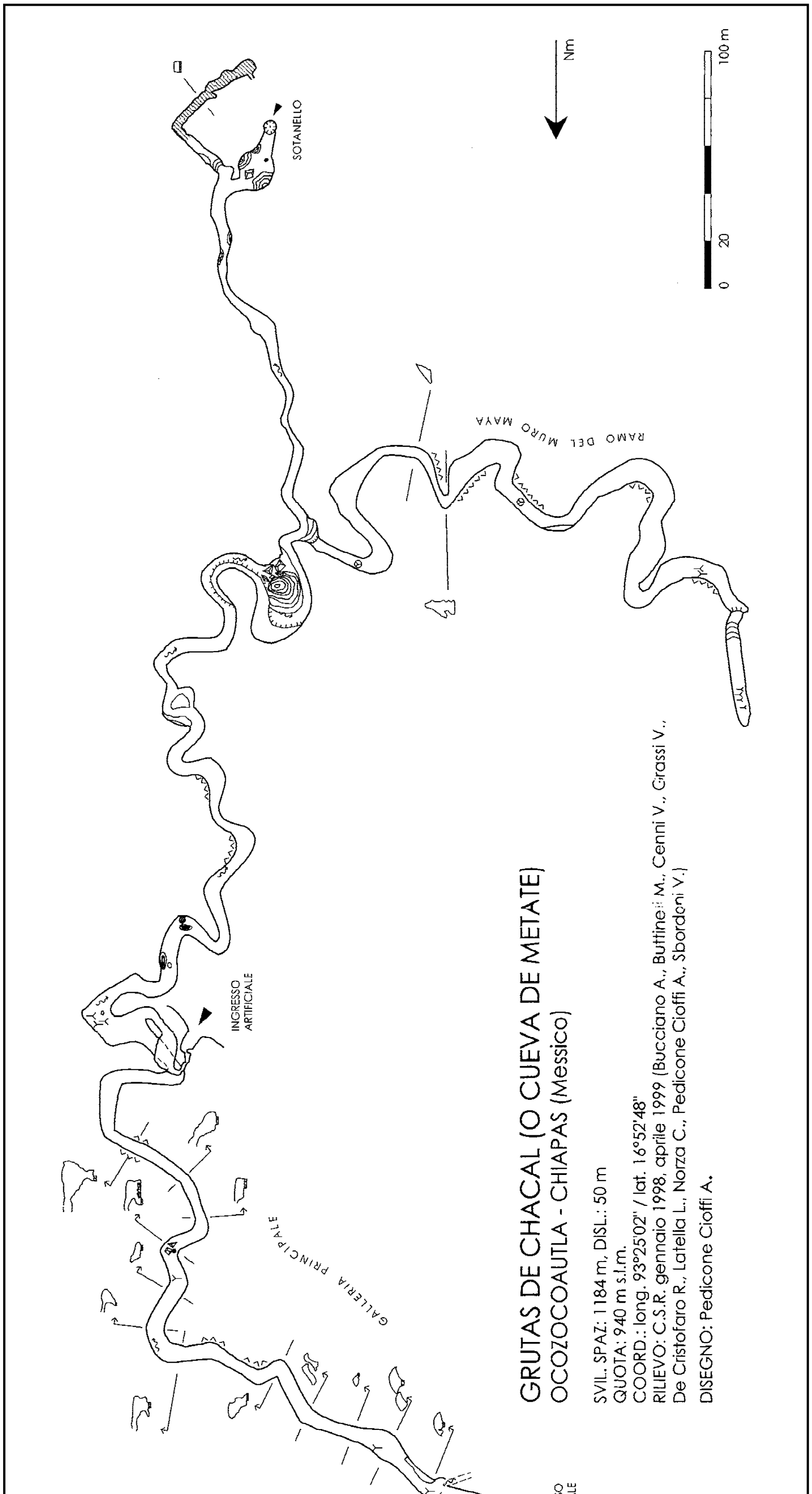
*Size*: length 320 m. (Half the survey was done with estimated distances, and inclinations could not be measured with the instruments at hand.)

*Directions*: We were led to the cave by two brothers, Guillermo and Roberto, who live in a *rancho* close to the Pemex station before reaching Berriozabal from Coita.

*Description*: From the entrance, formed by the uprooting of a *ceiba* tree, you walk through a small conduit that turns little by little to the west. After about 60 meters, you meet the river passage. From this point on, the floor is covered by water in all the rest of the cave. There is a short side passage to the right after about 10 meters, beyond which the passage continues, going south for another 55 meters to another branch to the right. Ahead, you continue toward the south-southwest, immersed in water covered in muddy, yellowish foam. At 235 meters from the entrance, low ceiling forces you to submerge even your head, but it isn't worth it, because up ahead the cave closes down in some small, flooded passage after a total distance of 320 meters.

The cave looks like a stream sink, but in the rainy season it fills up, and water flows out the entrance. The ceiling is flat, with several erosion domes. In the first part, fossil rudists extend out from the rock.

The ceiling domes in Sol de Piedra. *M. Monteleone*.


GRUTAS DE CHACAL (O CUEVA DE METATE)
OCOZOCOAUTLA - CHIAPAS (Messico)
SVIL. SPAZ: 1184 m, DISL.: 50 m
QUOTA: 940 m s.l.m.
COORD.: long. 93°25'02" / lat. 16°52'48"
RILIEVO: C.S.R. gennaio 1998, aprile 1999 (Bucciano A., Buttinelli M., Cenni V., Girassi V., De Cristofaro R., Latella L., Norza C., Pedicone Cioffi A., Sbordoni V.)
DISEGNO: Pedicone Cioffi A.
INGRESSO NATURALE
INGRESSO ARTIFICIALE
GALLERIA PRINCIPALE
RAMO DEL MURO MAYA
SOTANELLO
Nm
0 20 100 m

## 1998–2001

### OCOZOCOAUTLA ZONE

Cueva de Metate (or Grutas de Chacal)

*Location*: Rancho San Judas Tadeos de Chacal, Ocuilapa, Mpo. Ocozocoautla, Chiapas. 93°25′02″W, 16°52′48″N, elev. 940 m. Ocozocoautla quad (E15C58).

*Exploration and survey*: Circolo Speleologico Romano, January 1998 and April 1999.

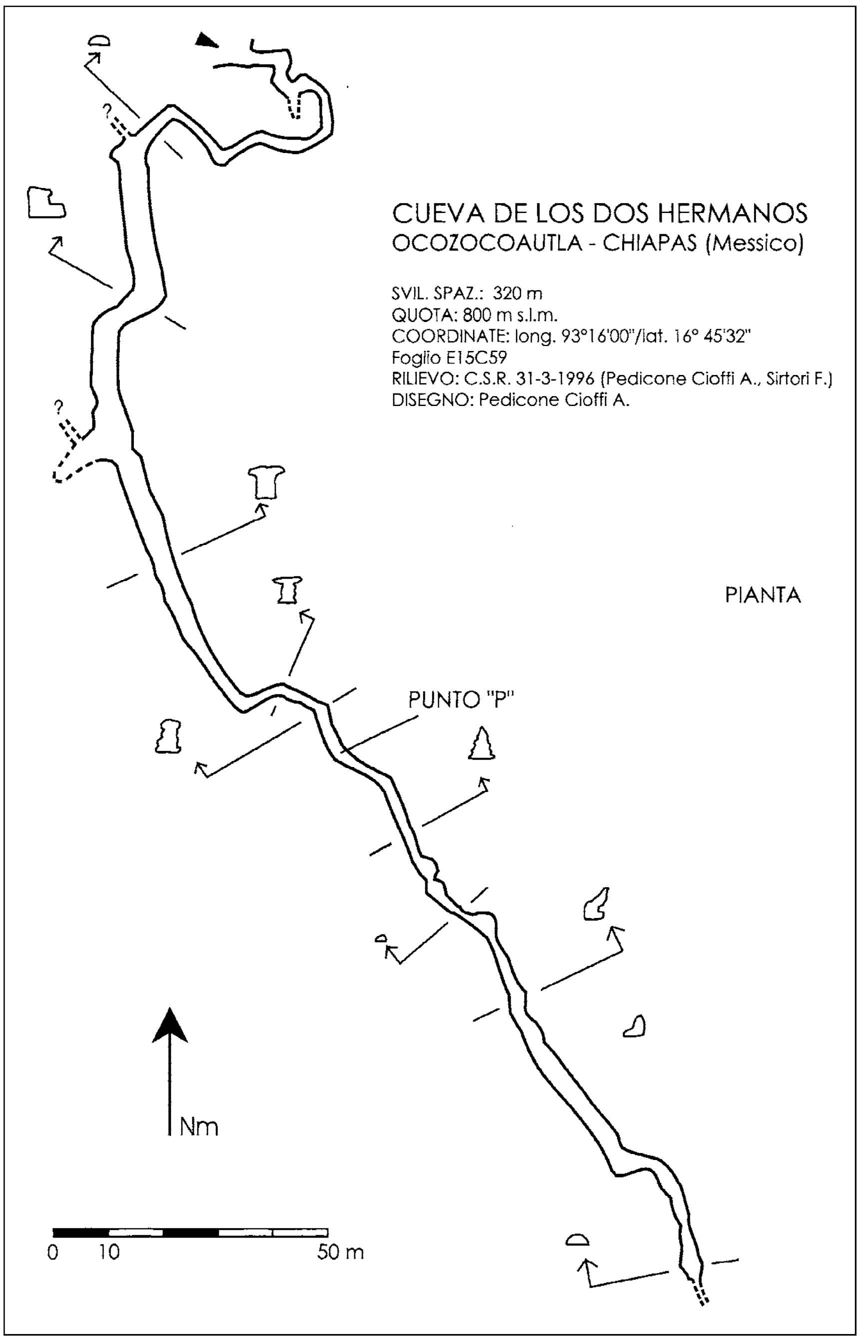
*Size*: length 1184 m, depth 50 m.

*Directions*: At kilometer 18 on the new road that connects Ocozocoautla to Apic Pac.

*Description*: A stream cave that has two natural entrances and a third one opened during the construction of the road. (The cave appears to have been previously explored and maybe surveyed; attempts to find information about it did not succeed.)

Entering from the road, you go about 80 meters down a slope that drops about 10 meters to a stream. Upstream, you get to the upper natural entrance, and downstream you come out at the base of a sotanito.

The metate in Cueve de Metate. *V. Sbordoni*.




The upper natural entrance looks like a room in an advanced state of collapse. It goes straight into a passage with a muddy floor. After 30 meters, the stream comes into the passage, and from this point the path winds along the stream, although there are several branches at a higher level.

The main passage is very large, 5 to 6 meters wide and 7 to 8 meters high. After 280 meters you can leave the riverbed and go up an extensive flowstone on the left side that leads to a fossil passage, Ramo del Muretto (Low Walls Branch, not surveyed), which grows to a large size and leads to a room with a drystone wall that delimits part of it. Such walls are found in the Maya Branch as well, and with some other evidence clearly indicate that the cave was used by the ancient inhabitants of the area.

Continuing in the active passage, after about another 120 meters you can go up to the right into the branch that leads to the artificial entrance by the road.

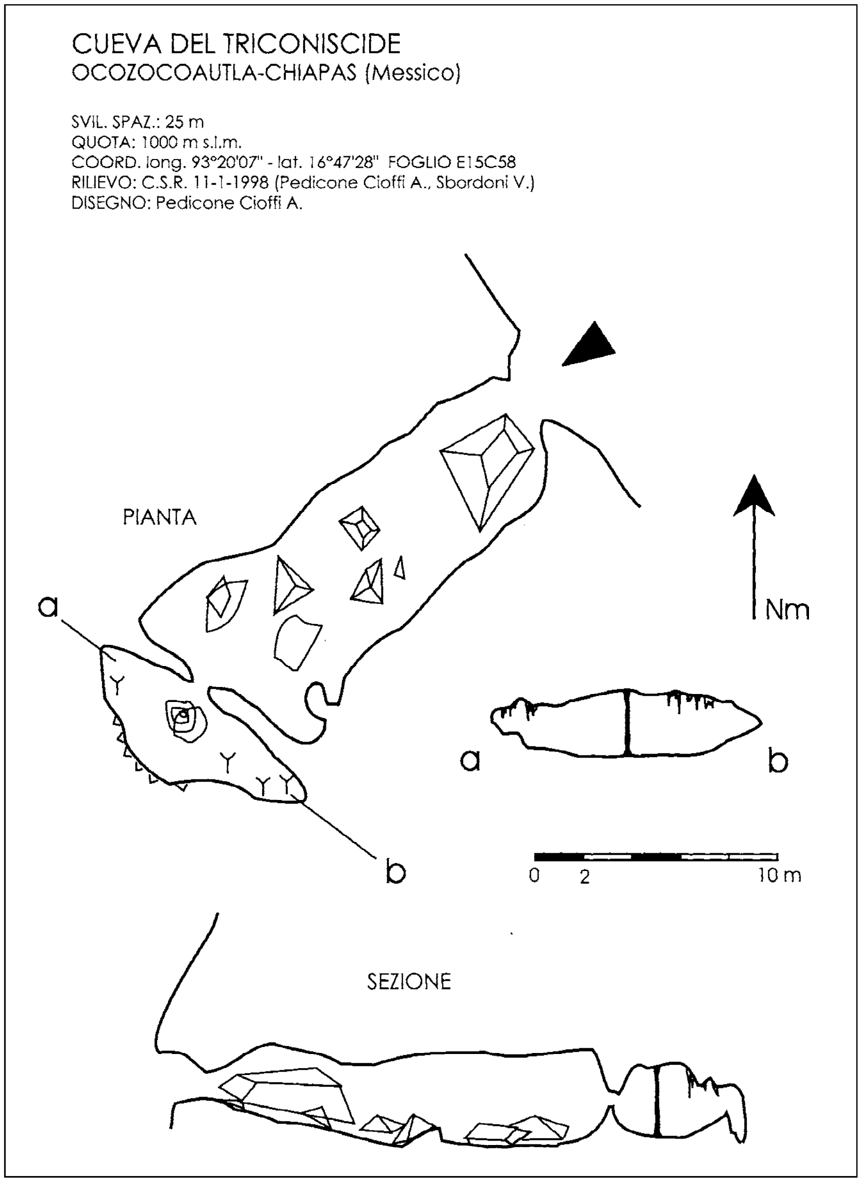
Downstream, you cross a lake beyond which the passage continues with the same morphology and size for another 300 meters. Then you reach a large stalagmite above the water level that occupies the left wall of a large loop. The stream flows under breakdown piled against the flowstone and soon reappears. Beyond this, going up a flowstone wall on the right takes you to the Ramo del Muro Maya (Maya Branch). It is a fossil part of the system, with extensive formations and flowstone-covered walls. As in the other fossil passage, you will discover various traces of the ancient visitors to the cave. This branch extends 400 meters.

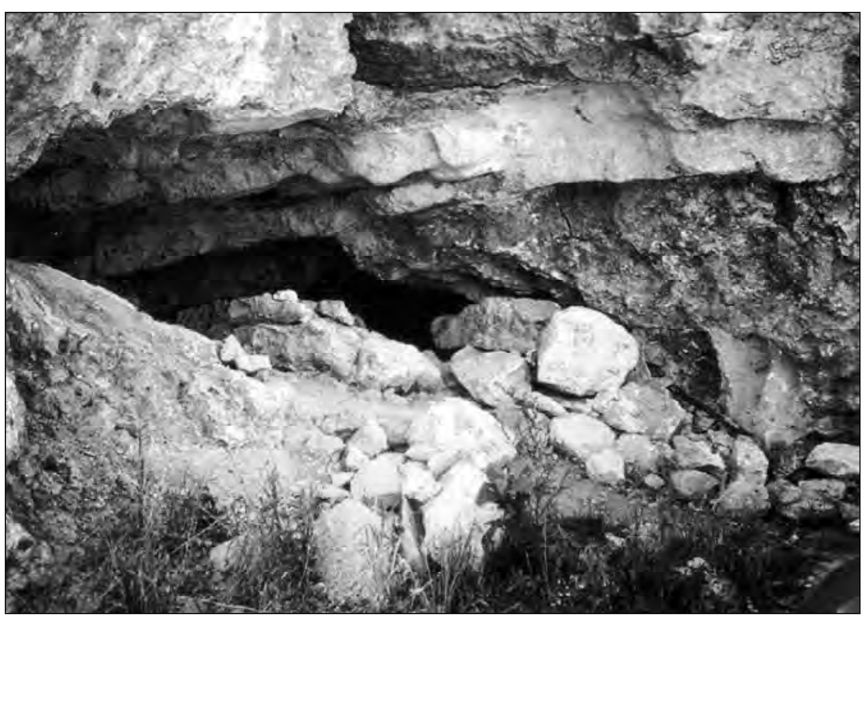
On downstream in the main passage, the size is a little smaller, but there are still wide flowstones on the walls. After another 150 meters you come to a T. To the left, the water runs in a uniform passage 2.5 meters wide and 2 meters high that ends after 80 meters at a sump. To the right is a room with breakdown on the floor and formations on the wall. Here is the other natural entrance to the system, the sotanito.

The cave is large all the way through, and the height increases to two or three levels where passages exist at the ceiling. These higher levels are characterized by the presence of many formations in a senile state. The lower level, subject to the flow of the stream, is often filled mainly with muddy sediments. In April, the water depth oscillates between 0.2 meters and 1.5 to 2 meters, but at many places there are signs of flooding to 1.5 to 2 meters close to the upstream entrance and 3 to 4 meters close to the downstream end, which shows that a large amount of water flows through the system in the rainy season. This is also shown by many tight meanders and scallops on the walls that indicate a fast current.

The small sotanito exit was probably once the exit of the river, which now goes into the sump in the other branch and passes under the sotanito.

Archaeological observation: A *metate* is a rectangular stone, slightly concave, which is placed on three supports so that it is slightly inclined. It serves to grind maize or other seeds when used with another stone, of cylindrical shape, called a *mano* or *metlapil*. The presence of a metate in the cave, along with earthenware, arrow points, and other elements, indicates unmistakably that the cave was used in the past as a shelter. This is also shown by the many walls of dry stone or mud-cemented pieces of formations that isolate small rooms from the rest of the cave. Those places were probably used for burials, as indicated by the many human bones found in flowstone.



The entrance to Cueva de Triconiscide. *A. Pedicone Cioffi.*

Cueva del Triconiscide

*Location*: Mpo. Ocozocoautla, Chiapas. 93°20′07″W, 16°47′28″N, elev. 1000 m. Ocozocoautla quad (E15C58).
*Exploration and survey*: Circolo Speleologico Romano, 11 January 1998.
*Size*: length 25 m.
*Directions*: At km 4.3 on the new road that connects Ocozocoautla to Apic Pac.

*Description*: The cave is 25 meters long and consists of two rooms separated by a small hole through formations. The first part, 15 meters long, is characterized by breakdown blocks that cover most of the floor, but the final room has more formations, although they are mostly destroyed.

A crevice filled with stones through which air is flowing is visible through flowstone close to one of the walls.

Cueva de Catarino

*Location*: Rancho del Quince-Ocozocoautla, Mpo. Ocozocoautla, Chiapas. 93°30′37.8″W, 16°44′58.5″N, elev. 720 m. Jiquipilas quad (E15C68).
*Exploration*: Circolo Speleologico Romano, 6 January 1998.
*Size*: length 60 m, depth 40 m (dimensions approximate).
*Directions*: From the road between Tuxtla and Cintalapa, turn onto the road to El Aguacero. The entrance is on the right after about 200 meters.

*Description*: The collapse doline that exposes the cave is 15 meters wide and has about the same depth. The descent is simple for the first 10 meters, while the last part requires a safety rope.

From the breakdown blocks at the bottom of the entrance, a passage extends about 10 meters. It is about 8 meters high and 4 meters wide. This leads to an oblong room about 10 by 13 meters floored with debris. Across the room, a short climb up flowstone leads to a small room overlooking a pit. After a descent of about 13 meters, the cave continues down small drops requiring rope. Exploration was stopped by lack of equipment.

Cueva del Laberinto de El Aguacero

*Location*: Balneario de El Aguacero, Mpo. Ocozocoautla, Chiapas. 93°31′31.8″W, 16°45′21.6″N, elev. 680 m. Ocozocoautla quad (E15C58).
*Exploration and survey*: Circolo Speleologico Romano, 21 January 1998.
*Size*: length 70 m, depth 5 m (inclinations not measured by instrument).
*Directions*: On the road from Highway 190 to El Aguacero, on the right shortly before the end.

*Description*: The cave is developed on two levels. The lower and higher entrances are separated by about 5 meters vertically and 10 meters horizontally.

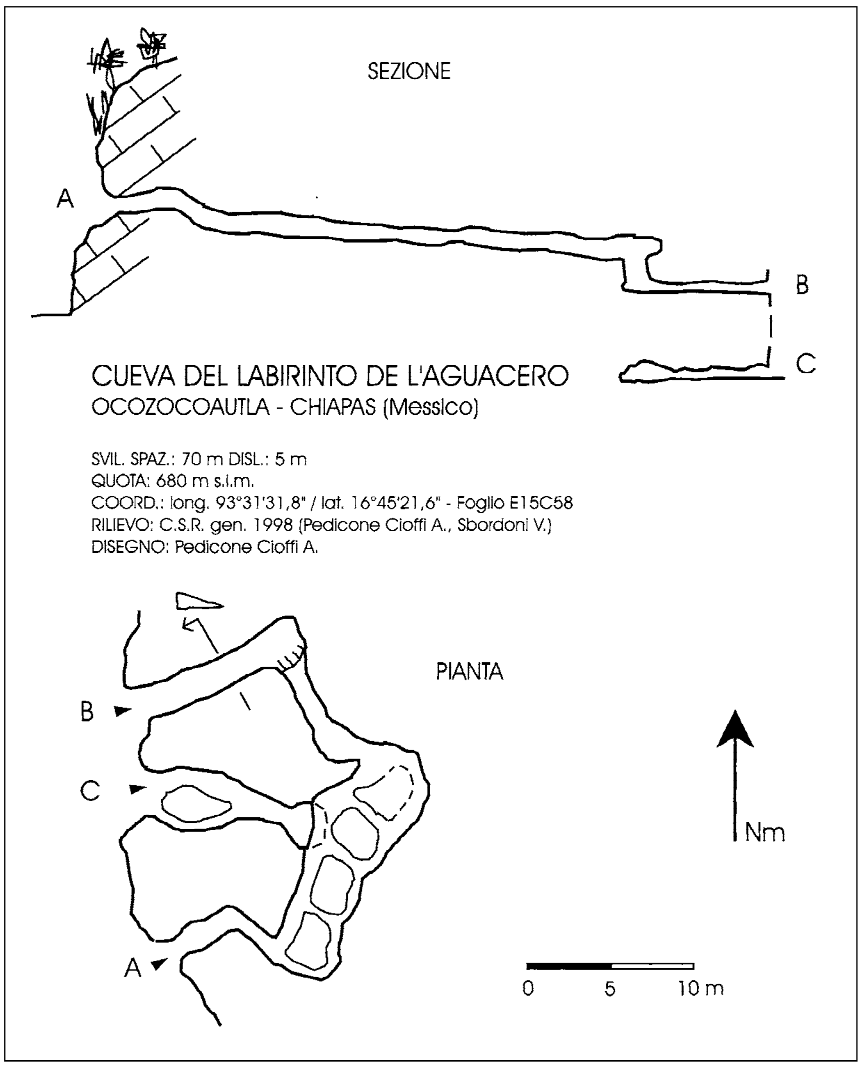
The upper level is a maze of small passages, with the main one averaging about 1 meter by 1 meter. Some parts of the floor are about 10 centimeters lower. A small pit about 3 meters deep leads to the lower level, where a passage 4 meters wide and almost completely blocked by dirt leads to the lower entrance.

A few meters from this lower entrance is another cave, 10 meters long and ending in a small room 3 meters wide. Probably a connection to the other cave is blocked here by mud and rocks.

Complesso Amate-Zapote

*Location*: Ocuilapa, Mpo. Ocozocoautla, Chiapas. Amate 93°24′58″W, 16°52′52″N, elev. 960 m. Zapote 93°24′55.8″W 16°52′53.8″N, elev. 940 m. Ocozocoautla quad (E15C58).
*Exploration and survey*: Circolo Speleologico Romano, 5 April 1999.
*Size*: length 245 m, depth between entrances about 20 m.

*Description*: From the Cueva del Zapote entrance, there is a nearly



horizontal passage. When explored, there was no flowing water, but in several places there were many traces of floods. This stream passage must drain very slowly, as the walls of the passage are often covered with a layer of mud.

After about 150 meters, the passage divides at a room. To the left, beyond the lowest point in the cave, is a room entered by a stairway carved in the solid rock, the Escalera Maya. At the top, a flat terrace slopes up to the roof. To the right, a passage about 20 meters long leads to the Cueva del Amate entrance room; a small, upper-level passage connects back to the Escalera Maya.

Cueva de las Cotorras

*Location*: Sierra El Limón, Mpo. Ocozocoautla, Chiapas. 93°26′35″W, 16°54′35″N, elev. 900 m. Ocozocoautla quad (E15C58).
*Exploration and survey*: Circolo Speleologico Romano, 6 April 1999.
*Size*: length 423 m, depth 120 m.

*Description*: A very large passage goes down a 45-degree slope to a bottom 120 meters lower. The last part is very different from the initial one in size and shape. In the first 250 meters you walk on a surface formed of mud-cemented breakdown, with growing vegetation. Then you reach a place where the slope changes to 70 degrees. You go down 50 more meters over big breakdown blocks, as the passage narrows to a funnel. The smooth floor is like an anteroom to the remaining part of the cave, which can be entered by climbing over a drystone wall, the Muro Maya, that blocks the passage.

Beyond is an unpretentious horizontal passage about 5 by 5 meters and 80 meters long, mostly decorated with formations. At its end, up a large flowstone, is a short passage to a tight spot. The room beyond, oblong and sloping slightly upward, is 10 meters high and 25 meters wide and is the last room in the cave. In its upper part, which is decorated with massive flowstone, there are two human skeletons incorporated in the calcite on the floor. Their fetal position makes them look like a mother with her son.

In general, the whole cave is in an advanced state of decay.

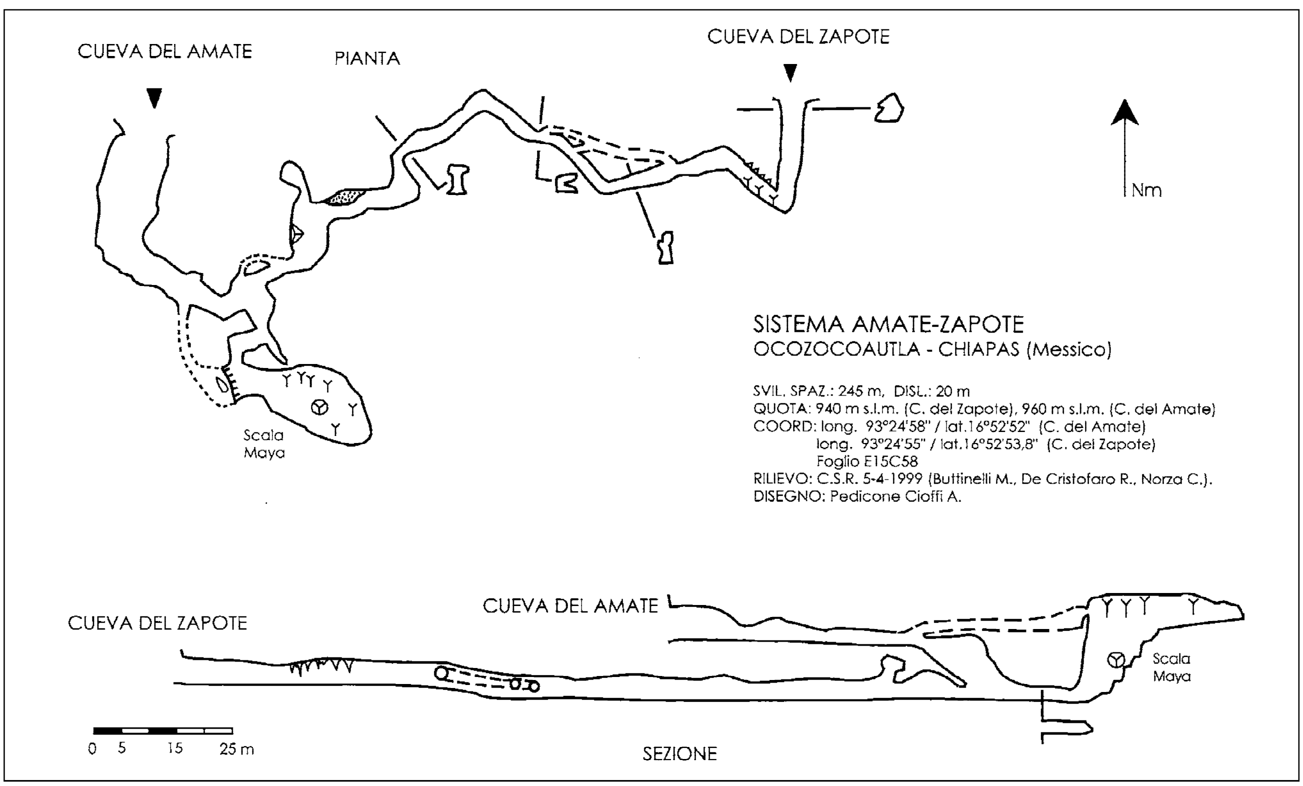
Cueva del Tigre

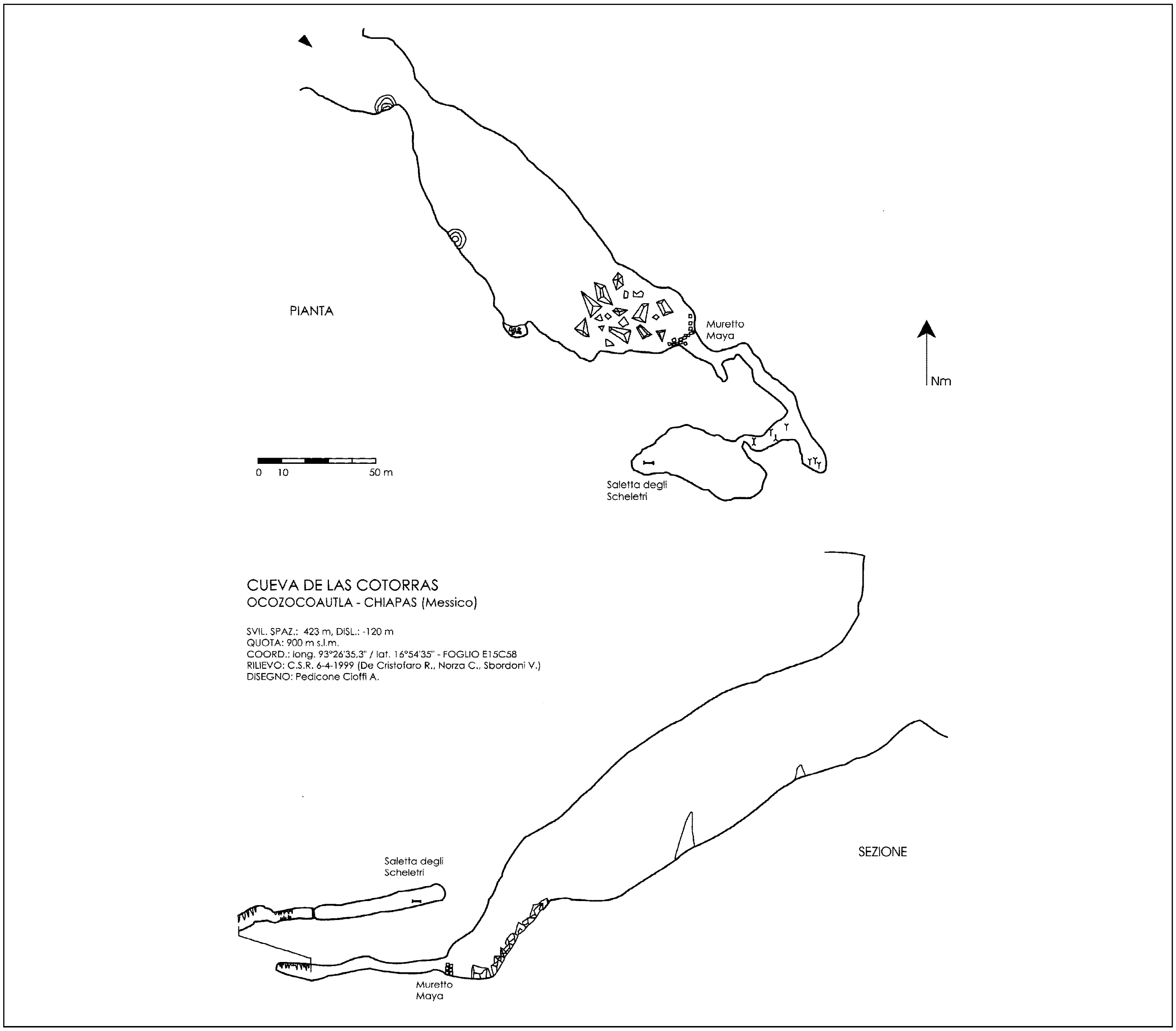
*Location*: Sierra El Limón, Mpo. Ocozocoautla, Chiapas. 93°26′35.5″W, 16°54′36″N, elev. 900 m. Ocozocoautla quad (E15C58).

The entrance to Cueva de las Cotorras. *V. Sbordoni*.

*Exploration and survey*: Circolo Speleologico Romano, 6 April 1999.
*Size*: length 212 m, depth 82 m.

*Description*: This is a large cave that opens on the bottom of a doline next to Cueva de las Cotorras. The cave begins






as a wide passage trending downward. The central part, for a length of about 50 meters, is level and more than 20 meters wide. Then the passage becomes narrower and steeper, ending at a depth of 80 meters in a very nice room full of formations. Unlike Cotorras, this cave is marked by vast collapses, especially in the first part.

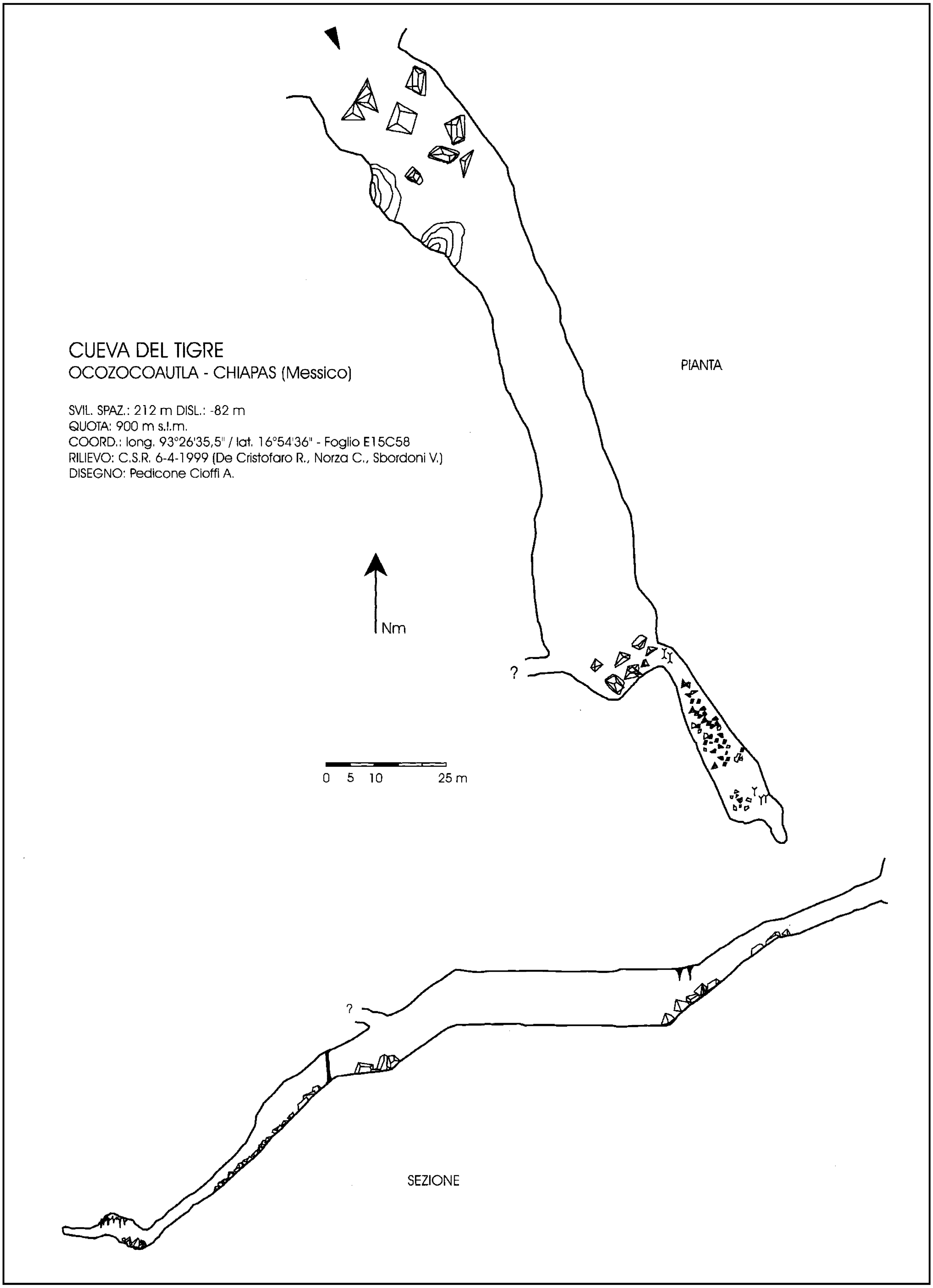
Sumidero de Tres Amates

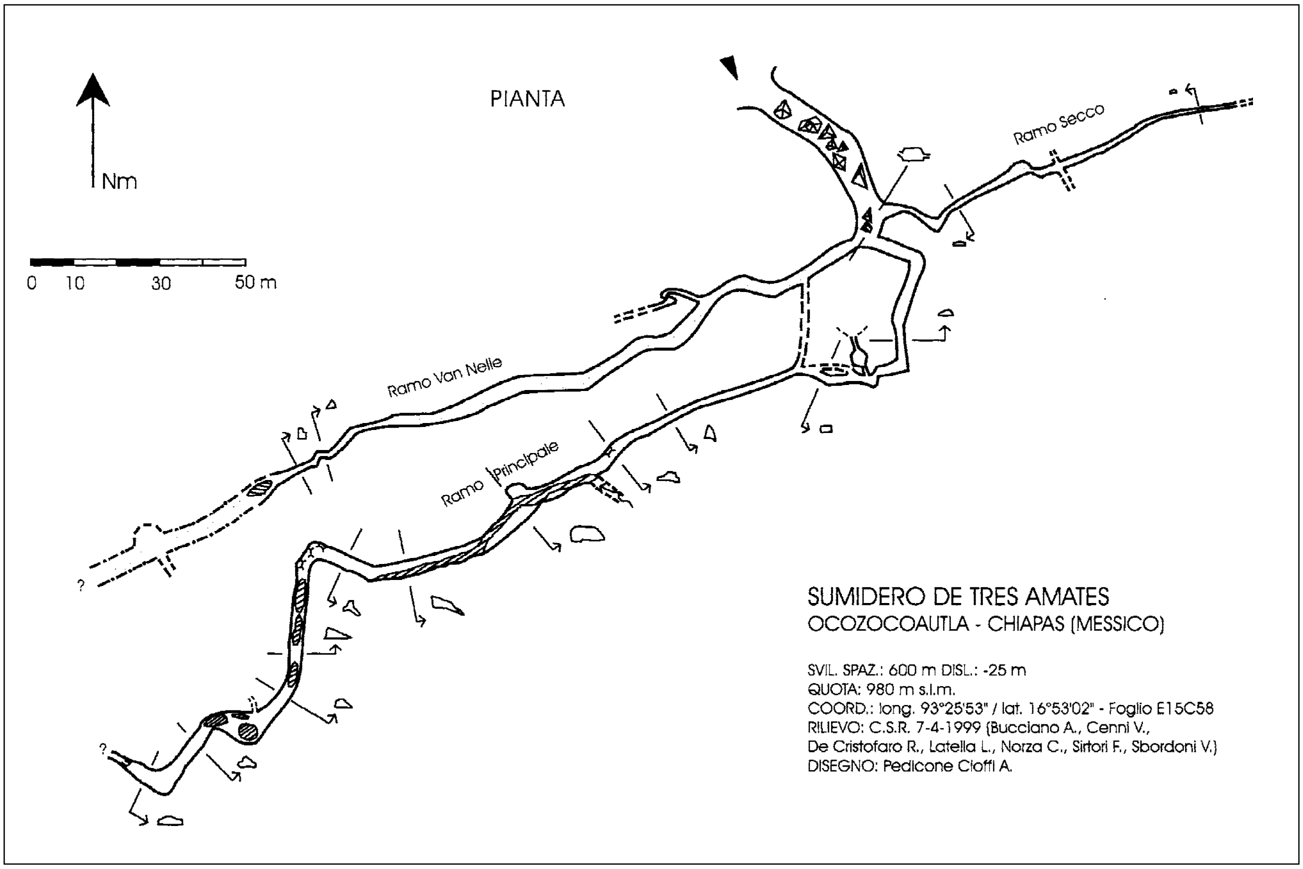
*Location*: Mpo. Ocozocoautla, Chiapas. 93°25′53″W, 16°53′02″N, elev. 980 m. Ocozocoautla quad (E15C58).
*Exploration and survey*: Circolo Speleologico Romano, 7–8 April 1999.
*Size*: length 600 m, depth approximately 25 m.

*Description*: This is an active stream cave with two parallel branches aligned NE-SW. From the entrance, you go downward to the southeast through a passage cluttered with breakdown blocks. After 40 meters, at a room, you come to an intersection with a slightly higher passage that extends upstream (Ramo Secco) and downstream (Ramo Van Nelle). Continuing ahead to the southeast, you follow the active branch, the Ramo Principale, which slowly swings around to the southwest. In the first part of the active branch, the water flows invisibly at a lower level. It comes in from a spring on the left of the passage about 100 meters beyond the junction room. We noticed other tributaries along the way. There are only poor formations, but mud deposits are abundant. The survey of this passage was stopped at a drop of a few meters, after 260 meters.

The upper level is only 1.5 meters above the active passage. Both directions are very low and wide, with floors entirely covered with mud that is more or less dry and compact; only the final section of the Ramo Van Nelle has some furrows from flowing water and some puddles. This downstream survey was stopped for lack of time, but the passage appears to continue with the same characteristics. There is no airflow.

A small crawlway connects the two branches, but it is blocked by formations.


CUEVA DEL TIGRE
OCOZOCOAUTLA - CHIAPAS (Messico)
SVIL. SPAZ.: 212 m DISL.: -82 m
QUOTA: 900 m s.l.m.
COORD.: long. 93°26'35,5" / lat. 16°54'36" - Foglio E15C58
RILIEVO: C.S.R. 6-4-1999 (De Cristofaro R., Norza C., Sbordoni V.)
DISEGNO: Pedicone Cioffi A.
PIANTA
Nm
?
0 5 10 25 m
?
SEZIONE




Cueva de las Palmas

*Location*: Río Grijalva, Mpo. Tecpatán, Chiapas. Elev. about 250 m.
*Exploration*: Circolo Speleologico Romano, April 2001.
*Size*: Length about 40 m.

*Description*: Wide, dry passage trending upward.

Cueva de las Cucarachas

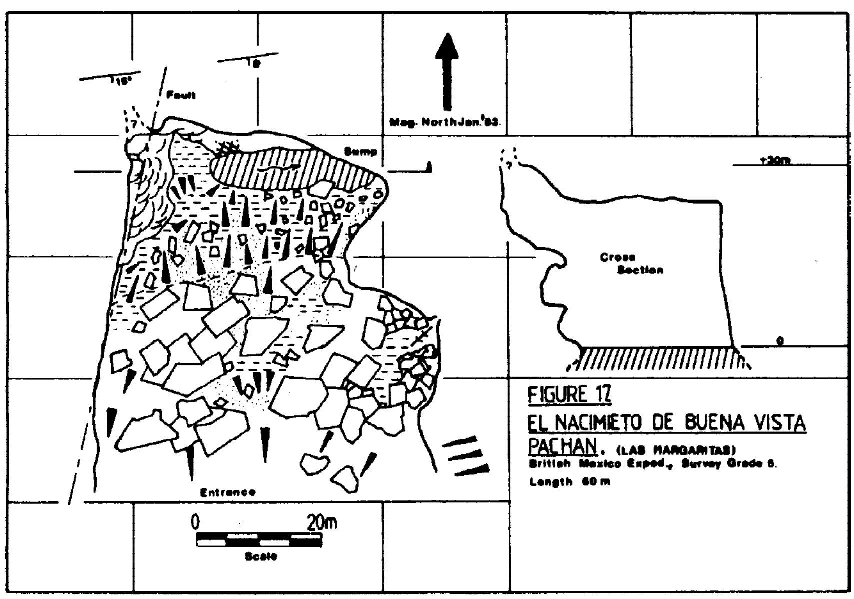
*Location*: Río Cedro junction with Río Grijalva, Mpo. Tecpatán, Chiapas. 93°18′00″W, 16°59′35″N, elev. 200 m. Chicoasén quad (E15C59).
*Exploration*: Circolo Speleologico Romano, April 2001.
*Size*: Length 12 m.

*Description*: A small cave with an entrance about 10 meters above water level on the right wall of the Río Cedro canyon.

LAS MARGARITAS AREA

Risorgenza de Sacomantic (Nacimiento de Buena Vista Pachán)

During the expedition in 2001, we visited some caves already explored by other speleological groups. In particular, in the Las Margaritas area we reached a big resurgence that feeds the course of the Río Soledad. From our survey and the position we determined, we discovered that this cave corresponds to the Nacimiento de Buena Vista Pachán explored and surveyed by the British during their 1982–1983 expedition. [See *AMCS Activities Newsletter* 18, page 51. The map here is from *Cave Science*, vol. 15, no. 2, page 61.] Sacomantic is the name given us by the



local guide who led some Circolo Speleologico Romano members to it during our reconnaissance of the area. The position by our GPS is 91°46′22″W, 16°18′36.6″N, while the British expedition gave 91°46′29″W, 16°18′18″N.

Cueva Chamburro

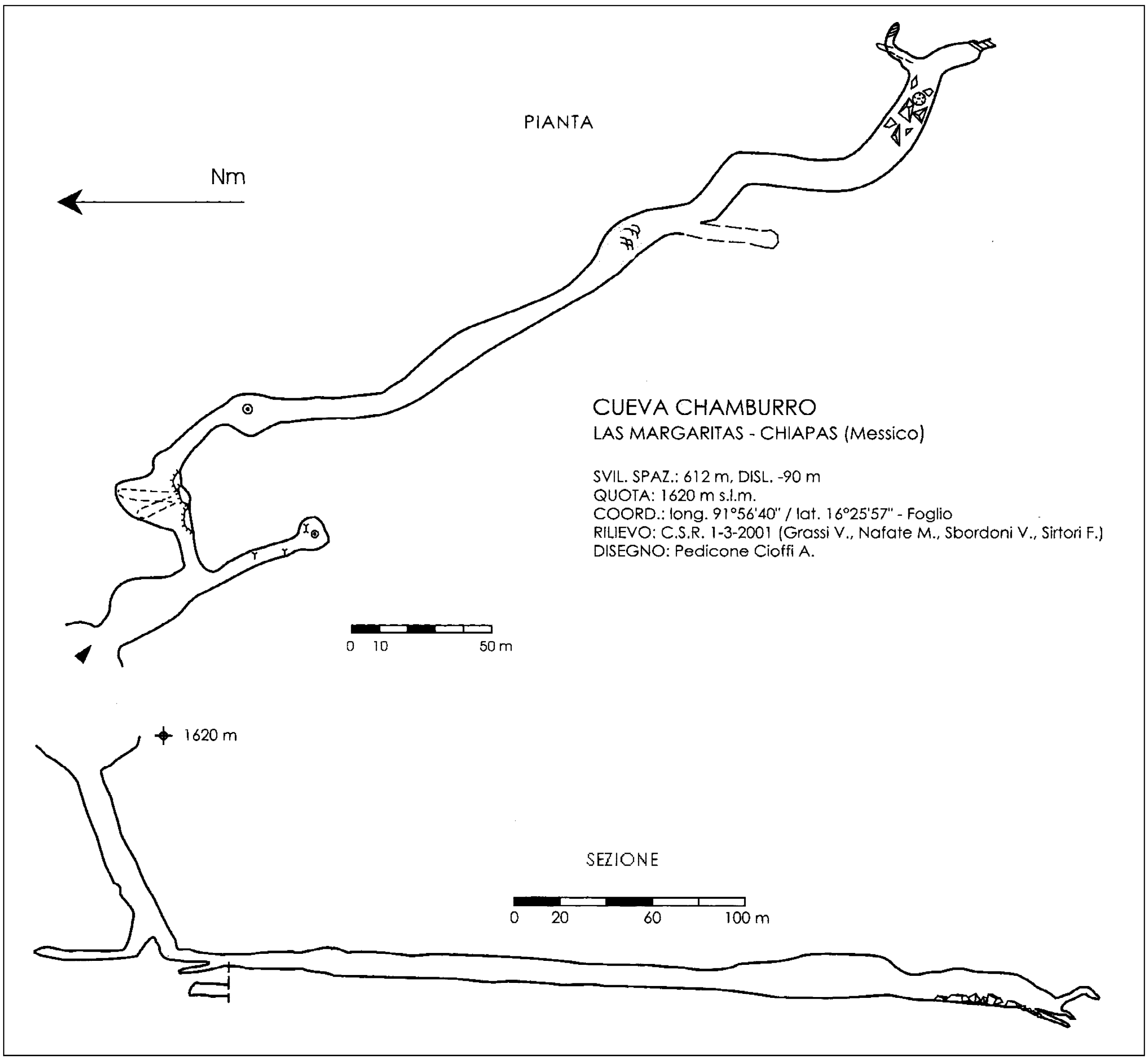
*Location*: Mpo. Las Margaritas, Chiapas. 91°56′40″W, 16°25′57″N, elev. 1620 m. Las Margaritas quad (E15D74).
*Exploration and survey*: Circolo Speleologico Romano, 1 March 2001.
*Size*: length 612 m, depth 90 m.
*Directions*: From Las Margaritas, take the road to Rafael Ramírez and Aquiles Serdan. The cave is more or less at the junction with the road to the village of Jalisco.

*Description*: The entrance is at the bottom of a funnel-like doline 35 meters deep and 50 by 70 meters wide and long. From the entrance you go through at straight slot, very steep, 80 meters long with a drop of about 60 meters. At the base, the cave goes on to the left, but there is another, narrower branch to the right. This second way, 50 meters long, is pretty well decorated with formations, if a bit muddy. In the final room, there is a column 15 meters high.

The main branch goes on between mostly dry rimstone dams to a small room with a column 12 meters high. Past this room you reach the stream, where you can walk either in the water or along the banks for about 100 meters until you arrive at a big room with mounds of mud and sand along its sides. The center of the room is mostly occupied by empty rimstone pools.

High on the right in this room is a branch going upward for 40 meters between unstable blocks. It ends in a little room with a small colony of vampires.

Past the big room in the main branch, after a few meters you can drop down through a hole that leads, after 15 meters, to some big breakdown blocks mostly submerged in the clear, deep water of a sump. The main route goes on to a funnel that is another point



where the stream sinks. Above, you continue up a steep slope for about 15 meters in passage that extends 40 meters to also end in a sump.

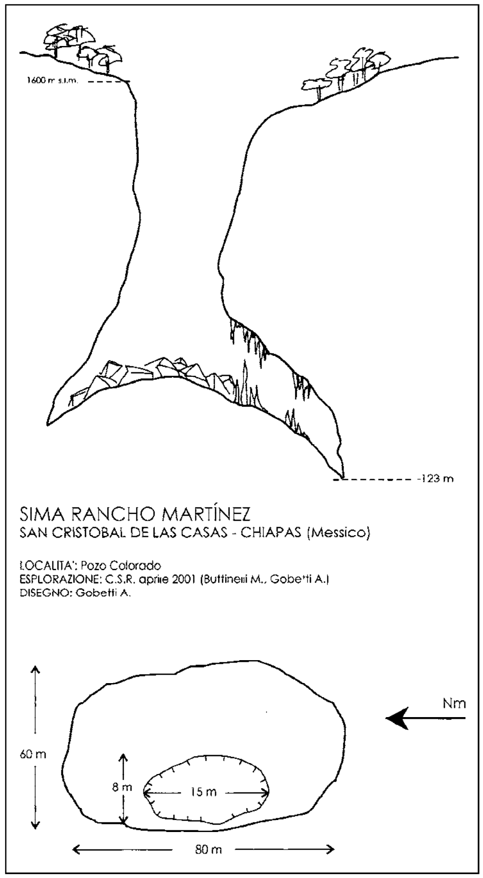
SAN CRISTÓBAL AREA

Sima Rancho Martínez

*Location*: Pozo Colorado, Mpo. San Cristóbal de las Casas, Chiapas. Elev. about 1600 m. Acala quad (E15D61).
*Exploration and survey*: Circolo Speleologico Romano, March 2001.
*Size*: depth 123 m.
*Directions*: Follow the road to Laguna Grande. The pit is about 1 kilometer past the village of Pozo Colorado.

*Description*: A small rivulet flows into this wide pit. You tie the rope to a tree that leans over the pit. There are ledges at –20 and –40 meters, and then a 30-meter free drop to the bottom. You land in a large room partly floored by debris and partly by formations. Part of the water that falls from the entrance forms another small stream, which flows about 1 liter per second. You can climb downward another 40 meters to some restrictions filled with mud where the water disappears. At the low point, there is much mud that would make further exploration difficult.

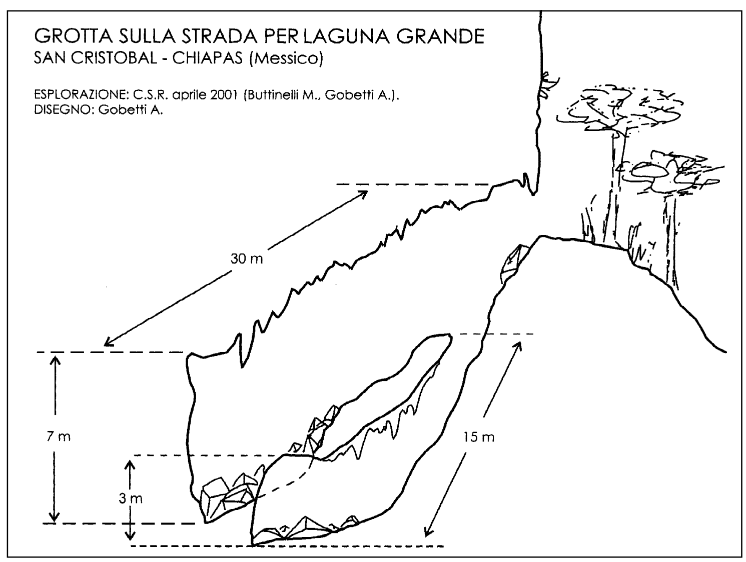
The description of this pit is very similar to Spaceman's Pit explored by the British in 1983. It is located in the same area, but the only location coordinate given for it is an elevation of a bit over 1800 meters. [The Brits' brief description of that cave and their map can be found in *AMCS Activities Newsletter* 18, page 55.]




Grotta sulla Strada per Laguna Grande

*Location*: Mpo. San Cristóbal de las Casas, Chiapas. San Cristóbal de las Casas quad (E15D62).
*Exploration and survey*: Circolo Speleologico Romano, 3 March 2001.
*Size*: length 30 m, depth 20 m.
*Directions*: The cave opens under a big rock about an hour's walk up toward highway 190 from Laguna Grande.

*Description*: The entrance is about 3 meters high and 4 meters wide and leads immediately to a steep slope in huge breakdown blocks that ends after 20 meters in a small room. In the middle of the slope on the left is another branch, 2 by 0.5 meters, that is even steeper. It leads about 10 meters to a larger room well decorated with stalactites and containing a small altar with several votive offerings.




Cueva del Pobrerito

*Location*: Francisco Villa, Mpo. San Lucas, Chiapas. 92°40′39″W, 16°37′21″N, elev. 1420 m. Acala quad (E15D61).
*Exploration*: Circolo Speleologico Romano, 9 March 2001.
*Size*: length 8 m, depth 4 m.

*Description*: A small hole that opens between rocks and descends with a helical trend.

Cuevas Exploradas en Chiapas por el Circolo Speleologico Romano en 1996 y 1998-2001

Ubicaciones, descripciones y mapas de cuevas en la zona norte de Chiapas exploradas por un grupo de espeleólogos italianos.

# OVERVIEW OF THE GEOLOGY AND HYDROLOGY OF COASTAL QUINTANA ROO

Donna and Simon Richards

GEOLOGY. The Yucatan Peninsula (figure 1) is a large limestone platform consisting predominantly of calcium carbonate deposited as sediments over many tens of millions of years. The deepest rock strata that have been drilled indicate that the base level was deposited in the Paleozoic era, some 250 to 500 million years ago. The surface strata were deposited more recently, with Eocene-age (34 to 56 million years ago) rock in the center, Miocene and Pliocene (1.8 to 23 million years ago) rock surrounding that, and Pleistocene (1.8 million to 11,500 years ago) and Holocene (last 11,500 years) rock around its perimeter. Most of the peninsula is low-lying, from 5 to 30 meters above sea level, with higher ground, up to 60 to 100 meters, in the Sierrita de Ticul to the west, with the oldest surface rock.

The state of Quintana Roo lies along the eastern seaboard of the peninsula and hosts the long underwater caves for which it is famous. These caves are in a band of the youngest surface rock approximately 10 kilometers wide, deposited in the last 1.8 million years, in the Pleistocene and Holocene epochs. Within this band runs a series of higher beach ridges, typically up to 1 to 2 kilometers from today's coastline, that date from Pleistocene times. Near Puerto Morelos in the north, this is a series of closely spaced ridges parallel to the coast, and in the south, near Tulum, they merge to form a single larger beach ridge. Most of Quintana Roo's known dry caves of significant size are formed under this ridge. The area from the ridge to the current coastline is a zone where our knowledge of the underwater caves is hazier; finding divable cave passage under the ridge is difficult, and most of the underwater caves have not been traced from the ridge through to the ocean.

Little is known about the stratigraphy in the peninsula, as few research boreholes have been drilled and their cores recovered for analysis. What we do know is that the surface rock is younger closer to the coast, and the rock strata are generally older the deeper one goes. It is also suspected that the area between the Holbox Fracture Zone and the coast moved downwards at some time before the Pleistocene, as a result of a process known as bank-margin failure, the collapse of the edge of the platform. More recent rocks were then deposited on top of the collapsed area. Based on this minimal information, figure 2 shows a possible subsurface structure.

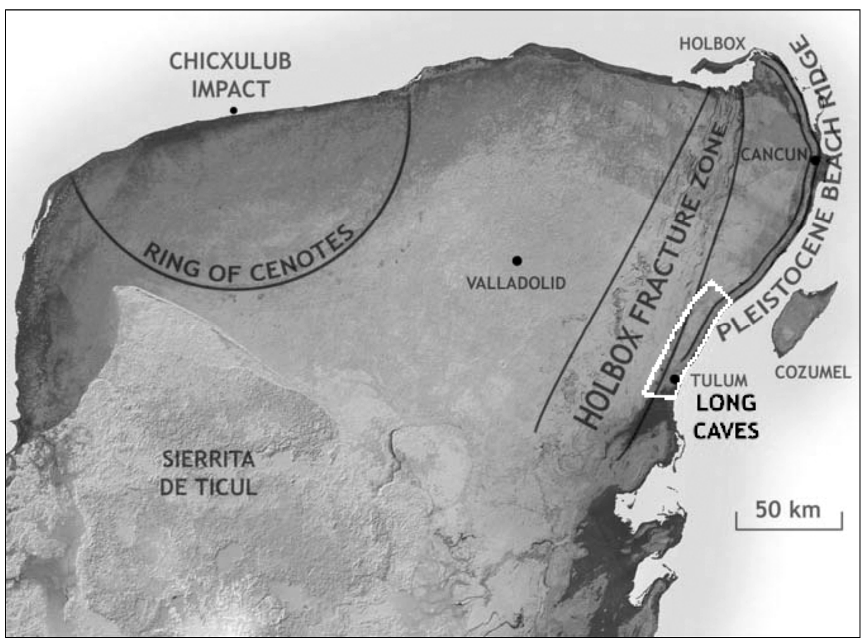



Figure 1, Mexico's Yucatan Peninsula. Principal geographic features include the Chicxulub impact zone, where a 10-kilometer meteor struck some 65 million years ago, now delineated by a "ring of cenotes" at the surface. On the Caribbean coast, a line of depressions and lagoons known as the Holbox Fracture Zone runs from Holbox in the north. A few kilometers in from the coast runs a Pleistocene beach ridge, which hosts a number of dry caves and also appears to influence the paths of underwater caves. Image courtesy NASA/JPL.

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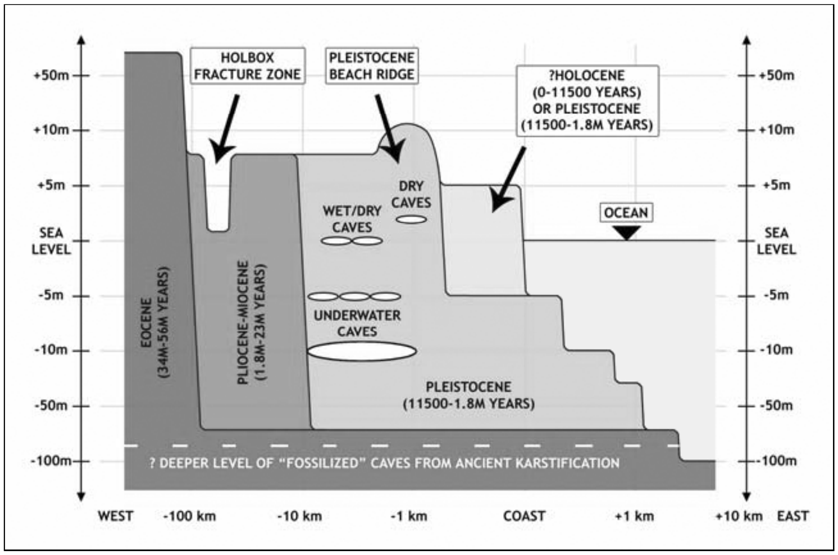



Figure 2, possible rock stratigraphy. The shallower rocks of coastal Quintana Roo appear to have been deposited over the last 1.8 million years. The beach ridge may be at the older end of this range, and the rock between it and the ocean may be younger. Most large dry caves are found under the beach ridge, and the long underwater caves lie mostly between the beach ridge and about 10 kilometers inland, roughly corresponding to the limit of the Pleistocene rocks. Farther inland lies the Holbox Fracture Zone and then older, higher rocks. Caves are developed at a number of levels, and while most probably have some flow route out to the ocean, few of them have been successfully traced there.

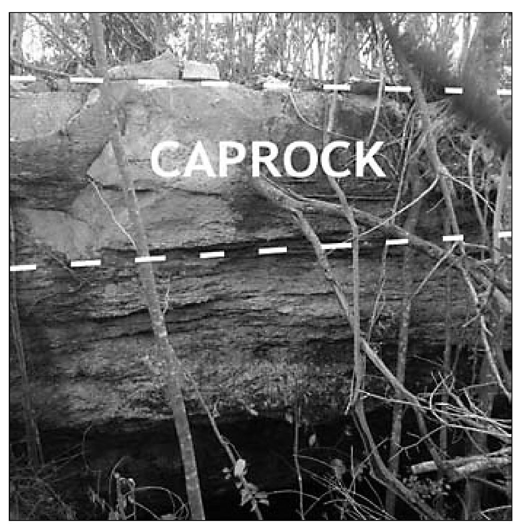
The Pleistocene was a period with many variations in sea level due to multiple ice ages. As a result, the sediments from which the limestone formed at a particular location were deposited at different times and under different conditions, resulting in a sequence of layers of rock with different characteristics, the beds being separated by bedding planes. Limestone is formed from beach sand, sediments in lagoons, grains of calcium carbonate aggregated by algae, and so on that have been compacted by the weight of overlying rock or sediments. The pores between the grains may then be partly or completely filled by other materials, including finer sediments, which naturally cement the grains together. One particular cementation process that acts on rock close to the surface is known as calichification. Rainwater dissolves some calcium carbonate from the grains, and, if the climate and other conditions are right, some of the rainwater remains close to the surface and later evaporates. When this happens, the dissolved calcium carbonate from the water is left behind and deposited in the intergranular pores of the rock, eventually filling all of the space between the grains. This makes a denser, harder rock called a caliche. If all the pores are filled by this natural cement, then water cannot easily flow through the rock, and it is then described as having a low permeability.

Throughout most of Quintana Roo, it is common to see a caliche caprock at the surface that is typically 0.3 to 0.5 meters thick. This caprock was probably formed initially from fine sediments, such as limey mud in lagoons or wetlands with fairly static water, and then cemented by calichification. Generally we expect the permeability of this layer to be low, but it is now extensively fractured and has other holes through it, perhaps from plants or tree roots, that provide routes for rainwater to enter the bed below. Cores recovered from wells drilled close to the coast have shown similar layers of caliche below the surface, one at about sea level (i.e., 5 to 7 meters below the land surface), and another several meters below that. Too few well cores have been obtained to give a very good picture of how extensive these layers may be and how they relate to the beach ridge, but we suggest that they may be significant in determining the water-flow routes and where caves form. Where the caliche layers are intact, water may flow along their surfaces, with downward infiltration into the deeper aquifer only where there are fractures and natural holes, and cave formation may therefore be focused in areas determined by the integrity and position of the caprock layers.

Below the surface caprock there are thicker limestone beds that can be identified, from a few meters to perhaps 20 meters or more thick. There is some variation among them, but generally they consist of fairly large calcium-carbonate grains, with relatively little cement between them and therefore high permeability. In some places we see large shells and coral fragments included in the rock.

HYDROLOGY. The groundwater chemistry and groundwater flow is known as the hydrology of the area. Because caves are formed by dissolution of limestone by water flowing through them, understanding the hydrology is a key part of understanding the processes by which caves formed. But the presence of caves will also affect

Figure 3. Caprock layer over a cenote. *Simon Richards*.



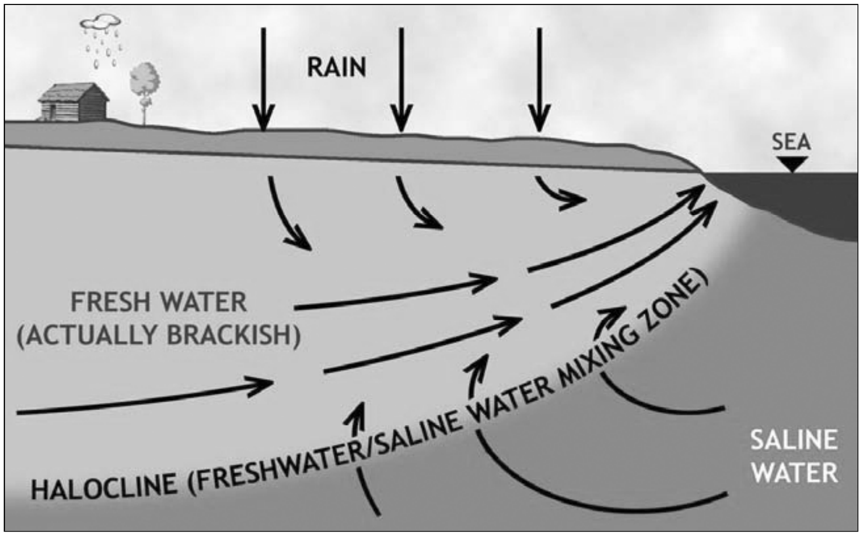



Figure 4, hydrology prior to cave formation. Near a coast, the groundwater consists of a freshwater "lens" floating on top of saline water. Freshwater flows out to the sea as a distributed diffuse flow, perhaps through the intergranular pores in the rock. There is some mixing between the freshwater and the saline water, so that the freshwater becomes brackish. Because some saline water is being mixed into the freshwater and then discharged with it to the ocean, there must be a compensating saline inflow below.

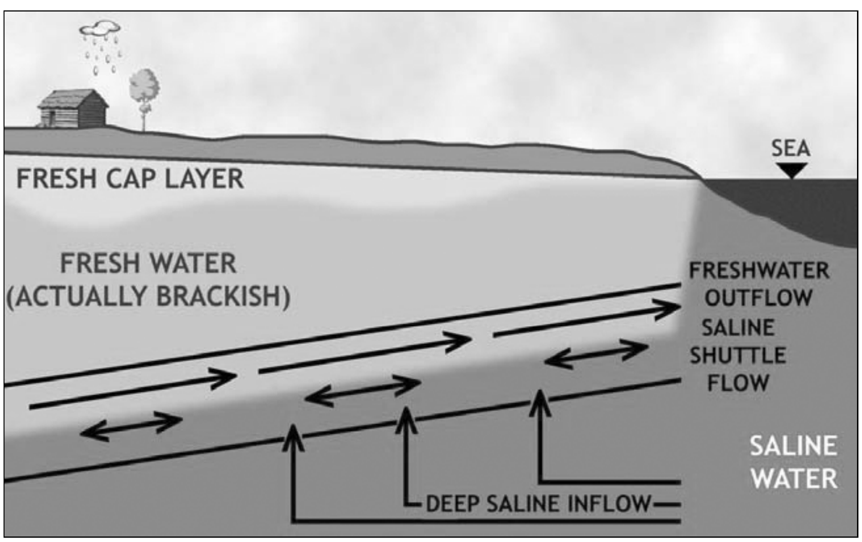



Figure 5, hydrology after cave formation. Studies by Patricia A. Beddows have shown that the vast majority of the freshwater is discharged via the cave systems and coastal springs. As a result, the freshwater lens is no longer curved but is much flatter and follows the level of the caves. There is still a deep inflow of saline water, possibly through a system of older, deeper caves, and there is also a "shuttle" flow, reaching several kilometers inland from the coast, of seawater into and out of the caves as sea level rises and falls with the tide and other factors.

the hydrology.

Prior to cave formation (figure 4), all flows are assumed to have been evenly distributed between many different routes, through the intergranular pores in the rocks, through some bedding planes, or through fractures formed by expansion or contraction of the rocks and settling of the peninsula. There is a lens of freshwater, derived from rainfall, floating on top of the saline water from the ocean, because the freshwater is less dense than the saline water. As the freshwater flows through the rock, there is some mixing at the interface with the saline water at the fresh-saline mixing zone, or halocline, making the freshwater slightly brackish. The freshwater is discharged into the ocean along with the saline water that has become mixed in with it, and so for the system to remain in balance there must be a compensating inland flow of saline water.

The formation of the caves changes the hydrology. The flow of water dissolves rock along its route, more rapidly where there is the most flow, in turn increasing flow in that route and therefore increasing the dissolution rate along that route. As a result, the routes which are the largest grow most quickly. This positive feedback causes some flow routes to grow to the point where they become sufficiently large to become classified as caves, large enough for a person to enter, with most of the water flow being focused in them. The process is known as karstification, and variants of it are responsible for all of the karst landforms we see: caves, sinkholes and so on.

Studies by Patricia A. Beddows, a hydrologist at McMaster University in Canada, caver, and cave diver who has done research in Quintana Roo, suggest that most of the water that reaches the coast flows through the caves. Some of these caves contain only freshwater, but many of them also have saline water below the freshwater, and a visible halocline. Beddows has also documented a saline "shuttle" flow from the sea via the cave passages: when sea level rises and falls, as a result of tides, changes in barometric pressure, and so on, there is a reversing of saline water in and out through the deeper cave passages.

Additionally, floating at the top of the freshwater layer is a so-called fresh cap layer, which is normally much less

Figure 6, video frame-grabs from caves in the region showing contrasting water layers. Left: Diver in the halocline. The diver's head and tanks are distorted due to the difference in density between freshwater and saline water diffracting light rays. Center: Light diffraction and waves on the halocline. Right: Tannic fresh cap layer floats on top of the freshwater layer in a dome. The dashed line shows the interface, which is obvious from a color difference in the color version of the photograph. *Simon Richards*.

brackish and may be tannic, corresponding to groundwater that has yet to join the flow system. It can be seen in domes in underwater caves, and the water in some cenotes consists of this fresh cap layer rather than the water flowing in the cave systems (figures 5 and 6).

ENVIRONMENTAL SIGNIFICANCE. The rapid flow of water through the caves, up to several kilometers per day, may transport environmental contaminants over large distances without any natural filtration and before natural processes have had time to break them down. Flow directions are not just from inland to coast as one might intuitively expect. Current practice is to obtain freshwater from wells about 10 kilometers inland and to inject sewage effluents deeply into the saline water close to the coast, where the hotels and most of the population are. This is based on the assumptions that the freshwater is flowing from inland to coast and the saline water is largely static, but there are two problems with these assumptions.

The first problem is that effluent tends to be closer to the density of freshwater than saline water, so it will rise up to the fresh-saline mixing zone or into the freshwater. Recent studies in the Florida Keys have shown that effluent can resurface in a matter of hours or days. The coastal area where effluents are injected is highly active hydrologically, with the saline shuttle-flow in and out connecting all of the tourist cenotes and beaches and the freshwater flowing out onto the beaches and reefs, so buoyant effluent could be transported to all of these places.

The second problem is that, even if the effluent cannot float upward immediately, because it has been mixed with so much saline water that the density difference is small or because there is no upward cave passage in the vicinity, Beddows's work shows that the contaminated mixture may flow long distances inland quite rapidly in the compensating inland flow or the shuttle flow of saline water and still eventually rise to be mixed with the flowing freshwater. Contamination of the saline water could therefore still result in contamination of the freshwater supplies, the cenotes, the tourist beaches, and the reefs, all of which underpin Quintana Roo's economy. [See also "Where Does the Sewage Go?" by Patricia Beddows in *AMCS Activities Newsletter* 25.]

Contamination of the fresh cap layer by surface activities is also potentially troubling, because it supports the wildlife in many of the wetland areas, but

Figure 7, a tourist cenote near Tulum. Beddows's work has shown that such cenotes contain water originating from the saline water zone, the freshwater layer, and the fresh cap layer, and therefore are at risk from contamination transported in any of these layers. *Simon Richards*.

little is known about the distribution or flow of water in this layer.

Another concern is the potential loss of the freshwater and fresh cap layers due to construction of marinas and "waterfront" accommodations on canals, which involves cutting trenches inland from the coast. In 2005, Hurricane Wilma removed sand from the beaches between Cancun and Tulum, exposing temporary springs flowing through fractures in the caprock. This suggests that there may be a shallow flow between the beach ridge and the ocean that is confined by the caprock layer where it is intact. Waterfront developments and construction of marinas could breach this caprock layer and open up new flow paths, causing the loss of the freshwater layer.

We thank Patricia Beddows, Jim Coke, and Olmo Torres Talamante for assistance in preparing this article.

Figure 8. Coastal wetland area near Tulum are migratory feeding zones and breeding grounds for a wide range of birds. The water in them may be part of the fresh cap layer, and its flow is by geological factors such as calichified caprock layers, but too little is known to assess the risk posed by environmental contamination. *Donna Richards*.

Figure 9. Left: Temporary coastal spring through caprock fracture on beach in Playa del Carmen after Hurricane Wilma. Right: "Waterfront" development in Puerto Aventuras. *Simon Richards*.


Síntesis de la Geología e Hidrología de la Zona Costera de Quintana Roo

Es discutida la geología de la región donde se encuentran las cuevas más largas de México, haciendo énfasis en los flujos de agua fresca y salada por debajo de la superficie. Estos flujos necesitan ser comprendidos para controlar el problema de la contaminación del agua en esta zona de rápido desarrollo.

# XII INTERNATIONAL SYMPOSIUM ON VULCANOSPELEOLOGY

Ed Waters

*Warnings about cowboy taxi drivers kidnapping tourists suddenly seemed terrifically believable as our Saddam Hussein–look-alike guide herded us through a series of dark, dingy back streets in a wet Mexican city. Arriving at his car did nothing to relieve the situation: it was a old Toyota devoid of any official taxi markings. "Saddam" threw a mountain of rubbish out of the car onto the pitch-black midnight streets and ushered us into the vehicle, a tight fit for the four of us. Chris later claimed that he could feel cockroaches crawling over his sandal-clad feet throughout the hour-long journey to our destination. Such was my introduction to Mexico.*

I had been invited to attend the XII International Symposium on Vulcanospeleology, being held in Tepoztlán, 74 kilometers south of Mexico City, in July 2006. The lucky invitation came about as a consequence of my interest in the lava tube caves of Iceland, this being the fault of my traveling companion, the world-famous (at least in vulcanospeleological circles) Dr. Chris Wood. We decided to attend and then spend an additional week visiting lava tubes across the Mexican volcanic belt.

The symposium attracted thirty-eight people from around the world, mainly from Europe, South Korea, the USA, and, of course, Mexico. Three days of fascinating presentations on everything from cave exploration across the globe to biology and speleogenesis held our interest, and the presentation days were interspersed with field trips to the extensive systems near Tepoztlán, before the meeting closed with a fantastic banquet.

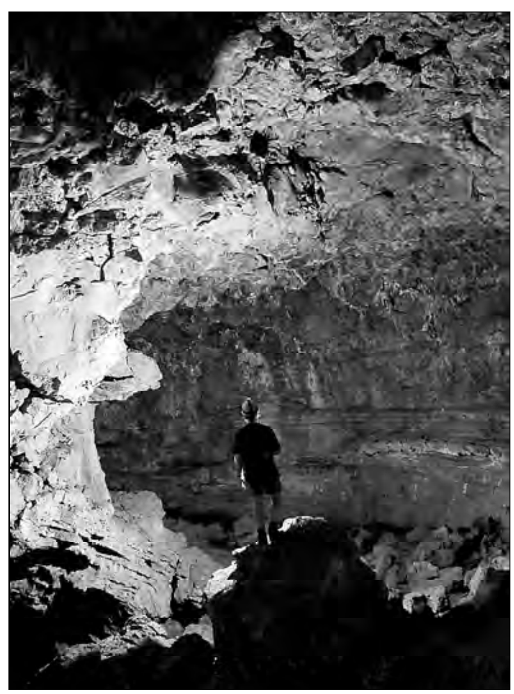
I was somewhat surprised to discover that, despite Mexico's world renown as a caving country, relatively little exploration has been carried out in its volcanic areas. Only one of these, the Suchiooc lava flow in the Sierra Chichinautzin near Tepoztlán, has received any serious attention. This work has been masterminded by Ramón Espinasa Pereña over the last fifteen years or so and has yielded over 28 kilometers of surveyed passage, including both the longest and deepest lava tubes in the continental Americas. [AMCS Bulletin 17 is Ramón's *Lava Tubes of the Suchiooc Volcano, Mexico*.]

The initial field-trip to the Los Cuescomates lava flow allowed us to examine surface features and become used to the terrain. Ramón confessed that the venue was chosen to see how people would cope with the elevation of well over 3000 meters. I was surprised to find the landscape dominated by evergreen trees and lush vegetation—perhaps my impressions of Mexico have been influenced by watching too many spaghetti westerns—but I did visit my first Mexican lava tube, the totally unimpressive Cueva Lago, a 15-meter-long through-trip.

After a fine lunch, we were taken to the impressive Cueva del Diablo, which lay at a lower elevation. Ramón commented that this was the first cave his team had visited in the area, nearly twenty years ago. They had been told of six entrances that lay within the thick vegetation (it was more like jungle), but that only three had been found thus far, two of these from inside Diablo. In this sort of undergrowth, you would literally have to fall down a hole to discover it.

Diablo is fascinating, being a major, braided master tube with about 2 kilometers of passage. Chris and I managed to separate ourselves from the huge snake of eminent vulcanospeleologists and explored nearly all the cave. The trip was enlivened by meeting a raccoon-like

Chris Wood in Cueva del Diablo. *Ed Waters*



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Reprinted from *Descent* 193, December 2006/January 2007, pages 34–35.

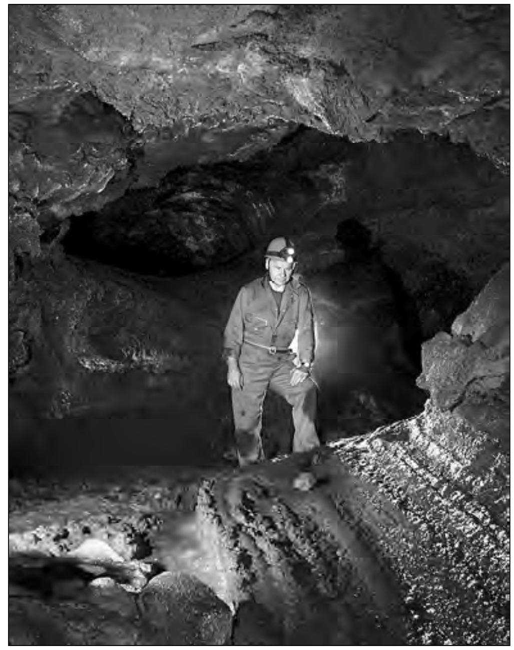
creature in a low crawl, then listening to John Pint and Stephan Kempe swapping tales of caving in the Middle East.

Our first serious caving trip was to the Chimalacatepec system. This has the greatest vertical range of any known tube in the continental Americas, just over 200 meters. We were divided into groups according to perceived ability. Somehow, I was in the "fast group," which would be the only one heading for the bottom of the cave, even though we were using the Cueva de Iztaxiatla entrance, only 100 meters above the lowest point. "No cameras if we are to get to the bottom," stated Ramón, but I quietly sneaked a small photo kit into my bag anyway.

Iztaxiatla lies on the Camino Real path leading from the small town of San Juan Tlacotenco, offering a long, steep climb of a couple of kilometers. The entrance is a hot *pooka*, a hole formed when the lava tube was active, that led to a 15-meter pitch that was rigged with two ropes for SRT plus a ladder. All three were in use at once to move the vast number of people up and down in a reasonable time.

Below the pitch, a narrow passage led to a couple of small pitches, which Chris and I free-climbed to drop into a larger passage. Up flow led to a very tight constriction (El Esfínter, the Sphincter), that linked to the higher entrances. We headed down flow, where the steeply sloping passage with a loose boulder floor met a hands-and-knees crawl leading to a 2-meter-high passage with a welcome solid floor. Ramón and his friends had found a series of pre-Hispanic archaeological artifacts here. Suddenly, the tube opened to perhaps 6 meters wide and 10 meters high, only to end at a complete lava seal. By the time we emerged, we felt we had earned our treat, a fantastic meal of stuffed cactus prepared by Jorge, one of the local cavers.

The final field-trip was to Cueva de la Iglesia, formed beneath the town of San Juan Tlacotenco. We had been warned that the cave was complex. This was somewhat of an understatement, as the system is a vast labyrinth on many levels and well over 5 kilometers long. During the trip Ramón even took the precaution of placing candles at every junction to aid our return, and he has visited the cave many times. Most of the Iglesia passages are relatively small, either stooping-height or perhaps just walking-sized, with plenty of crawls scattered around. The cave shows many fine lava features and secondary calcite and opal formations. It was a fine end to the symposium.



Chris Wood examining flow marks in Cueva del Ferrocarril. *Ed Waters*.

The day after the closing banquet saw the first of the post-symposium trips. Most of the delegates had left, with only a small group staying behind to carry on caving. A visit to Cueva del Árbol was planned, but the ravages of the banquet night had left their mark, particularly on Ramón, so we decided that the long walk past Chimalacatepec would be best left until our hangovers had dissipated. Instead, we wimped out and visited Cueva del Ferrocarril; at 6.25 kilometers long, it is the longest known tube in the continental Americas and, if anything, is even more complex than Iglesia. It has been open for much longer than Iglesia and is well known to locals, so it has suffered from rubbish being tipped in and graffiti. It also has far more crawling than Iglesia, much of which is over jagged *aa* lava floors. In places the cave is separated from Iglesia by only 15 meters, and Ramón remains hopeful that one day the two caves will be connected, probably through a very low and painful crawl, of which many remain to be pushed by some anorexic masochist.

Hangovers gone, the next day we summoned the courage to undertake the long walk up to Cueva del Árbol. By now I was acclimatized well, and the walk did not seem too bad, even if we did become lost in the thick woodland. The enormous Árbol entrance collapse is descended via an 8-meter pitch and leads to a huge passage heading steeply downhill, taking in a couple of difficult climbs, until it runs beneath Chimalacatepec, though no connection has yet been made. Unfortunately, I did not see

Marcus Gary in the entrance to Cueva de la Iglesia. *Ed Waters*.

Jan Paul van der Pas in Cueva del Ferrocarril. *Ed Waters*.

much of the cave, as a silly tumble on loose rocks lacerated my hands and I had to leave.

From Tepoztlán we headed for Perote and, en route, visited the Alchichica Maar, a lake formed several thousand years ago in the hole left by a volcanic explosion. The following day saw us in terrain which was more akin to my preconceived ideas of Mexico: semi-desert covered in cacti and thorny scrub. We visited the newly rediscovered Chinacomoztoc, a cave that had been described by a geologist in 1910. While organizing the conference, Ramón had asked some local cavers to look for it. Though the cave is now full of sediment because a stream had been diverted down it, 1.5 kilometers of very large down-flow passage, in four segments, is still accessible.

Our first shock came when Ramón stopped us about 50 meters short of the entrance and explained that a nest of African killer bees was living there, and that we would have to nip into the cave quickly to avoid upsetting them. The second was the overpowering stench of guano; the caves near Tepoztlán had bat colonies, but not on this scale. The third was being buzzed by a 2-meter-wingspan owl, while the fourth came from almost stepping on a diamondback rattlesnake in one of the entrance collapses. The cave is superb, however, being a large master tube much modified by breakdown, with three or four large roof collapses. Many more such tubes must await discovery in Mexico.

Cueva Volcancillo is located in a nature park full of large pine trees, with the entrance 10 meters down the side of a precipitous 100-meter-deep crater. Volcancillo descends steeply to a roof collapse, then continues, much larger, with fine lateral benches. We stopped at the top of a 7-meter pitch with daylight filtering in through a small hole above us. The cave continues for another 150 meters from this point. The only other excitement came from lifting Chris into a small side passage that Ramón had never seen before and was not on the survey. It produced 2 meters of passage and a Chris covered in liquid guano.

This was the last of the caving, though we enjoyed a day's rafting on the Río Actopan, a fascinating trip starting where the river appears from beneath a 40-kilometer-long lava flow, the same one as at Volcancillo. Interestingly, the locals know of a cave entrance with the sound of rushing water in it . . . .

Back in Mexico City we said our farewells before boarding our flights back to Britain by way of the States, ready to subject ourselves to the ordeals of passing US immigration yet again, but that is another story. After a highly enjoyable symposium, I am now left with the long wait until 2008 for the next one, on Jeju Island in South Korea.

XII Simposio Internacional de Vulcanoespeleología

Este simposio se llevó a cabo en Tepoztlán, al sur de la Ciudad de México, en julio de 2006. Este artículo, escrito por un espeleólogo británico, describe las cuevas visitadas durante y después del simposio.

The main passage in Chinacomoztoc. *Ed Waters*.

# SIERRA LA GAVIA, COAHUILA

Peter Sprouse

The impetus for this trip was to check out a blowing pit that I'd been shown two months before in the Sierra la Gavia. This mountain range crosses Highway 57 between Monclova and Saltillo. In January 2006, while on a bat-research trip for Bat Conservation International, some lads from the Ejido Tuxtepec had shown us a cave called Cueva del Guano in Cañón Verde a few kilometers north of their village. They also mentioned a blowing pit far up the ridge, which I decided to have a look at while my companions checked out the cave. It was indeed right on top of the ridge, and blowing a lot of air.

With me on this trip were usual suspects Philip Rykwalder and Charley Savvas. Philip's Montana caving buddy Jason Ballensky flew out to join us. Kathleen O'Connor was a relatively new caver along for her first Mexican pit. Champion rope-climber Susan Souby joined us, along with veteran caver Rune Burnett, who had volunteered to run chuck wagon for us. We left Buda, Texas, on March 23 and met up with the rest of our crew at a Taco Cabana in San Antonio. From there we drove to Eagle Pass, near which Rune got a speeding ticket for allegedly doing 87 mph, which seemed unlikely because he was following our truck, which was moving a lot slower than that. Soon we were across the border and had made the short drive to La Azufrosa, south of Allende, where we camped by the sulfur springs.

Just above the springs is Cueva de La Azufrosa, a fascinating rectilinear maze cave we had been mapping over the past year. The next morning we prepared to enter the cave to try and push two promising leads where we had previously stopped due to large numbers of bats. We donned histoplasmosis masks and formed two survey teams. Jason, Philip, and Kathleen took a left-hand route to push a stream passage that Jean Krejca and I had been in two months before. They mapped a section of walking passage and saw that it continued on, smaller, but there were too many bats to proceed. These were the ghost-faced bat, *Mormoops megalophylla*, and there are several thousand of them in this cave. They even saw a snake catch a bat in the left-hand passage. Meanwhile Charley, Susan and I tried to push a lead that went to the right a bit farther in, but we also had too many bats. They were falling off the walls onto the floor of the crawlway, where they were in danger of becoming furry kneepads for us, which wouldn't be good. So we contented ourselves with cleaning up a bunch of minor side leads.

When all were out of the cave, we headed south through Monclova and on to our destination, Tuxtepec, where we obtained permission and arranged porters for the next day. All set, we drove up to the foot of the mountain and pitched camp. We built a fire, and Rune and Susan served up some great tacos. Rune had brought his full camp kitchen and served us royally the whole trip. Later that evening I drove back down to the Tuxtepec road to wait for Saltillo cavers Monica Ponce and Javier Banda, and after a long wait they arrived. They left Monica's car in the village, and I drove them up to camp.

Saturday morning we packed up for the hike to Pozo la Gavia, leaving Rune to mind camp. Four fellows from the village came up to help us pack gear. Our hike initially took us up the gravelly course of the Cañón Verde, and then we began the steep climb up the ridge itself. We were climbing the spine of a buttress, picking our way through cactus and lechuguilla. From time to time we would stop to enjoy the view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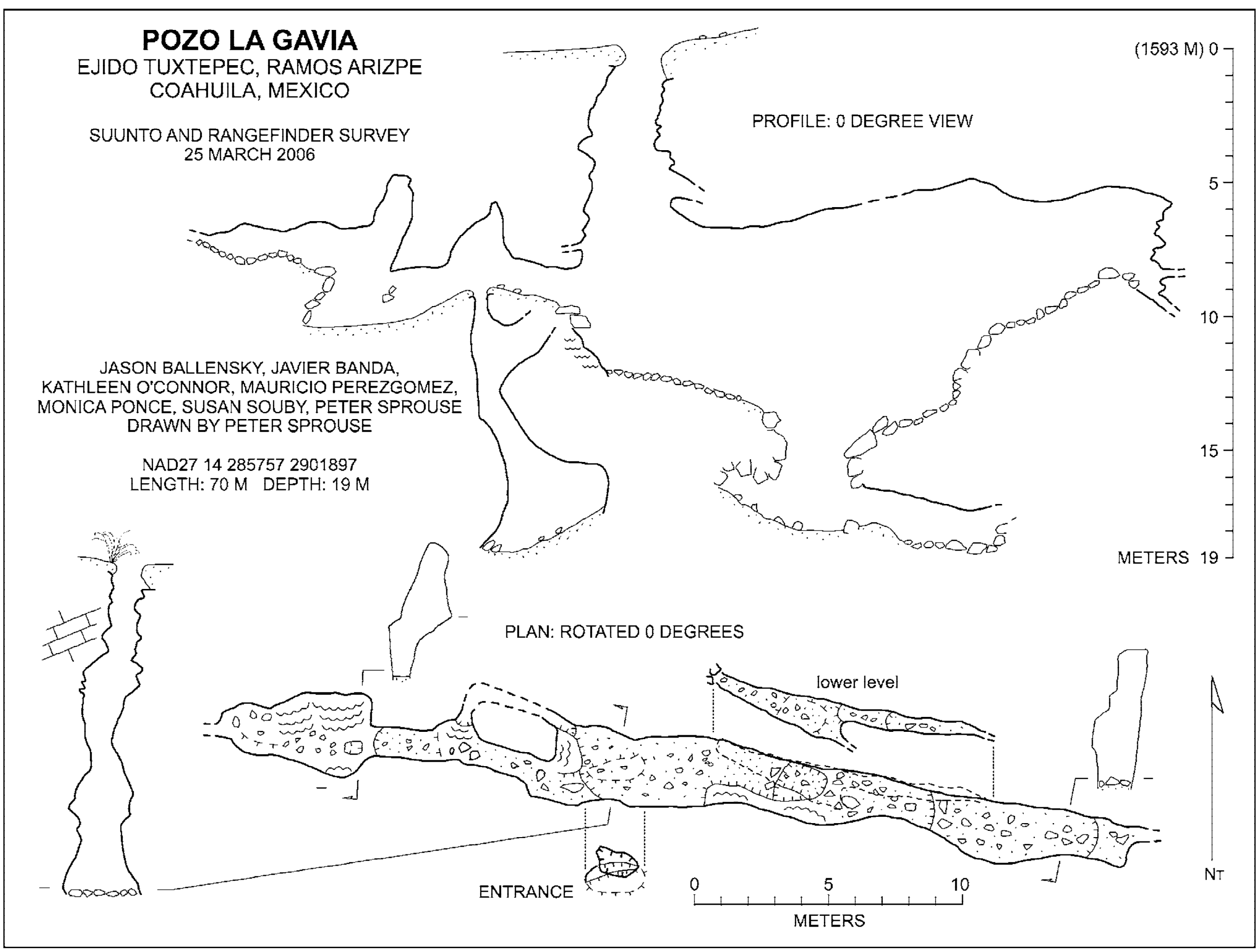
Susan, Charley, and Kathleen prepare for the hike. *Peter Sprouse.*

of the desert below, where in the distance we could see the trucks glimmering in the morning sun. Philip and Jason got up first (of course) and rigged down the first drop, then came back up to await us. It seemed to be a tectonic cave, which was discouraging. The wind was as strong as before and made entry quite dusty. The first drop was 13 meters into a linear crack. To the west it went about 20 meters, and Kathleen collected an amblypygid off the wall, a possibly new species. To the east it went the same distance, where Charley found a scorpion and a pseudoscorpion, likely new as well. A short second drop led to a crawl that soon pinched, despite airflow that seemed to come from everywhere. While we were in the cave, Mauricio Pérezgomez and Isidro Juárez, more cavers from Saltillo, arrived. We wrapped up the survey and hiked down to tour Cueva del Guano. It is located on the east flank of Cañón Verde, not far inside the mouth of the canyon. We shot a bunch of pictures in the spectacular lower formation room, known as the Pollenturtotem Room. Rune treated us to a great spaghetti and salad dinner, and we watched the slides



Wind blows up dust as Kathleen enters Pozo la Gavia. *Peter Sprouse*.

of the day on the laptop, till people dropped.

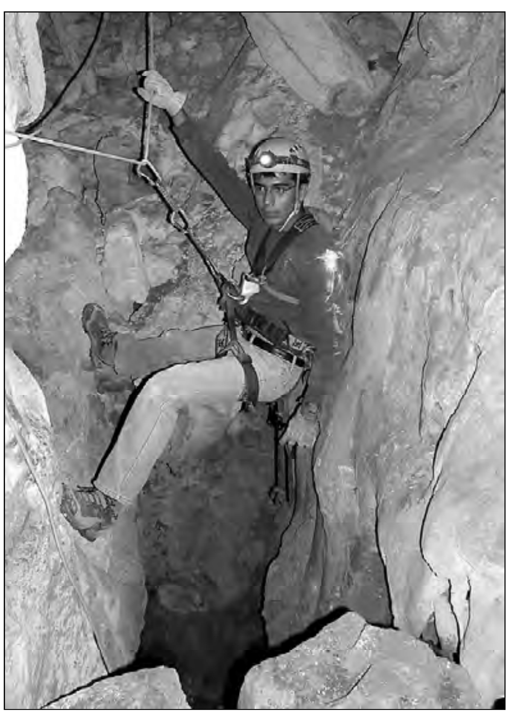
The next day we decided to tour nearby Pozo Cokendolpher, a great cave we had found on the January trip. This has an impressive pit entrance in a steep arroyo on the west side of the sierra, which I had visited on the earlier trip. Leaving Rune in camp again, we drove over in Mauricio's and my trucks. I left them all at the end of the road in the desert floor, where you could see the cave entrance area 2 kilometers away. After dropping them off, I drove solo down to Ejido la Reata at the south end of the Sierra la Gavia to investigate rumors of a cave with water. I picked up two guides, Felipe and Jorge, and we drove to the synclinal ridge to the south, which appeared to be made of sandstone. They pointed out a hole in a shallow valley part way up the mountain. When we reached it, I saw that the entrance was formed in crumbly shale below a layer of bedrock with lots of fossil oyster shells. It was 10 meters long and sloped down to a pool 3 meters across with hundreds of dead and dying bees and some mosquito larvae in it. It wasn't clear if this is a natural cave or if it had been dug, but I went ahead and made a quick survey, and then I returned my guides to the village. Then it was time to drive back to the trailhead and await the Pozo Cokendolpher crew. It was a number of hours before their headlamps appeared on the distant hillside. They arrived in several small groups, and all declared it was a fine trip that involved four rope drops to a large, well-decorated passage at the bottom of the cave. Back at camp, Rune fixed us another great dinner, we watched the daily slide show, and then it was time for our friends from Saltillo to depart. We watched their taillights diminish across the desert for thirty minutes.

[The earlier trip is described in an article in *AMCS Activities Newsletter* 29, pages 69–74, which includes a map of Cueva del Guano.]

Sierra la Gavia, Coahuila

El Pozo la Gavia está en las alturas de la Sierra la Gavia al norte de Tuxtepec, Coahuila. Fue explorada y topografiada en marzo de 2006. Aparentemente es una cueva principalmente tectónica.

Isidro traverses over the second pit in Pozo la Gavia. *Peter Sprouse*.



Runi at the grill. *Peter Sprouse*.

LA VENTA
EXPLORING TEAM

# THE CAVES OF CUATRO CIÉNEGAS

Italo Giulivo, Marco Mecchia, Leonardo Piccini, and Giuseppe Savino

The Cuatro Ciénegas Project was born in 1998 and began with two reconnaissance trips, organized in order to evaluate the speleological potential of the area. Three expeditions were carried out in 2000, 2001, and 2002, with the main aim of understanding the reason for the occurrence of approximately 165 pools in a small area where water is scarce—in other words, to understand the connection between those pools and the hydrogeological setting of carbonate ridges of this area of about 10,000 square kilometers. The area we had to survey was very wide, and virtually no roads, harsh terrain, and almost no water outside of the valley made the logistics quite difficult. Speleological exploration on the mountains and in the many canyons that cross them allowed us to survey 65 caves, and scuba-diving in several lakes of the plain resulted in surveys of the main pools.

It is important to emphasize that the research that has been carried out has a value that, hopefully, will go beyond the understanding of the hydrogeological features of the investigated area. We believe that the information we gathered could be a tool for safeguarding this strange environment, now constantly threatened by a dwindling water supply and increasing water salinity. Mineralogical analyses, on the other hand, dealt with the close relationship between the caves and mining activities, as the caves were often used as guano and fluorite mines. Samples taken during the expeditions allowed us to identify many cave minerals, some of which represent real scientific novelties.

All the research has been carried out in collaboration with major Mexican institutions, among which are CONABIO (National Committee for Biodiversity), UNAM (University of Mexico Ecology Institute), and, above all, the researchers of the Cuatro Ciénegas Natural Park for Animal and Plant Protection, directed by SEMARNAT. In fact, part of the area that is being investigated has been protected since 1994, thanks to the many small lakes and their wonderful natural habitats.

The Cuatro Ciénegas valley is located in the state of Coahuila in northern Mexico, about 80 kilometers west of Monclova. The plain is located approximately 700 meters above sea level and is surrounded by a ring of mountains that reach an elevation of 3000 meters. The climate is dry, and rainfall is very scarce, just 250 millimeters per year on the plain and some 300 to 400 millimeters in the mountain areas. The temperature is characterized by drastic variations, ranging from 0°C in winter to 44°C in the summer, with an annual average of 22°C. All of the mountains that surround the valley, the Sierra la Purissima, the Sierra San Vicente, la Menchaca, la Madera, la Fragua, and San Marcos y Pinos, are deeply carved by countless canyons, whose presence is one of the attractions of the area. Another significant feature lies at the foot of the mountains, in the center of the plain: some 165 ponds of spring water.

From a geologic point of view, the Cuatro Ciénegas area has a quite simple setting. Long structural ridges that emerge from the plain characterize the area. Their slopes are deeply engraved by canyons and transverse valleys. Cretaceous limestone is the main rock of the area, which also contains beds of marly siltite and small gypsum lenses. The limestone beds are quite prominent, and their thickness ranges from a few centimeters to more than a meter. Volcanic activity during the Tertiary was correlated with hydrothermal phenomena. In time, these two factors led to mineralization in the deeper layers of the carbonate progression.

It is likely that the Cuatro Ciénegas valley originated by the draining of large endorheic basins, mostly because of the dry climate that followed a wet period during which rainfall led to the formation of the many deep canyons in the mountains and the consequent filling of the basins with alluvium. Compared to the regional geologic interpretation, theories about the genesis and development of the karst phenomena in the area are rather problematical. One thing is for sure, though. It is a very old karst that had its major development in remote times. The typical surface-karst landforms, dolines and karren, are almost absent. Examples of karren can only be found at higher elevations on the ridges, where the soil is scarce and bare rock is widespread. Deep karst is not very well developed, either, and only a few complex caves occur in restricted areas. Most of the caves can be found on the steep faces of the canyons. Other caves, located at the foot of the canyon walls, had a different genetic history, as a phase of vadose deepening followed initial phreatic karst development. We have also explored and mapped caves that display a clear hydrothermal origin, as indicated by the

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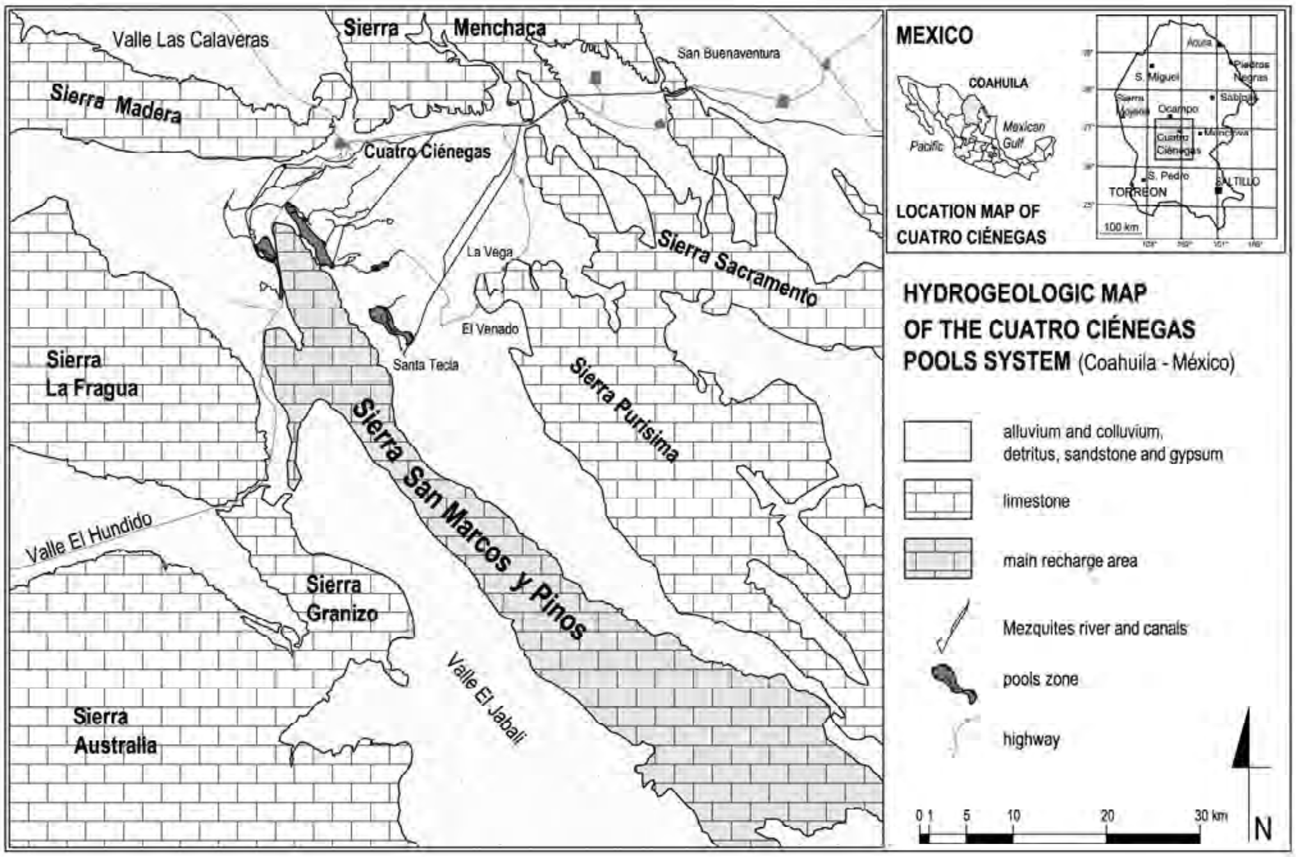



rounded ceiling domes and the traces left by slow water flows. The constant changes in the landscape have probably led to the destruction of parts of the underground networks.

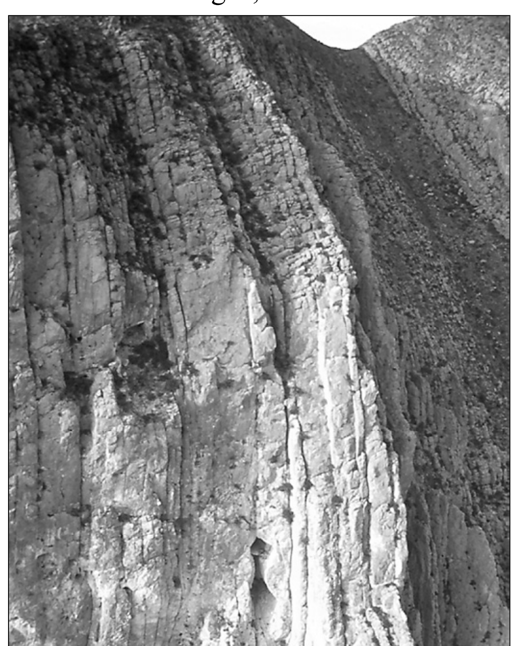
Exploration was carried out following two different approaches, regular caving for caves and mines and cave diving for the ponds. We found approximately 65 caves, mapping a total of about 8000 meters of cave passages; exploration was particularly focused on the many canyons in the mountains surrounding the Cuatro Ciénegas valley. These canyons have been walked through both upward and downward, climbed, and surveyed from the air. Exploration of the old and now abandoned zinc, lead, and silver mines that can be found around the old mining village of Mineral de Reforma disclosed some cave features. During the third expedition, we descended through the artificial shafts of the La Fortuna and El Rosario mines. At the bottom of the latter we found traces of rather active precipitation, such as cave pearls and small stalactites.

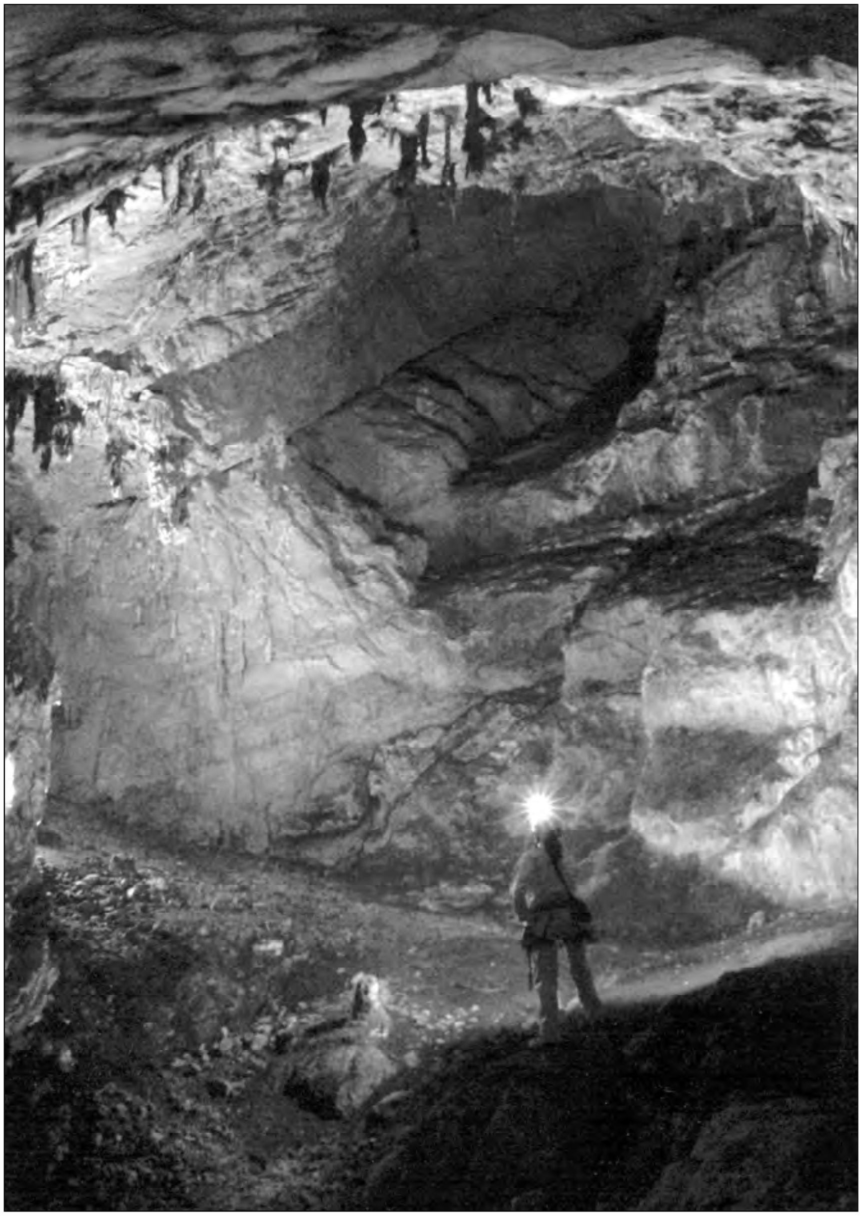
The many ponds of the Cuatro Ciénegas area have been dived, studied, and mapped in order to understand the origin of their waters and figure out their connection with the karst water of the area. All the ponds have a similar morphology, bowl- or funnel-shaped; their diameters range from 3 to 25 meters, and they are up to 19 meters deep. Pozas Azul, La Becerra, La Churince, Santa Tecla, Escobedo, and La Campana are some of the most renowned; they all are unusual habitats and have therefore been declared protected areas by SEMARNAT.

*The Sierra San Vicente* is a minor ridge, branching off the Sierra Agua Chiquita, southeast of Cuatro Ciénegas. The structure is that of an asymmetrical anticline with a southwest face. Its western side shows very steep, up to vertical, slopes. This side is cut by canyons that run transversely to the structure and to the bedding of limestone.

Several interstratal caves, mostly small in size, testify to deep karstification. Along the main crest line we found some small caves along the fissures that cover large portions of the main ridge, due to gravitational deformation. Several

The entrance to Cueva de los Murciélagos, Sierra San Vincente.





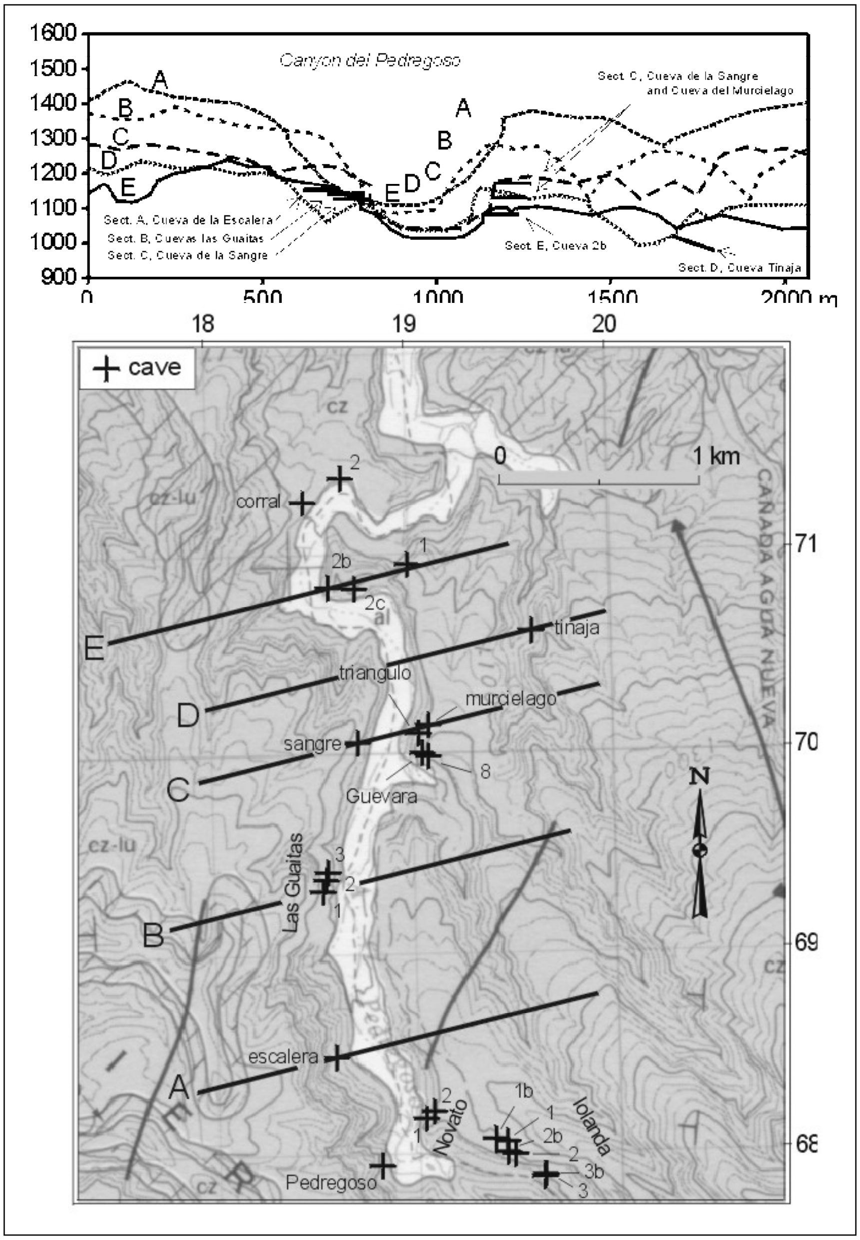
The big room in Cueva de los Murciélagos.

entrances open along the gorge walls, mostly concentrated in the areas characterized by vertical bedding, particularly in Cañón La Madera and Cañón El Guano. The latter hosts the entrance to Cueva de los Murciélagos, which, with other minor caves nearby, was exploited for guano, with the removal of several thousand cubic meters of deposit that covered the floor of a vast underground hall. The entrance to this cave is about 50 meters up on the right side of the valley. The morphology is typical of a canyon deepened from a tunnel of elliptical section, still present on top of it, which developed along a vertical bed. Some meters in, the route opens into a big hall 20 meters wide, 100 meters long, and 35 meters high. The floor is covered by a thick deposit of detritus, with great blocks fallen from the ceiling and walls. The vertical bedding allowed the cave to reach a stable shape. The origin of this cave is not clear, but some signs suggest to us the segment of a great collector, brought to light by the incision of the surface drainage network. But the existence of an extension of the original conduit northwards is still to be proved.

*The Sierra La Purísima* consists of a set of long ridges, elongated northwest-southeast, situated southeast of Cuatro Ciénegas, with a total extension of 70 kilometers. The ridge shows the structure of an asymmetrical anticline facing west. Deep canyons, either transverse or longitudinal, cut the northern sector. Among them is the particularly notable Cañón El Pedregoso, which in its last 7 or 8 kilometers shows very steep, at times vertical, slopes. This canyon was carefully investigated because of the several cave entrances present on its steep sides, especially in a portion about 4 kilometers long where caves were quite evident. The systematic exploration of all the accessible caves allowed us to make a detailed description of their geomorphic and genetic features.

The Pedregoso caves seem to have been formed by the circulation of meteoric waters and must have developed before the entrenchment of the canyon, when the limestone was locally still covered by higher formations. The caves in the upper parts of the walls have some tens of meters of development; the longest one, Cueva Murciélago, is 130 meters long. The passages we found here were mostly formed by water under pressure, show a sub-circular section, and originated along favorable beds or at the intersection point between these layers and variously oriented fractures. Most probably these caves developed below the water table, in an aquifer confined by the overlying marly cover. This process must have taken place during early hydrologic conditions that produced the net of phreatic tubes we can today recognize at different elevations down to the foot of the walls.

The major caves lie at the foot of the walls at the contact between limestone and marls: Cueva El Pedregoso, 380 meters long, and Cueva las Guaitas, 220 meters. These caves consist also of passages showing morphology due to water under pressure that developed along planes that may correspond to the contact with an underlying less karstifiable limestone. These caves seem to have been randomly intersected by the deepening of the canyon, and the persistence of water flow after the canyon formed, shown by some passages with vadose morphologies, may also be due to the contact. Vadose entrenchment must then be contemporary with the final deepening of the canyon. The biggest cave in this zone is near the mouth of the canyon and is known as Cueva Tinaja. It is 670 meters long, with a total




Profiles and map of Cañón Pedregoso, with the locations of major caves.

vertical extent of 98 meters. It was exploited for guano extraction in the past, and it consists of a passage gently descending to the northwest. For this cave we also suggest a mainly phreatic origin.

Farther south, in the central and southern sectors of La Purísima, the relief is not so rugged as in the northern part, and the whole structure is more eroded. Here we do not know of any significant caves. But several mines are present, principally that of Mineral de Reforma, which was exploited for seventy years beginning in 1890 and is developed on several levels to a depth of 700 meters. A partial investigation of the vast net of galleries in this mine allowed us to discover some small natural caves, notable for concretions and at times covered by calcite crystals.

*The Sierra San Marcos y Pinos* is one of the major ridges in the area, and runs northwest to southeast for over 105 kilometers. Unlike the other sierras, Marcos y Pinos shows a symmetrical shape, narrow at the northern end and wider at the southern one, where it reaches a width of 15 kilometers. The numberless canyons that cut it on both sides are not as deep as in other areas, and longitudinal valleys are completely lacking. The geological structure seems to be more evident than in nearby ridges and stands as a beautiful example of an anticline. Surface karst is almost absent, though some sectors show small-scale forms of corrosion in massive and thick limestone layers. The narrow canyons that cut the steep slopes show several entrances on walls or at their foot, but they are mostly niches or interstratal caves that rarely develop for more than 20 meters. As for underground karst phenomena, in this sierra we know two caves of some size and importance that open onto a side-canyon on the southeast side of Canyon El Rosillo, a wide and deep valley that crosses the ridge. Both caves were places for intense extraction of phosphorite, a rock that is mainly made of phosphates. Phosphorite is generated by the decay of limestone due to organic acids that derive from the process of guano decomposition. This proves the caves are very old and have been inhabited by bats for a long time.

The main cave, which we named Cueva del Rosillo 1, consists of a passage 930 meters in length, quadrangular in shape, which goes nearly straight southeast and has an average width of 10 meters, whereas its height varies from 6 to 20 meters. Its size decreases in the final part, from the lowering of the ceiling and the presence of fill that raises the floor. The passage ends in flowstone deeply corroded by organic acids of biogenic origin. Along the whole passage, the roof shows ceiling and lateral niches, which are sometimes due to corrosion triggered by guano deposits. The walls are engraved with large scallops 1 to 2 meters in size, which indicate a very slow water flow.

Cueva del Rosillo 2 opens just opposite Rosillo 1 and shows similar features, but shorter length. They are no doubt two segments of the same cave, cut by the incision of the valley. Their great size suggests the presence of an ancient and significant stream passage that drained the waters of a wide sector of the Sierra San Marcos y Pinos toward the northwest.

*The Sierra La Fragua* is a squat ridge, almost rectangular in shape, with west-northwest–east-northeast orientation, situated southwest of Cuatro Ciénegas. Its size makes it the major range in the region, since its surface area is over 1000 square kilometers. Its structure is that of a strongly asymmetrical anticline facing south-southwest, characterized by a wide northern slope with an inclination of only a few degrees. Its shape resembles that of a monocline, with the typical morphology of a cuesta. A dense net of parallel canyons cuts the northern side, not so deep, yet very tortuous. The longest ones reach 20 kilometers in length. The vast sloping plain of the northern side does not show any sign of deep karst landforms. The southern side shows, on the contrary, short but deep incisions, with walls up to more than 600 meters high and narrow parts where the bottom cannot even be seen. Several still-unexplored caves open along the walls of the gorges that descend to the north. They are mostly interstratal caverns, and their development rarely exceeds a few meters. Only two caves have been explored in this vast area.

The first one opens in the bed of Canyon del Junco, and consists of a 20-meter pit, the entrance of which lies between rock and talus, descending into a long fracture plugged by rubble on the bottom. Notwithstanding the cave's evident state of deterioration, some relict forms on the walls and the ceiling suggest a hydrothermal origin.

The most interesting cave in this area, Cueva del Rancho Guadalupe, is in the northern sector of the range. The entrance, a small circular pit 2 meters deep, is situated on a rocky slope, some meters above the edge of the plain. The small drop, perpendicular to the strata, leads to a descending passage about 1.5 meters in diameter with dome forms that indicate an origin due to rising thermal water. Remains of crusts, mainly consisting in calcite, that once covered the walls can also be noted during the descent. After a few tens of meters, the cave divides into several tunnels that connect some spherical rooms. The walls are often covered with calcite or gypsum crusts. One of the descending tunnels leads to a larger passage, inclined along the bedding, that opens onto a large chamber. Here the dissolving action of thermal waters has left hemispherical holes up to 4 meters in diameter on the ceiling and the walls. After their excavation phase, hydrothermal waters, slowly receding, covered the walls and ceiling of this vast room with calcite crusts. Today the calcite cover has mostly come off the walls and has formed a granular deposit on the floor. On the other hand, the great speleothem deposits date to the post-hydrothermal phase; they indicate a phase of seepage water, now only rarely active.

The cave is highly interesting for its morphological and mineralogical features, and the examination of collected samples allowed the identification of many types of minerals, among which are some extremely rare ones.

As already described, this cave represents a good sample of the monogenic hydrothermal type, the structure of which consists of a large base chamber from which secondary branches and tunnels depart upwards. The cave is usually inactive, but the presence of fresh formations testifies to occasional dripping, probably fed the sinks along a surface channel during heavy rainfalls.

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Wall pockets due to hydrothermal flow covered by calcite crust, Pozo del Junco.

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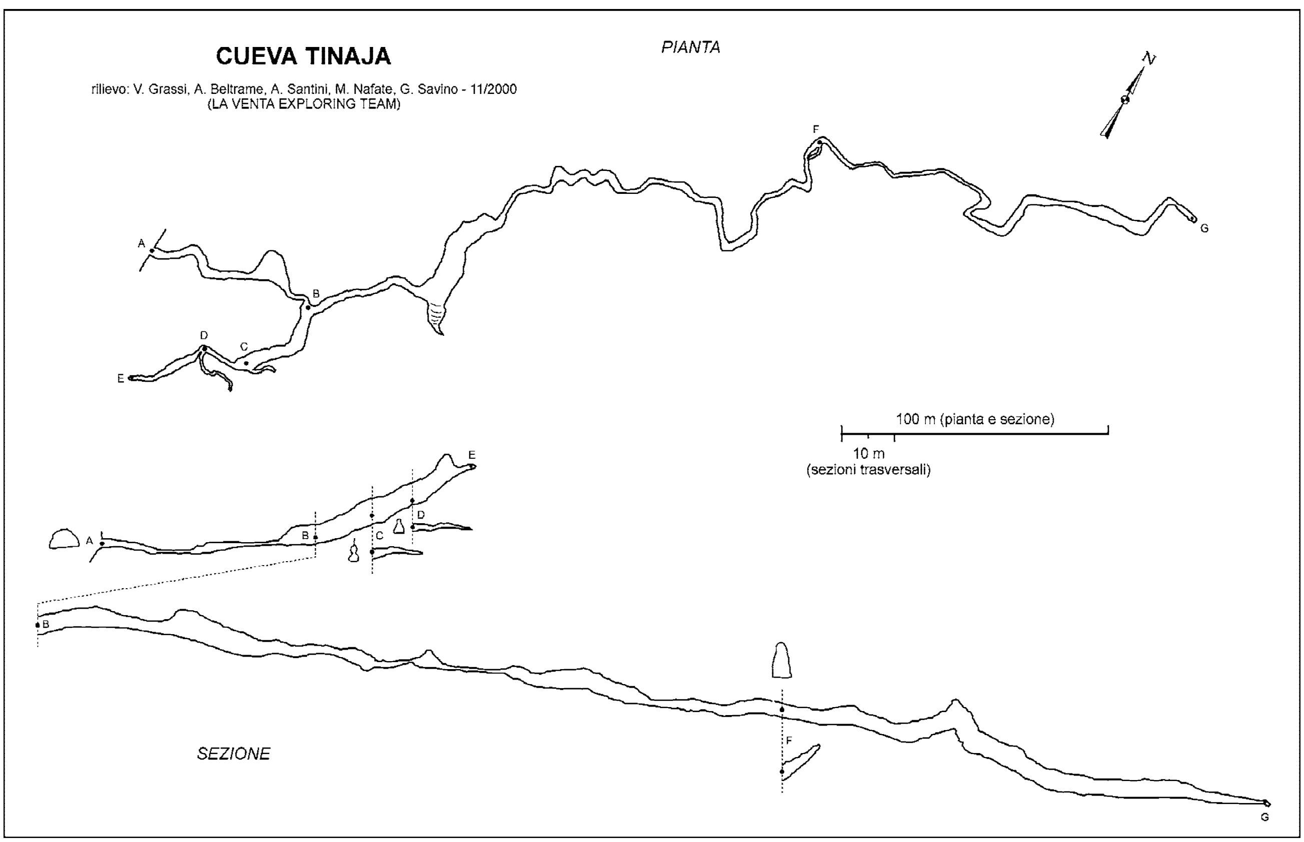
Las Cuevas de Cuatro Ciénegas

El grupo italiano La Venta exploró cuevas y minas en el área de Cuatro Ciénegas, Coahuila, en 2000, 2001 y 2002. El texto describe la geografía del área donde encontraron las cuevas.

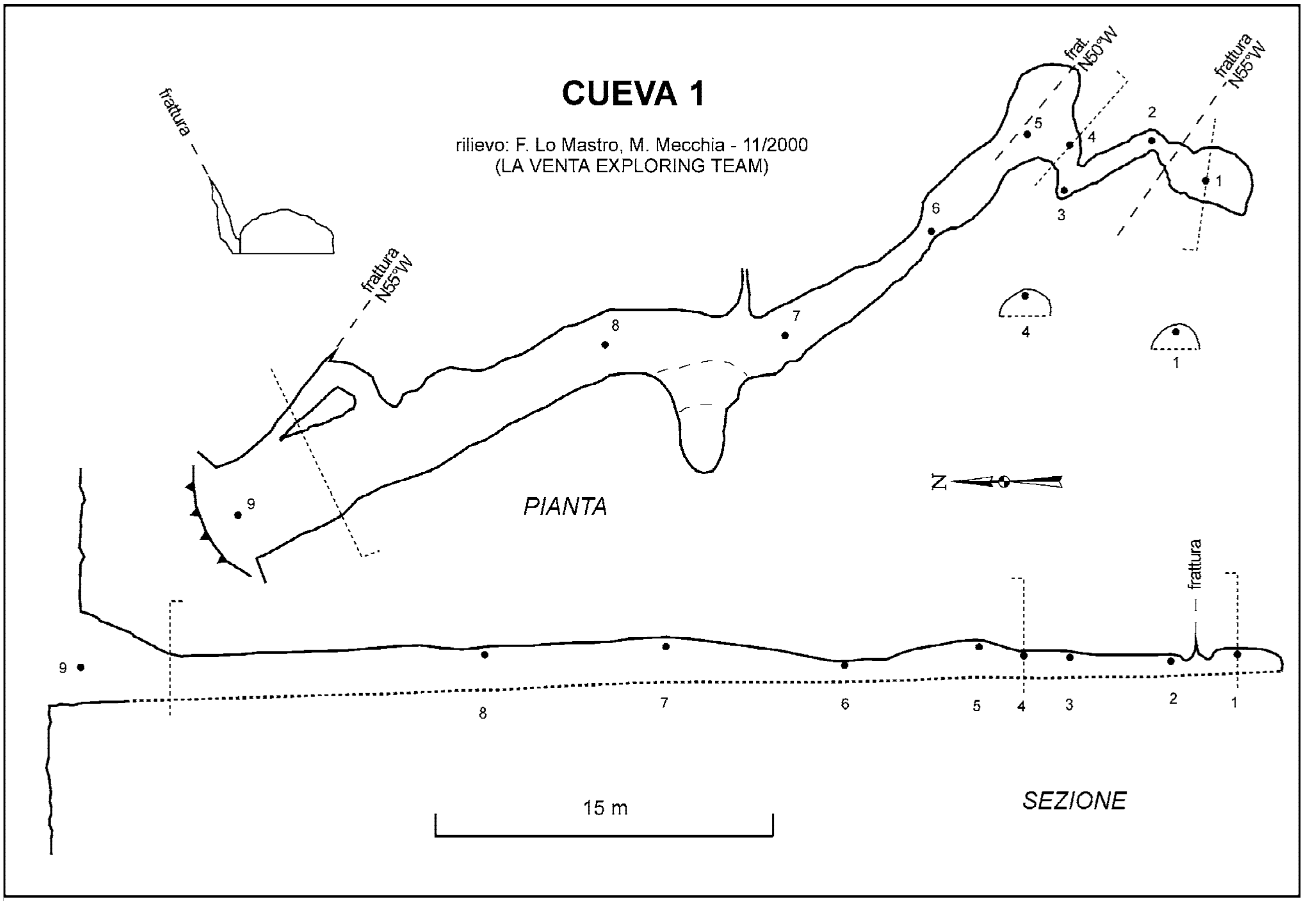
# Cave Maps

Map Page **A**

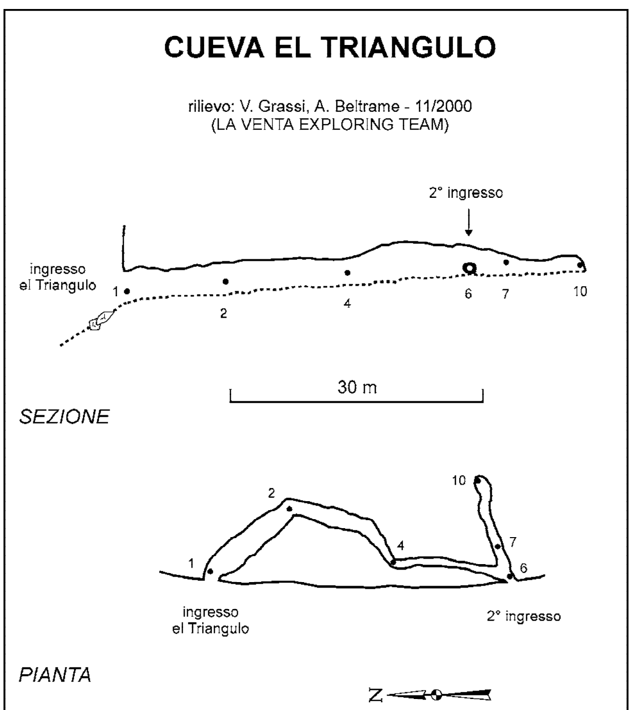


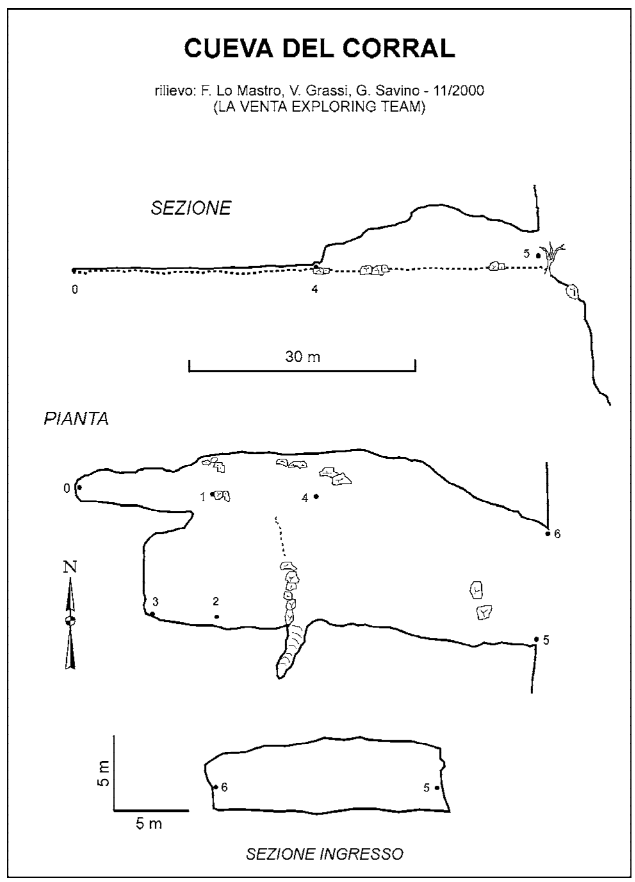
# Caves surveyed during La Venta expeditions to Cuatro Ciénegas

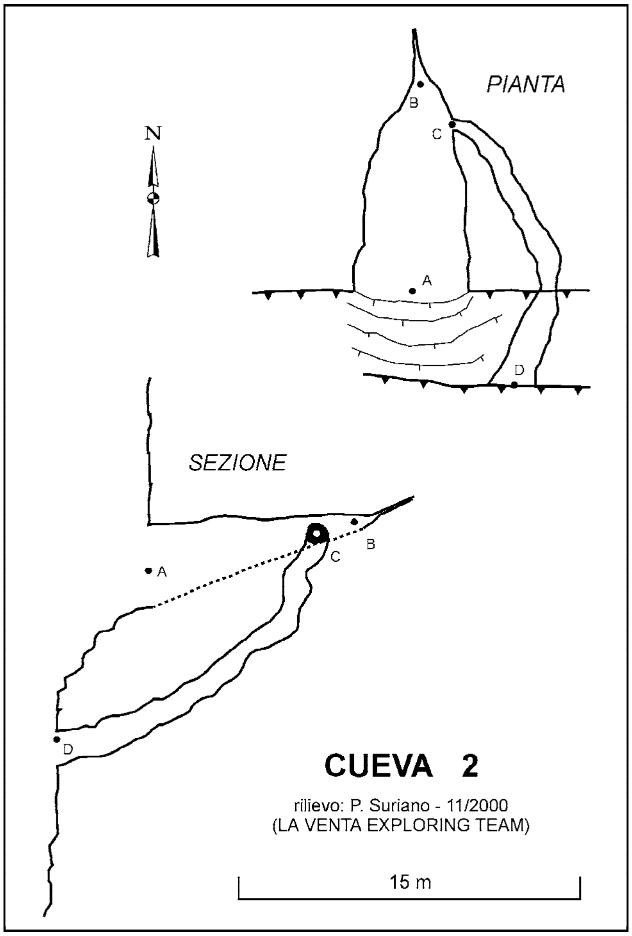
| Cave | Map Page | Area | Zone | UTM E (NAD27) | UTM N (NADS27) | elevation m a.s.l. | length m | depth m |
|---|---|---|---|---|---|---|---|---|
| Poza La Campana | D | Plana | 13 | 795309 | 2975031 | 693 | 105 | -19 |
| Cueva Tinaja | A | La Purisima | 14 | 219648 | 2970619 | 1020 | 670 | +30, -64 |
| Cueva 1 | B | La Purisima | 14 | 218398 | 2970942 | 1080 | 52 | +1 |
| Cueva 2 | C | La Purisima | 14 | 218675 | 2971380 | 1030 | 25 | +3, -7 |
| Cueva el Corral | B | La Purisima | 14 | 218482 | 2971260 | 1045 | 62 | 0 |
| Cueva 2B | C | La Purisima | 14 | 218600 | 2970830 | 1080 | 25 | +1 |
| Cueva 2C | D | La Purisima | 14 | 218730 | 2970820 | 1085 | 46 | 0 |
| Cueva el Triangulo | B | La Purisima | 14 | 219036 | 2970092 | 1130 | 55 | +4 |
| Cueva el Murcielago | E | La Purisima | 14 | 219085 | 2970132 | 1170 | 132 | +5 |
| Cueva Guevara 1958 | C | La Purisima | 14 | 219102 | 2969989 | 1170 | 93 | +6 |
| Cueva 8 | D | La Purisima | 14 | 219080 | 2969978 | 1205 | 17 | 0 |
| Cueva de la Sangre | C | La Purisima | 14 | 218732 | 2970050 | 1125 | 85 | +16 |
| Cueva las Guaitas | F | La Purisima | 14 | 218545 | 2969308 | 1140 | 220 | + 13 |
| Cueva las Guaitas 2 | F | La Purisima | 14 | 218560 | 2969356 | 1136 | 21 | +5 |
| Cueva las Guaitas 3 | F | La Purisima | 14 | 218564 | 2969391 | 1132 | 33 | +5 |
| Cueva la Escalera | N | La Purisima | 14 | 218592 | 2968480 | 1150 | 70 | +3 |
| Cueva Jolanda 1 | E | La Purisima | 14 | 219432 | 2968048 | 1155 | 20 | 0 |
| Cueva Jolanda 1b | E | La Purisima | 14 | 219375 | 2968058 | 1150 | 15 | 0 |
| Cueva Jolanda 2 | G | La Purisima | 14 | 219473 | 2967982 | 1215 | 20 | 0 |
| Cueva Jolanda 2b | G | La Purisima | 14 | 219434 | 2967993 | 1210 | 25 | 0 |
| Cueva Jolanda 3 | H | La Purisima | 14 | 219622 | 2967895 | 1180 | 7 | 0 |
| Cueva Jolanda 3b | H | La Purisima | 14 | 219627 | 2967875 | 1185 | 20 | 0 |
| Cueva Novato 1 | J | La Purisima | 14 | 219035 | 2960165 | 1180 | 45 | +11 |
| Cueva Novato 2 | J | La Purisima | 14 | 219075 | 2968205 | 1178 | 45 | +5 |
| Cueva el Pedregoso | G | La Purisima | 14 | 218814 | 2967935 | 1160 | 381 | -8 |
| Cueva del Canyon Haciendita | H | La Purisima | 14 | 217500 | 2958270 | 1025 | 20 | +5 |
| Cueva Rosillo 1 | J | S. Marcos y Pinos | 14 | 220497 | 2936552 | 1360 | 1110 | +53, -47 |
| Cueva Rosillo 2 | K | S. Marcos y Pinos | 14 | 220519 | 2936754 | 1400 | 223 | +5, -12 |
| Cueva de los Desperados | L | S. Marcos y Pinos | 14 | 226928 | 2929657 | 1780 | 25 | -7 |
| Cueva Grande | K | S. Marcos y Pinos | 14 | 227733 | 2928717 | 1800 | 45 | +24 |
| Cueva de la Estrella | K | S. Marcos y Pinos | 14 | 218855 | 2939982 | 1340 | 7 | +1 |
| Volcan F scavo 1 | L | S. Marcos y Pinos | 13 | 795281 | 2963523 | 1129 | 15 | -6 |
| Cueva del Vivero | P | S. Marcos y Pinos | 13 | 795046 | 2963027 | 1290 | 30 | -9 |
| Cueva de los Murciélagos | L | San Vincente | 14 | 216561 | 2984987 | 1030 | 120 | +20 |
| Cueva Alta de L'Angosta | N | San Vincente | 14 | 218300 | 2982650 | 1180 | 75 | +2 |
| Pozo del las Espinas | O | San Vincente | 14 | 216500 | 2988040 | 1180 | 18 | -8 |
| Cueva la Espantosa | M | San Vincente | 14 | 221619 | 2980082 | 1141 | 40 | +6 |
| Cueva SV 1 | I | San Vincente | 14 | 216360 | 2987850 | 1050 | 13 | +1 |
| Cueva SV2 | I | San Vincente | 14 | 216370 | 2988350 | 1060 | 11 | +3 |
| Cueva del Guano di Don Beto | N | Madera | 13 | 784740 | 2987267 | 976 | 402 | +31, -26 |
| Cueva del Molino | M | Madera | 13 | 788770 | 2991800 | 850 | 20 | 7 |
| Cueva la Leona | M | Menchaca | 13 | 784202 | 3017873 | 1253 | 464 | +35 |
| Cueva Hundida | O | Menchaca | 13 | 784234 | 3018462 | 1253 | 854 | -122 |
| Cueva Vibora | P | Menchaca | 13 | 784243 | 3017986 | 1290 | 180 | -60 |
| Cueva de las Hornamentas | O | Menchaca | 13 | 707121 | 3092521 | 919 | 10 | +1 |
| Cueva Rancho Guadalupe | P | La Fragua | 13 | 745782 | 2977148 | 1280 | 190 | -26 |
| Pozo del Junco | P | La Fragua | 13 | 772193 | 2971058 | 1300 | 70 | -28 |

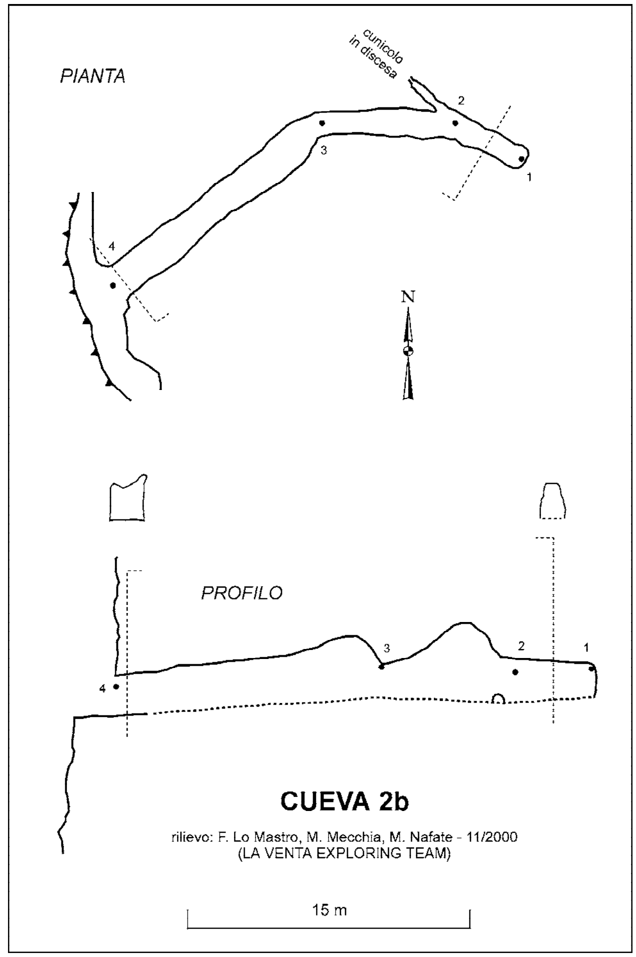

CUEVA 1
rilievo: F. Lo Mastro, M. Mecchia - 11/2000
(LA VENTA EXPLORING TEAM)
frattura
frattura N55°W
frat. N50°W
frattura N55°W
PIANTA
SEZIONE
15 m
N

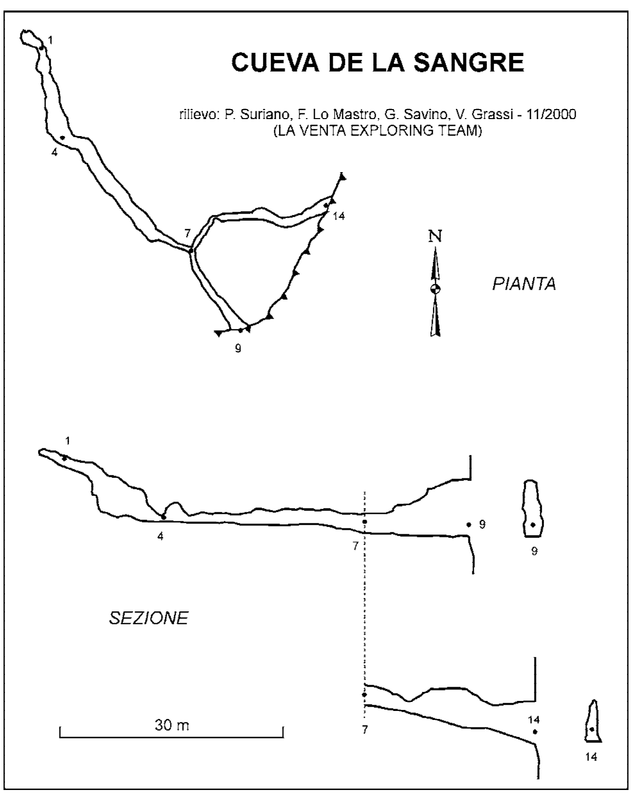
**B**


CUEVA EL TRIANGULO
rilievo: V. Grassi, A. Beltrame - 11/2000
(LA VENTA EXPLORING TEAM)
2° ingresso
ingresso el Triangulo
30 m
SEZIONE
ingresso el Triangulo
2° ingresso
PIANTA
N

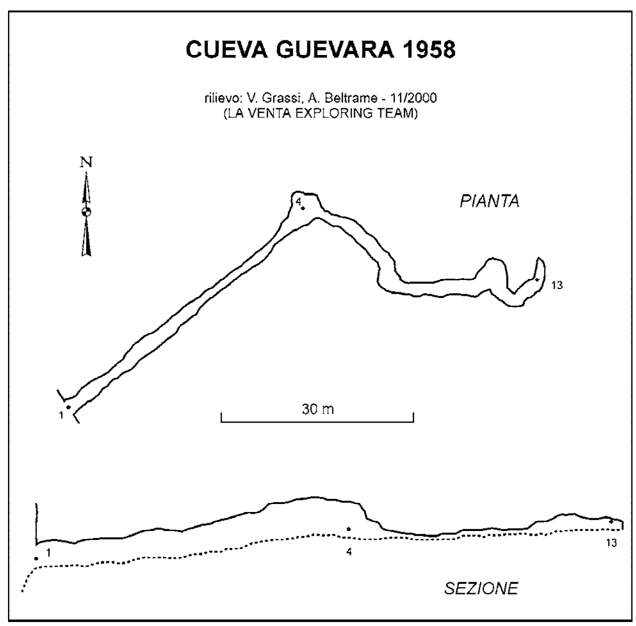

CUEVA DEL CORRAL
rilievo: F. Lo Mastro, V. Grassi, G. Savino - 11/2000
(LA VENTA EXPLORING TEAM)
SEZIONE
30 m
PIANTA
N
5 m
5 m
SEZIONE INGRESSO


PIANTA
N
A
B
C
D
SEZIONE
CUEVA 2
rilievo: P. Suriano - 11/2000
(LA VENTA EXPLORING TEAM)
15 m

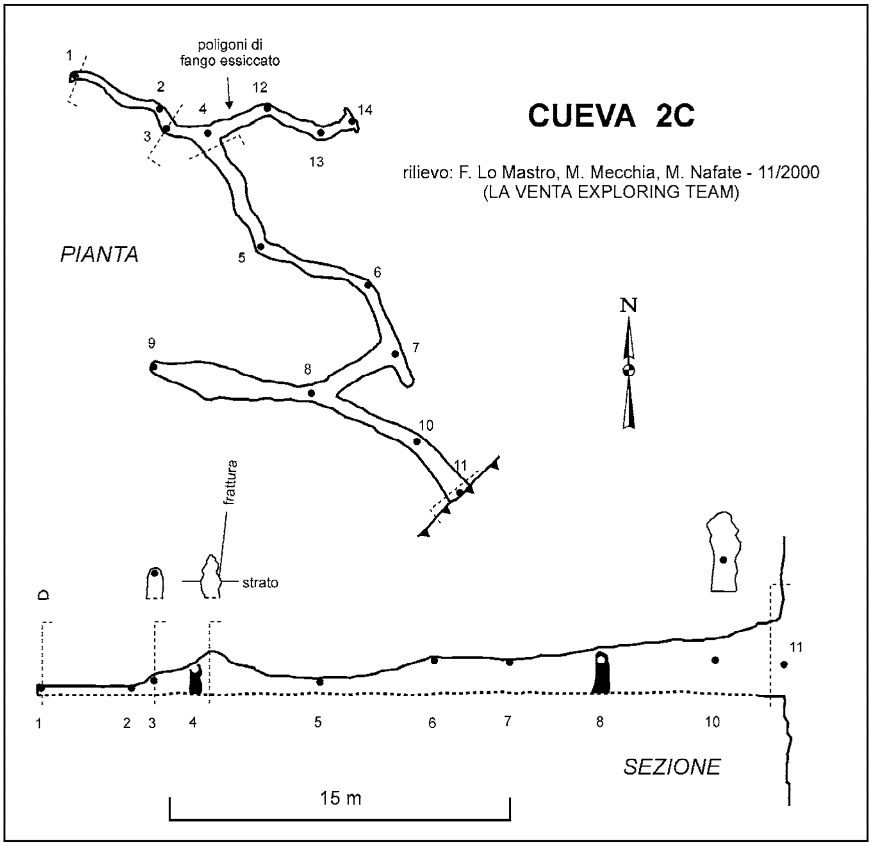

PIANTA
cunicolo in discesa
1
2
3
4
N
PROFILO
CUEVA 2b
rilievo: F. Lo Mastro, M. Mecchia, M. Nafate - 11/2000
(LA VENTA EXPLORING TEAM)
15 m

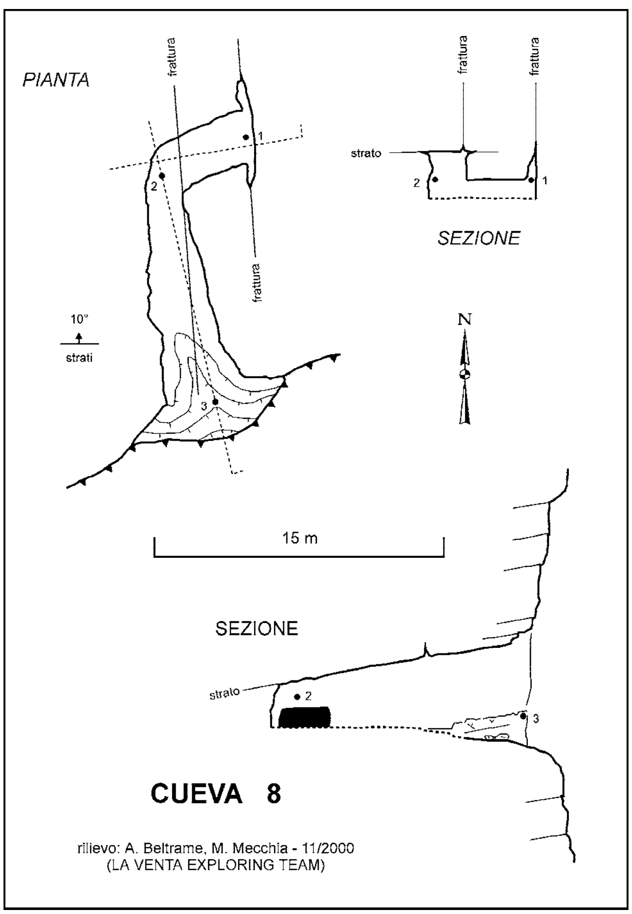

CUEVA DE LA SANGRE
rilievo: P. Suriano, F. Lo Mastro, G. Savino, V. Grassi - 11/2000
(LA VENTA EXPLORING TEAM)
1
4
7
9
14
N
PIANTA
SEZIONE
30 m

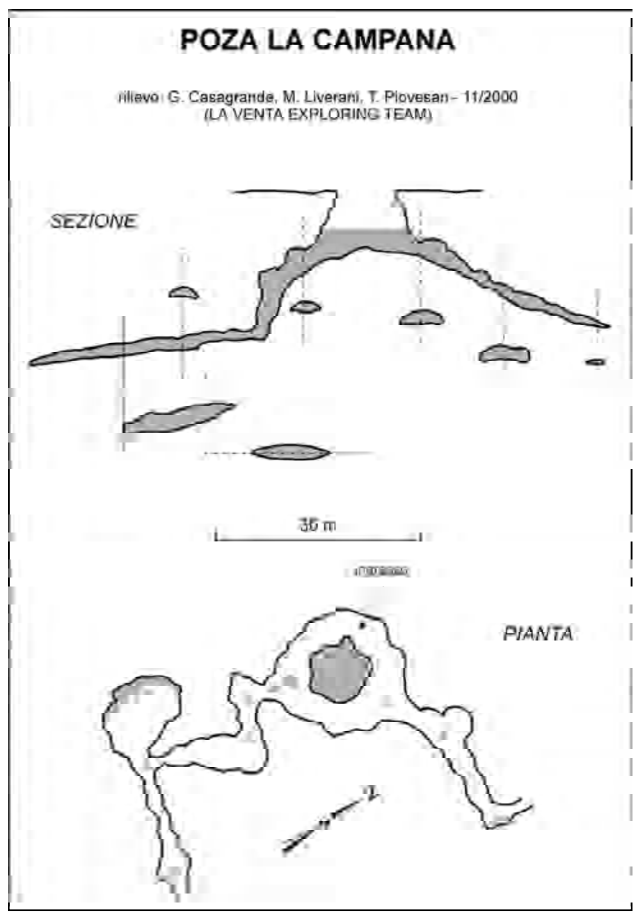
C

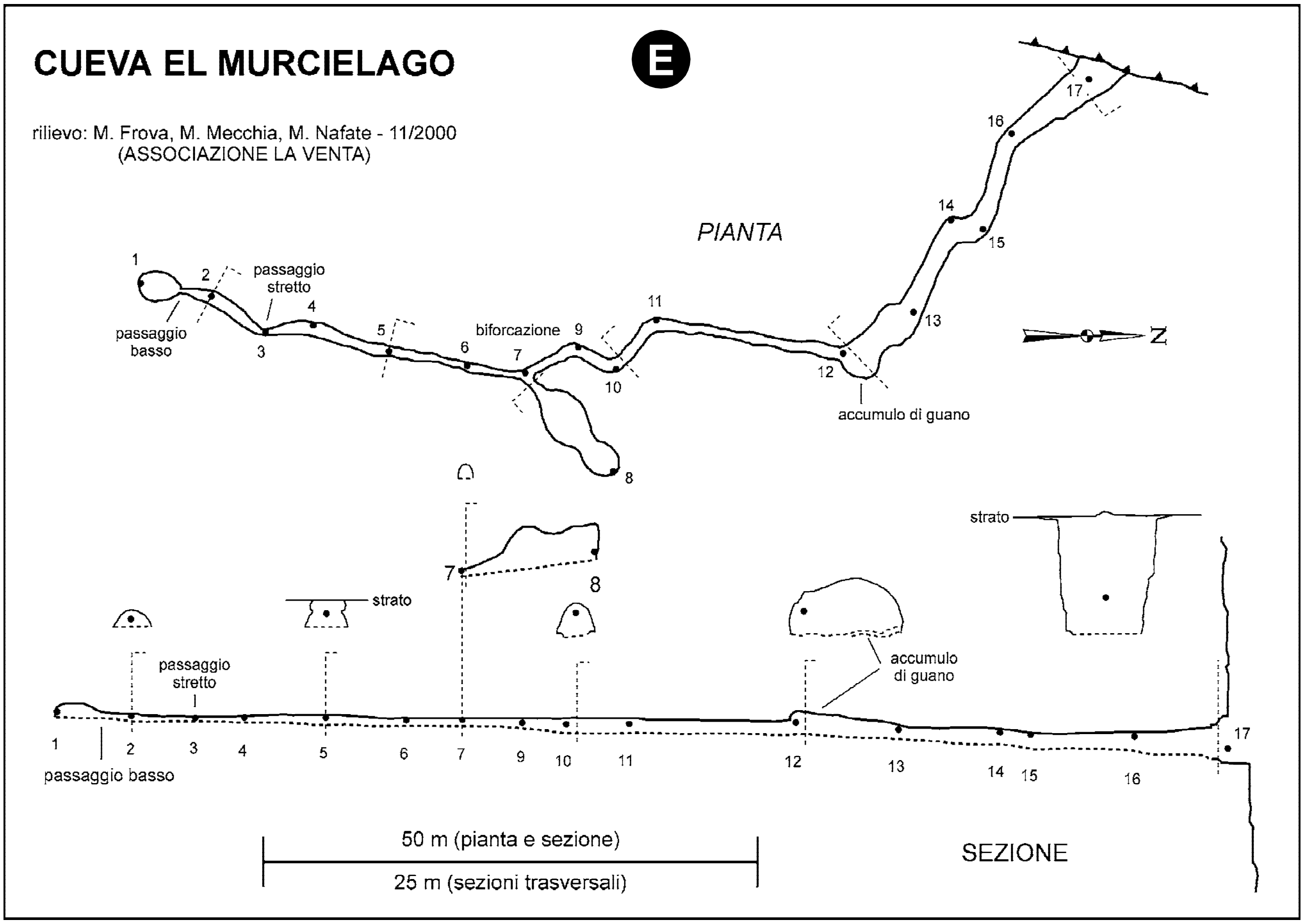

CUEVA GUEVARA 1958
rilievo: V. Grassi, A. Beltrame - 11/2000
(LA VENTA EXPLORING TEAM)
N
PIANTA
1
4
13
30 m
SEZIONE

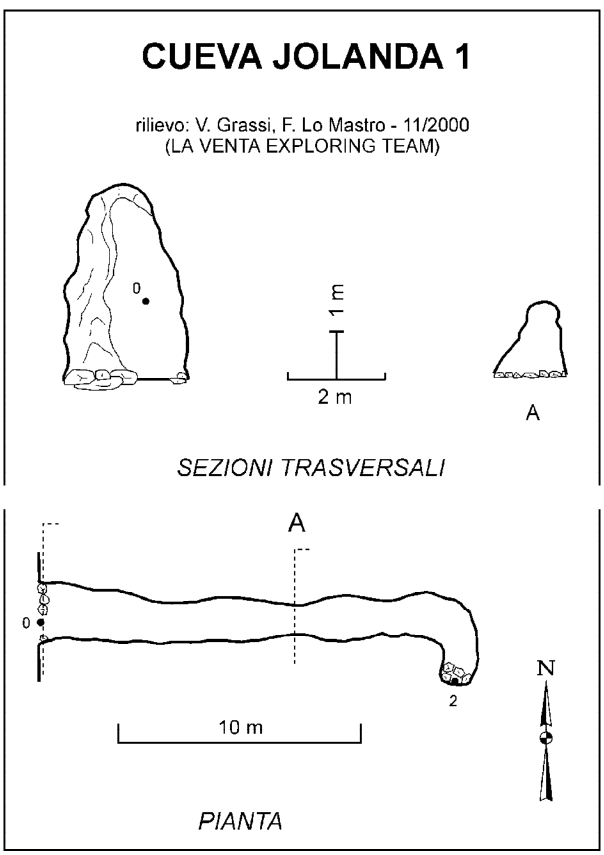
**D**

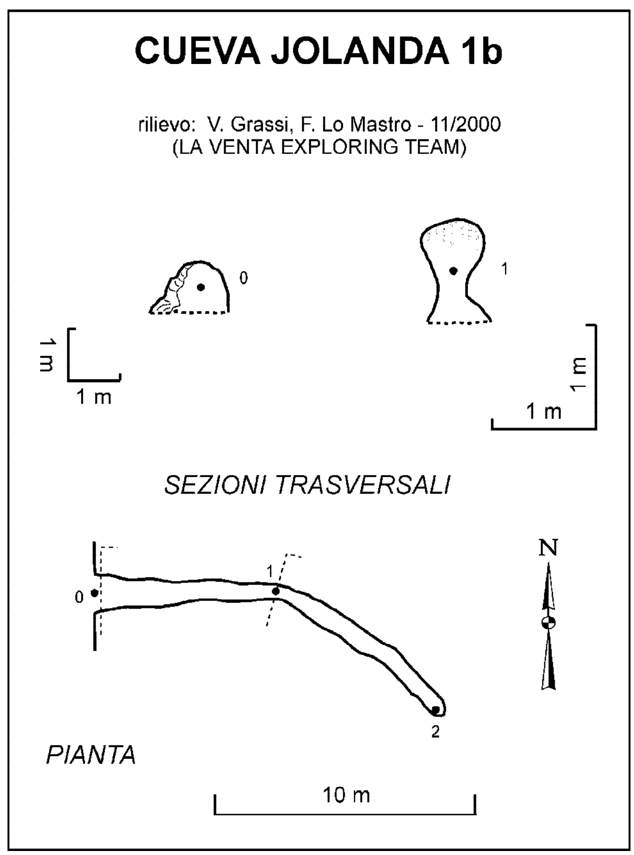

CUEVA 2C
rilievo: F. Lo Mastro, M. Mecchia, M. Nafate - 11/2000
(LA VENTA EXPLORING TEAM)
poligoni di
fango essiccato
PIANTA
N
frattura
strato
SEZIONE
15 m
1
2
3
4
5
6
7
8
9
10
11
12
13
14


PIANTA
frattura
frattura
10°
strati
strato
SEZIONE
N
15 m
SEZIONE
strato
CUEVA 8
rilievo: A. Beltrame, M. Mecchia - 11/2000
(LA VENTA EXPLORING TEAM)
1
2
3

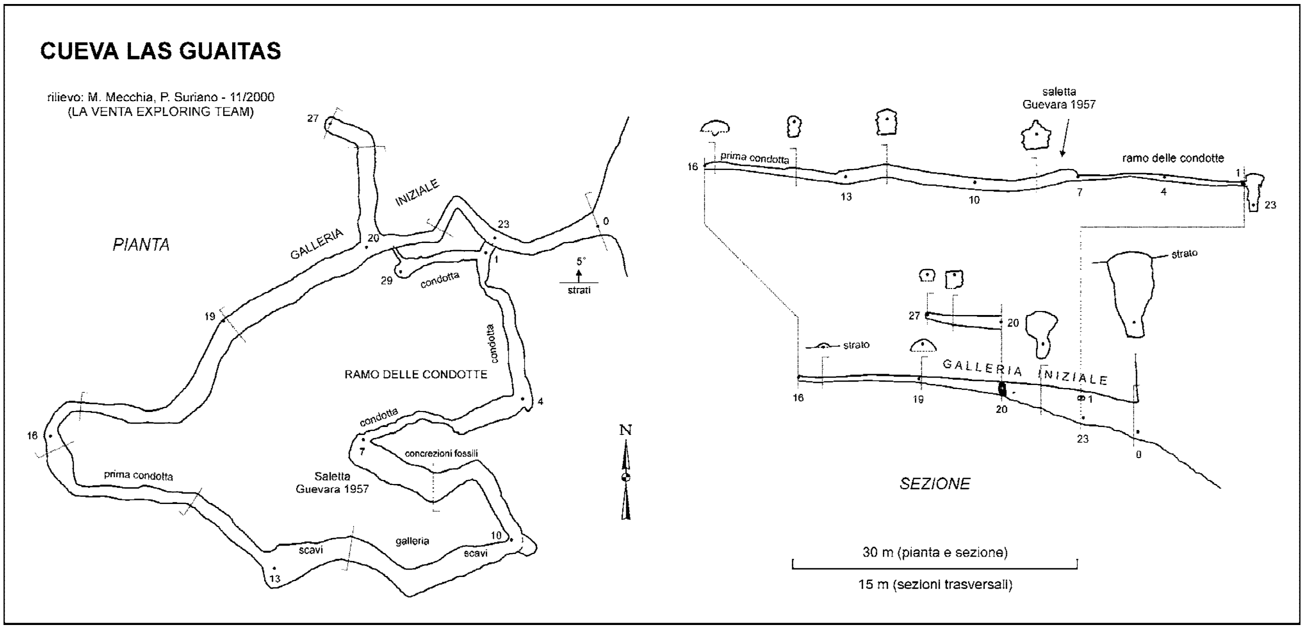

POZA LA CAMPANA
rilievo: G. Casagrande, M. Liverani, T. Piovesan - 11/2000
(LA VENTA EXPLORING TEAM)
SEZIONE
30 m
PIANTA

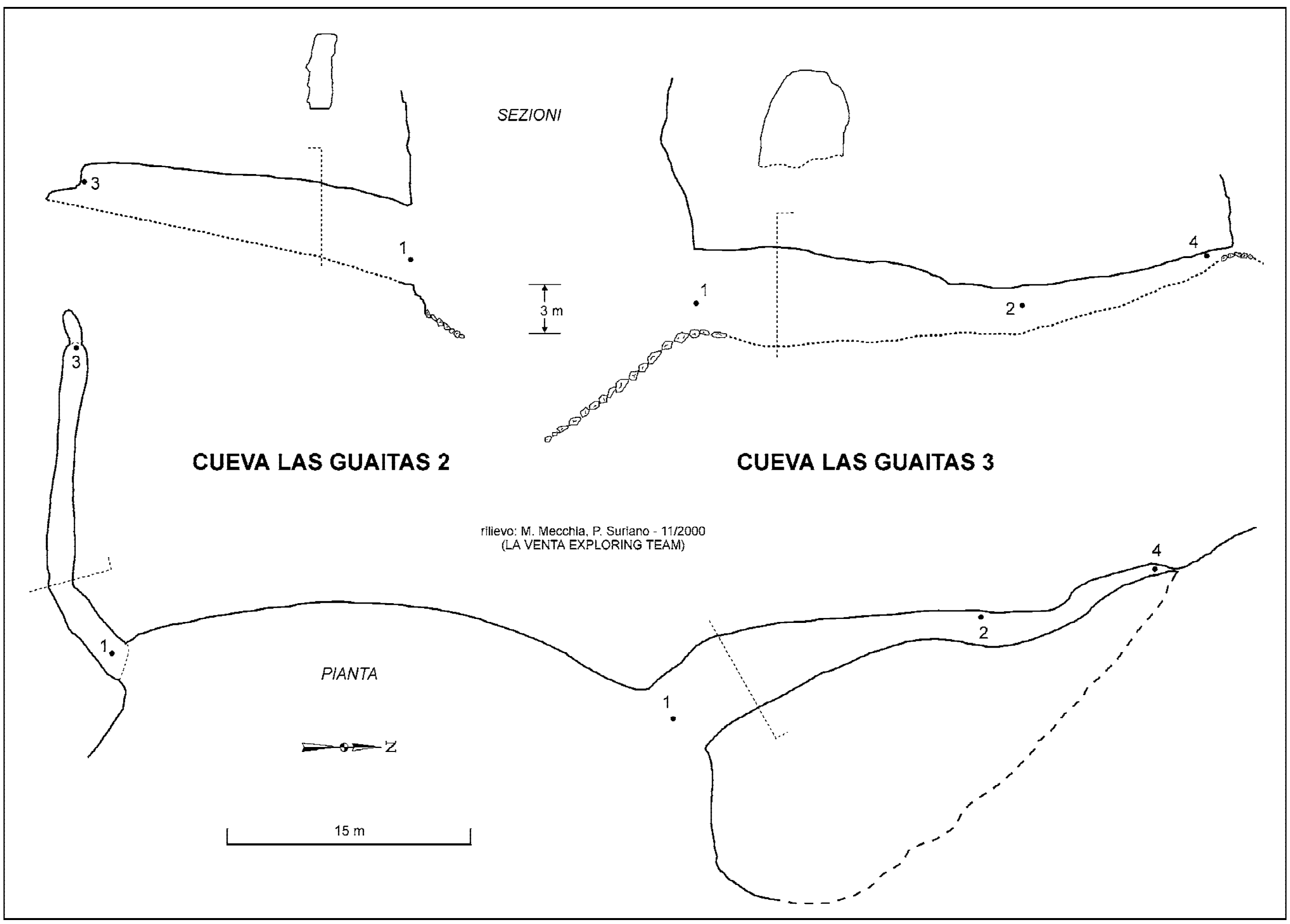

CUEVA EL MURCIELAGO
E
rilievo: M. Frova, M. Mecchia, M. Nafate - 11/2000
(ASSOCIAZIONE LA VENTA)
PIANTA
passaggio stretto
passaggio basso
biforcazione
accumulo di guano
strato
passaggio stretto
passaggio basso
accumulo di guano
strato
50 m (pianta e sezione)
25 m (sezioni trasversali)
SEZIONE

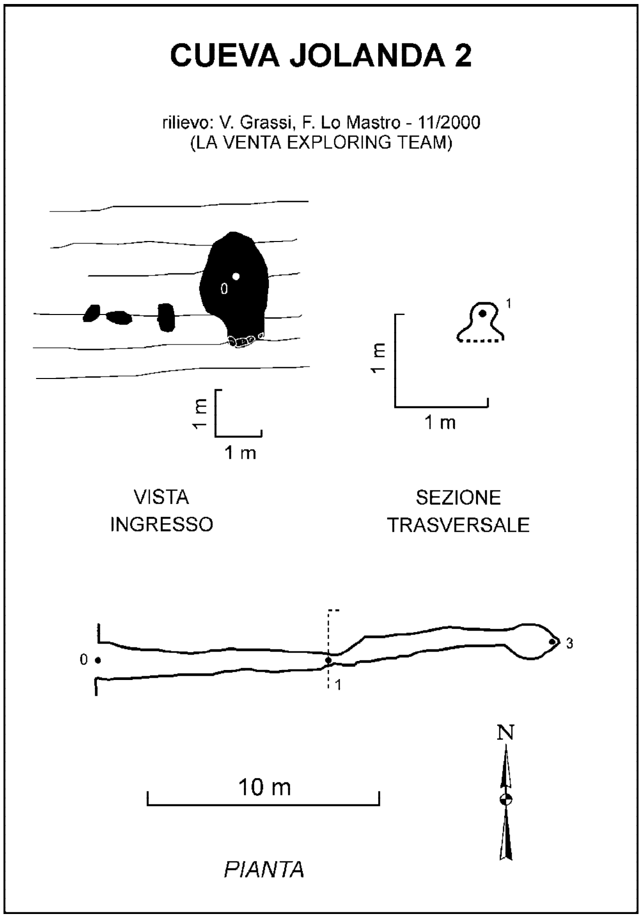

CUEVA JOLANDA 1
rilievo: V. Grassi, F. Lo Mastro - 11/2000
(LA VENTA EXPLORING TEAM)
1 m
2 m
A
SEZIONI TRASVERSALI
A
10 m
N
PIANTA

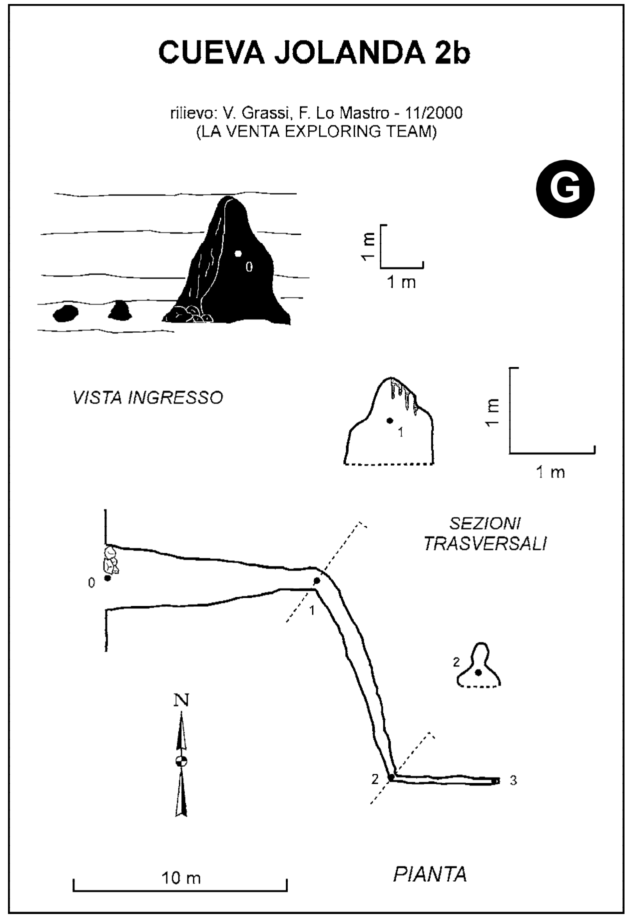

CUEVA JOLANDA 1b
rilievo: V. Grassi, F. Lo Mastro - 11/2000
(LA VENTA EXPLORING TEAM)
1 m
1 m
1 m
1 m
SEZIONI TRASVERSALI
N
PIANTA
10 m

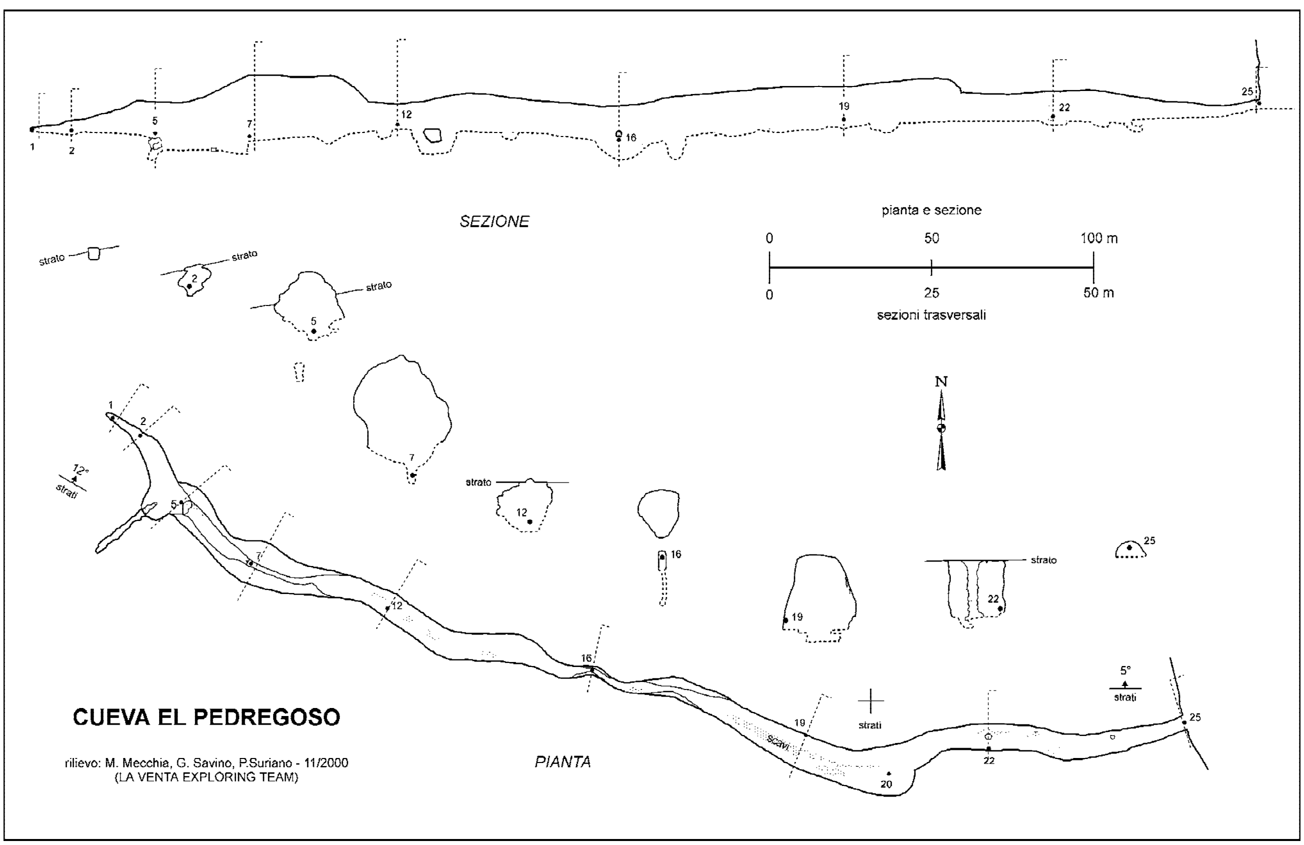
F


CUEVA LAS GUAITAS
rilievo: M. Mecchia, P. Suriano - 11/2000
(LA VENTA EXPLORING TEAM)
PIANTA
GALLERIA
INIZIALE
condotta
RAMO DELLE CONDOTTE
concrezioni fossili
Saletta
Guevara 1957
prima condotta
scavi
galleria
strati
N
saletta
Guevara 1957
ramo delle condotte
strato
GALLERIA INIZIALE
SEZIONE
30 m (pianta e sezione)
15 m (sezioni trasversali)

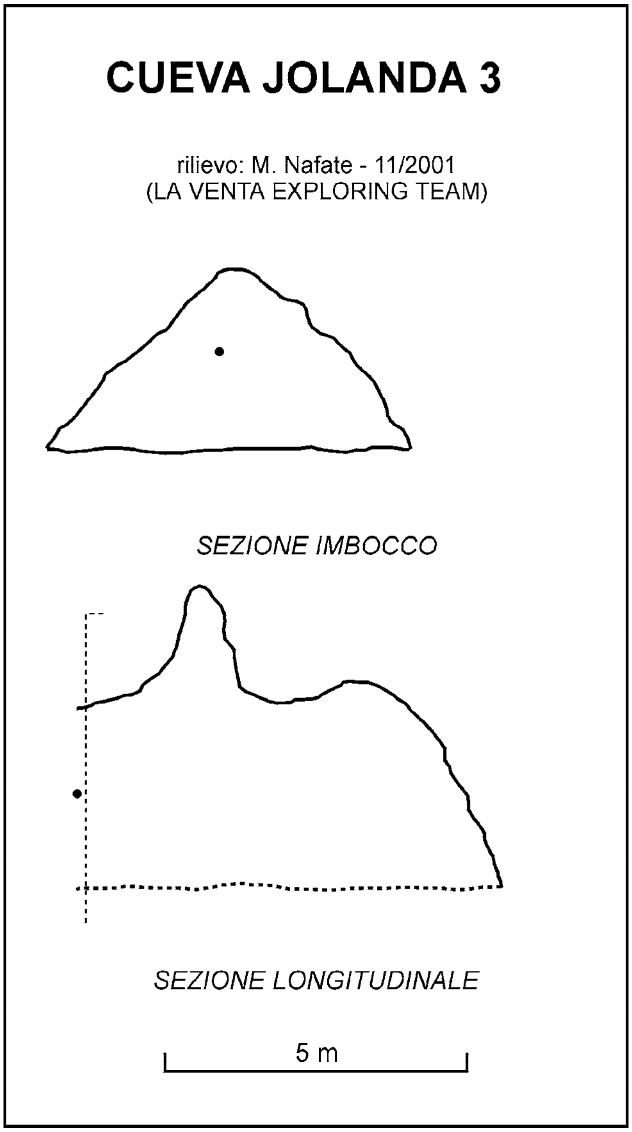

SEZIONI
3 m
CUEVA LAS GUAITAS 2
CUEVA LAS GUAITAS 3
rilievo: M. Mecchia, P. Suriano - 11/2000
(LA VENTA EXPLORING TEAM)
PIANTA
N
15 m

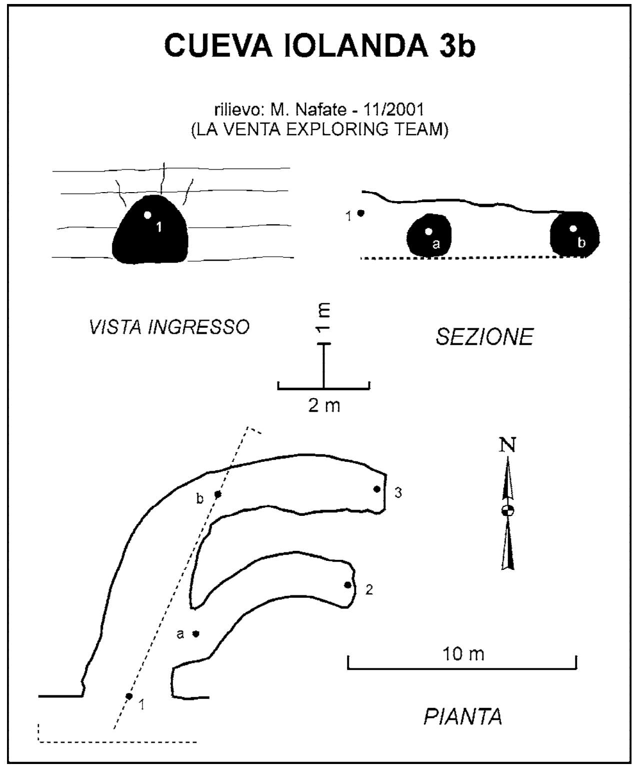

CUEVA JOLANDA 2
rilievo: V. Grassi, F. Lo Mastro - 11/2000
(LA VENTA EXPLORING TEAM)
1 m
1 m
1 m
1 m
VISTA
INGRESSO
SEZIONE
TRASVERSALE
10 m
N
PIANTA

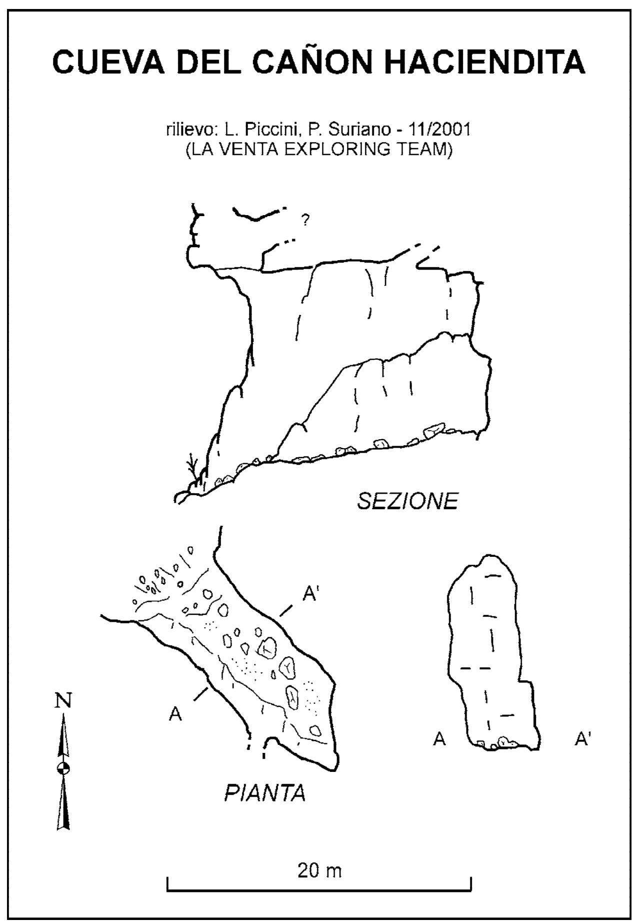

CUEVA JOLANDA 2b
rilievo: V. Grassi, F. Lo Mastro - 11/2000
(LA VENTA EXPLORING TEAM)
G
1 m
1 m
VISTA INGRESSO
1 m
1 m
SEZIONI
TRASVERSALI
N
10 m
PIANTA


SEZIONE
pianta e sezione
0
50
100 m
0
25
50 m
sezioni trasversali
strato
N
CUEVA EL PEDREGOSO
rilievo: M. Mecchia, G. Savino, P.Suriano - 11/2000
(LA VENTA EXPLORING TEAM)
PIANTA
scavi
strati

H

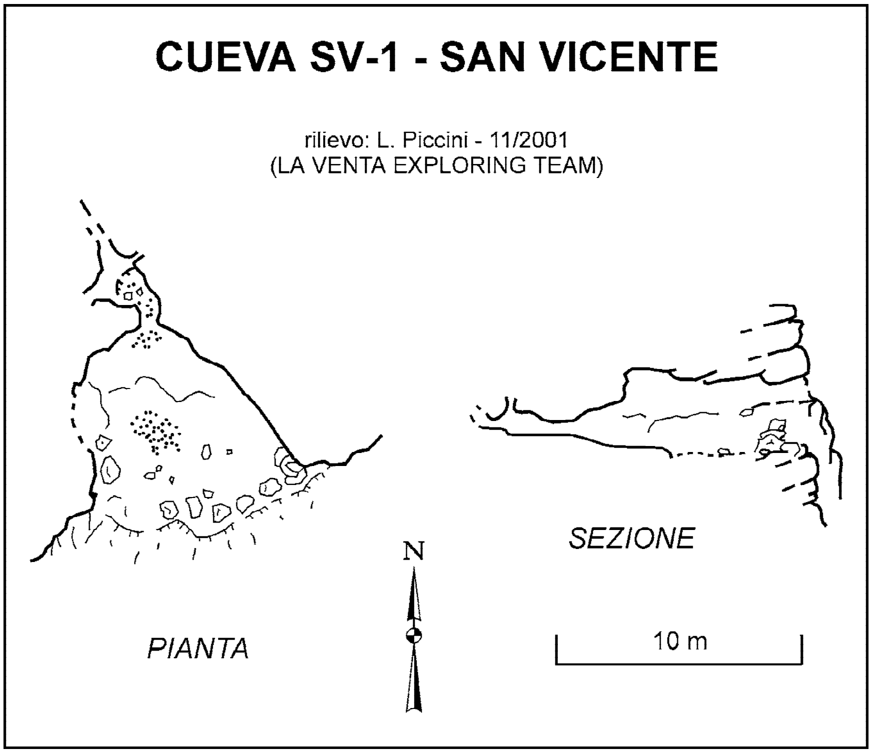


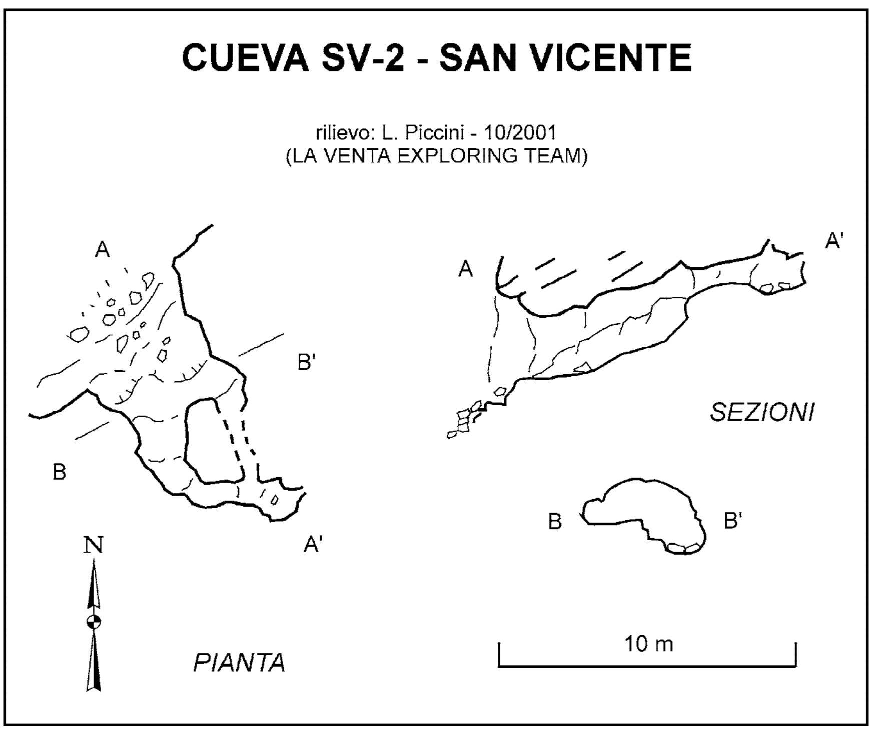



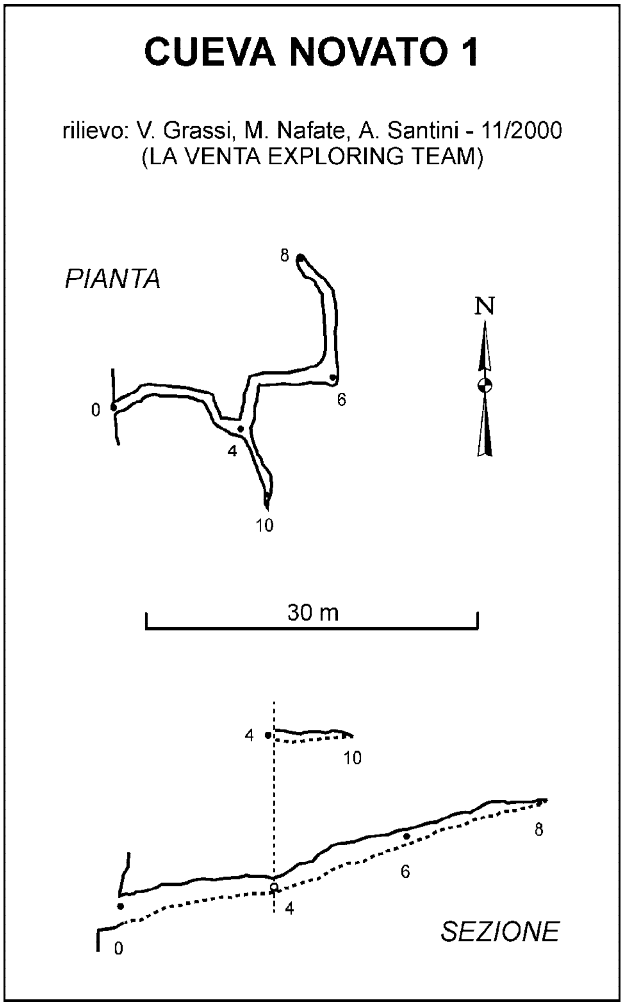



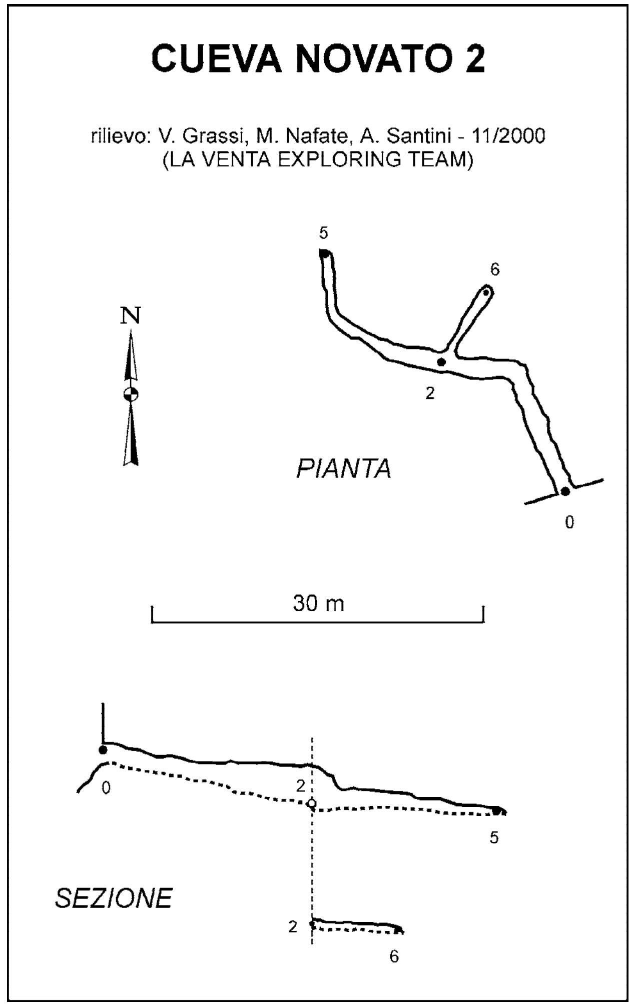

The cave the La Venta group calls Cueva Rosillo 1 was mapped in 1975 by Bill Russell and others. They named it Cueva del Porvenir. That map appears in a short article in the *Texas Caver*, August 1980, pages 74–76.

The Italian's Cueva del Guano di Don Beto is known locally as Cueva de Anteojo. —Peter Sprouse

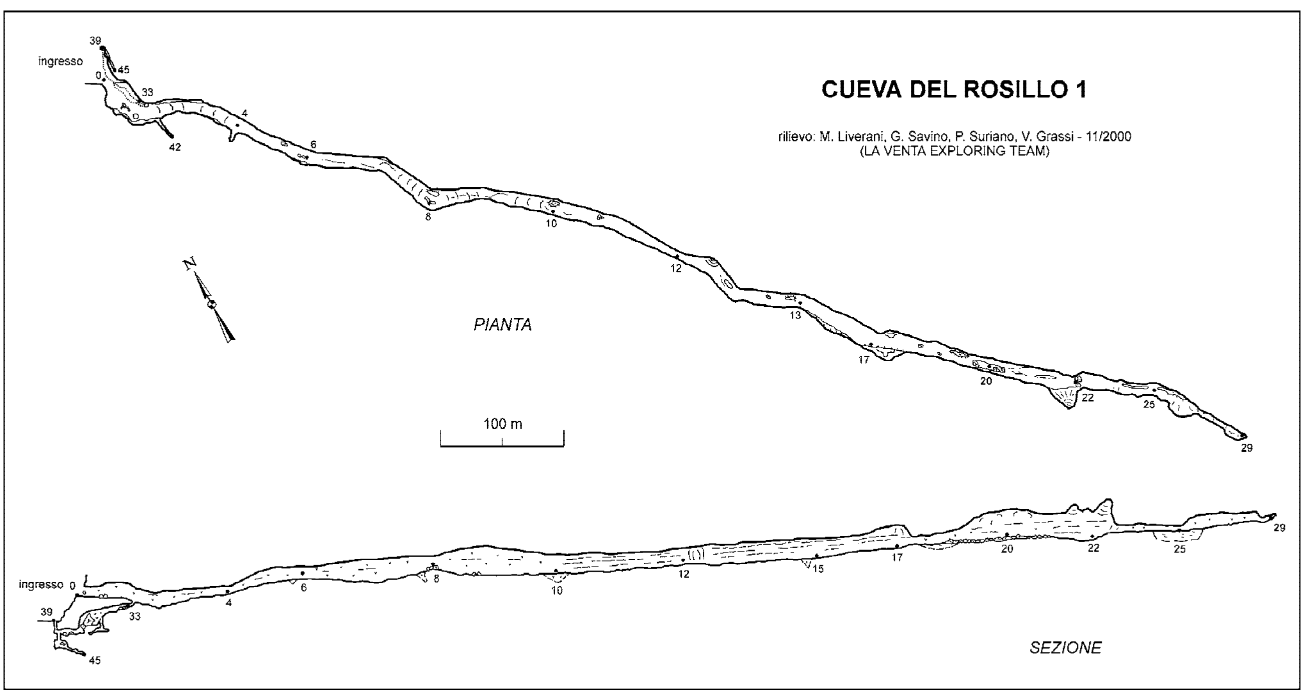

CUEVA SV-1 - SAN VICENTE
rilievo: L. Piccini - 11/2001
(LA VENTA EXPLORING TEAM)
SEZIONE
N
PIANTA
10 m

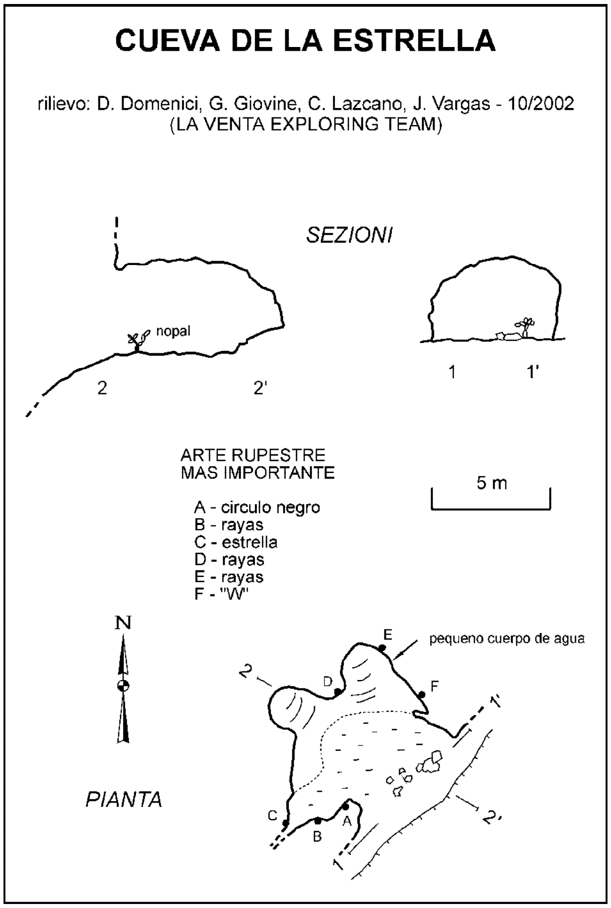

CUEVA SV-2 - SAN VICENTE
rilievo: L. Piccini - 10/2001
(LA VENTA EXPLORING TEAM)
A
B'
B
N
A'
A
A'
SEZIONI
B
B'
PIANTA
10 m

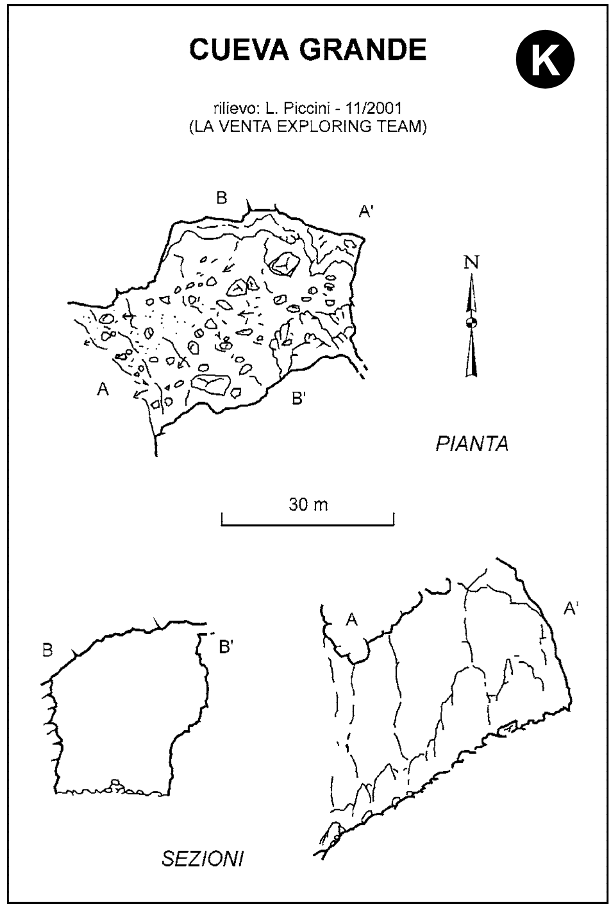

CUEVA NOVATO 1
rilievo: V. Grassi, M. Nafate, A. Santini - 11/2000
(LA VENTA EXPLORING TEAM)
PIANTA
N
30 m
SEZIONE

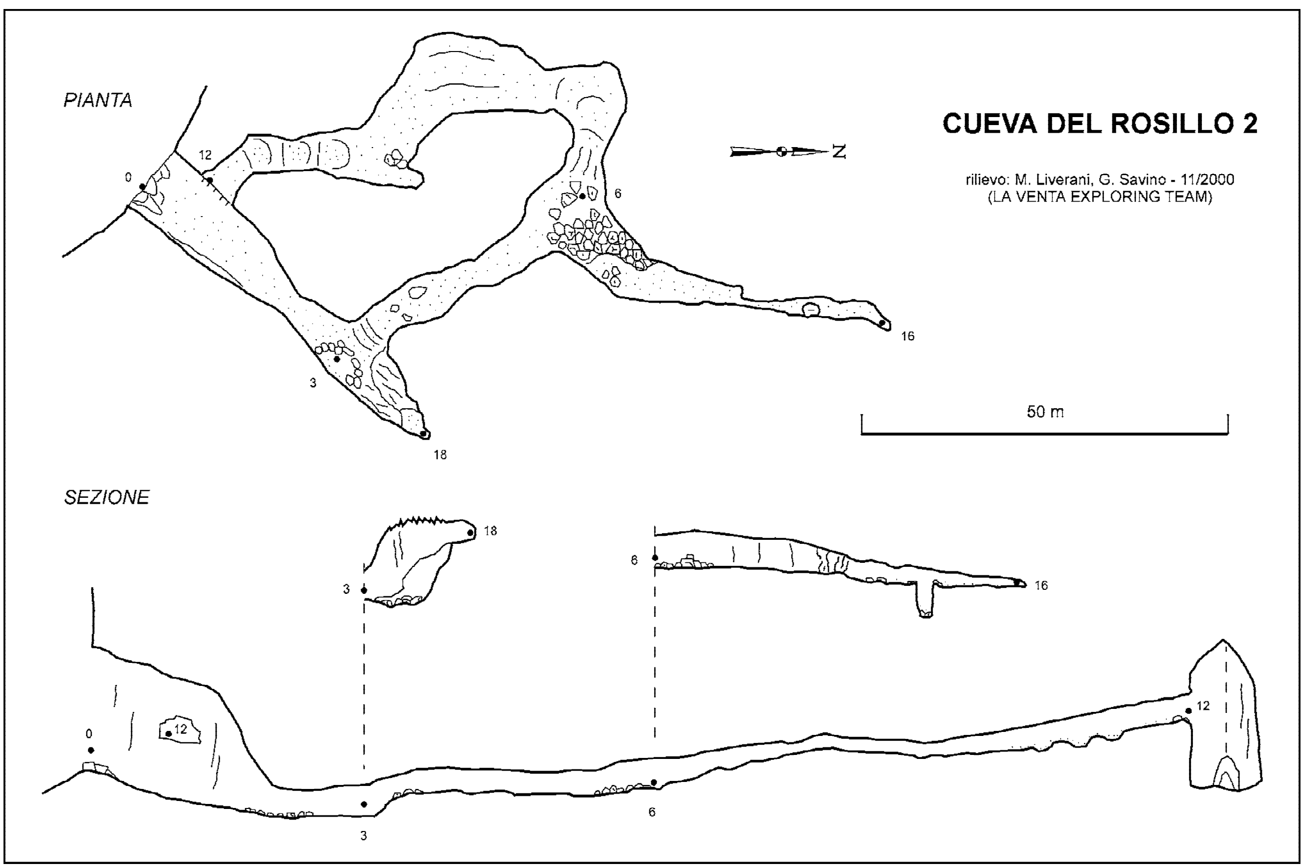

CUEVA NOVATO 2
rilievo: V. Grassi, M. Nafate, A. Santini - 11/2000
(LA VENTA EXPLORING TEAM)
N
PIANTA
30 m
SEZIONE

J

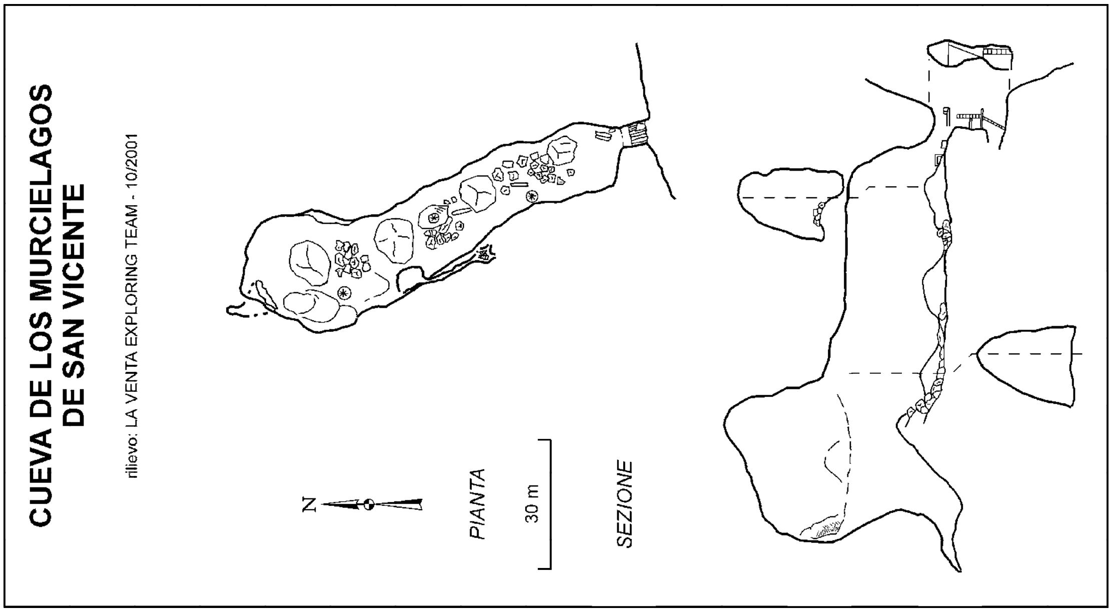

CUEVA DEL ROSILLO 1
rilievo: M. Liverani, G. Savino, P. Suriano, V. Grassi - 11/2000
(LA VENTA EXPLORING TEAM)
ingresso
N
PIANTA
100 m
SEZIONE

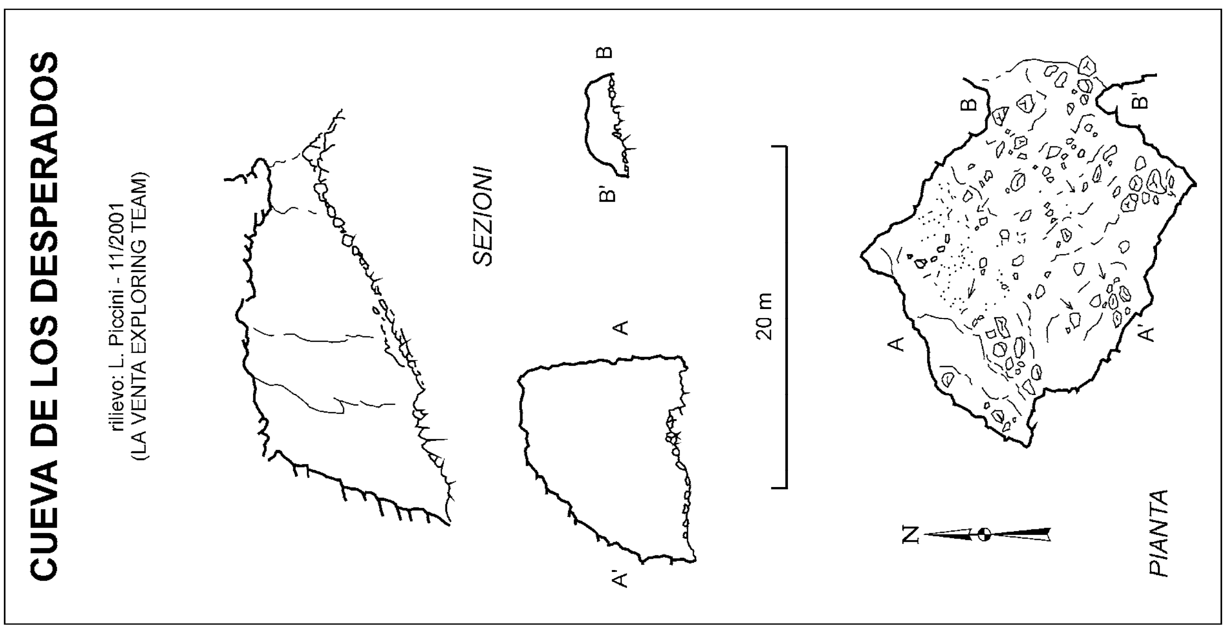

CUEVA DE LA ESTRELLA
rilievo: D. Domenici, G. Giovine, C. Lazcano, J. Vargas - 10/2002
(LA VENTA EXPLORING TEAM)
SEZIONI
nopal
2
2'
1
1'
ARTE RUPESTRE
MAS IMPORTANTE
A - circulo negro
B - rayas
C - estrella
D - rayas
E - rayas
F - "W"
5 m
N
PIANTA
pequeno cuerpo de agua
E
D
F
C
B
A

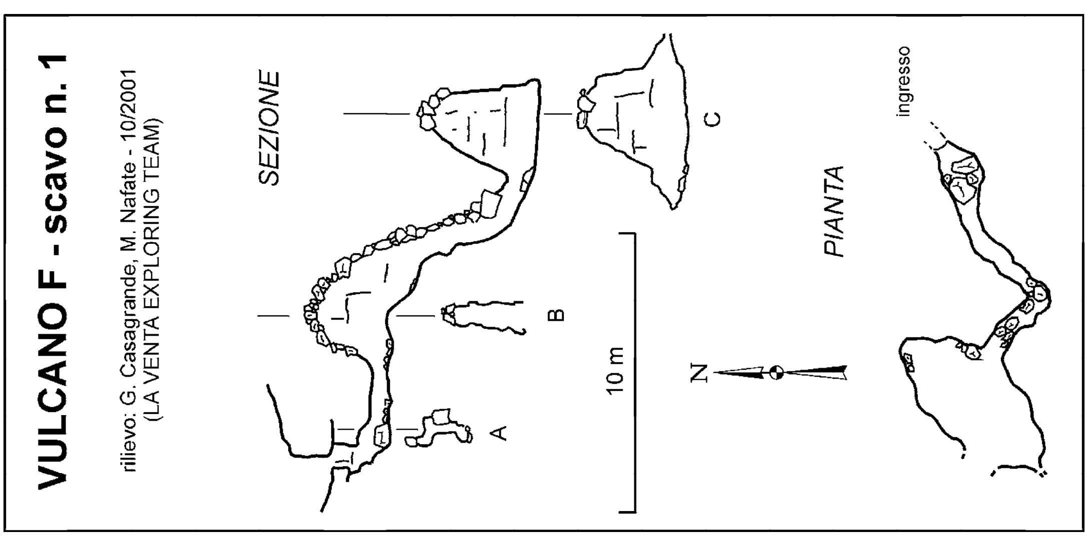

CUEVA GRANDE
K
rilievo: L. Piccini - 11/2001
(LA VENTA EXPLORING TEAM)
B
A'
N
A
B'
PIANTA
30 m
B
B'
A
A'
SEZIONI

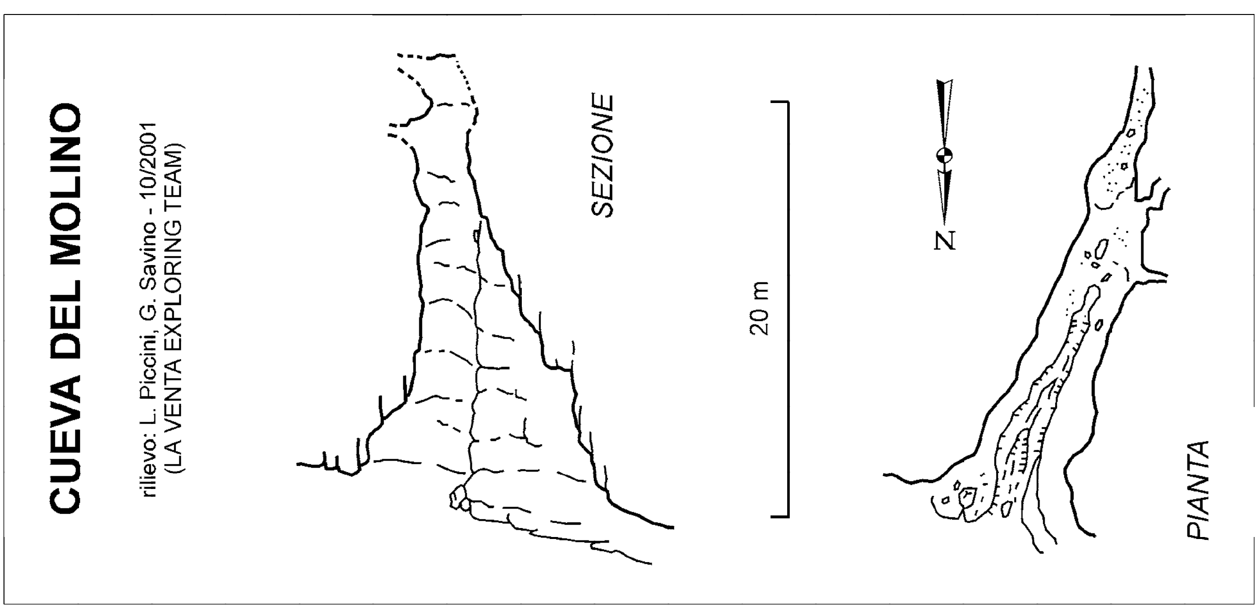

PIANTA
CUEVA DEL ROSILLO 2
rilievo: M. Liverani, G. Savino - 11/2000
(LA VENTA EXPLORING TEAM)
N
0
12
6
16
3
18
50 m
SEZIONE

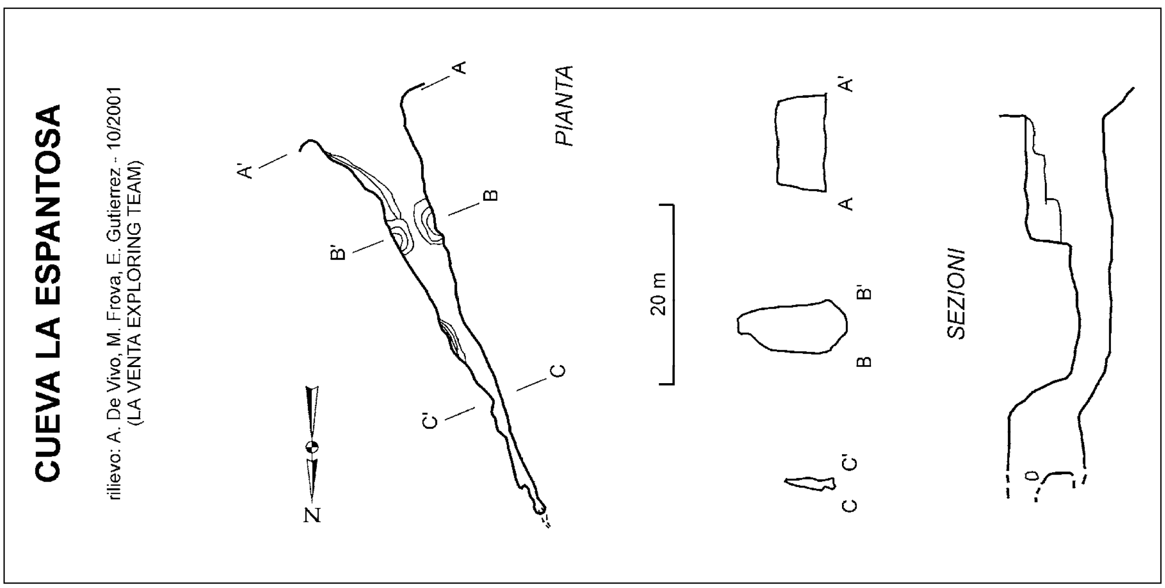
L

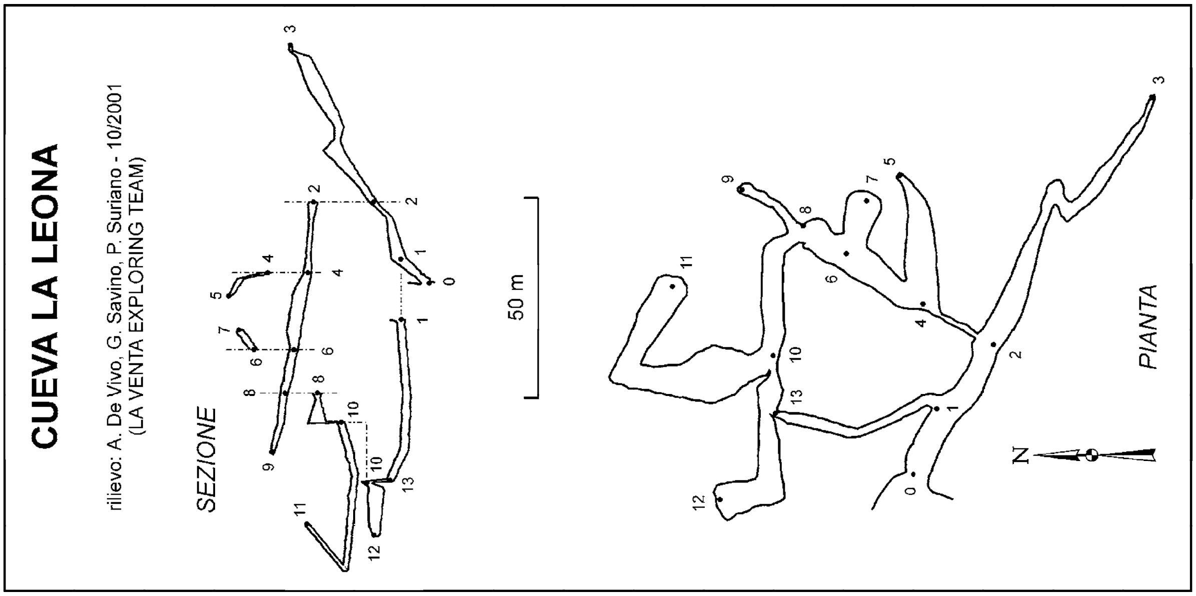

CUEVA DE LOS MURCIELAGOS
DE SAN VICENTE
rilievo: LA VENTA EXPLORING TEAM - 10/2001
N
PIANTA
30 m
SEZIONE

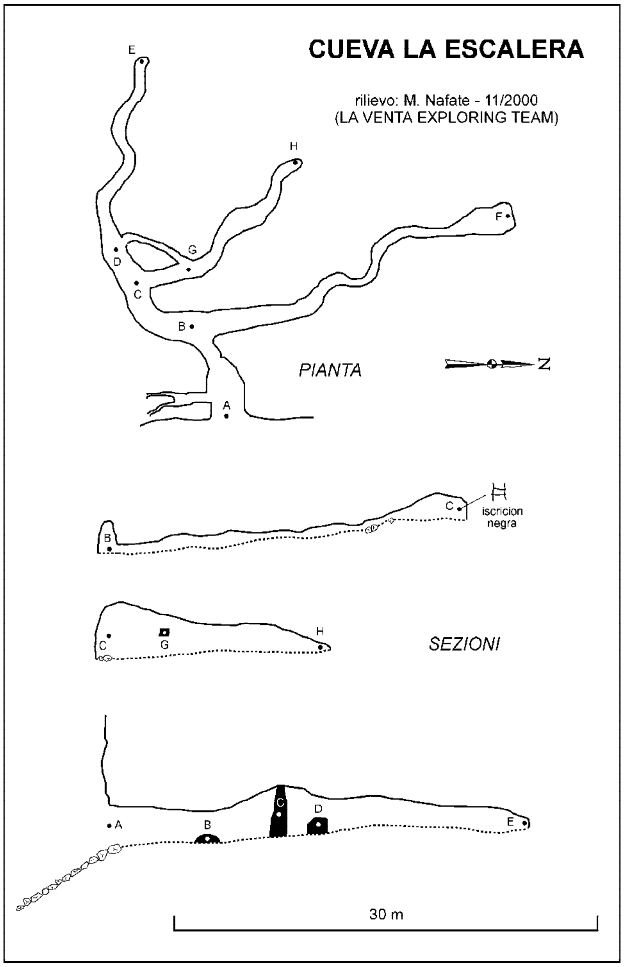

CUEVA DE LOS DESPERADOS
rilievo: L. Piccini - 11/2001
(LA VENTA EXPLORING TEAM)
SEZIONI
A'
A
B'
B
20 m
N
PIANTA
A
A'
B
B'

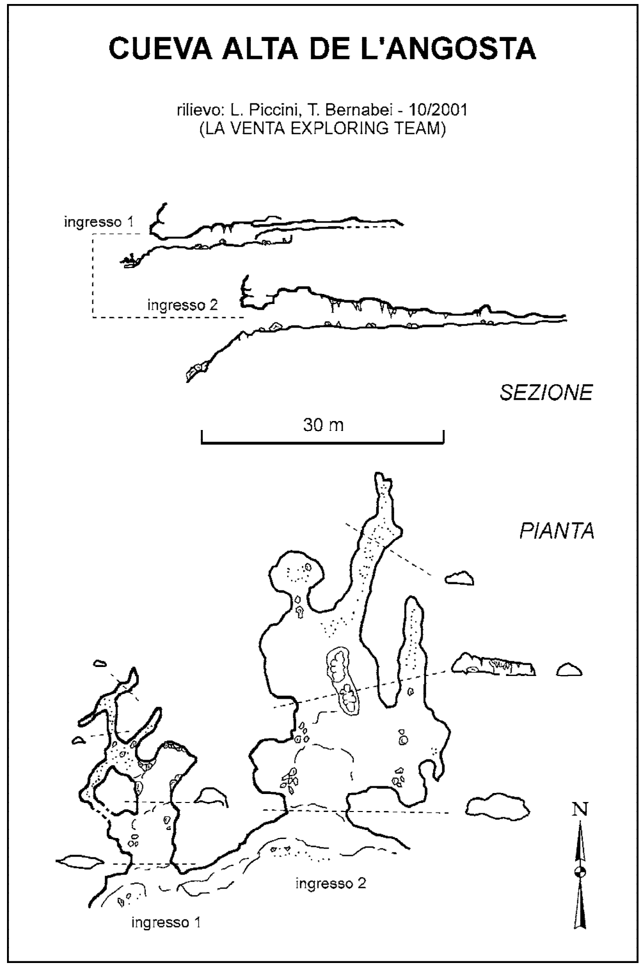

VULCANO F - scavo n. 1
rilievo: G. Casagrande, M. Nafate - 10/2001
(LA VENTA EXPLORING TEAM)
SEZIONE
A
B
C
10 m
N
PIANTA
ingresso

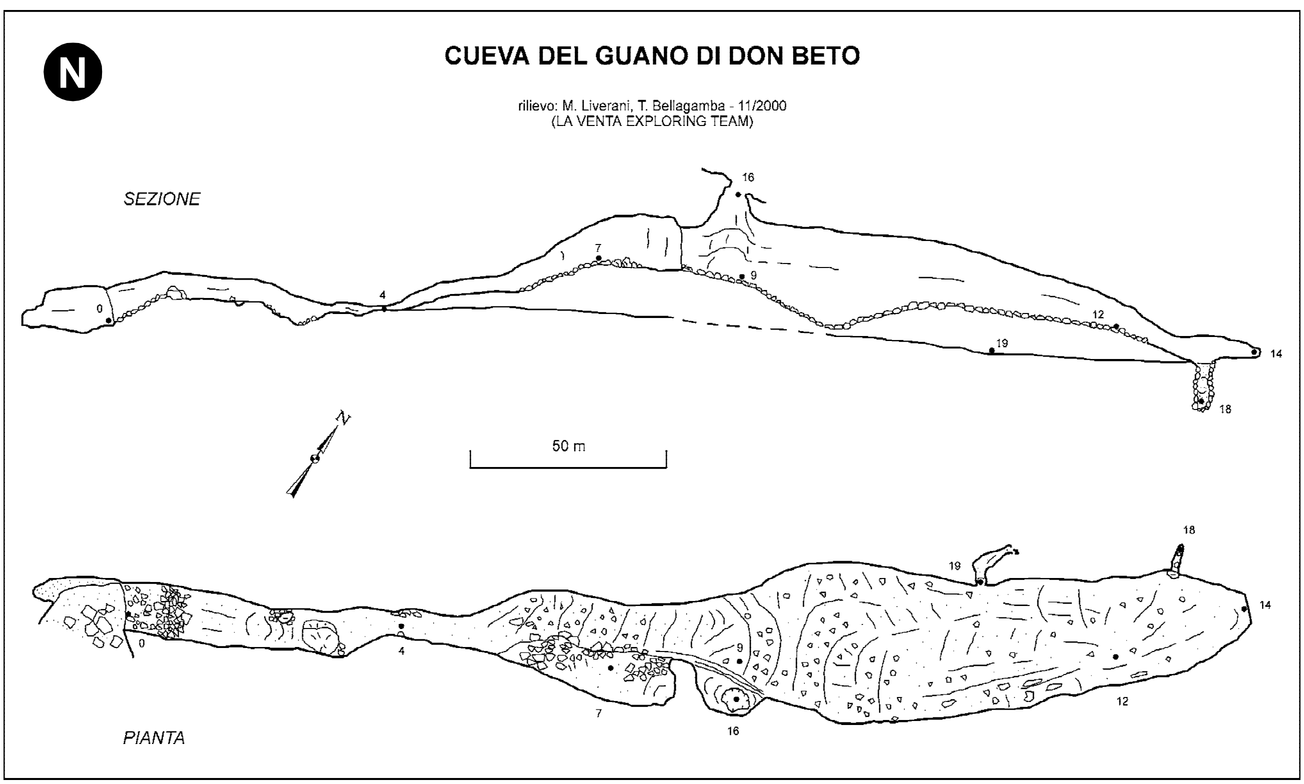

CUEVA DEL MOLINO
rilievo: L. Piccini, G. Savino - 10/2001
(LA VENTA EXPLORING TEAM)
SEZIONE
20 m
N
PIANTA

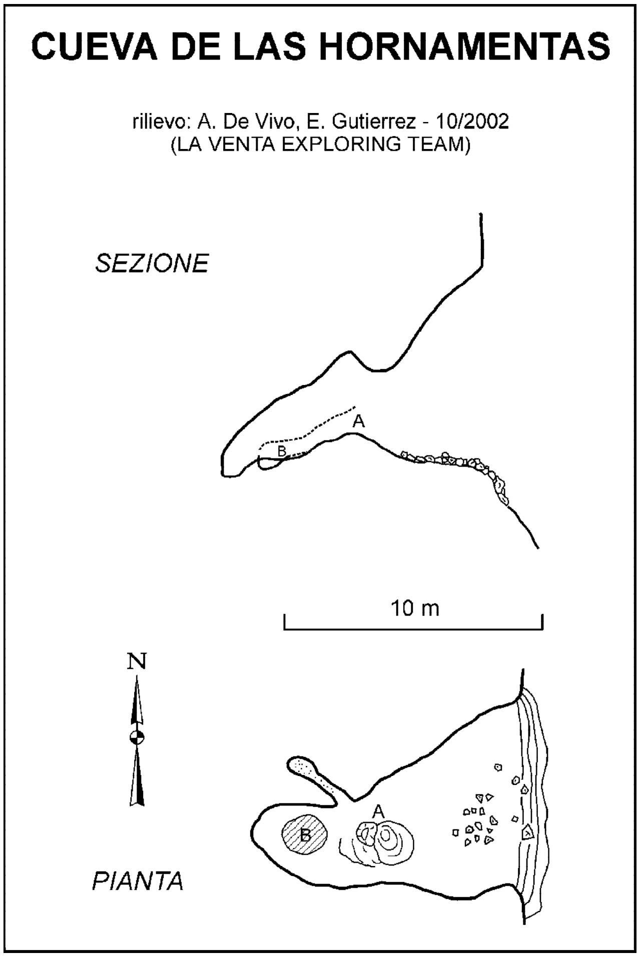

M
CUEVA LA ESPANTOSA
rilievo: A. De Vivo, M. Frova, E. Gutierrez - 10/2001
(LA VENTA EXPLORING TEAM)
N
A'
A
B'
B
C'
C
PIANTA
20 m
SEZIONI
0

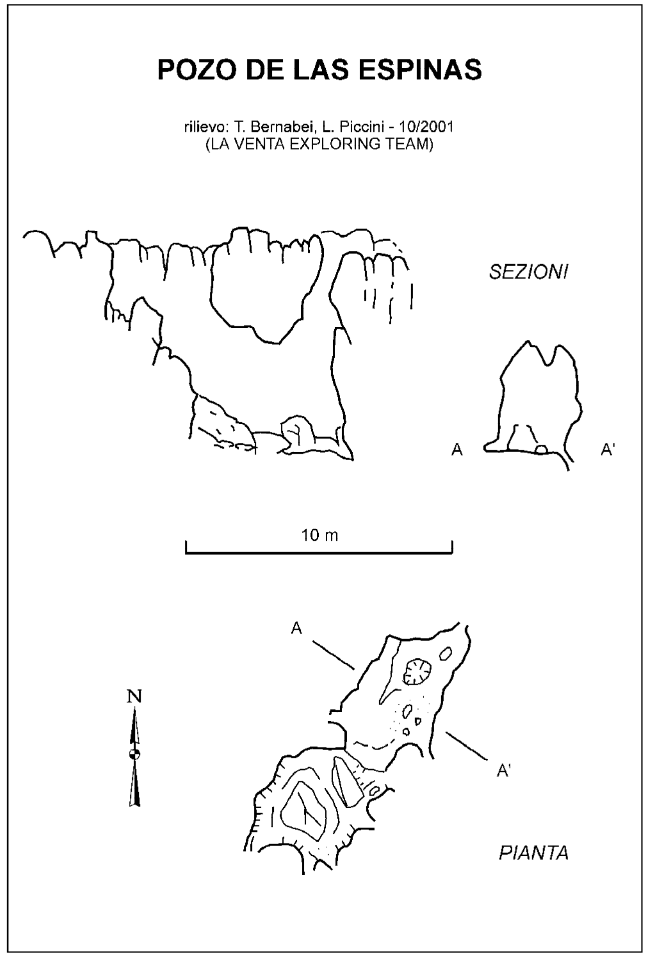

CUEVA LA LEONA
rilievo: A. De Vivo, G. Savino, P. Suriano - 10/2001
(LA VENTA EXPLORING TEAM)
SEZIONE
50 m
PIANTA
N


CUEVA LA ESCALERA
rilievo: M. Nafate - 11/2000
(LA VENTA EXPLORING TEAM)
PIANTA
N
iscricion negra
SEZIONI
30 m

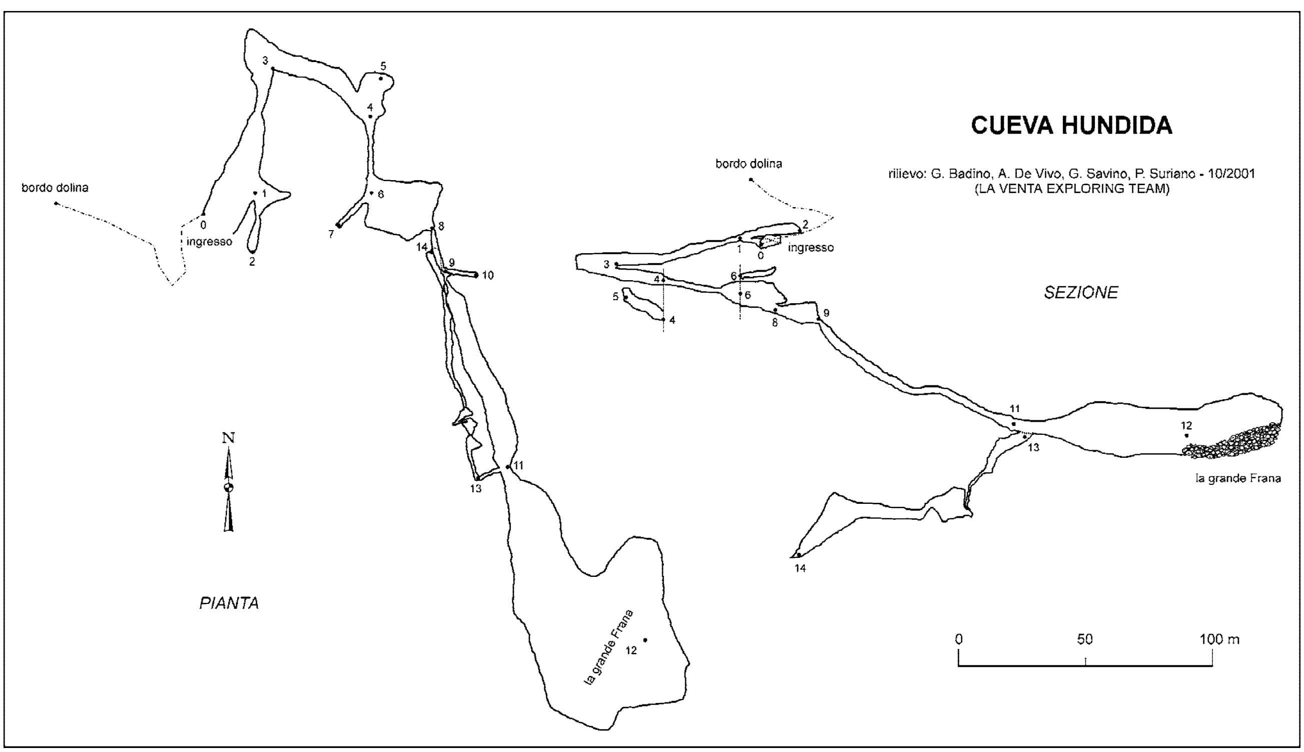

CUEVA ALTA DE L'ANGOSTA
rilievo: L. Piccini, T. Bernabei - 10/2001
(LA VENTA EXPLORING TEAM)
ingresso 1
ingresso 2
SEZIONE
30 m
PIANTA
N
ingresso 2
ingresso 1


N
CUEVA DEL GUANO DI DON BETO
rilievo: M. Liverani, T. Bellagamba - 11/2000
(LA VENTA EXPLORING TEAM)
SEZIONE
50 m
N
PIANTA


CUEVA DE LAS HORNAMENTAS
rilievo: A. De Vivo, E. Gutierrez - 10/2002
(LA VENTA EXPLORING TEAM)
SEZIONE
A
B
10 m
N
A
B
PIANTA

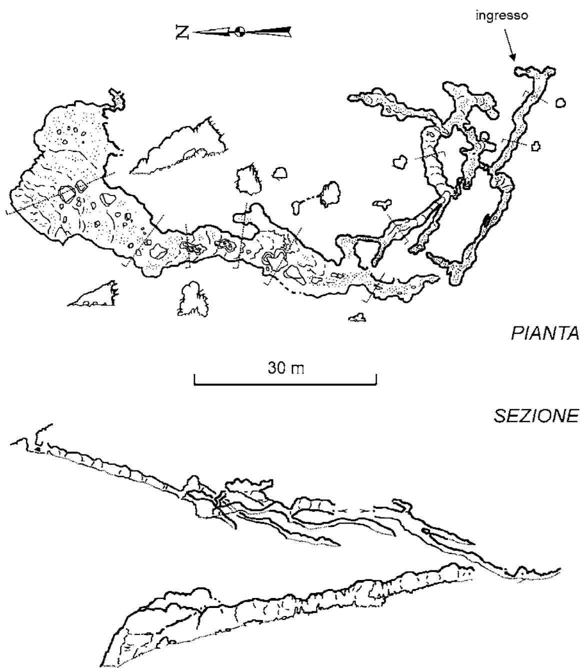

POZO DE LAS ESPINAS
rilievo: T. Bernabei, L. Piccini - 10/2001
(LA VENTA EXPLORING TEAM)
SEZIONI
A
A'
10 m
A
N
A'
PIANTA

O


CUEVA HUNDIDA
rilievo: G. Badino, A. De Vivo, G. Savino, P. Suriano - 10/2001
(LA VENTA EXPLORING TEAM)
bordo dolina
ingresso
N
PIANTA
la grande Frana
bordo dolina
ingresso
SEZIONE
la grande Frana
0
50
100 m

## CUEVA RANCHO GUADALUPE

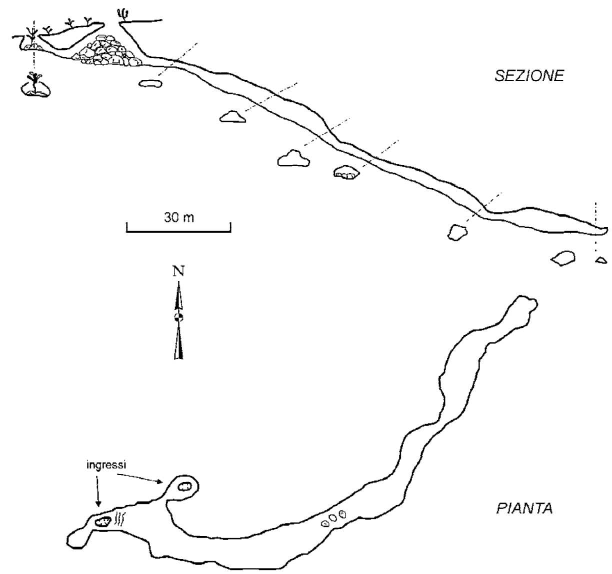
rilievo: M. Liverani, Piccini L., A. Gianolio, T. Bellagamba,
R. Abiuso, M. Frova, Savino G. - 2000-2001
(LA VENTA EXPLORING TEAM)




## CUEVA DE LA VIBORA

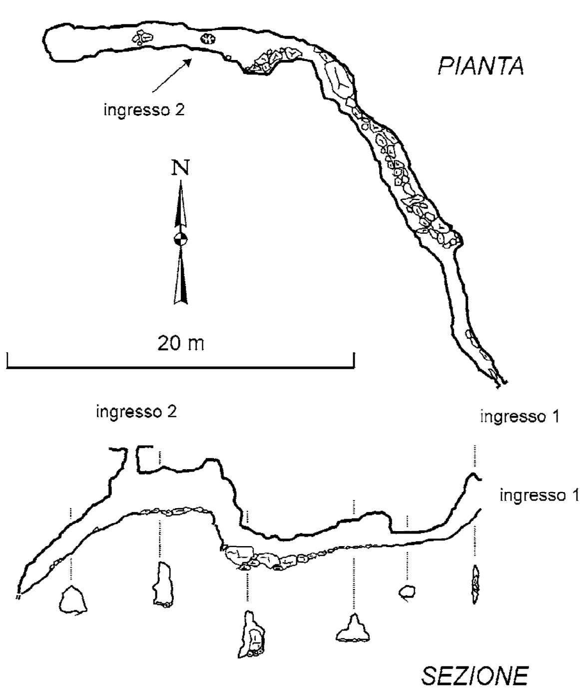
P

rilievo: LA VENTA EXPLORING TEAM - 10/2001



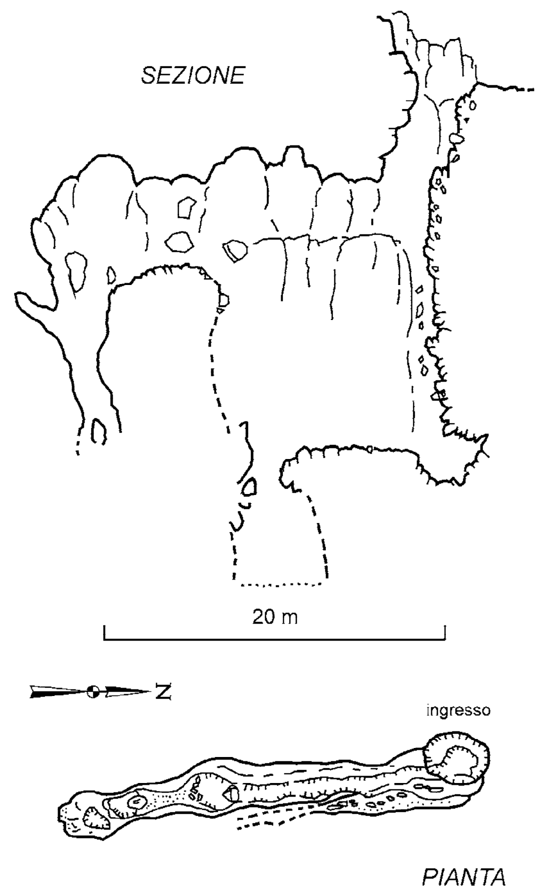

## CUEVA DEL VIVERO

rilievo: G. Casagrande, M. Nafate - 10/2001
(LA VENTA EXPLORING TEAM)




## POZO DEL JUNCO

rilievo: L. Piccini, A. De Vivo, P. Suriano - 11/2001
(LA VENTA EXPLORING TEAM)



# CUEVA DEL ZURDO, NAYARIT

## John Pint

We left the pleasures of a hot pool of water in the state of Nayarit and headed for Sanganguey Volcano, located about 25 kilometers southeast of Tepic, to determine whether we could find any lava tubes there. Three of us, Canadian Chris Lloyd, Mexican Luis Rojas, and I, drove into the little town of San José Mojarras, Nayarit, and tried our standard technique for locating caves: we went to the main plaza, found an old-timer sitting on a bench, and mentioned the word *cueva*. We quickly discovered that you have to be careful using this approach in Nayarit. Our informant immediately started to tell us all about a place that was dark "and has plenty of *muchachas*."

"No," we told the man. "We mean a hole in the ground, full of mud and guano—and with bats instead of girls."

Well, we got a funny look, but our old-timer did know of one such cave in a nearby community, and off we went, finally arriving at the grocery store of a very big man named Don José, who asked us exactly what we wanted in his cave.

"To see what kind of bats you have."

"*De veras*, and what about the treasure?"

"In forty years, I haven't seen any treasure."

"Well, it doesn't matter, because the cave entrance is only this big" (indicating the size of a soccer ball).

"*Bueno*, we don't have to go inside, but just seeing the entrance will tell us if this is a lava tube."

Here followed a long description of lava tubes, limestone caves, deep pits, ropes, and ladders, interspersed with anecdotes and jokes that put Don José at ease and produced a smile on his face.

"And, of course, we always give the land owner a detailed map of the cave."

"A map, eh? . . . *Bueno*, maybe you'd like to take a look at the entrance; it's only five minutes from here."

Big Don José, his big son, and a big friend all somehow squeezed into Chris's truck, and off we went, bouncing over what could euphemistically be called a road between two large fields of blue agaves. Then we walked to the cave entrance, a collapse of big basalt blocks. There was a space about 60 centimeters high and 1.5 meters wide with a dark cave beyond, and air smelling of guano was wafting out of it. "You see," said Don José, "nobody could fit through that little hole."

Much to Don José's surprise, we slid right into the cave like three lizards. Although none of us had helmets and we had only a few little lights, we saw enough to figure this cave was worth a return visit. And, of course, there was the nice current of air blowing out of a low passageway. . . .

A month or so passed. Then, determined to show visiting Australian caver Greg Middleton a whopper of a lava tube, Sonia Calvillo, Chris Lloyd, and I took our visitor back to the little town of Colonia Moderna, where we hoped to visit a "really big" cave that Don José had told us about. A nice old guy named Don Eduardo was supposed to take us there, but instead led us to a small cave that was not very interesting, except for the fact that Greg was the only one bitten by the cave's ants, suggesting that Australian meat merits its reputation for being extra tender.

Giving up the hunt for The Big One, we went back to Don José's Cueva del Zurdo. While Chris and Greg did a geological examination inside, Sonia and I proposed to start the survey. However, it turned out that somehow none of us had brought along a clinometer, or even a protractor and a string, each thinking the other would have one. Fortunately, Chris had by then discovered more cave beyond the entrance room, so we stowed the survey gear and began exploring.

The first room is about 10 by 20 meters, with a going passage at the far


thepints@saudicaves.com
Revised from http://www.saudicaves.com/mx/zurdo

Aussie Greg Middleton leaving Don Eduardo's disappointingly small cave. *John Pint*.

end. The walls and roof of the passage are composed of pumice tuff and are therefore exceedingly soft. A belly-crawl leads through a small room into the Obsidian Room. The floor of this room is covered with breakdown, but the ceiling consists of small, tightly packed obsidian fragments. Both Chris and Greg stated that obsidian in a lava cave is rare indeed, and possibly uniquely here.

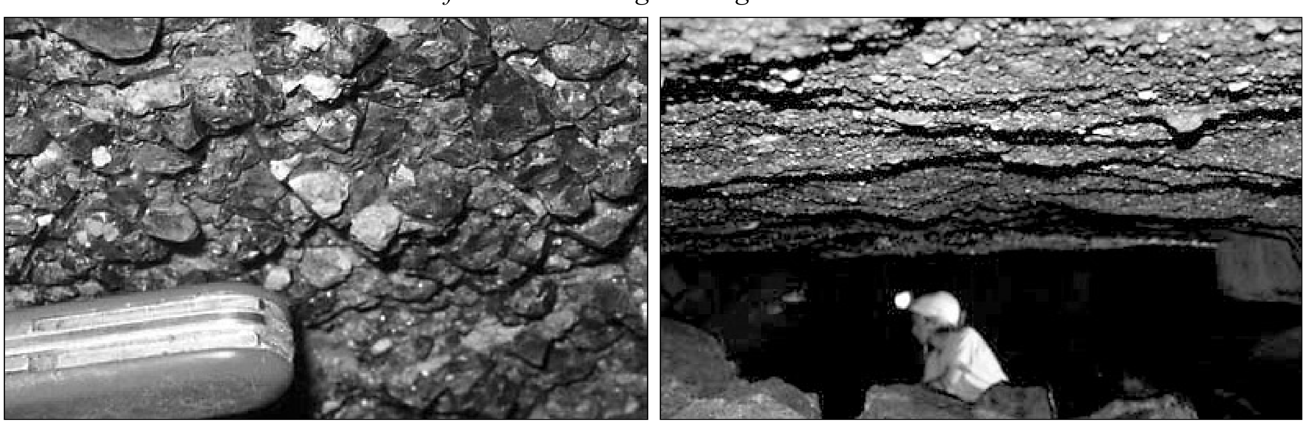
In this area we found two puddles of semi-liquid vampire goo and a great deal of fresh guano deposited by insectivorous bats. We also spotted a little spider and what looked like a cockroach with an ovaloid form. Along the wall were entrances to several other passages, each shaped in cross-section like an A and so symmetrical that I wondered whether they might not be man-made, considering how soft the walls are. Chris disappeared into the biggest of these passages, resulting in a mass exodus of bats. It appears there are at least three species in this cave, and we hope we can find a bat expert interested in visiting this place. Rather than cause any more disturbance to the bats, we decided to postpone further exploration (and our survey) until we could do this at night when the bats are all outside.

Near the end of November 2006, we finally got enough cavers together to carry out the survey of the cave. The crew consisted of Luis and Mary Rojas, Sonia Calvillo, Chris Lloyd, and me. Our plan was to camp outside the cave so we could survey at night when the bats would be devouring the local bugs. We pulled into Colonia Moderna in the late afternoon and told Don José our plan. "Where are you going to camp?" he asked, "It's all full of weeds." Well, of course, we weren't afraid of a few weeds, so off we went. Chris parked nice and close to the cave and we jumped out of the car, and that's when we discovered what Don José was talking about. In one minute, our pants were covered with hundreds of the prickliest burrs the world has ever produced. We had no problem learning the local name for these diabolical stickers, *huizapoles*, as they seemed to repopulate our clothes and shoes as fast as we could pull them off, and even weeks later, back home, we continued to find them in the most unexpected places. By the time we got our tents up and had plucked all the "wee-sa-POL-es" (that's the pronunciation) off one another, it was dark. Chris had kindly chopped a path to the cave, and we crawled inside to begin the survey.

One of the passages off to the side of the first room was almost completely covered with a white sheen caused by tiny water droplets stuck to what I assume is one of those bacterial mats that Diana Northup gets all excited about. At the far end of this room, there's a small opening that one could easily miss. Sliding through on your belly leads you to a room with a smooth, flat floor, where I decided to leave the thermometer and hygrometer. A smooth slope upward at the other end of this room leads deeper into the cave. This passage is typical of many in the cave: it's A-shaped and flat on the bottom. I still wondered if human beings had not assisted in enlarging the openings of this cave, but Chris says all the passages were formed by natural processes.

The next room was the Obsidian Room, where we spotted several of the biggest *tindarapos* (also known as *tendarapos* or *canclos* or *cancles*) we had ever seen, as well as some smaller ones with very noticeable white "elbows," so I handed the end of the survey tape to Mary Rojas in order to take some pictures. I went to drag the tripods, flashes and other stuff into this room, got some good shots of the ugly critters, and then followed the surveyors into the next room. This was the bat roost where we had stopped last time. Now it was mostly empty, except for a number of small bats with cute little faces hanging practically in front of our eyes, their wings tightly folded. They were no longer than five centimeters and, of course, I wanted a picture. Sad

The ceiling of the Obsidian Room in Cueva del Zurdo is made up of closely packed fragments of obsidian. *Left: John Pint. Right: Greg Middleton*.

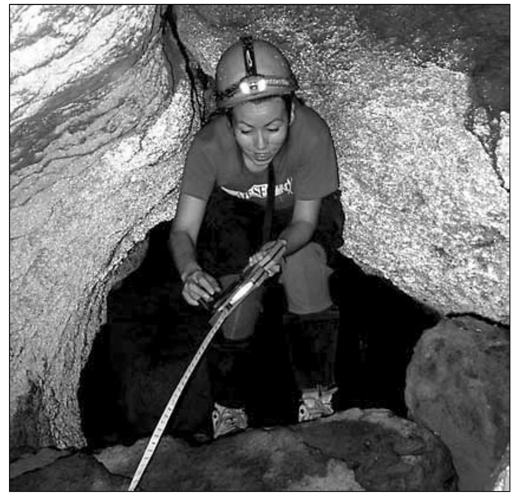


to say, however, the cave photography came to an end in this room, as every picture I took came out foggy. I had measured 22°C and 98% humidity back in the second room, but the bat zone felt much hotter and stickier, so much so that all of us were beginning to feel exhausted. However, we observed a number of interesting things in this area, which is about 100 meters inside the cave. First, there was a nest of leaf-cutter ants, and next to their hole was what to them must have been a veritable mountain of chewed-up leaves, upon which these ants cultivate a tasty fungus. Normally, this farm is located in a tunnel of the ants' making, but in this case they could use a hot, dark cave provided by Mother Nature.

We also discovered a glass Pepsi bottle, the only human artifact we saw. It has what seems to be an old, 1940s logo on one side and a more recent logo on the other and was made in Mexico, obvious proof that the ancient Aztecs preferred Pepsi over Coke. A bit farther on, we found an interesting room with only one thing in it: a rectangular, flat-topped rock about 60 centimeters long by 20 wide and 20 high. The floor was perfectly flat and smooth, and the rock, which was in the center of the room, had obviously been transported here from elsewhere. Could this spot have been used for ceremonies or meetings? OK, archeologists, when does the investigation start?

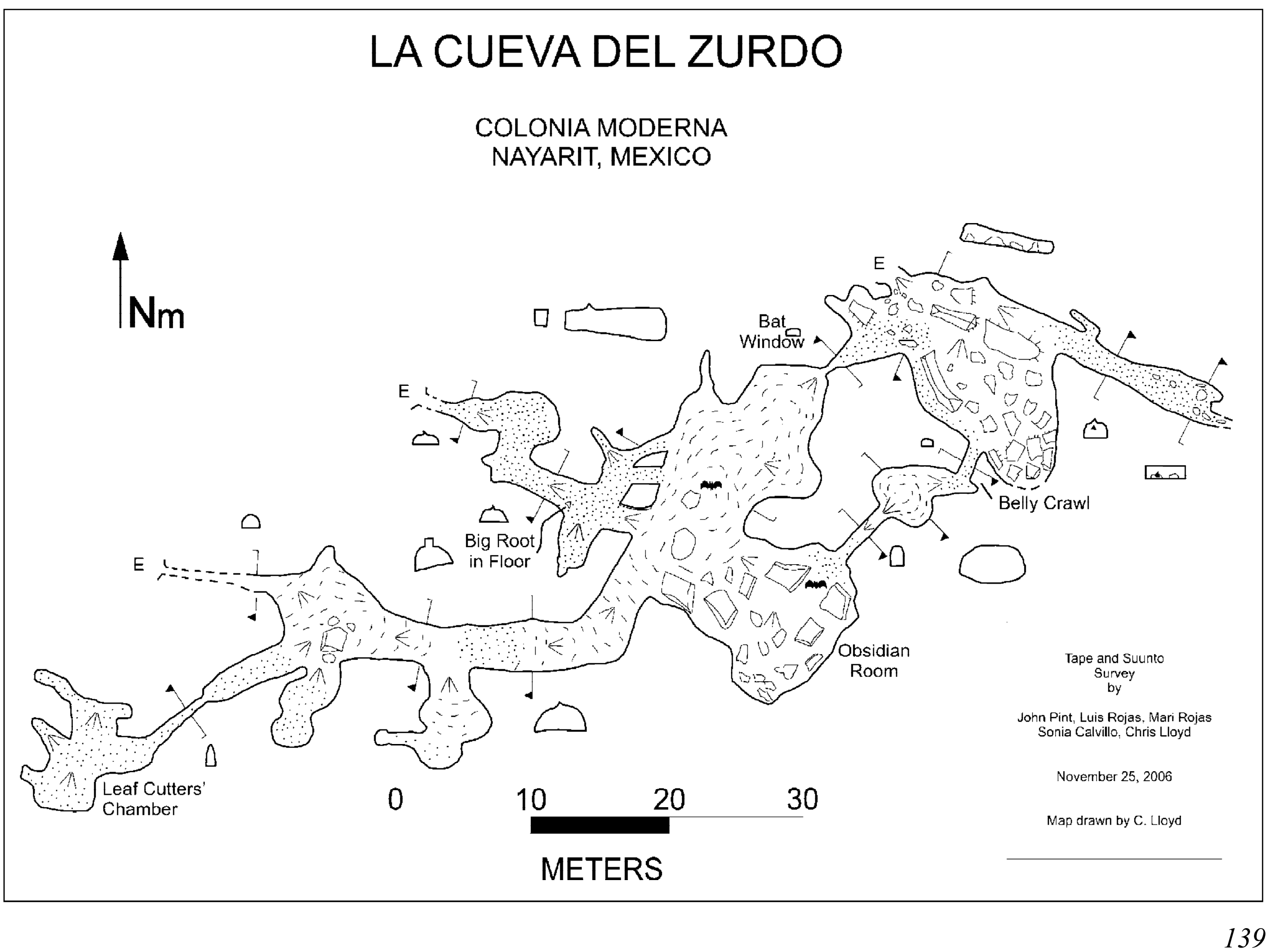
In this part of the cave, there were passages going every which way, most of them beginning as a more-or-less triangle-shaped opening. At the end of two of them we found ceiling exits, no doubt used by the bats.

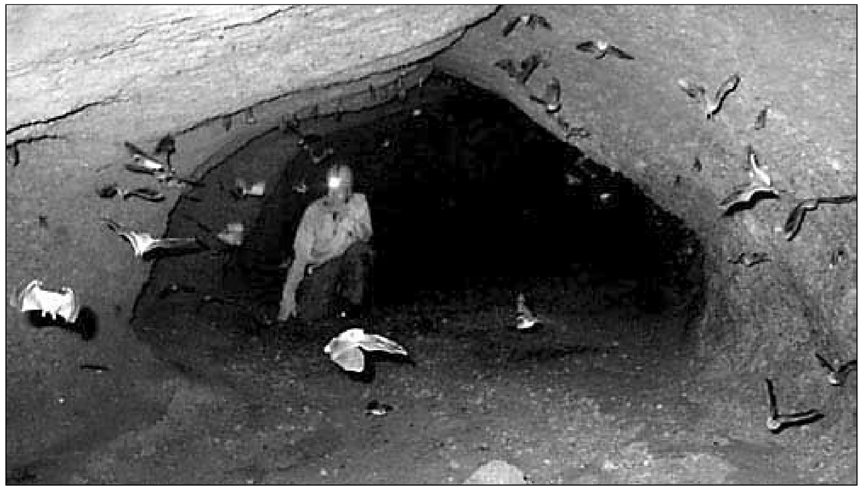
After mapping some 240 meters of passages, we headed out. Along the way, in the Obsidian Room, Luis and I spotted the strangest cave creature we'd ever seen. It has the oversized legs of a walking stick, but a shorter and thicker body. It didn't react to a flashlight circling it, so we imagined it was blind. Once again, we got no pictures, having left the cameras in less steamy parts of the cave.



Sonia Calvillo surveying between walls with a white sheen from water drooplets. *John Pint.*

We left the cave dripping with sweat, quickly finished off all the beer, and soon crawled into our tents. Although we seemed to be in the middle of nowhere, with the great hulk of Sanganguey Volcano looming above us in the night sky, we could still hear, all too





Chris Lloyd with bats in one of the larger side passages. *John Pint*.

clearly, the blast of trumpets from a Mariachi band somewhere on the other side of the cane field. It was a typical Mexican Saturday-night fiesta, but I was so worn out from the steamy cave that I didn't even notice at what time the music was replaced by the natural sounds of crickets and owls.

The next morning we packed up and spent a bit of time with Don José, who proudly showed us his tobacco crop. Thousands of tobacco leaves were neatly hung side by side beneath a tin roof. As none of us knew much about this crop, Don José demonstrated how to tell a good tobacco leaf from a bad one. "Just crumple it up in your hand. When you let go, a good leaf will quickly resume its original shape, whereas a low-quality one will stay crumpled." The only smoker in our group was Luis Rojas, but I'm sure he'll bear this info in mind next time he camps in a tobacco field.

As we had plenty of time on our hands, having completed the cave survey, we decided to check out a local town named "Las Cuevas" (which we had spotted on the map) to see if there were actually caves there. So we drove to San José Mojarras and started hunting for a dirt road heading towards Las Cuevas. Well, we found a road all right, but it forked quite a few times, and all we could do each time was to randomly pick a direction. This technique worked perfectly, no doubt because the car was full of typical cavers with the extraordinary ability to sniff out *cuevas* at a distance. Thirteen kilometers from San José Mojarras, we arrived at our goal.

Las Cuevas turned out to be a typical *pueblito* in all respects but one: a surprisingly large number of people had a boat in their back yards. When we stopped to chat with a local youth, he explained that we were very close to the banks of the Santiago River, which, the young man told us, is broad and clean in this area, and very nice for boating. This seemed hard to believe, as this river is a stinking soup of toxic waste after it flows around the city of Guadalajara, about 250 kilometers upstream. "No, no," said our informant, "the river is clean here. Many people in our village are fishermen, including me. We get very nice *tilapia* from the Santiago River." Of course, we also asked about the *cuevas* for which this village is named. "Ah, these caves are on the property of Don Antonio Cabanilla." Soon we were chatting with Don Antonio's wife, who assured us her husband was very much interested in caves and such, and a little while later Don Antonio himself took us on a tour of a river and waterfall on his property. We were amazed at how beautiful this place is, but Don Antonio remarked that there's another waterfall farther down the hill that is much bigger and more impressive. "Come and camp here on my property. I'll show you several nice places to swim, and I'll take you to several caves around here."

On our way back, we ran into a fellow named Don Simón who also promised to take us to several mysterious pits he knew about. Don Simón turned out to be quite a comedian, and after he drank one beer, he had us all in stitches.

Swimming holes, waterfalls, boating, fishing, and caves! Las Cuevas turned out to be quite a find. Don't worry, Don Antonio—we'll be back.

## Cueva del Zurdo

La Cueva del Zurdo es una pequeña y poco común cueva en Nayarit. Está formada en tufa volcánica suave y parte del techo está constituido por pequeñas piezas de obsidiana densamente apretadas.

# TWENTY YEARS OF BELGIAN CAVING EXPEDITIONS IN MEXICO

Richard Grebeude

*This short article is a summary by Yvonne Droms from "Vingt ans d'expéditions spéléos belges au Mexique," a paper presented at the Explo 2000 meeting in Europe. Most of the omitted material deals with the group's earlier work in Austria. The full paper in French can be found at http://home.scarlet.be/continent7/gsab/mexplos/20ans.htm or http://home.tiscali.be/continent7/gsab/mexplos/20ans.htm. The bibliography appended will direct you to relevant publications, including updates beyond the year 2000.*

The Groupe Spéléo Alpin Belge (GSAB) was formed in 1977 in Belgium when a small group of young but experienced cavers decided to tackle deeper and more technical caves abroad. The group first concentrated on the Alpine karst regions in Austria, where they discovered and explored a number of deep caves by using a "light and fast" technique that allowed them to map 1000-meter-deep caves without any underground bivouacs. All this practice paid off in 1988 in Mexico, when a group of seven GSAB members explored and mapped Akemati (1135 meters deep, 4918 meters long) from top to bottom in less than a week. Here is a summary of their expeditions from 1980 to 2000.

GSAB started their exploration in Mexico in 1980 in the area of Cuetzalan, Puebla, (Sumidero de Chichicasapan) but soon turned their attention to the large, unexplored area between Huautla, Oaxaca, and Zongolica, Veracruz. Starting in 1981, reconnaissance trips were organized to this area, where some very wet caves were explored in the area of Coyomeapan, Puebla. Between 1985 and 1990, GSAB mapped almost 100 kilometers of passage in a number of caves, including three caves deeper than 1000 meters (Sistema Ocotempa, Sistema Akemati, Akemabis), one 800 meters, one 700 meters, several between 650 and 500 meters, and numerous caves between 500 and 300 meters in depth, and also found various pits between 80 and 150 meters deep.

The 1995 expedition was dedicated to reconnaissance in the resurgence area in order to find out if other major caves, besides Coyolatl and Atlixicaya, existed there. Only about 5 kilometers of new passage was found, mainly in two caves, including OZ 20, 260 meters deep and 2500 meters long.

In 1997, a small team attempted to explore Atlixicaya, but a sudden flood closed the cave after almost drowning part of the team. Reconnaissance continued in the resurgence area, and 6 kilometers of new passage was found in three caves, including OZ 21, 280 meters deep and 2400 meters long.

The 1999 expedition again concentrated on reconnaissance, this time in the area highest in elevation, between 2200 and 3200 meters. Two successive high camps were established at 2500 meters, as well as a base camp at 2150 meters in the village of Zoquitlán, Puebla. Few caves over 50 meters deep were found during the first two weeks of the expedition (Charcolingua, –150 m, was the deepest), and so the group moved down to 1750 meters elevation, closer to the resurgences, and spent a week prospecting, but found nothing deeper than 120 meters or longer than 200 meters.

The fourth week of the 1999 expedition was spent at 1550 meters in Cerro Azul, above known passage in the resurgence cave Coyolatl. The most important finds include two caves, TZ 2 and TZ 7, 314 meters deep, that connected at the level of a huge room 200 by 300 meters in size, and a third cave, Tlamanictli (TZ 1), 450 meters deep and 2093 meters long, that ended in a gigantic room 250 by 500 meters, which became the largest room found in Mexico, and one of the largest few rooms known on earth.

In February–March 2000, a larger group returned to continue in the same area. A number of caves were found, mainly under 120 meters deep, but Sumidero de Tepecuitlapa yielded 1850 meters of passage to 485 meters depth, and TZ 14 had 642 meters of passage and a depth of 268 meters. TB1 (Sumidero Roberto), which was opened by widening a constriction, yielded 830 meters and a depth of 400 meters. The expedition ended with the discovery of two promising caves that were not fully explored.

In conclusion, the first twenty years of GSAB exploration in this area of Mexico showed that, even though a picture of the hydrogeological system in their area of Puebla is starting to emerge, there is still much to be discovered in less-worked areas before all the known sections of the system can be connected.

Principales cavités découvertes et explorées sur la zone d'exploration belge au Mexique **(through 2000)**

**Cavités de plus de 200 m de profondeur**

| | Nom | Secteur | Dénivelé (m) | Dévelop. (m) | Remarques |
|---|---|---|---|---|---|
| 1 | AKEMATI | Principal | -1 226 | 4 918 * | contient 1 puits de plus de 100 m + 2 puits de plus de 90 m |
| 2 | SISTEMA DE OCOTEMPA | Principal | -1 070 | 4 720 | contient plus d'1 puits de plus de 100 m + d'1 puits de plus de 200 m |
| 3 | AKEMABIS | Principal | -1 015 | 1 505 * | contient plus d'1 puits de plus de 100 m |
| 4 | AKEMASUP | Principal | -840 | 1 100 | contient 1 puits de plus de 100 m / jonctionne avec Akemati à 840 |
| 5 | SISTEMA H31 - H35 | Principal | -753 | 5 745 | |
| 6 | AZTOTEMPA | Principal | -700 | 4 000 * | contient une grande salle de + de 2,5 ha |
| 7 | CUAUBTEMPA SUP | Principal | -640 | 900 | |
| 8 | SISTEMA ATLALAQUIA | Principal | -623 | 4 530 | contient 1 puits de plus de 100 m + une grande salle de + de 2,5 ha |
| 9 | MEANDRO QUE CRUCA | Principal | -588 | 2 500 | |
| 10 | YOMETA | Principal | -582 | 721 | contient 1 puits de plus de 100 m |
| 11 | SUMIDERO DE TEPECUITLAPA TZ3 | Principal | -485 | 1 850 | |
| 12 | TLAMANICTLI TZ1 | Principal | -450 | 2 093 * | contient une grande salle de + de 7 ha |
| 13 | SISTEMA H3 - H4 | Principal | -430 | 1 300 | |
| 14 | SUMIDERO ROBERTO TB1 | Principal | -400 | 831 | |
| 15 | QUIPA XITLAMA | Sud-Ouest | -339 | 450 | |
| 16 | SOT. DEL RIO COYOMEAPAN | Sud-Ouest | -337 | 3 900 | |
| 17 | SUMIDERO DEL RIO XOCOTLAT | Sud-Ouest | 323 | 1 500 | dénivelé : +15, -308 |
| 18 | SISTEMA TZ2 - TZ7 | Principal | -314 | 1 390 | contient une grande salle de + de 2,5 ha |
| 19 | POMNOSATL | Principal | -310 | 560 | |
| 20 | SUMIDERO DE CAMPO NUEVO | Principal | -309 | 824 * | |
| 21 | CUEVA XANTILCO 0Z8 | Résurgences | -300 | 1 840 | |
| 22 | SISTEMA ICTLATLELA | Principal | 297 | 1 835 | dénivelé : +13, -284, contient 1 puits de plus de 100 m |
| 23 | SOTANO ATLALAQUIA | Principal | -285 | 470 | |
| 24 | OZ21 | Principal | -280 | 2 400 | |
| 25 | TZ00 - 14 | Principal | -268 | 642 | |
| 26 | SOTANO DE LAS MALAMUJERES | Principal | -264 | 300 | |
| 27 | OZ20 | Principal | -260 | 2 500 | |
| 28 | COYOLATL | Résurgences | +240 | 20 000 * | |
| 29 | AQUIDOUCI | Sud-Ouest | -235 | 650 | |
| 30 | CUAUBTEMPA | Principal | -232 | 250 | |
| 31 | ATLIXICAYA | Résurgences | 232 | 13 000 * | dénivelé : +92, -140 |
| 32 | SISTEMA HOLJUAZTLE | Nord | -204 | 1 630 | |
| 33 | SIMA CHARCOLINGU | Supérieur | -150 | 260 | |

* Exploration non complètement terminée
Trop nombreux, les gouffres de -150 à -200 m ne sont pas repris dans cette liste.
Le Charcolingu est cité, car c'est actuellement la cavité de plus de 100 m de profondeur la plus haute du massif, elle s'ouvre à 2 650 m d'altitude !
La cavité importante la plus basse du massif est l'émergence de Coyolatl à 400 m d'altitude.

**Cavités de plus d'un kilomètre de développement**

| | Nom | Secteur | Dévelop. (m) | Dénivelé (m) | Remarques |
|---|---|---|---|---|---|
| 1 | COYOLATL | Résurgences | 20 000 * | +240 | |
| 2 | ATLIXICAYA | Résurgences | 13 000 * | 232 | dénivelé : +92, -140 |
| 3 | SISTEMA H31 - H35 | Principal | 5 745 | -753 | |
| 4 | AKEMATI | Principal | 4 918 * | -1 226 | contient 1 puits de plus de 100 m + 2 puits de plus de 90 m |
| 5 | SISTEMA DE OCOTEMPA | Principal | 4 720 | -1 070 | contient plus d'1 puits de plus de 100 m + d'1 puits de plus de 200 m |
| 6 | SISTEMA ATLALAQUIA | Principal | 4 530 | -623 | contient 1 puits de plus de 100 m + une grande salle de + de 2,5 ha |
| 7 | AZTOTEMPA | Principal | 4 000 * | -700 | contient une grande salle de + de 2,5 ha |
| 8 | SOT. DEL RIO COYOMEAPAN | Sud-Ouest | 3 900 | -337 | |
| 9 | MEANDRO QUE CRUCA | Principal | 2 500 | -588 | |
| 10 | OZ20 | Principal | 2 500 | -260 | |
| 11 | SISTEMA PUTREFACTION | Résurgences | 2 400 | -139 | |
| 12 | OZ21 | Principal | 2 400 | -280 | |
| 13 | TLAMANICTLI TZ1 | Principal | 2 093 * | -450 | contient une grande salle de + de 7 ha |
| 14 | SUMIDERO DE TEPECUITLAPA TZ3 | Principal | 1 850 | -485 | |
| 16 | SISTEMA ICTLATLELA | Principal | 1 835 | 297 | dénivelé : +13, -284, contient 1 puits de plus de 100 m |
| 16 | CUEVA XANTILCO 0Z8 | Résurgences | 1 840 | -300 | |
| 17 | SISTEMA HOLJUAZTLE | Nord | 1 630 | -204 | |
| 18 | AKEMABIS | Principal | 1 505 * | -1 015 | |
| 19 | SUMIDERO DEL RIO XOCOTLAT | Sud-Ouest | 1 500 | 323 | dénivelé : +15, -308 |
| 20 | SISTEMA TZ2 - TZ7 | Principal | 1 390 | -314 | |
| 21 | SISTEMA H3 - H4 | Principal | 1 300 | -430 | |
| 22 | CUEVA DEL RIO TOPITZATL | Principal | 1 290 | 50 | dénivelé : +33, -17 |
| 23 | CUEAVA DE LA CANA | Résurgences | 1 220 | 104 | dénivelé : +102, -2 |
| 24 | MONTITLA | Principal | 1 020 | -71 | |

## BIBLIOGRAPHIC NOTES

compiled by Bill Mixon

There is nothing published by the AMCS about the 1980 and 1981 GSAB trips. *Speleo Flash* 126, 1981, contains an article on the 1980 trip by Jean Pierre Braun and an article on the 1981 trip by Michel Scouflaire.

"Mexico News" in *AMCS Activities Newsletter* 13 contains a summary of the GSAB 1982 and 1983 trips, with maps of Sumidero del Río Xocotlat, Sótano del Río Coyomeapan, and Cueva de las Ranas. The maps there are reprinted from an article in *Speleo Flash* 134, November 1982, by Georges Feller.

The 1983 expedition is covered in the article "Zoquitlán 83" by Patrick Bestgen in *AMCS Activities Newsletter* 14, pages 82–87, condensed and translated from *Speleo Flash* 140, December 1983. This article contains maps of Lochatouxe, Aquidouchi, Consoladores, Borrachon, Cueva de Alcomonga, and Sótano del Río Coyomeapan.

The 1985 expedition is briefly described in "Mexico News," *AMCS Activities Newsletter* 15, in an item based on material by Georges Feller in *Speleo Flash* 148, December 1985. That issue of *Speleo Flash* contains additional material on that expedition, including some maps never printed by the AMCS. Some of them are appended to this article.

The 1985 expedition is also the subject of an article "Belgian Explorations at Zoquitlán," by Georges Feller, Patrick Bestgen, and Richard Grebeude in *AMCS Activities Newsletter* 16, pages 51–58. That article includes maps of the Río Coyolatl resurgence cave, AL7, the entrance drop in Ocotempa, and Aztotempa.

The GSAB 1987 expedition is briefly summarized in "Mexico News," *AMCS Activities Newsletter* 18, under both Puebla and Veracruz, based on material in *Regards* 4, 1988, by Richard Grebeude. Included are maps of Meandre que Traverse, Pozo con Carne, and Pomnosatl, all in Puebla, and Hojuaztle and Atlalaquia, Veracruz.

There was an apparently independent Expe Sous Sierra 87 by the Belgian group Equipe Spéléo de Saint-Nicolas. Maps from that trip are in a separate article in this issue of the *AMCS Activities Newsletter*.

There is an article in *Regards* 9, 1991, about the 1988 GSAB expedition. It apparently escaped our attention at the time. Some maps from that issue are reproduced below, including profiles of Akemati, –1135 meters, and Ocotempa, –1170 meters.

Issue 9 of *Regards* also contains an article, by F. Saussus, about the 1989 GSAB trip. There is a paragraph about that trip in "Mexico News," Puebla, *AMCS Activities Newsletter* 18, based on a note in *Regards* 5, 1989.

Subsequent expeditions, before 2006, appear to have been very poorly documented, with no new cave maps published. I have searched the standard international cave bibliography and found nothing more than described below.

All I can find for 1990 is a paragraph by Ramón Espinasa in "Mexico News," Puebla, in *AMCS Activities Newsletter* 18. But it states that Akemabis was found as a new entrance to Akemati, which is apparently not true, because Akemabis is still listed as a separate 1000-meter deep cave.

There is a brief note from Richard Grebeude about the 1995 and 1997 GSAB expeditions in "Mexico News," Puebla, *AMCS Activities Newsletter* 23. There is also a table there on page 11 of the deepest caves in the Belgian area as of 1997. *Regards* 28, 1997, contains a one-column summary of the 1997 trip. This appears, translated by Melanie Alspaugh, in "Mexico News," Puebla, *AMCS Activities Newsletter* 24.

*Regards* 45, 2002, contains a short note by Richard Grebeude on the 2002 GSAB trip. It appears, translated by Yvonne Droms, in "Mexico News," Puebla, *AMCS Activities Newsletter* 26.

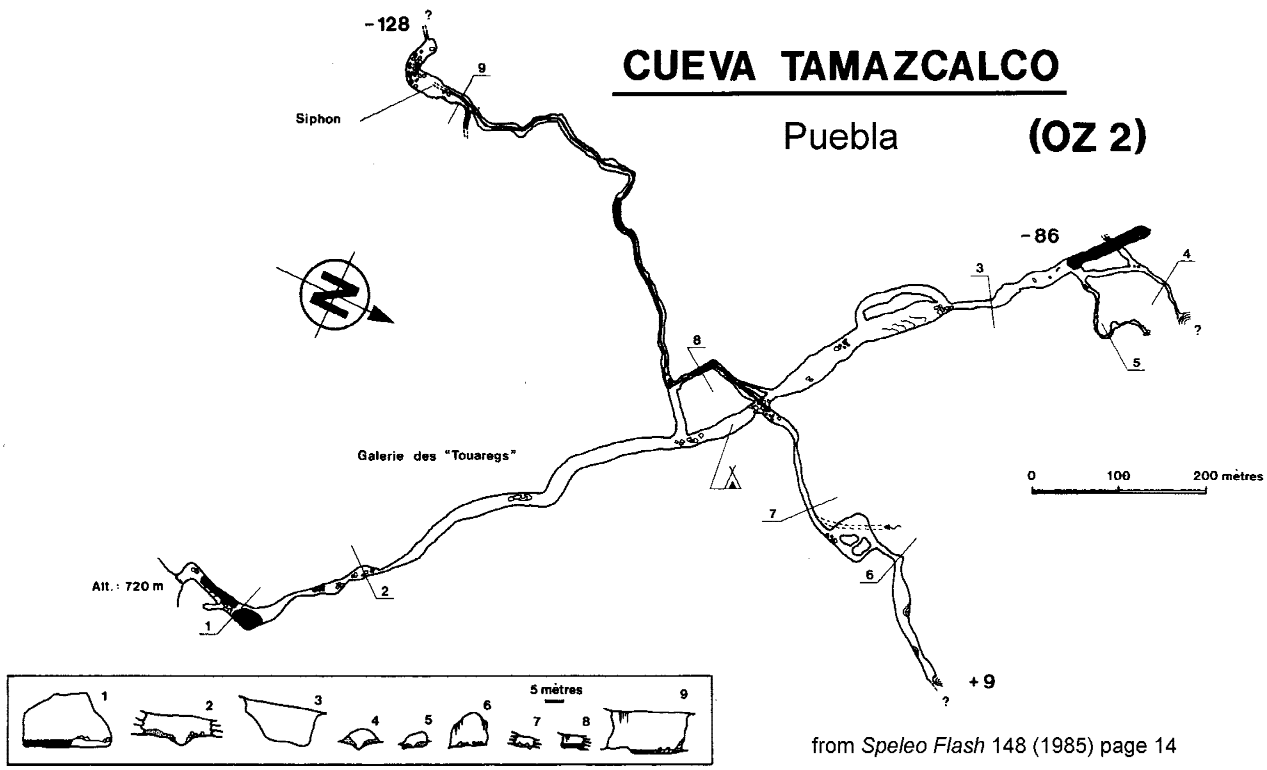
*Regards* 48, 2003 (in the pull-out "Spéléo-Info" section) contains notes on the 2003 trip written by Richard Grebeude, Serge Delaby, and Sophie Verheyden. A summary by Yvonne Droms appears in "Mexico News," Puebla, *AMCS Activities Newsletter* 27.

*Regards* 60, 2005, contains a short article by Richard Grebeude on the 2005 GSAB expedition. A summary by Yvonne Droms appears in "Mexico News," Puebla, *AMCS Activities Newsletter* 29.

See the article "A Dream Fulfilled at Coyolatl," by Gustavo Vela, in *AMCS Activities Newsletter* 29, pages 37–41, for the 2006 expedition, which accomplished a major, long-sought connection. An area map with stick maps of caves appears there. There is also an article by Richard Grebeude in *Regards* 64, 2006.

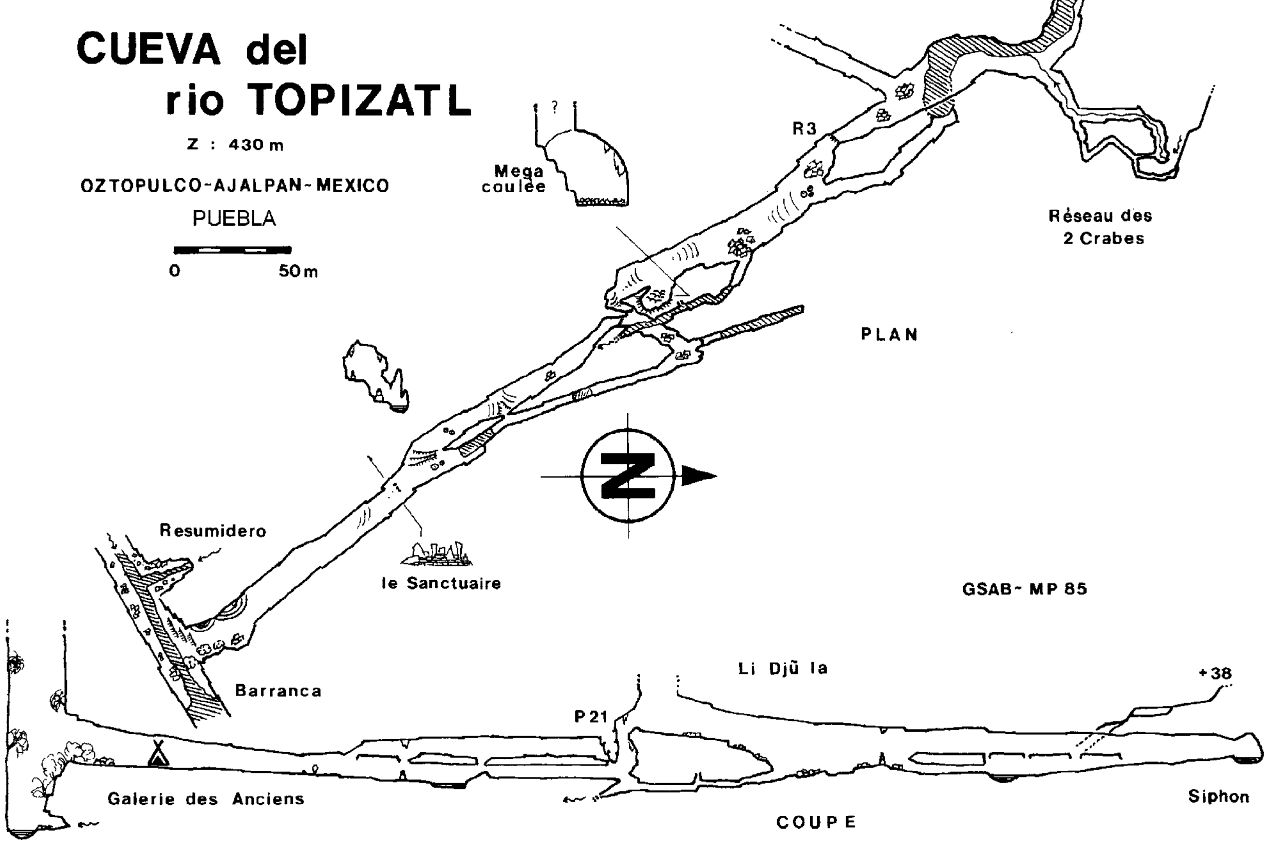

### Veinte Años de Expediciones Espeleógicas Belgas en México

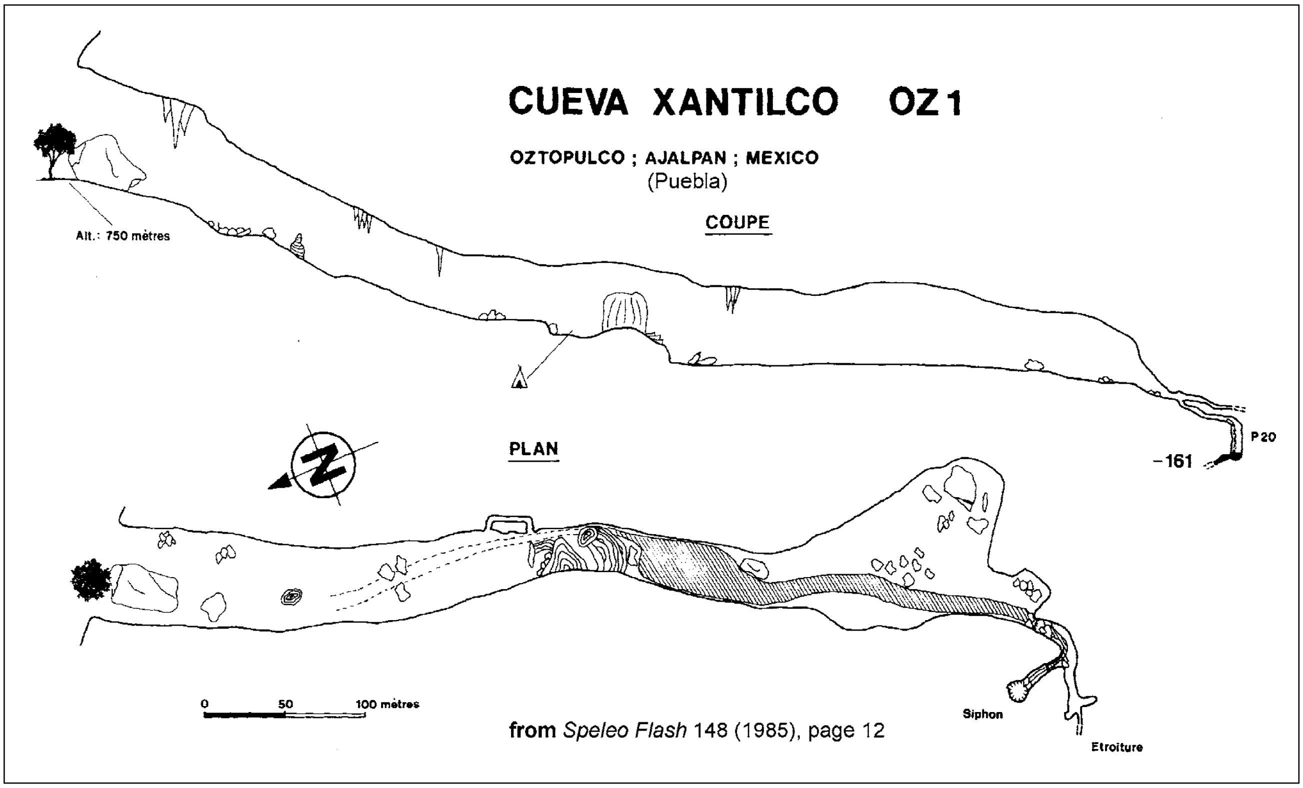
Espeleólogos del Groupe Spéléo Alpin Belge visitaron el área entre Huautla, Oaxaca y Zongolica, Veracruz, enfocando la mayor parte del trabajo en la Sierra Zongolica en Puebla o en la cercana Orizaba. Se presenta un resumen de su trabajo entre 1980 y 2000 y también algunas reimpresiones de mapas.



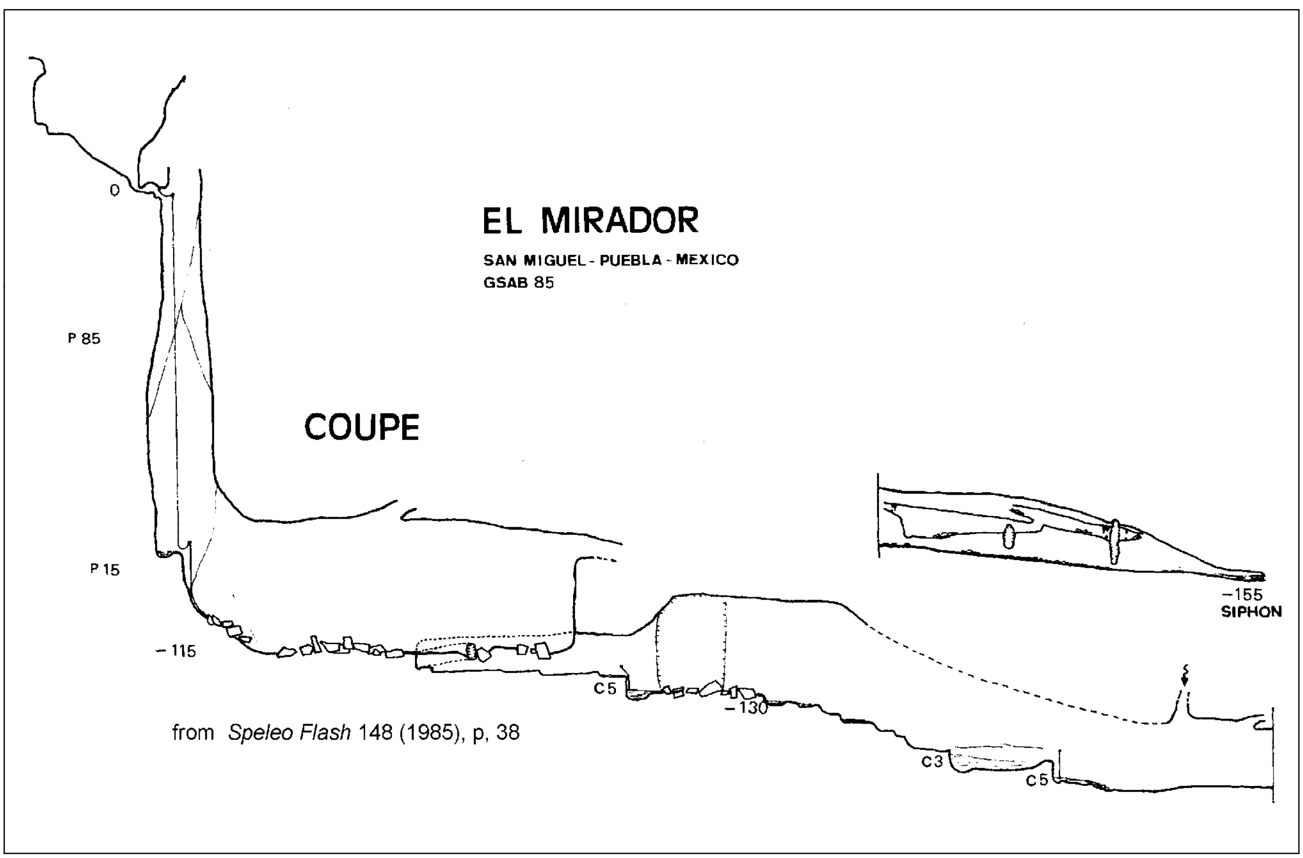

from *Speleo Flash* 148 (1985) page 14

from *Speleo Flash* 148 (1985), p. 16

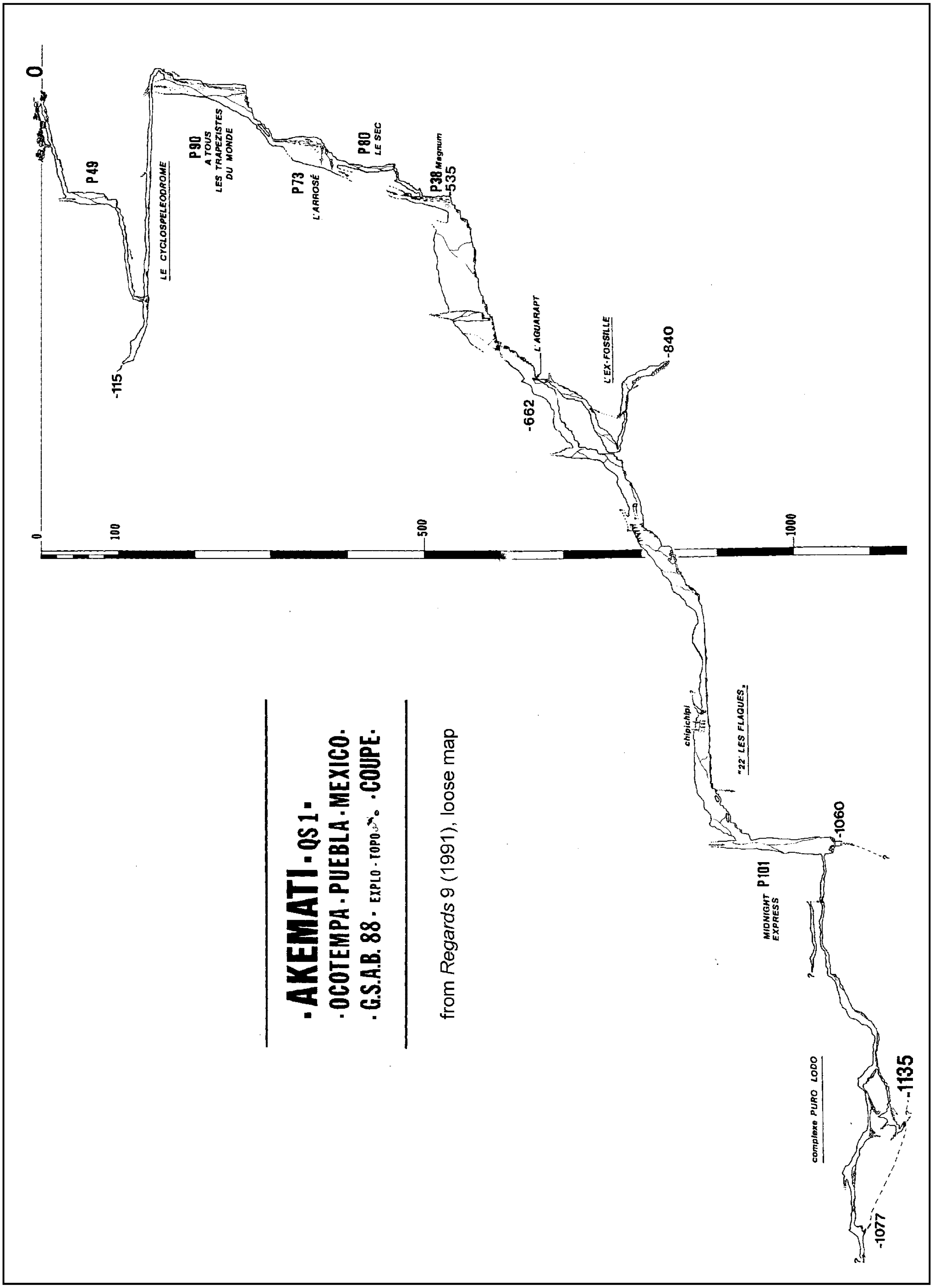





from *Speleo Flash* 148 (1985), page 12




from *Speleo Flash* 148 (1985), p, 38

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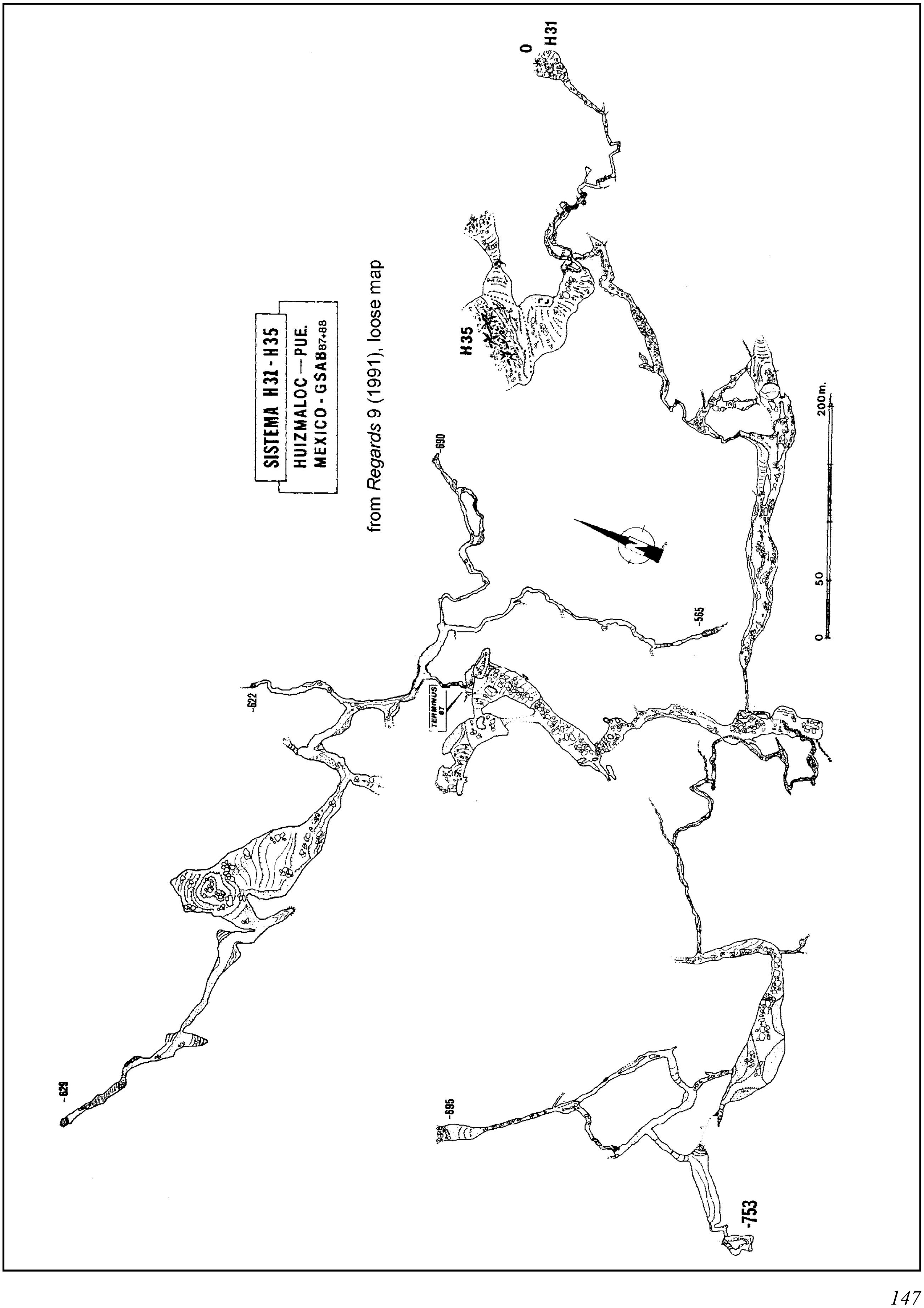


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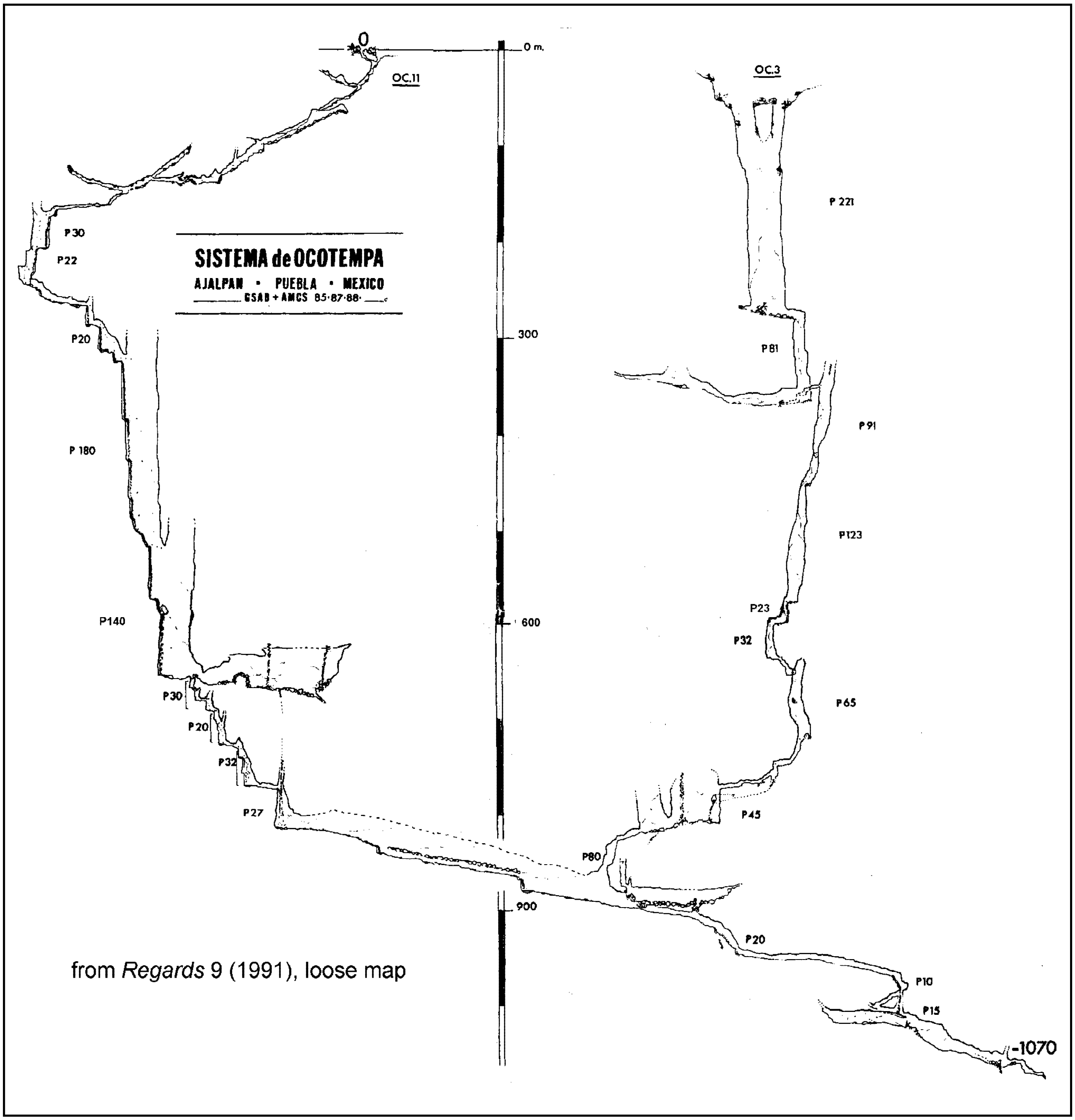



from *Regards* 9 (1991), loose map

# MAPPING CHIKIN HA WITH A PASSIVE FLUXGATE MAGNETOMETER

Richard Wylde

*This article describes an interesting idea for attempting to control the errors in an underwater cave survey. It clearly has much more limited range and much less accuracy than the traditional "cave radio," but does not require the underground apparatus to remain in place for a long time. It also requires less thrashing around in the jungle.*

The underwater cave systems of the Yucatan Peninsula in Mexico are some of the most beautiful caves in the world. Formed in recent geologic time, many of them show evidence of past vadose periods, such as stalactites, flowstone, soda straws, and stalagmites that could only have been formed in dry caves when the sea level was much lower during the ice ages, when water was locked up in ice on the continents. The caves have been flooded since the water rose again at the end of the last ice age, some twelve thousand years ago.

All rainwater landing inland finds its way through porous limestone into small channels and then increasingly large channels to the sea. The formation of cave systems by dissolution is aided by the intrusion of salt water below, leading to extensive haloclines, junctions between cool, fresh water on top and slightly warmer, denser salt water below. Where the waters mix, they are able to dissolve additional calcite, creating extensive horizontal cave passages.

From a cave-diving point of view, the systems on the Caribbean Coast of Quintana Roo are mostly very shallow, often averaging only 13 meters water depth or less, allowing long penetrations. The systems are very complex and extensive, so considerable effort needs to be made to avoid becoming lost.

Cave-diving instructor Fred Devos, who is based in the Yucatan, and I have been mapping a small system called Chikin Ha (Mouth-Sun Water), an extension of the much larger Ponderosa system, some 15 kilometers long. Technically, Chikin Ha is not part of the Ponderosa system because it is not possible to travel from one to the other through a cenote without being exposed to rain, should it be raining. Chikin Ha was first explored by Danny Riordan and Bil Philips in the late 1990s. For a beginner in underwater mapping with limited time in the Yucatan, it has proved to be a cave on the right scale to map. A thin nylon line runs through the cave system, tied off to outcrops of rock on the wall, to aid navigation into and, more importantly, out of the cave. Our mapping technique uses traditional equipment—depth gauge, magnetic compass, and fiberglass tape measure—to determine the positions of the stations where the line changes direction. The distance to the other wall at each station is also measured and aids the sketching of the walls of the cave. Typically, a small section of cave, perhaps some ten stations over a distance of 150 meters, is measured in one dive. The measurements are written on a slate and, during a second dive, a freehand sketch is made of the walls and any interesting cross-sections. The process is then repeated until all of the main line and any side-passage lines have been completed. [See "Surveying Underwater Caves" by Jim Coke in *AMCS Activities Newsletter* 24.]

The natural inaccuracies in the instruments are magnified by the difficulty of operating underwater. Time is limited, and errors of measurement and recording are easier to make than above ground. An independent way to confirm the position of a mapping station in the cave would be useful to limit and correct the buildup of errors. By connecting the position of a station underwater to a GPS reading above ground and relating that to the length of the underground survey from the entrance, the level of error can be determined, and this can be used to adjust the map.

I was drawn to the possibility of using the field of a permanent magnet in the cave and a magnetometer on the surface to provide location and error correction by the article "PIC Magnetometry Logger" by John Becker in the July and August 2004 issues of *Everyday Practical Electronics*, a popular UK hobbyist magazine. The author described how to build a magnetometer data-logger, using two fluxgate sensors and a small microprocessor-based recording device. Becker had configured the two sensors to act as a gradiometer, looking at the difference between two aligned sensors spaced about a meter apart, and he had written firmware that would take a reading about every second, recording the raw data in non-volatile memory for subsequent downloading into a PC for analysis.

Fluxgate magnetometers are simple directional magnetic sensors developed during the Second World War to detect submarines. (See sidebar.) Becker's design used FGM-3 fluxgate magnetometers constructed by the small UK manufacturer Speake and Co., giving

r.wylde@terahertz.co.uk
A version of this article appeared in *Underwater Speleology*, August 2006.

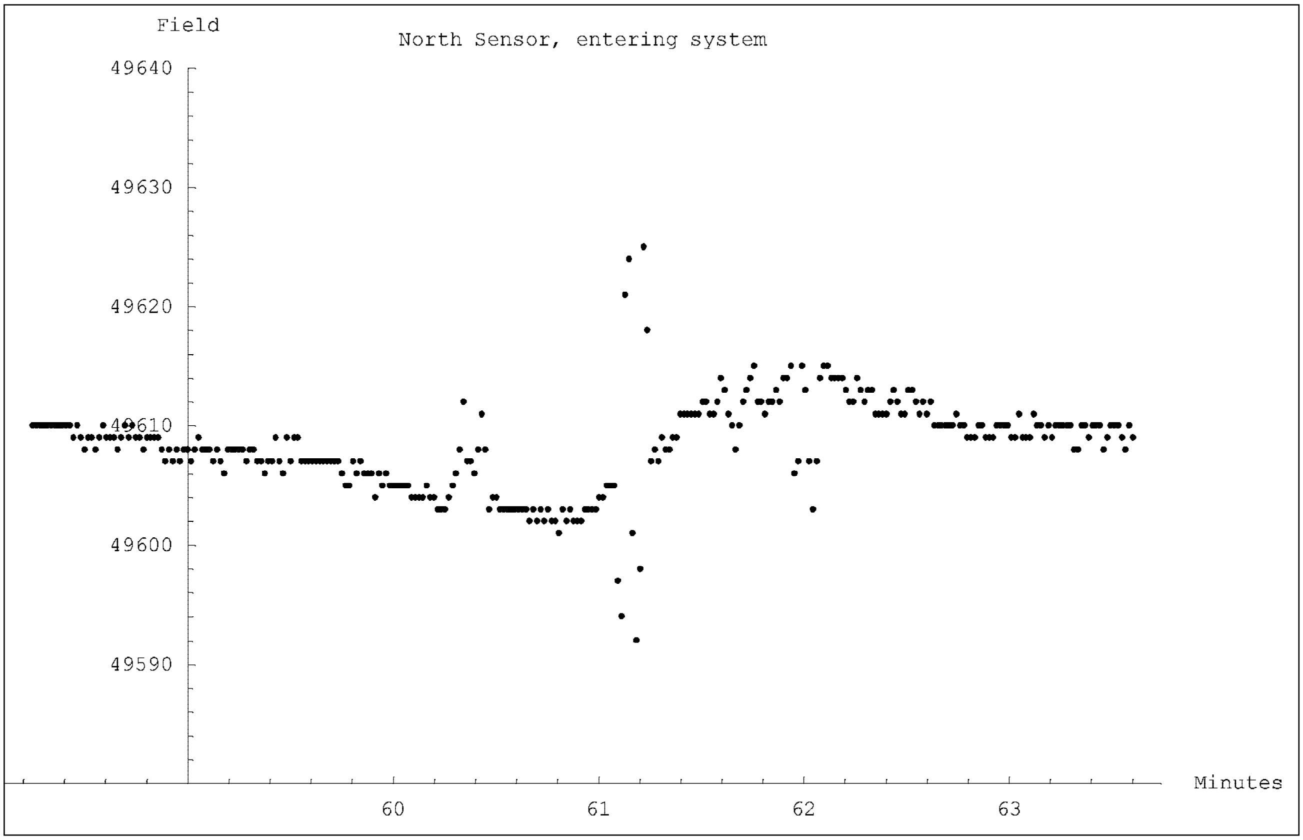



Figure 1. North sensor output during inward journey, showing flips.

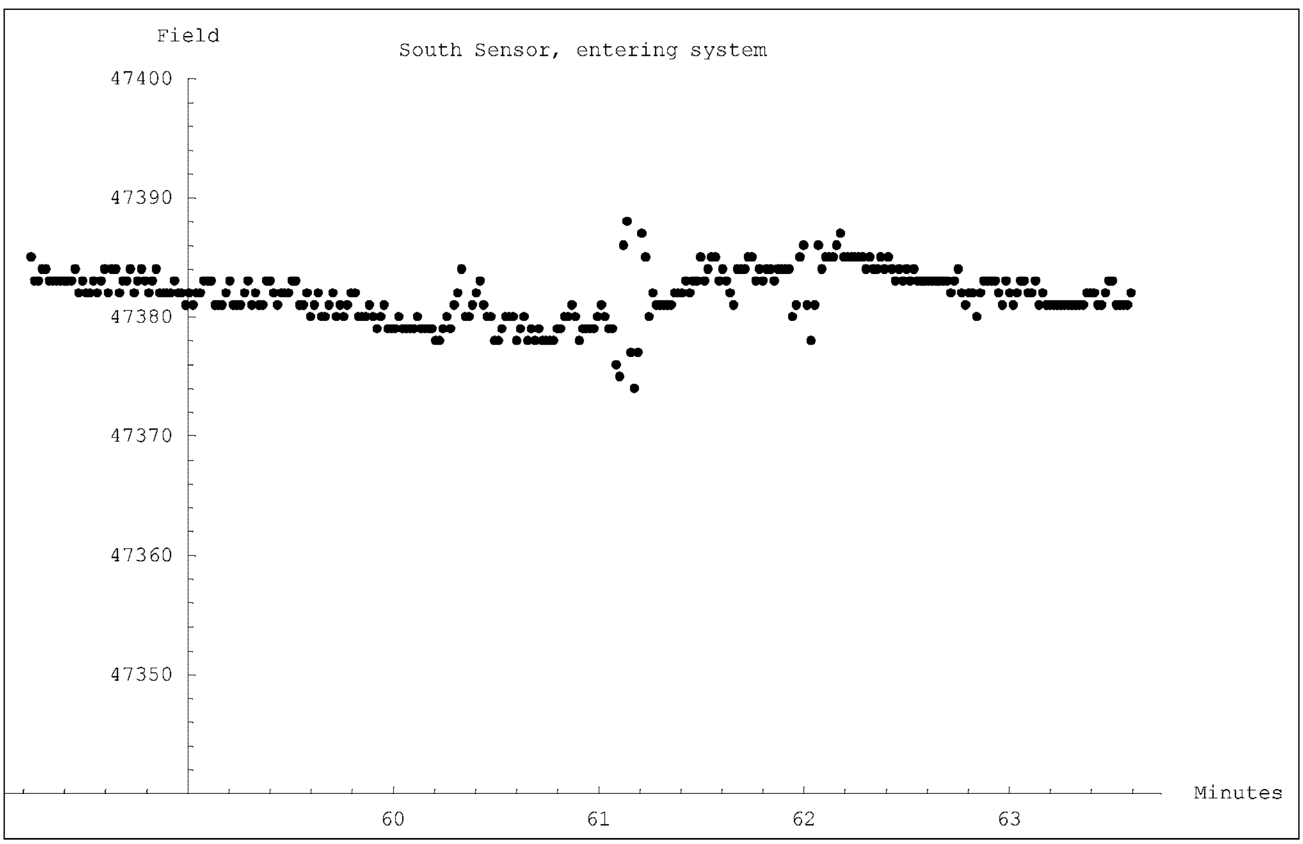



Figure 2. South sensor output during inward journey, showing flips.

sensitivity of a few gamma. (One gamma is $10^{-9}$ tesla or $10^{-5}$ gauss. For comparison, the earth's magnetic field ranges from 0.3 to 0.6 gauss or 30 to 60 microtesla.) A gradiometer of the type described in Becker's article was constructed. Trials on land showed that it could detect the presence of a magnetic moment from a few kilograms of some permanently magnetized ferrite slabs at a distance of 10 meters or so. A neutrally buoyant version of the magnet was constructed by Simon Richards using four kilograms of neodymium magnets in plastic tubes.

The magnet was towed into a cave system in the spring of 2005 and left at a known station, aligned with its field vertical. Unfortunately, it proved impossible to walk through the thick jungle while carrying the gradiometer with sufficient stability to get good readings, so an alternative approach was taken. The two fluxgate sensors were split and separated by a 10-meter cable. The sensors were then placed above the predicted position of a station, as determined by the traditional survey. This was not a trivial task in itself, cutting a way through scrub jungle with poisonous plants and the odd tarantula. The sensors were near the predicted position, at the ends of a line orthogonal to the line arriving at the underground station. The sensors were oriented to measure the vertical component of the magnetic field. The exact time that the magnetometers started to collect data was recorded, and the magnet was taken into the cave, with its pole axis held horizontally. At seven stations, the target station and three on either side of it, the magnet was flipped briefly so that its field pointed up twice and then down twice, and the exact time was recorded. Two divers were involved, one to manipulate the magnet and the other to record the station numbers and times. Two divers are needed for safety, anyway. After a short rest, the divers returned the magnet to the surface, passing back by the stations.

The map shows the two locations in the cave at which this experiment was performed. In the data shown, the sensors were placed north and south of a station just beyond the connection between the main line and a bypass line that had been introduced to avoid a shallow section of the cave that would complicate decompression planning for divers in the system. This is the location of cross-section II in the entrance area of the cave map. The effect of flipping the magnet is superimposed upon a slow change in the field due to the passage of the horizontally oriented magnet. The signals from the north and south sensors during the inward passage, including the flips, are shown in Figures 1 and 2. The north sensor data from the outward passage is shown in Figure 3. Because of the limited detection range, only the flip signals from the closest adjacent stations are visible in the data. Figure 4 shows the theoretical curve for an outward passage of a horizontal magnet (not to the same scale), which agrees with the background data.

By using the recorded times, one can match the peaks from the flips to the station numbers. In the case shown, the highest signal was at the intended target station, but the signal from the north sensor was a factor of 2 higher than that from the south sensor, indicating that the magnet did not pass under the center of the 10-meter surface line. One attraction of this approach is that one

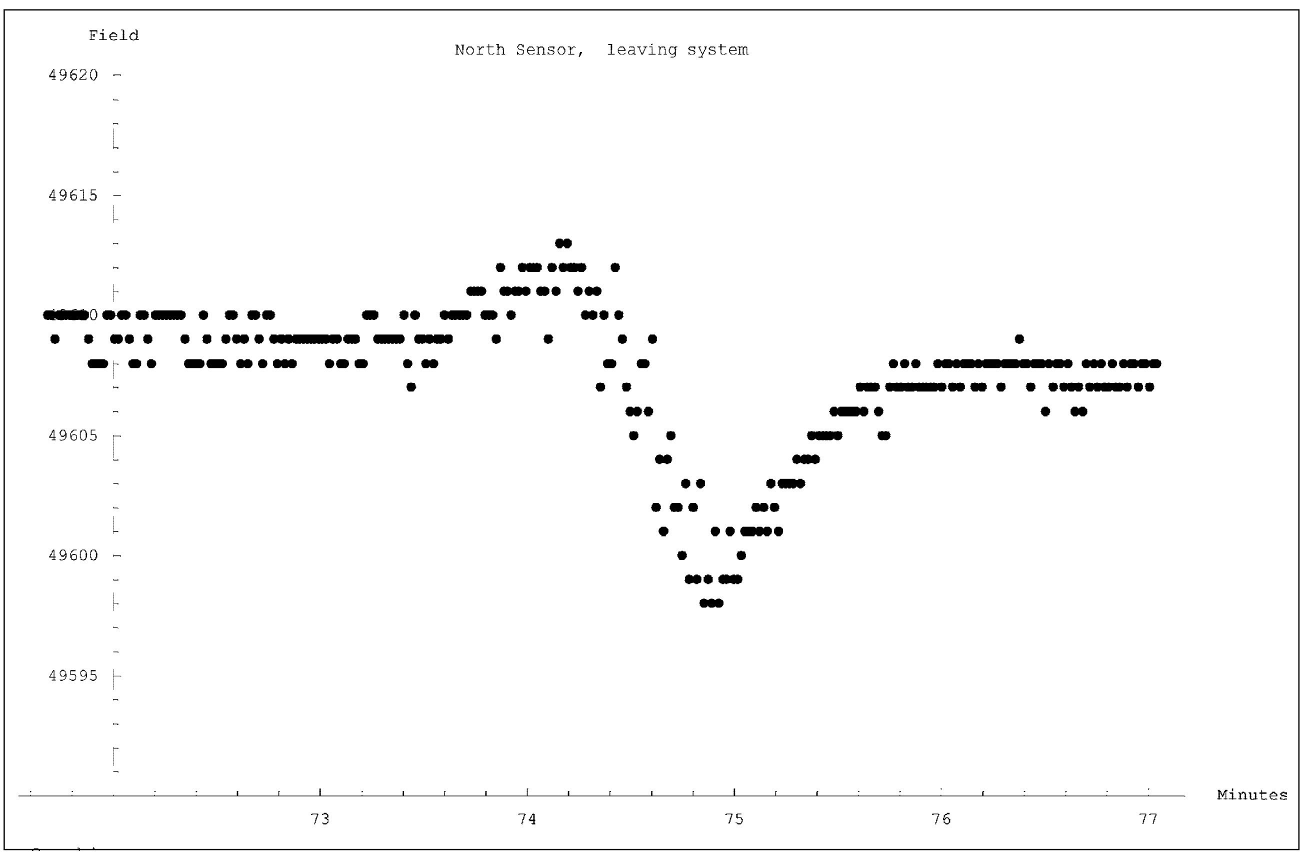
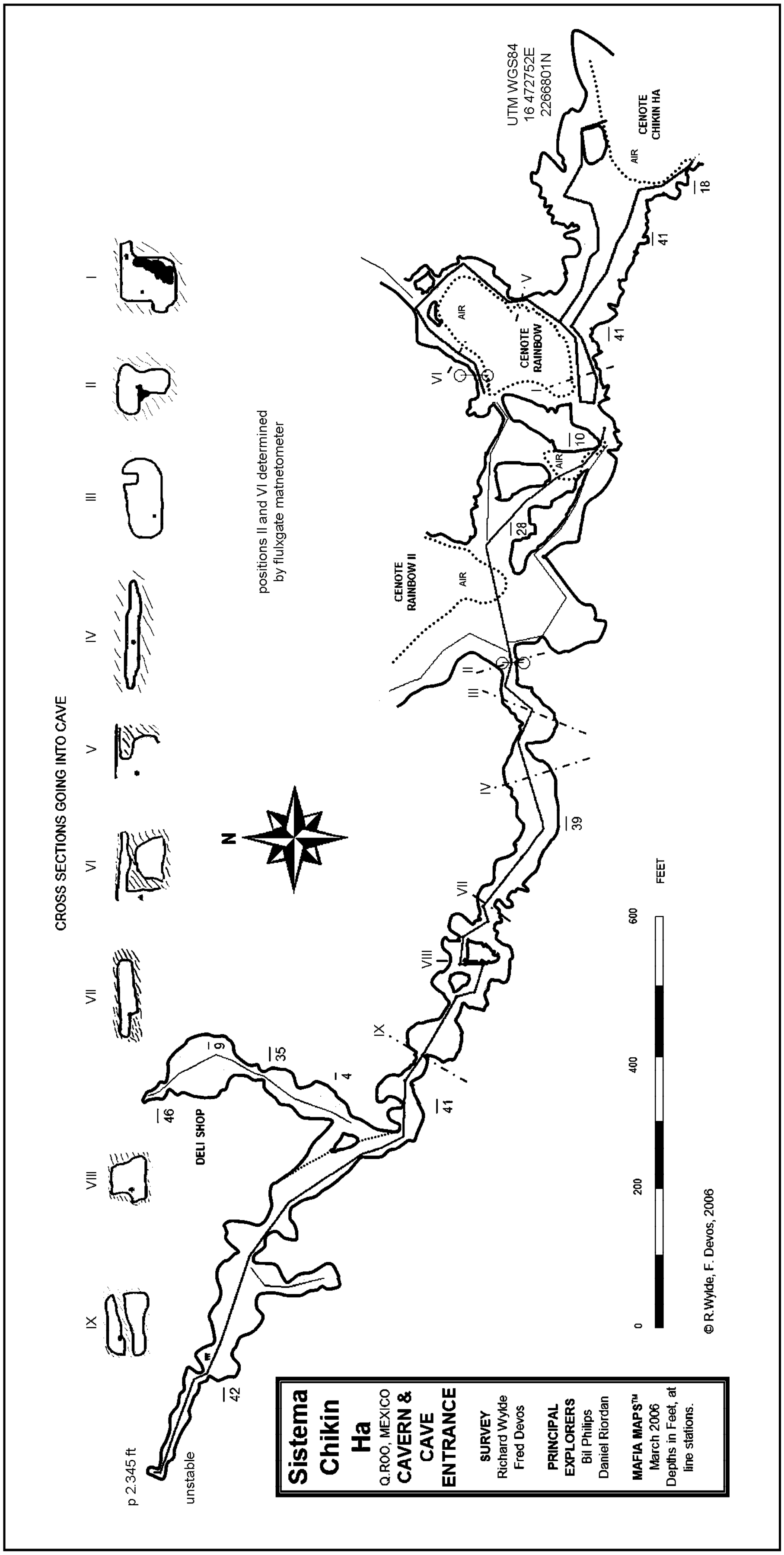



Figure 3. North sensor output during outward journey.


Sistema
Chikin
Ha
Q.ROO, MEXICO
CAVERN &
CAVE
ENTRANCE
SURVEY
Richard Wylde
Fred Devos
PRINCIPAL
EXPLORERS
Bil Philips
Daniel Riordan
MAFIA MAPS™
March 2006
Depths in Feet, at
line stations.
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CROSS SECTIONS GOING INTO CAVE
I
II
III
IV
V
VI
VII
VIII
IX
positions II and VI determined
by flulxgate matnetometer
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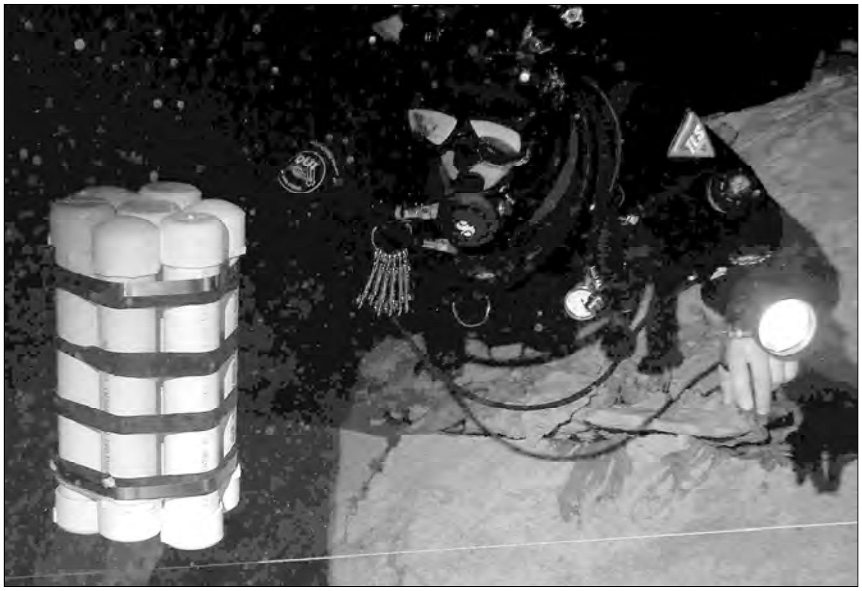

Diver with the magnet, which consists of neodymium magnets sealed in a PVC pipe. Additional pipes provide neutral buoyancy. *Richard Wylde*.

Measuring the azimuth at a station. *Richard Wylde*.

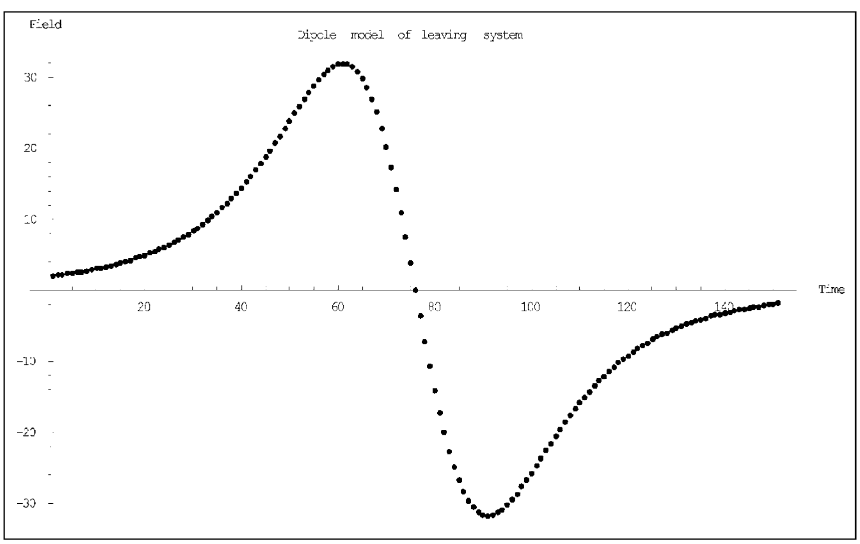


Figure 4. Predicted form of signal during return journey.

is not relying on just one measurement. All of the data points have a part in confirming the position of the sensors with respect to the station. For example, one also sees the effect of the flips at the stations adjacent to the target station. A further check is given by the slow variation during the movement of the horizontal magnet past the area, both on the inward and outward journeys. Furthermore, given knowledge of the shape of the field and the depth of the station, the ratio of the signals can give the position of the target station along the direction connecting the sensors. Since the dipole field from the magnet drops as the cube of the distance, the signal ratio actually converts to a 3.5 to 6.5 north/south ratio.

The Chikin Ha map shown here was prepared using an Excel-based program, Mafia Maps. The program calculates the positions of the stations, and it is possible to include loop-closing data for a station and have the program adjust other stations accordingly. The graphic capabilities of Excel were then employed to draw the map. The small circles at the locations of cross-sections II and VI show symbolically where the sensors were positioned for the two measurements, but not necessarily their true positions relative to the underground lines. From the station II data discussed above, the magnetometer data gave a correction of 11.3 meters east and 6.7 meters north, calculated on the basis of the magnitudes of the flip signals at the target and adjacent stations. The combined error of 13 meters in a surveyed distance of 279 meters indicates an original survey error of 4.7 percent.

Our approach with a permanent magnet underwater and a fluxgate magnetometer on the surface has allowed the error in a traditional underwater survey of a small cave, such as Chikin Ha, to be reduced by perhaps a factor of 3, and this improvement would increase when used in longer caves. Using a permanent magnet underground does not add significantly to the divers' task-loading, as might setting up an RF coil, and good signal-to-noise ratio is obtained. With two sensors, the path scanned can be a good 30 meters wide in the direction orthogonal to the divers' direction of travel along their line. More sensors could easily be added at fairly low cost. The cost of the electronics was no more than \$300. Depth capability could be increased by using more magnetic material. Care would be needed to ensure that the increased field did not trigger the magnetic switches on scooters used to transport the divers into the cave. When the current magnet was placed too close to a scooter in the truck on the way to the dive site, we heard a whirring sound from the back.

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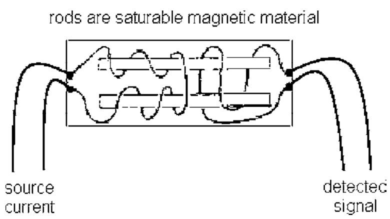
I'd like to thank Simon Richards for kindly developing the neutrally buoyant magnet. The mapping and use of the magnetometer would not have been possible without the dedication and instruction of Fred Devos, my companion in the underwater world of Chikin Ha. This article is dedicated to the memory of Steve Berman, whose patient teaching and wonderful example introduced me to cave diving. He died in the Devil's Eye System in Gilchrist County, Florida, on May 7, 2001.

## THEORY

The figure shows two saturable magnetic rods wound in opposite senses by two coils. An AC current, the source current, is passed through the first coil. In the absence of any external field, both rods are magnetized with the same intensity, but opposite directions, so there is no net magnetic flux found in the detection loop shown on the left-hand side, and therefore no induced voltage. This is also the case if enough current is passed though to saturate both rods, which are made from a material that easily saturates at a known and stable value. If, however, an external field




is applied along the rod axes, the symmetry is upset. In the half of the cycle in which the field of the coil is adding to the existing magnetization, saturation arrives a bit earlier, because it depends on the total magnetic intensity, external plus that of the coil. In the other half of the cycle, where the magnetization due to the coil opposes that of the existing field, saturation occurs a bit later, because the sum of the two is somewhat weaker than the field of the coil alone. There is then a net flux though the detecting coil, which can be amplified and detected electronically. This is the basis of a fluxgate magnetometer sensor.

The dipole field from a magnet, such as generated by our underwater device, is given by

$$B \propto |\vec{r}|^{-5}(3(\vec{m}\cdot\vec{r})\vec{r} - \vec{m}|\vec{r}|^{2}),$$

where *m* is the magnetic moment and *r* is the vector from the dipole to the point of measurement. A scalar amplitude coefficient is omitted. At a constant angle from the magnet to the point of measurement, the field decays as the distance cubed. It is this rapid decay which may limit this technique to shallow caves, such as found in the Yucatan. This formula, inserted into Mathematica, a program that provides easy vector calculations, allows the quick determination of the vertical component of the vector field, given the depth, orientation, and lateral offset of the magnet, such as plotted in Figure 4.

The field is, of course, more complex than a simple distance-cubed decay. The vector nature of the equation shows, for example, that a magnet aligned horizontally placed vertically below a sensor gives no vertical field: the dot product in the first part of the equation, $m{\cdot}r$ is zero, and the second term has no vertical component. That is why the signal is zero when the horizontal magnet is passing below the sensor, as seen in both Figures 3 and 4.

### Topografiando Chikin Ha con un Magnetómetro Pasivo de Medición de Flujo

Se realizó un experimento interesante en una cueva subacuática en Quintana Roo. Se colocaron magnetómetros en la superficie para detectar un gran magneto acarreado a través de la cueva por espeleobuzos. Esto permitió ajustar el mapa de la cueva, compensando por desviaciones en la topografía subacuática. Sin embargo la técnica tiene un alcance limitado y no es tan precisa como los espeleorradios de inducción magnética.

History

# THE SELENITE CAVES OF NAICA, MEXICO

William F. Forshag

A characteristic feature of many of the ore deposits of Mexico that are found in the Cretaceous limestones of the country is the presence of caves in close association with the ore. One such cave discovered in 1912 during mining operations in the Potosi Mine at Santa Eulalia, but now destroyed, was remarkable for the wonderful beauty of its calcite and gypsum crystal growths. It was the habit to illuminate this cavern with a multitude of candles, and for sheer brilliance and delicacy it probably surpassed anything yet discovered. In many of these caves calcite predominates, sometimes as botryoidal masses, sometimes in coral-like groups of crystals, or again as entire coatings of dogtooth spar. In a few, gypsum is the chief mineral, and it is usually present in most of them.

Of the gypsum caves, the most remarkable are those of Naica, a small mining camp in the state of Chihuahua. To reach them one goes to the station of Concho on the Mexican Central R. R. 130 kilometers south of the city of Chihauhua and from here by a narrow-gauge line to Naica, a distance of about 30 kilometers. There are two caves at Naica, the better known one being that in the Maravilla Mine. The cave is on the third level and is guarded by a heavy wooden door to prevent the entrance of vandals. It is the habit of the owners, the Naica Mines of Mexico, a subsidiary of the Penoles Company, to care for this cave and to prevent as far as possible the marring of its beauty by the promiscuous removal of crystals, a policy that should be respected by all visitors. A short passage leading from the door takes one to a chamber lined on walls and ceilings with numerous colorless crystals of gypsum from six inches to over a foot in length. The floor of the cave is littered with blocks of limestone that have sluffed off the roof and are now covered with a coating of botryoidal calcite and scattered over with long, blade-like or short, stumpy crystals of gypsum. In the grottoes between these boulders of limestone are usually one or more clear selenite crystals like figures in niches. The crystals from the roof and upper walls are partially redissolved, so that they resemble icicles rather than crystals, but those found in the lower portions of the cave are clear, colorless, and well formed. Many contain channels filled with water and carry movable bubbles.

From this chamber, a stairway leads down into an extension where the gypsum crystals have grown to an enormous size. Many of them are four and five feet long, and a few probably reach six feet (fig. 1). They grow from the floor of the cave in a manner resembling the maguey plants so common on many of the hills of Mexico. These large crystals are colored a light gray by included mud, but are often capped by a clear white termination. They are somewhat rounded on their prism zones, but are bright and shiny. The walls are studded with scattered crystals of selenite of a stumpy habit. Further on, the way leads thru a narrow opening, just large enough to permit the passage of a man, completely lined with blade-like crystals and forming a veritable corridor of swords. There crystals reach a length of two to three feet and are opaque white in color. From this passage one descends a few feet into the largest chamber of the cave. The floor ahead rises at an angle of about 30° and is completely banked with myriads of selenite blades one to three feet in length. At the crest of the floor there arises a remarkably fine radiated group of crystals over four feet high, gray in color but tipped with white and glistening brightly in the light of the lamps. Nearby is the only huge crystal of the stumpy type noted, a crystal that must weigh 60 pounds. From this single crystal grows a long blade of selenite almost four feet long. Beyond these the cave rapidly narrows until it becomes a mere crack.

A second cave, in the neighboring Lepanto Mine, adjoins the one in the Maravilla and may actually be a continuation of it. In the one chamber

Figure 1. Huge gypsum crystals, Maravilla Mine, Naica, Chihuahua. *William Forshag.*

Reprinted from *The American Mineralogist*, volume 12, pages 252–256 (1927). The author was at the U.S. National Museum.

of the cave the front and right walls are covered with gypsum crystals for about two thirds of their height. The crystals from this cave are entirely of the long-bladed habit, but are better formed than those of the Maravilla. They lack, however, the clear watery transparency of many of those in the latter mine, being colored dark grayish brown by included mud.

As has already been noted, the selenite crystals belong to two types: long prismatic blades and short, stubby ones. The prismatic crystals have the faces *b*(010), *m*(110), and $n(\bar{1}11)$ and rarely *l*(111) and are almost invariably twinned after the fashion of fig. 2A. By far the commonest habit is for the twins to be terminated by the rear pyramid $n(\bar{1}11)$, simulating orthorhombic crystals like fig. 2A. Very rarely is the crystal terminated by the front pyramid *l*(111) and then terminated by a re-entrant. Very few were of this latter habit, and these were found only after a special search was made for them. The stumpy habit is relatively much shorter along the *c* axis, so that they may be equi-dimensional, or, what is still more common, are somewhat elongated along the *a* axis. They have the prismatic zone deeply striated, *l*(111) prominent, and $n(\bar{1}11)$ very small

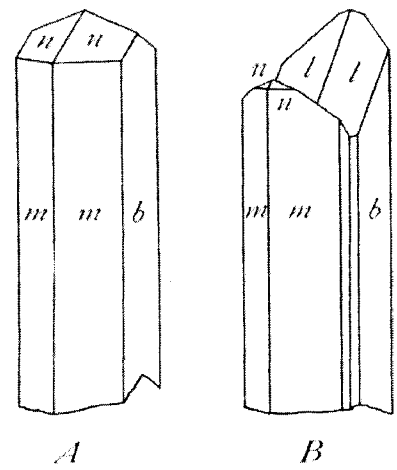



Figure 2. Twin crystals of gypsum.

or absent. These crystals are considerably less abundant than the long, bladed form and have only been noted on the walls and in the very lowest portions of the Maravilla cave.

Many of the caves of the type just described are directly connected with ore bodies. At Los Lamentos, for instance, the caves are considered an almost positive indication of ore below and owe their origin to the oxidation of sulphide ores. Although there is a decided increase in the volume of the minerals upon the oxidation of the sulphides, the sulphuric acid and soluble sulphates generated are removed and account for a certain amount of the material lost. These spaces are then considerably enlarged by the action of surface water to form the larger chambers of the caves. The caves at Naica, however, are as far as is now known not immediately connected with ore bodies, and it is obvious upon an inspection of them that they are greatly enlarged cracks or slightly faulted zones. The enlargement has taken place partly by the action of surface waters, but also by sulphate waters, the result of sulphide oxidation. The manner of growth of the numerous crystals is not clear, particularly as the caves are now completely dry; and no reasonable suggestion as to the growth of the huge crystals from the floor has occurred to the writer.

The author gratefully acknowledges his indebtedness to Prof. Palache for financial assistance from the Holden Fund of Harvard University and to Mr. A. C. Fox, superintendent of the Naica Mines of Mexico, for permission to visit the caves and collect specimens.

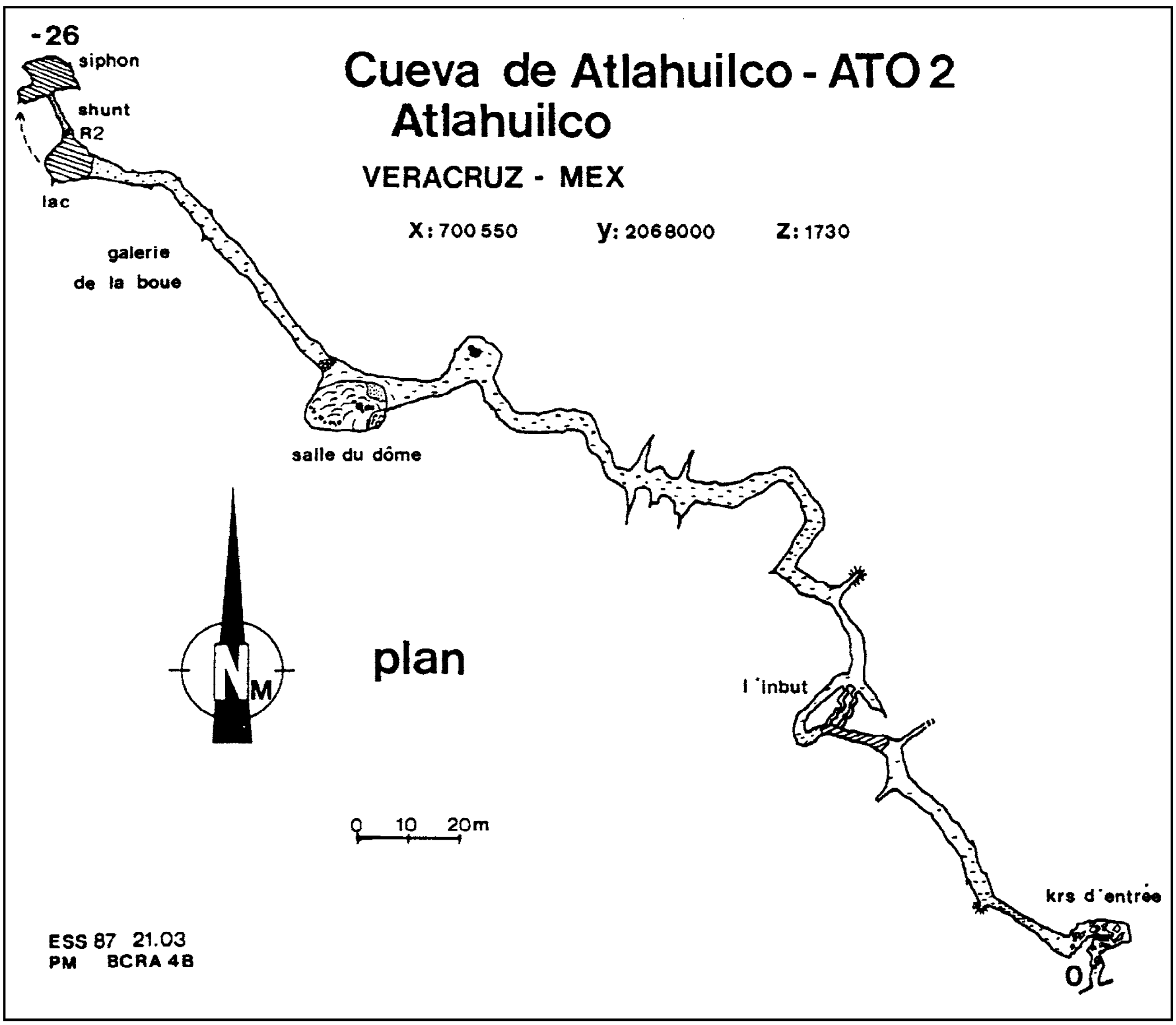
## Las Cuevas de Selenita de Naica, México

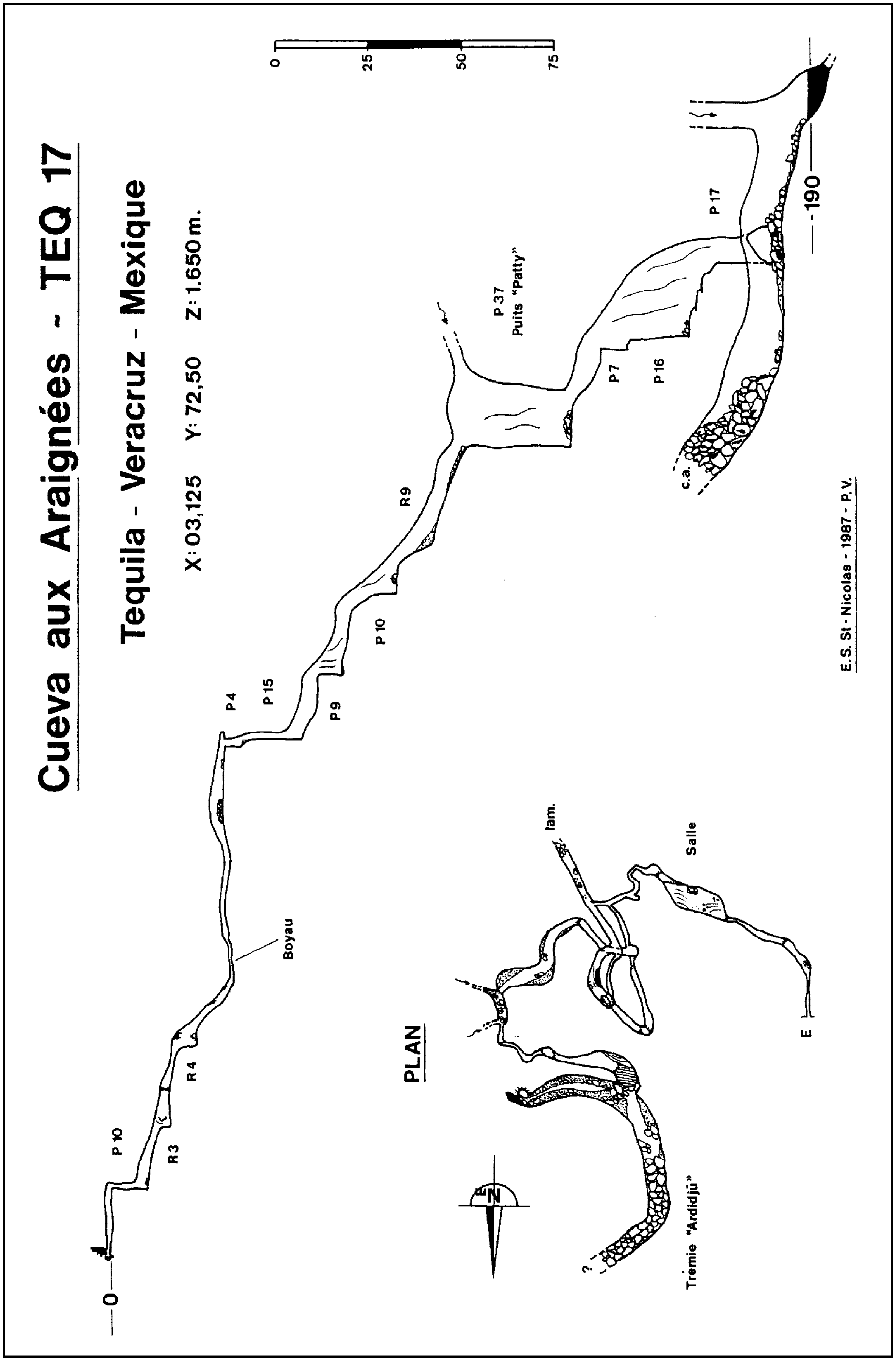
Esta reimpresión de un artículo de 1927 describe las Cuevas de las Espadas en la mina de Naica, Chihuahua, versiones más pequeñas de la recientemente descubierta Cueva de los Cristales.

# SELECTED MAPS FROM EXPÉ SOUS SIERRA 1987

In 1987, the Union Belge de Spéléologie had an expedition to the Sierra Zongolica in Veracruz. It was organized by the Equipe Spéléo de Saint-Nicolas and lasted from March 2 to May 3. They found 175 caves and explored 137 of them, mapping more than 20 kilometers of cave. The deepest found was 438 meters, with totals of seven over 200 meters and twenty-two over 100 meters deep. The longest was 2100 meters, with totals of seven over 1000 meters and fifteen over 500 meters long. The deepest pits were 110, 106, 015, and 101 meters deep.

The project produced the sixty-six-page report *Expé Sous Sierra, Mars–Avril 87*, published in 1989, from which the following maps are reproduced. Articles on the expedition appear in *Regards* 2, 1987, where many of the same maps appear, much reduced. Another article appears in *Spelunka* 30, 1987, not seen by me. There is also a book edited by Didier Warnant, *Pour une poignée de bolards: La Méxique* (1987). It is a diary of the expedition.—Bill Mixon

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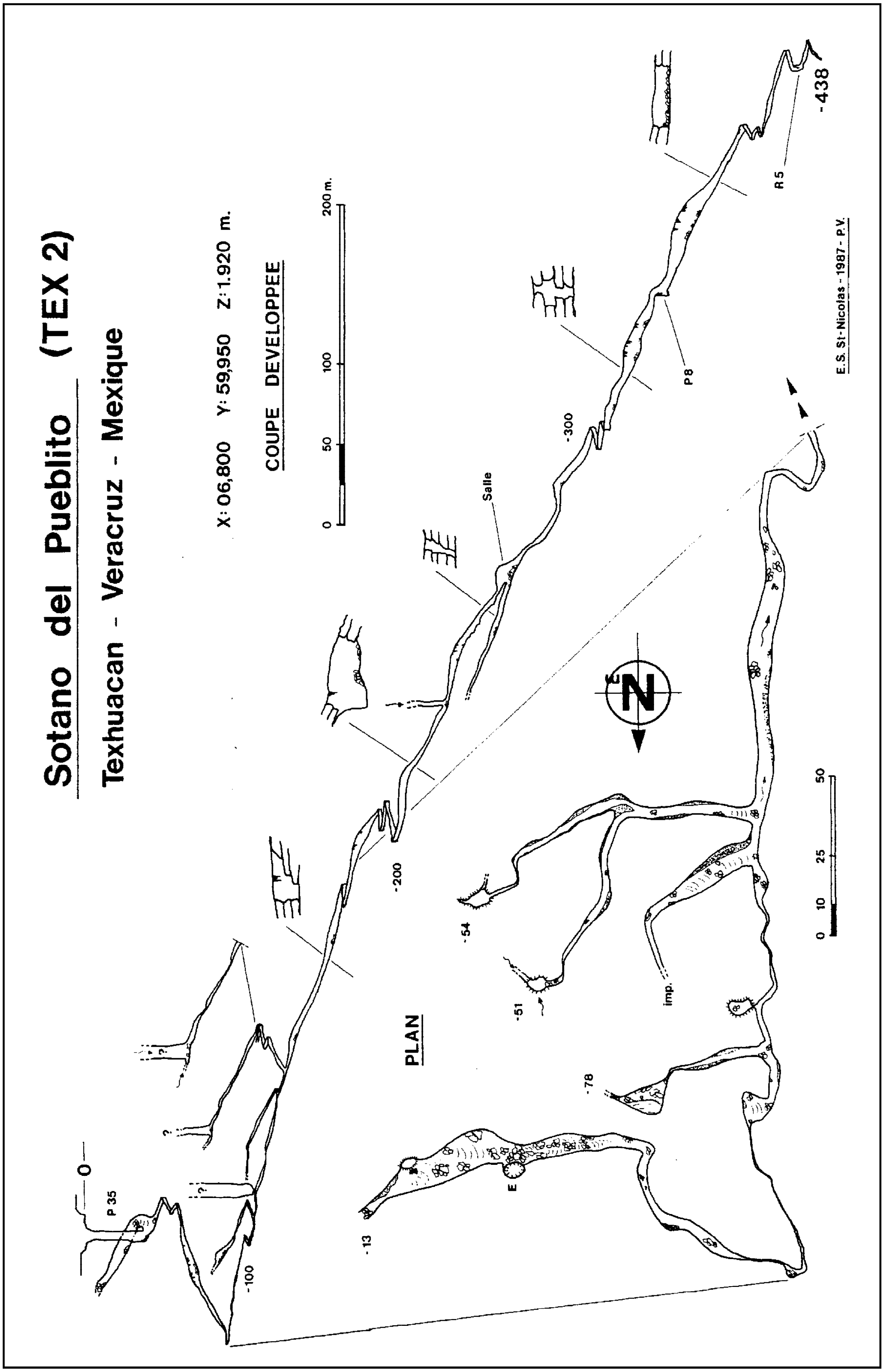
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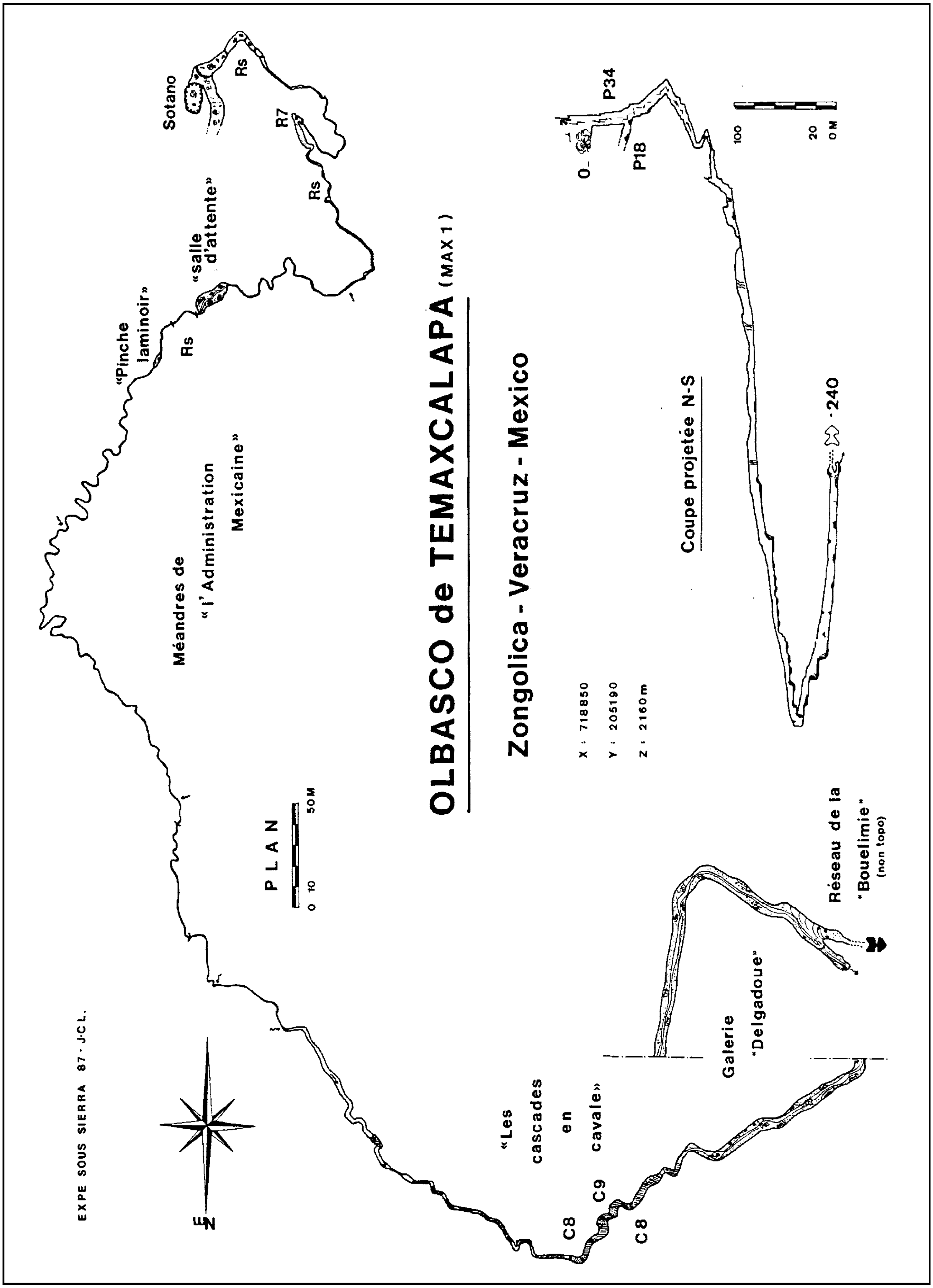
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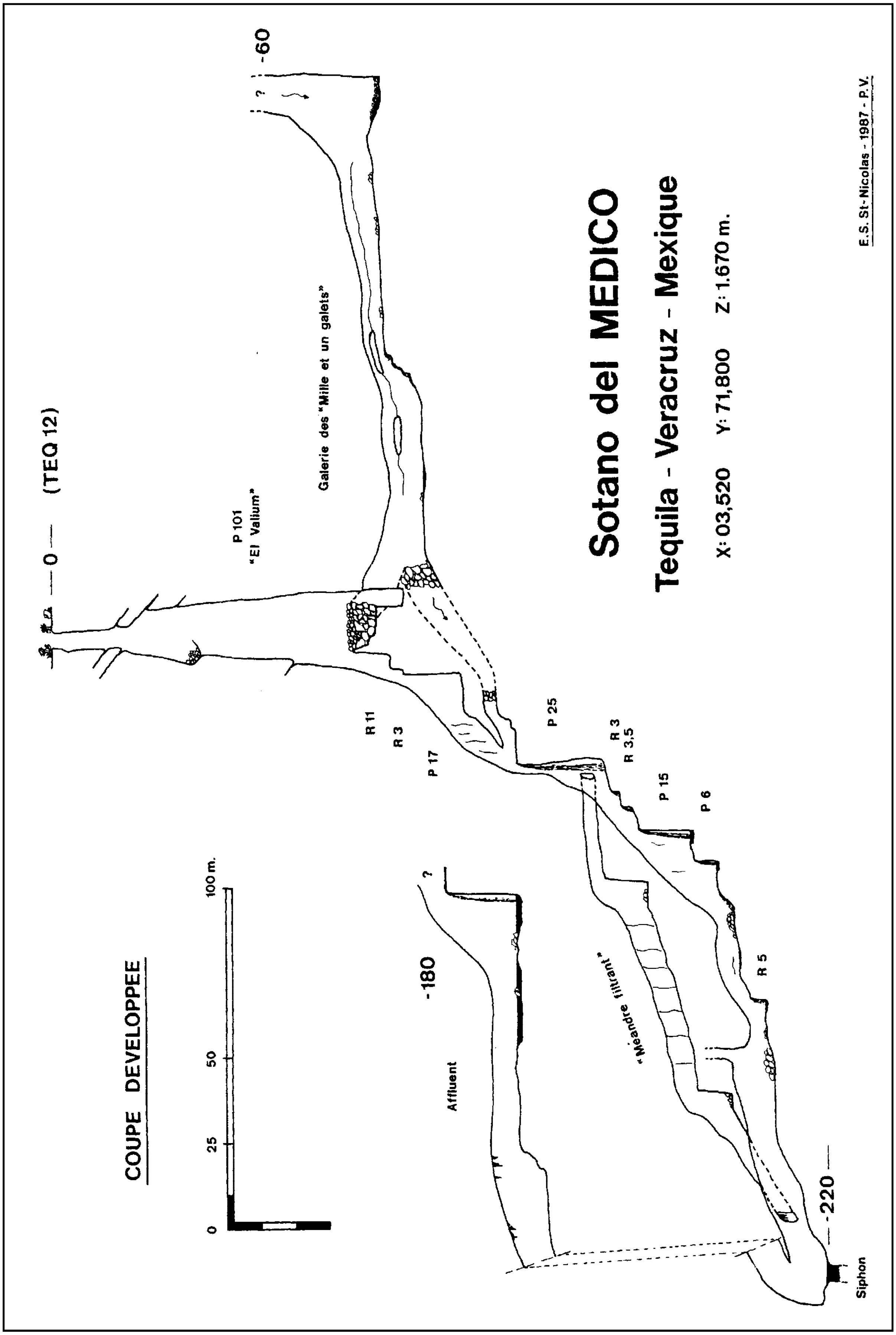
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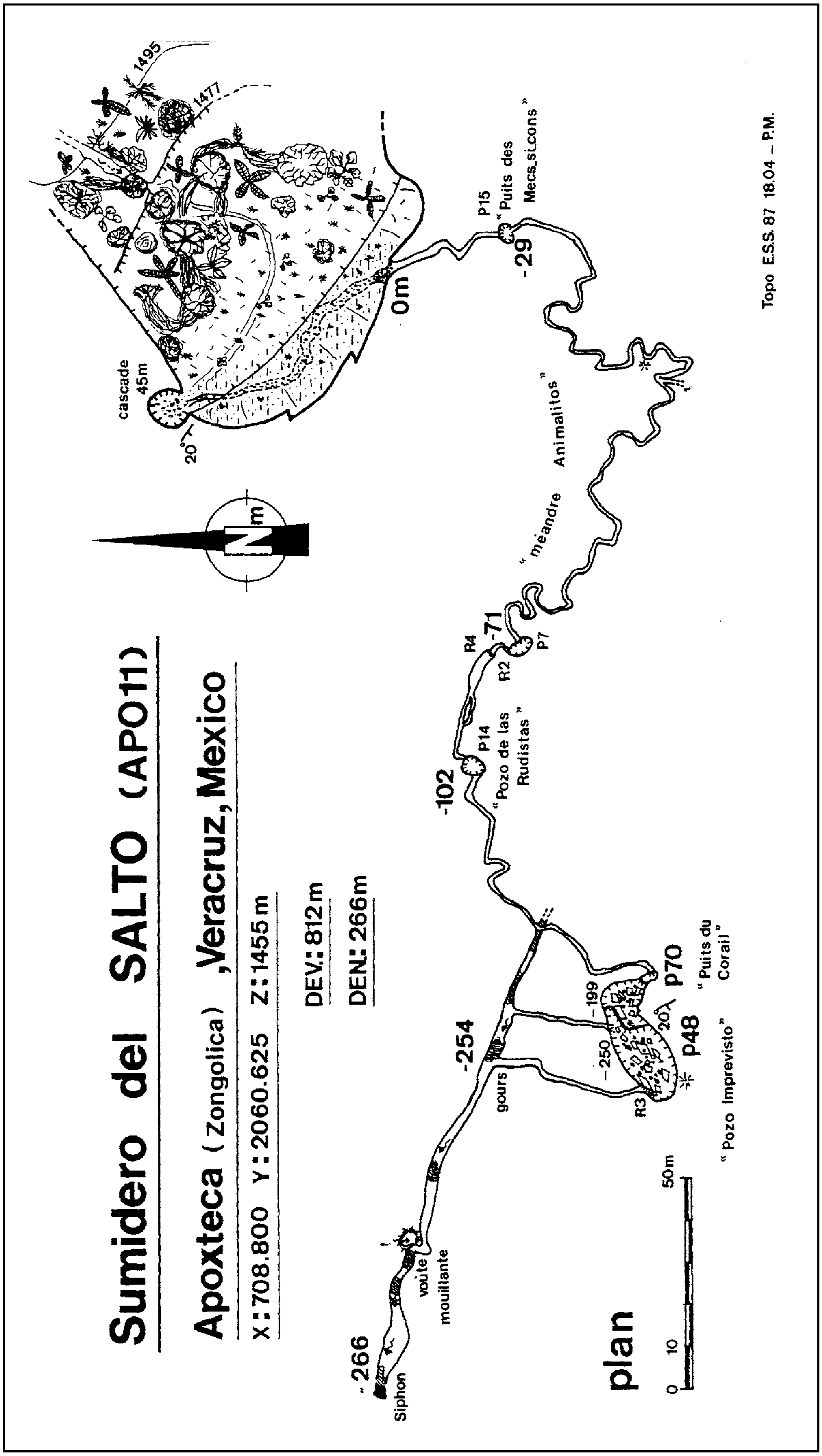
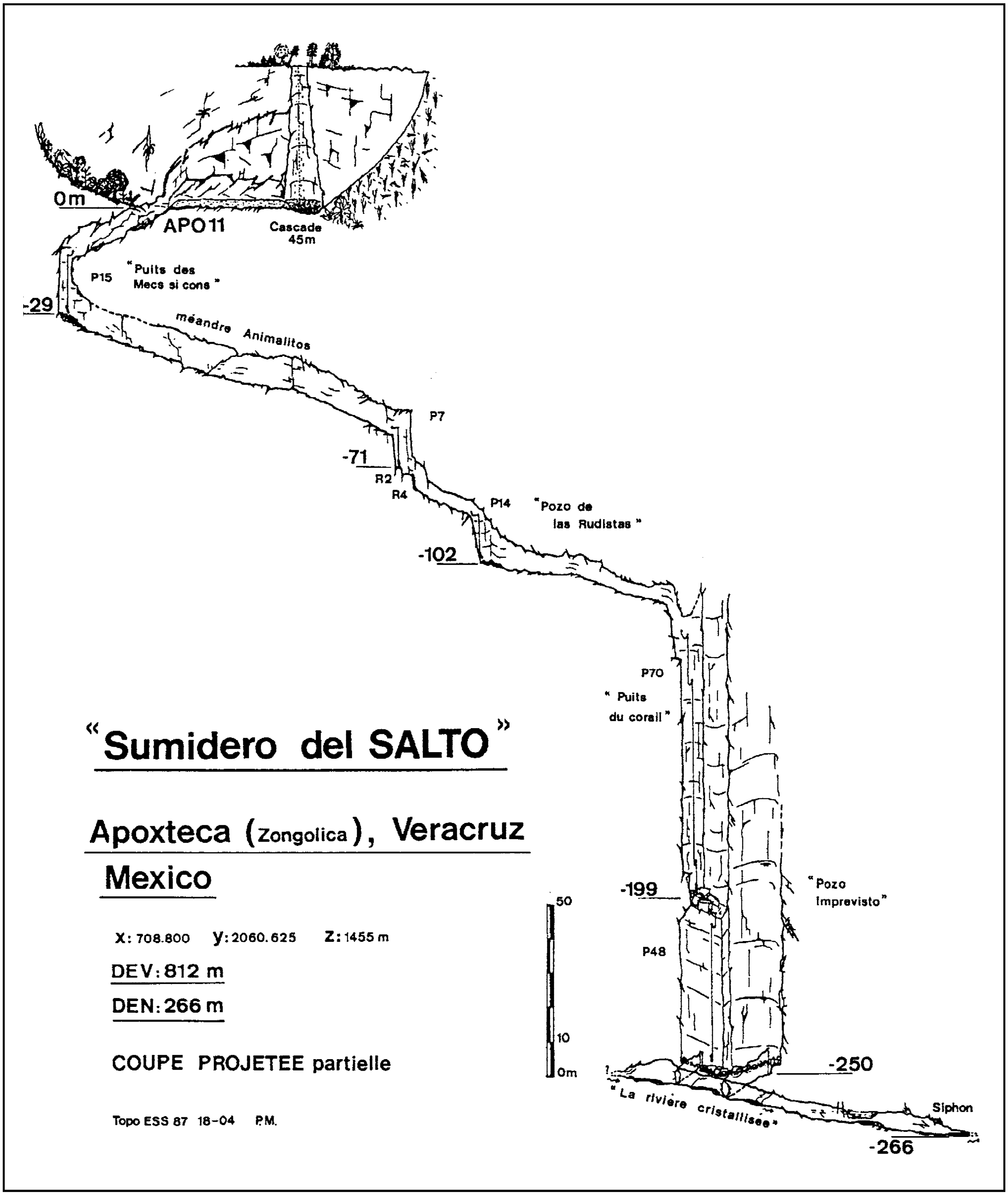
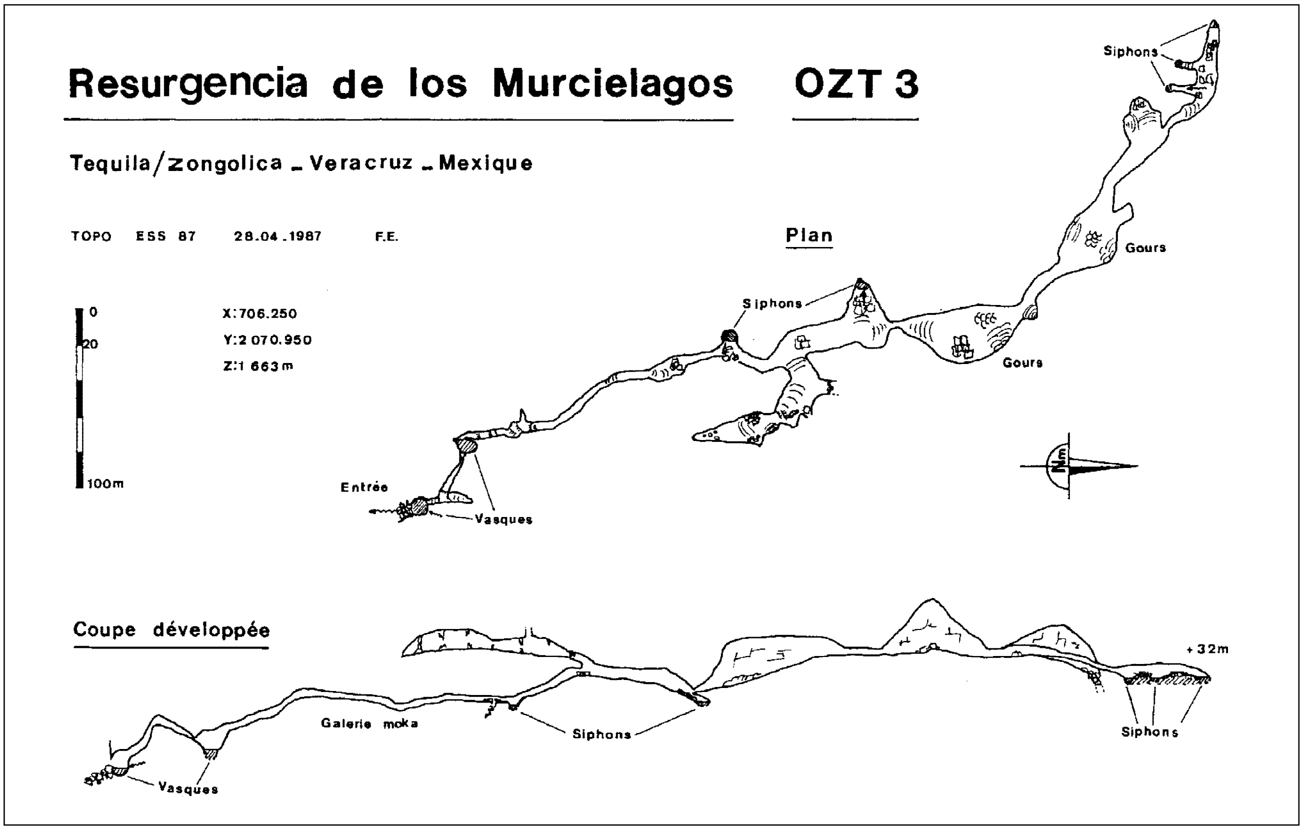
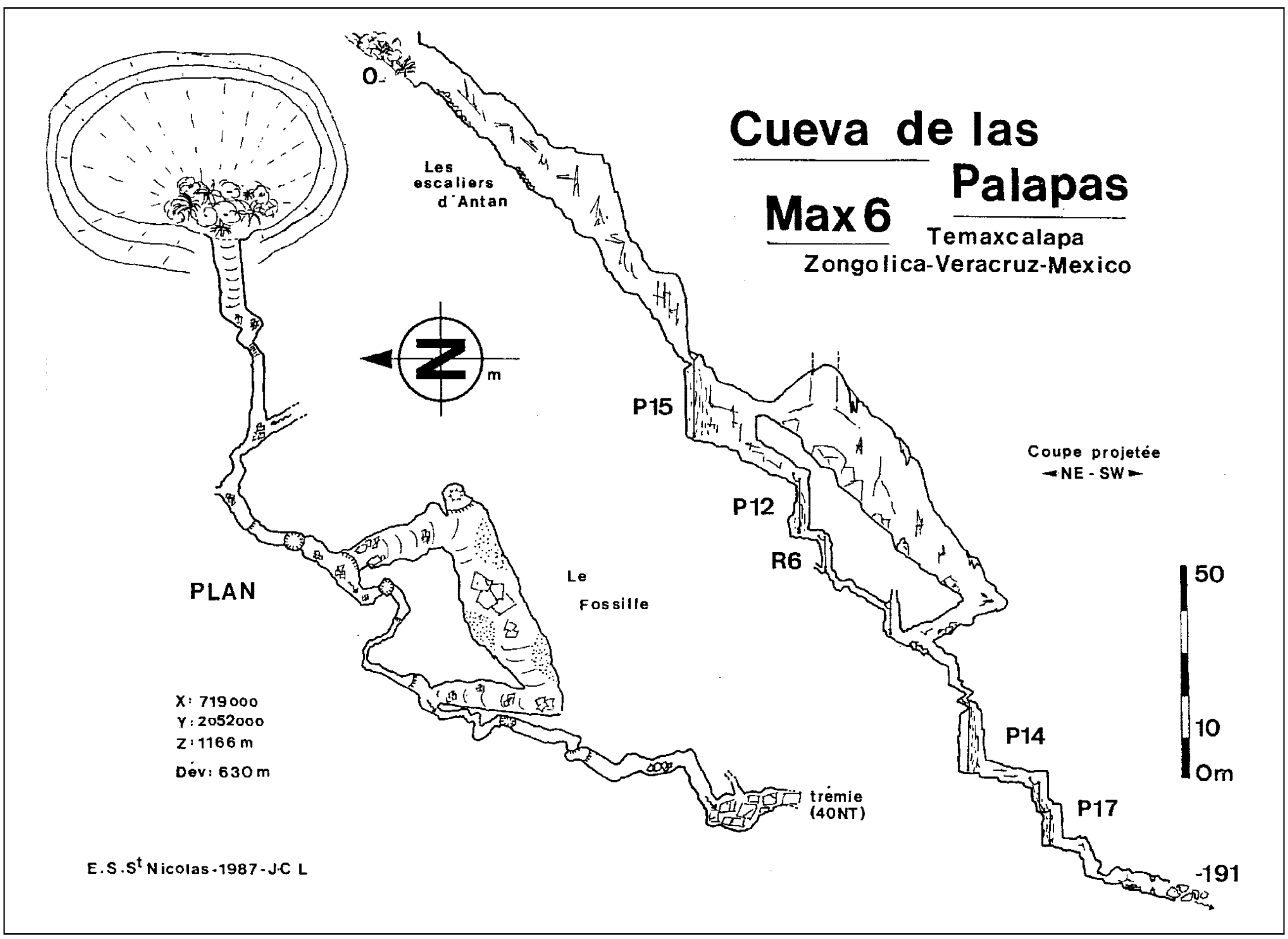
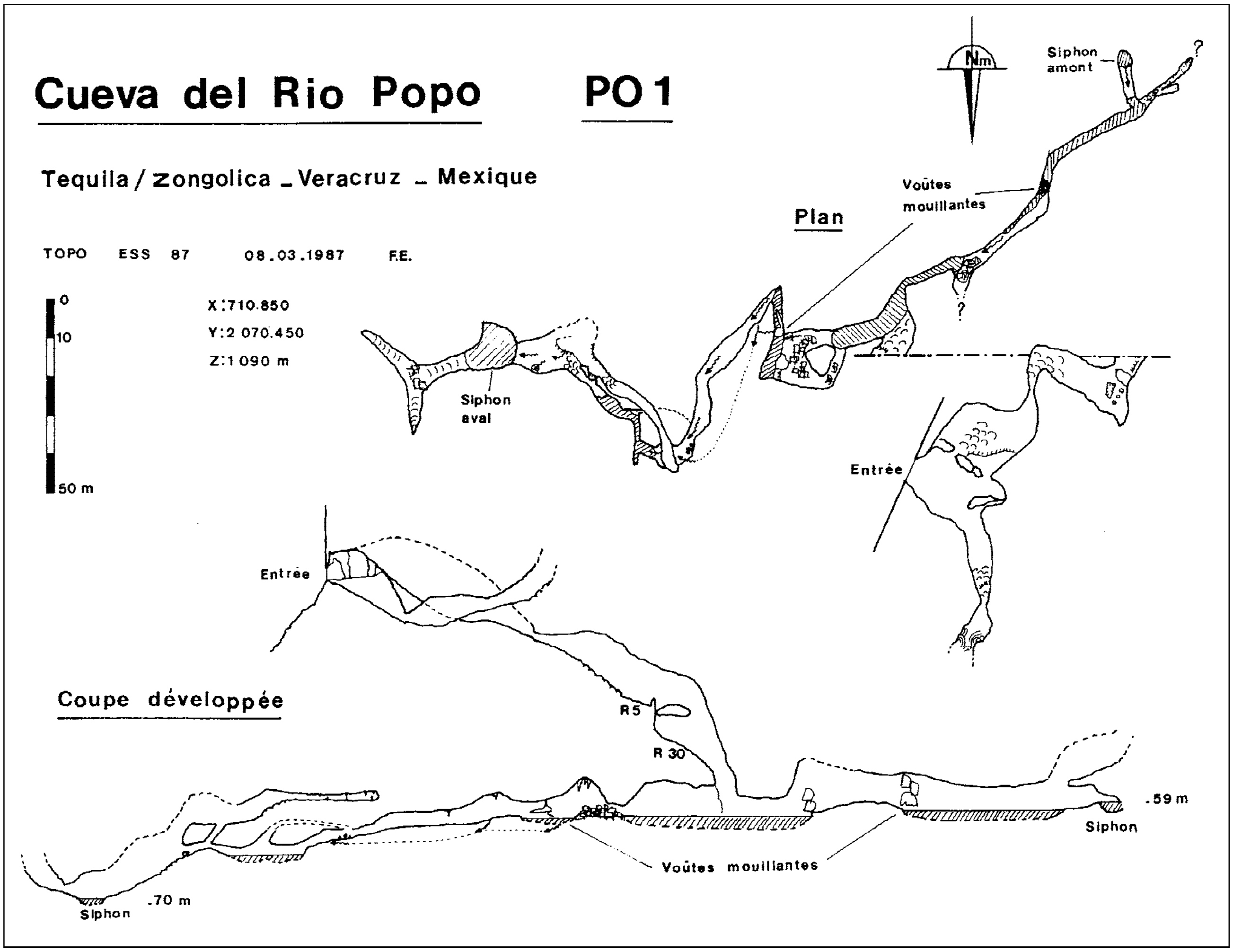
?


Sumidero del SALTO (APO11)
Apoxteca ( Zongolica) ,Veracruz, Mexico
X : 708.800 Y : 2060.625 Z : 1455 m
DEV.: 812 m
DEN.: 266 m
plan
0 10 50m
Topo E.S.S. 87 18.04 _ P.M.
1495
1477
cascade
45m
20°
0m
P15
" Puits des Mecs_si_cons "
-29
" méandre Animalitos "
-71
R4
R2
P7
P14
" Pozo de las Rudistas "
-102
-254
gours
-199
-250
P70
" Puits du Corail "
p48
" Pozo Imprevisto "
R3
20
voûte mouillante
-266
Siphon


0m
APO11
Cascade
45m
P15
"Puits des
Mecs si cons"
-29
méandre Animalitos
P7
-71
R2
R4
P14
"Pozo de
las Rudistas"
-102
P70
"Puits
du corail"
"Sumidero del SALTO"
Apoxteca (Zongolica), Veracruz
Mexico
X: 708.800 Y: 2060.625 Z: 1455 m
DEV: 812 m
DEN: 266 m
COUPE PROJETEE partielle
Topo ESS 87 18-04 P.M.
50
10
0m
-199
"Pozo
Imprevisto"
P48
-250
"La rivière cristallisée"
Siphon
-266


Resurgencia de los Murcielagos OZT 3
Tequila/Zongolica - Veracruz - Mexique
TOPO ESS 87 28.04.1987 F.E.
Plan
0
20
100m
X:706.250
Y:2 070.950
Z:1 663m
Siphons
Gours
Siphons
Gours
Entrée
Vasques
Coupe développée
+32m
Galerie moka
Siphons
Siphons
Vasques


Cueva de las Palapas
Max 6
Temaxcalapa
Zongolica-Veracruz-Mexico
0
Les escaliers d'Antan
P15
P12
R6
P14
P17
-191
Coupe projetée
NE - SW
50
10
0m
PLAN
Le Fossille
X: 719000
Y: 2052000
Z: 1166 m
Dév: 630 m
trémie (40NT)
E.S.St Nicolas-1987-J-C L




Selección de Mapas de Expé Sous Sierra 1987

Estos mapas son del reporte de una expedición a México por el Equipe Spéléo de Saint-Nicolas, un grupo de espeleología belga, en 1987.


Cenote de Mucuyché, Yucatán
Engraving by
Frederick Catherwood, 1843