Sótano de las Golondrinas

Description

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TERRY W. RAINES

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PDF reprint from scans of the original, February 2011. The text in this PDF has been "read" by Adobe Acrobat and is searchable to the extent that the OCR was successful. This bulletin has been largely superseded by AMCS bulletin 10, *Caves of the Golondrinas Area*, by Peter Sprouse and Jerry Fant, 2002, but it, especially the color photographs, remains of historical interest.

INTRODUCTION

Sótano de las Golondrinas is presently the deepest known free-fall pit in the world. Unlike other "free-fall" record holders, the drop in Golondrinas is completely free. There are no ledges or climbing against a wall. The pit was first entered during April of 1967 and later surveyed during June of that year. Previously, the greatest drop that had been descended by cavers in the Western Hemisphere was slightly over 500 feet. The 1094 foot drop in Golondrinas more than doubled this old record and thus became a real challenge to equipment and technique. Using methods of rappel and prusik previously employed in other Mexican sótanos, Golondrinas was successfully explored without difficulty.

In the following pages of text, the sótano itself is described, as well as the area in which it is located and the early explorations. A short section is also included which describes the climbing equipment and techniques that have been used. At the very end of this booklet are descriptions of the eight full-color photographs that are contained in a separate envelope. A two-color cave map is also included with this Bulletin to further illustrate Sótano de las Golondrinas.

Many people contributed to the successful publication of this Bulletin. Of greatest assistance were the officials and residents of the Aquismón area who granted permission and aided our explorations. John Fish and Bill Russell donated their time and knowledge to the writing of two sections of this Bulletin. John wrote the Cave Description and Speleogenesis and Bill not only wrote the Regional Geology but also donated more time to the assembling of the Bulletin. Carl Kunath, aided by John on the cave map, is responsible for drafting all the illustrations. Bill Deane furnished Figures 4 and 5 of the photographs and Carol Russell offered her skill as proofreader. Other people serving in helpful capacities were Gill Ediger, Michael A. Sanborn, and members of the University of Texas Speleological Society. To all of the above people I am deeply indebted.

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LOCATION

Sótano de las Golondrinas is located in the east-central portion of Mexico in the southeast corner of the state of San Luis Potosí (lat 21° 36'N.; long 99°06'W.). This unusual pit has formed deep in the heart of the Sierra Madre Oriental, a rugged range of mountains extending north into the Big Bend area of Texas, U.S.A. and south, far into the state of Veracruz. To the east a low coastal plain contrasts sharply with the high mountains, while to the west the Central Plateau is only 3000 feet lower than the 9000 foot high peaks of the range.

The only town in the Golondrinas area that is accessible by motor vehicle is Aquismón (see Geology section, page fig. 2). It is located at the eastern base of the Sierra Madre, 51 km by road south of Ciudad Valles, S.L.P. Aquismón, the commercial and political center of the area, is reached by a short paved road leading west from Highway 85, the Inter-American Highway. All travel west of Aquismón is by foot or horseback on a network of trails that interconnect all inhabited places. These trails are often steep and rocky, though all main trails are traveled by pack animals. Lack of dependable surface water limits settlements to a few areas. In these areas fields are cleared by cutting and burning; corn is then planted on what soil may be found. Coffee is grown extensively, and there are small fields of sugar cane. The western part of the Golondrinas area is higher and drier, with hardwoods, and at higher elevations, pines; in the lower, more humid area to the east the vegetation is more varied and tropical.

Permission to enter Sótano de las Golondrinas must be obtained in writing in the form of a letter of introduction from the Presidente of the Municipio de Aquismón, whose office is located in the building on the north side of the square in Aquismón. Identification indicating affiliation with a university or other institution of higher learning usually expedites matters. After an introductory letter is secured, arrangements for the hike west must be made. In the past cavers have customarily carried their personal gear and hired a local guide to carry the climbing ropes. Fifteen pesos a day is considered a fair wage for this service. Mules may also be hired to carry equipment. They rent for 20 pesos each per day and a guide who cares for them is normally paid 15 pesos per day.

The main trail to all points west begins its steep climb immediately at the edge of Aquismón. Following this trail one must surmount two mountain ranges, cross two valleys, and partially ascend a third range. At this point the village of Tamapatz is reached, approximately 11 km from Aquismón. It is absolutely essential that all cavers go directly to Tamapatz where they must present the letter of introduction to the Juez Auxiliar. Official permission to explore caves in the area will be acknowledged, and any aid or directions the caver may need will be enthusiastically given. From Tamapatz it is a 4 km hike northwest to Golondrinas. The entrance is somewhat obscured by dense tropical vegetation, but the people of the area are very helpful in giving directions.

Before entering the Golondrinas area, the caver should be aware of some of the conditions that exist.

Hiking is very exhausting for those not accustomed to it. The temperature is frequently above 90 degrees and high humidity prevails. A hat and salt are necessary. When caving between June and September (the rainy season) heavy daily showers should be expected. Camping is possible in unused fields and occasionally in shelters. Permission must always be obtained. It goes without saying that all cavers must respect the local customs and always remain courteous and polite. The caving potential of the area is too great to allow avoidable incidents to jeopardize public relations. In order to keep Mexican caving on a firm basis and to insure that your group will have the latest information on the caves of an area, contact the AMCS when planning a trip.

CAVE DESCRIPTION and SPELEOGENESIS

Sótano de las Golondrinas (Pit of the Swallows) lies near the eastern base of the Sierra de Unión (see Geology section, page 8, fig. 2) at an elevation of about 2400 feet (740 meters). The local people applied this name because of the tens of thousands of swallows that inhabit the pit. Seeing the swallows and the beautiful green parrots slowly circling as much as a thousand feet below the entrance is a breathtaking sight.

The nearly circular entrance is on a steep mountainside and has 109 feet (33.2 m) of relief. It measures 205 feet (62.5 m) by 160 feet (48.8 m) and is surrounded on three sides by trees and dense undergrowth. The lowest side is a barren area of karren crisscrossed by many narrow fissures up to 15 feet deep. Only on the low side is it convenient to rig the pit.

In 1967 when Sótano de las Golondrinas was explored and mapped, it was (and perhaps still is) the deepest free-fall pit and the largest shaft known in the world. Because of the importance of the pit, a plane table and telescopic alidade were used for surveying and a wire with negligible stretch employed for measuring the vertical drop. The walls of the pit bell out rapidly, giving a free drop at any point around the entrance. As may be seen on the map, the shortest possible drop is 1091 feet (332.5 m) free-fall. The usual rigging point is 1094 feet (333.5 m) above the floor and the maximum drop is 1235 feet (376.4 m) free-fall. These measurements have a little more meaning when one realizes that the Empire State Building would easily fit into this sótano and its top would be about level with the high side of the entrance.

When one looks over the edge, the shape of the pit presents an optical illusion such that the walls look nearly vertical and the floor seems not much larger than the entrance area. Only when one has rappelled several hundred feet does the pit come into its proper perspective. Reaching the bottom is like entering another world. The nearest wall is 200 feet away. After heavy rains small waterfalls pour from openings a thousand feet above. During the day no artificial light is necessary because of the large amount of sunlight that enters the pit. Because Golondrinas is located south of the Tropic of Cancer, a beam of sunlight shines directly on the floor for several hours a day during the summer months, causing a curious phenomenon. Sunlight warms up the guano-covered floor and a cloud several hundred feet high forms, slowly oscillating up and down (see Photographs, fig. 6). The floor has an area of about 6 acres, a little more than the average city block, and is 1000 feet (304.8 m) long by 440 (134.1 m) wide. Weathered guano and scattered breakdown cover the entire floor. In places the guano (from the swallows) is several feet thick. The bottom has 246 feet (75.0 m) of relief, with several hills of breakdown, intermittent streams, and a deep trough along the south wall. The lowest point in the cave lies in the trough and is 1306 feet (398.1 m) below the entrance.

The origin of Sótano de las Golondrinas is not yet fully understood. The factors controlling the localization of the pit and their relative importance cannot be evaluated without more information. An extremely large quantity of unsaturated water had to be supplied to produce such an immense chamber. Considering the shaft as a truncated elliptic cone, the volume of the present void is about 200 million cubic feet (6 million cubic meters), or five times the volume of the well-known Gruta del Palmito (Bustamante, Nuevo León). Golondrinas, Hoya de Guaguas, and Sótano de Cepilla--the largest known pits of the area--are all developed along prominent fractures. Golondrinas is elongated parallel to a set of northwest-trending fractures that may be related to the thrust fault and fold west of the pit (see Regional Geology). The straightness of the south wall in plan view and the 500 foot sheer wall in section B-B' of the cave map are controlled by these joints. Two passages of section A-A' in the west wall are developed along the most prominent fractures and are unexplored.

Evidently, Sótano de las Golondrinas was formed by: 1) development of a large phreatic room, and 2) collapse of ceiling and wall rock. The floor of the shaft is composed entirely of breakdown and guano, and is 225 to 275 meters above the nearest resurgences, 15 km away. It is likely that the bedrock floor of the phreatic chamber is two or three hundred feet or more below the lowest point in the cave, and the walls may have extended upward to the present breakdown surface or even above it. Collapse of wall and ceiling rock began when the roof became unstable, and proceeded slowly until the surface was intersected. The major joint set and percolating ground water undoubtedly greatly assisted the collapse process. The fragmented limestone that collected at the bottom could readily be dissolved if the water chemistry was appropriate, because of the increase in limestone surface area. Probably the top 800 feet or more of the pit has been formed by collapse as indicated by the shape of the pit and the lack of solutional features.

Present day modifications of Golondrinas are proceeding slowly. Surface drainage does not directly enter the pit and was not a factor in its formation. Guano, minor quantities of flowstone, and small pieces of breakdown below the entrance (from plant root wedging) are being added to the cave, but the rate of accumulation is very slow. A small waterfall issues from the lower passage on the west wall and usually sinks quickly in the breakdown after depositing some calcite. Following heavy rains water runs across the floor and sinks in gravel and mud in the deep trough along the south wall. Other small stream channels are found in the cave, which indicates that at times small springs pour into the cave and some erosion occurs. The floor of the alcove in the west wall has been eroded by water flowing into a tiny hole, leaving a prominent ridge in the breakdown and guano. It is quite likely that the pit is being deepened by subsurface solution of breakdown and gradual subsidence or slumping. Removal has apparently been concentrated along the south wall, producing the large trough and a 60 foot cliff of recemented breakdown. For subsurface solution of breakdown to be important, a large quantity of groundwater would be required to flow through the old phreatic chamber, since the waterfalls provide only a minor amount of water.

Sótano de Cepilla, near Tamapatz, presents a history similar to that hypothesized for Golondrinas. The walls recede sharply from the small entrance to form a pit 300 feet in diameter and nearly 500 feet deep at the lowest point. One wall of the pit is composed of recemented breakdown, which is now collapsing. About one-third of the floor is covered by active flowstone deposited from waterfalls, and calcite is forming in a lake at the bottom. The rest of the floor is covered by breakdown and conglomerate (from the wall of conglomerate). In a low portion of the floor much of the breakdown is "rotten" because of solution and the floor appears to be subsiding due to subsurface solution.

Thus, the large pits in the Golondrinas area have had a history characterized by development of a large, deep phreatic chamber and stoping of ceiling and wall rock. When there has been extensive solution of the breakdown by groundwater a deep pit has formed. Probably the same fractures that dominate the shape of the pits also controlled the groundwater flow through the deep phreatic rooms when they were formed. Although the detailed solution chemistry and hydrology have not been worked out, it appears that Golondrinas may be deepening because of solution of the breakdown by water flowing through the old phreatic chamber and causing subsequent subsidence.

REGIONAL GEOLOGY

INTRODUCTION

Sótano de las Golondrinas lies in one of the largest and best developed Mexican karst regions. In an area of over 500 square kilometers from Xilitla north to the Río Santa María, solutional processes have shaped the landscape and surface drainage is absent. The southern part of the area is a high mountainous plateau with peaks extending to elevations of over 2900 meters. This high area is separated from the lower ranges to the north by an east-west solutional valley.

The Golondrinas region of this report lies in the topographically lower northern area and extends from Aquismón on the east to the San Luis Potosí-Querétaro border on the west, and from Tampaxal north to Tansosob (fig. 2). This area, while mountainous, is lower and less rugged than the high area to the south. Elevations range from less than 100 meters above sea level in the lowlands east of Aquismón to over 1100 meters at Cerro el Mirador 10 km to the southwest. Three subparallel ranges cross the area: The Sierra de Aquismón and the Sierra de Linja in the east, and the Sierra de Unión in the west.[1] Separating these ranges are relatively flat sinkhole-pitted lowlands. The entire drainage of the area west of the Sierra de Aquismón is underground, and with the exception of small local areas, there is no evidence of any mechanical erosion--even short gullies are absent.

STRATIGRAPHY

Regional Relations

The stratigraphy of the Golondrinas area is dominated by the thick accumulation of Cretaceous limestones. These rocks were deposited in lagoons that bordered the sea during Cretaceous time, where the deposition of sediment kept pace with subsidence to form several thousand feet of limestone. Most of this sediment was deposited as lime mud in relatively deep water, but in shallow areas, sediment was derived directly from shell reefs. These reefs were not large solid bodies, but were unconsolidated shell mounds, the individual shell "reefs" being only a few hundred meters long. Together with the much larger volume of inter-reef sediment, they formed large calcareous banks, several of which have been named. To the northeast of the Golondrinas area was the El Abra Bank that bordered the deep water to the east. This bank had a relatively large amount of reef material and now forms the El Abra Formation that is exposed along the eastern edge of the Sierra Madre Oriental. Southwest of this bank and very similar to it were the Jacala and Sierra Ladrón banks. These two banks, together with numerous smaller banks, now form the El Doctor Formation that extends throughout the Sierra Madre from Cd. Victoria to Pachuca. During late Cretaceous

[1] The Sierra de Linja is also known as the Sierra de Manja, and in the south as the Sierra de Eureka; the name Sierra de Unión is used principally in the vicinity of the barrio of Unión, and locally the range is also called the Sierra de Tamapatz, the Sierra de Mirador, and the Sierra de San Rafael.

time large amounts of clastic sediments, carried into the area from the west, killed and buried the reefs. These sediments now form the Agua Nueva, San Felipe, and Méndez Formations. The relation between the formations is indicated in Figure 1, a generalized east-west cross section showing the formations as they existed at the close of the Cretaceous.

Jurassic System

Rocks of Jurassic age are not exposed in the Golondrinas area, but are exposed to the south and west and probably underlie the Cretaceous in the area. Thirty kilometers to the west, near Jalpan, the thin-bedded impure limestone and black shale of the upper Jurassic Las Trancas Formation directly underlies the El Doctor Limestone (Segerstrom, 1961). To the south in the canyon of the Río Moctezuma, rocks of the same nature grade upward into cherty thin-bedded limestone that underlies the Cretaceous massive limestones (Heim, 1940).

Cretaceous System

The base of the Cretaceous is not exposed in the Golondrinas area, but lower Cretaceous limestone of the Lower Tamaulipas and Otates Formations probably underlie much of the area. These formations are not present to the west where the El Doctor lies directly on the Jurassic, but they are exposed south of Xilitla and north near Cd. Victoria.

El Doctor Limestone. The El Doctor is the oldest formation exposed in the area and is by far the most widely occurring rock unit. In the Golondrinas area the El Doctor is probably 600 to 700 meters thick, thinning to the south but thickening to the southwest toward the Jacala Bank. The base of the formation is not exposed and it is not possible to determine accurately the local thickness of this unit. Segerstrom (1961) has estimated this formation to be almost 1000 meters thick in the Jacala Bank 30 km southwest of Golondrinas. Heim (1940) gives the thickness of the El Doctor at Xilitla as at least 400 meters and thicken-

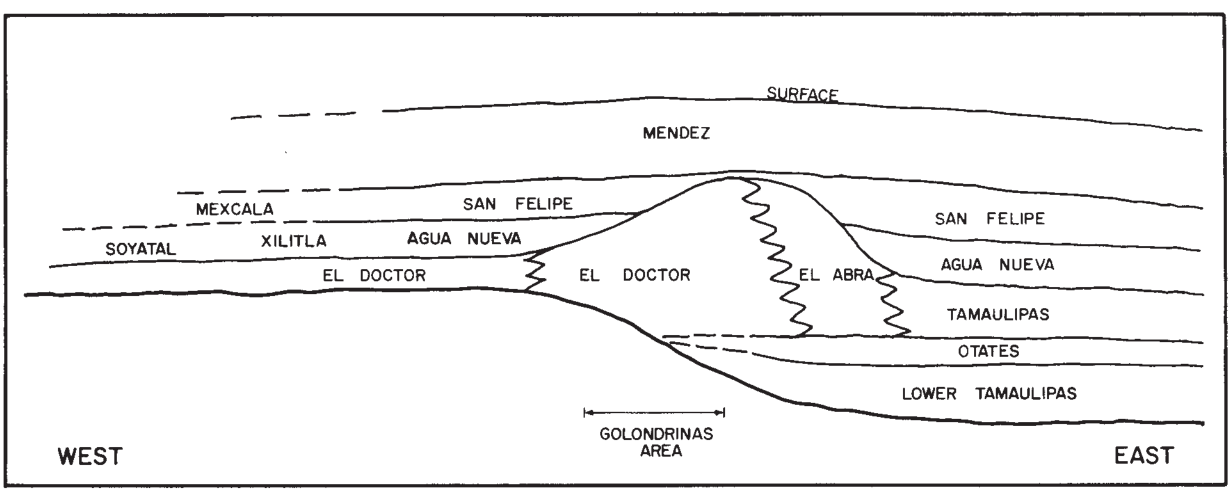
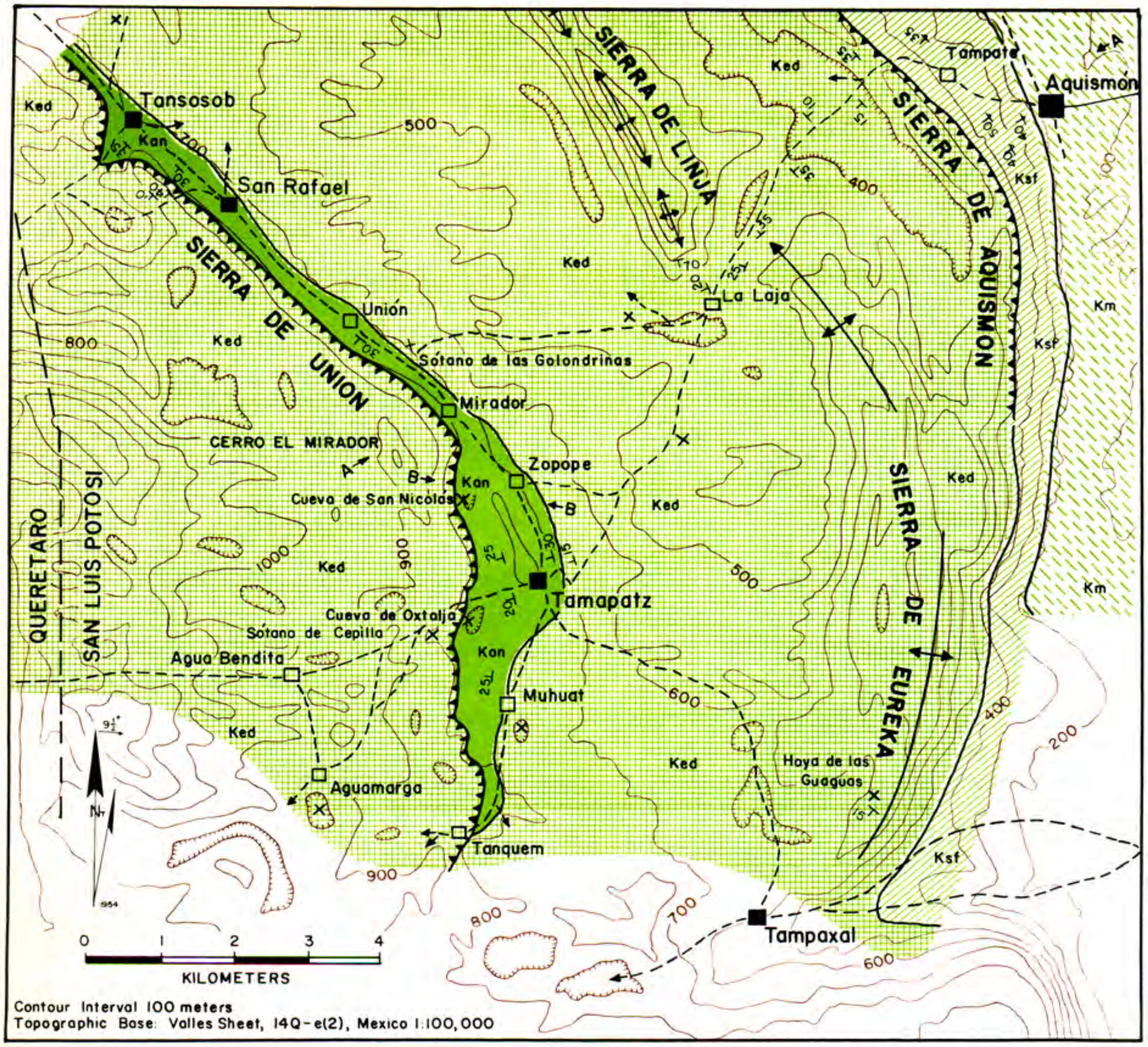


Figure 1. East-west cross section showing the formations of the Golondrinas area and their equivalents at the close of the Cretaceous.



GEOLOGIC MAP OF THE GOLONDRINAS AREA
SAN LUIS POTOSI, MEXICO

EXPLANATION

SEDIMENTARY ROCKS

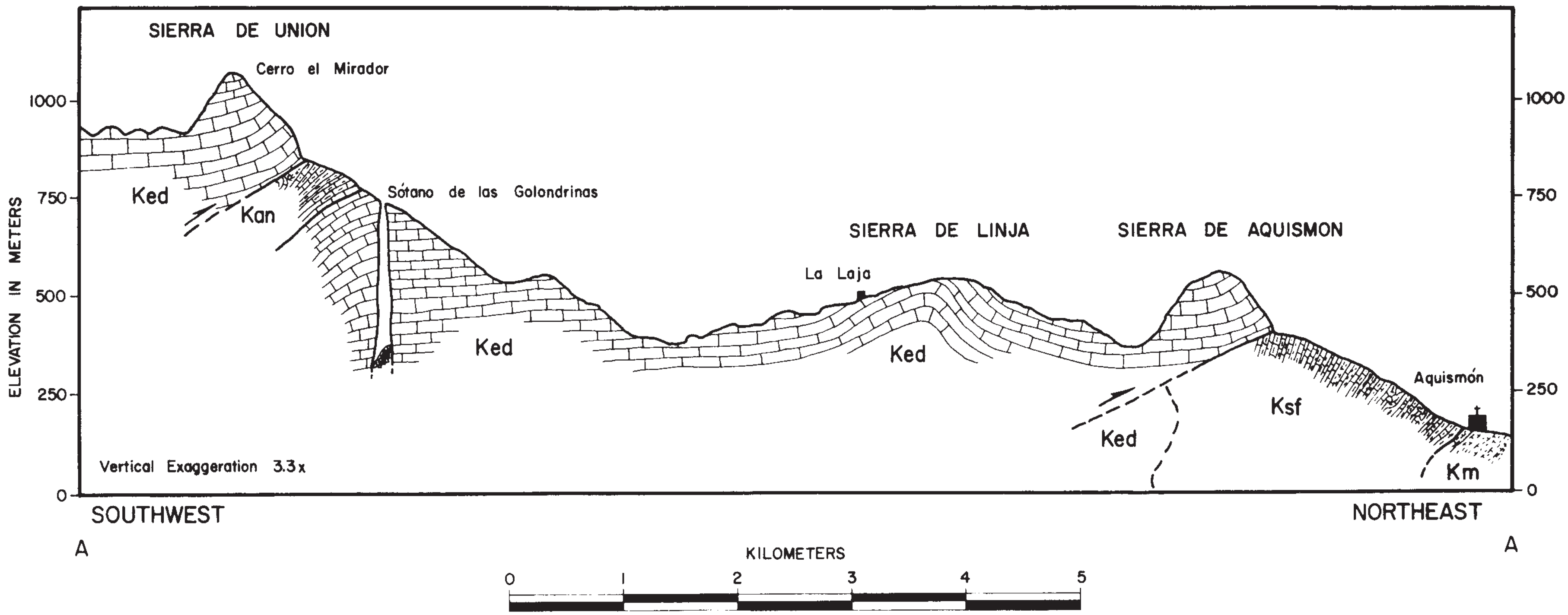
CRETACEOUS

- Km — Méndez Formation
- Ksf — San Felipe Formation
- Kan — Agua Nueva Formation
- Ked — El Doctor Limestone

- Administrative Center — Cabecero
- Town — Pueblo
- Hamlet — Ranchería Barrio

- Road
- Main trail
- State boundary
- Anticline
- Plunging anticline
- Edge of thrust sheet
- Contact
- Strike and dip
- Strike and dip of overturned beds
- Cave or pit

Figure 2



CROSS SECTION FROM AQUISMON SOUTHWEST THROUGH EL MIRADOR

Figure 3

ing to the north. Over 500 meters of undisturbed El Doctor is exposed in the canyon of the Río Santa María 12 km north of Sótano de las Golondrinas. Within the Golondrinas region, the thickest exposed section is in and above Sótano de las Golondrinas, where over 500 meters of the El Doctor is present.

The El Doctor Limestone of the Golondrinas area is a thick-bedded, light gray limestone, with beds usually from 1 to 2 meters thick, although in several places there are zones where beds range from 10 to 30 centimeters thick. A prominent zone of thin-bedded flaggy limestone with beds averaging about 15 centimeters thick is exposed from south of Tamapatz to north of Tansosob and forms the uppermost 50 meters of the El Doctor. The thick-bedded zones tend to form extensive areas of lapies, with pinnacles 1 to 3 meters in height, and frequently crossed by deep, solutionally widened joints.

The El Doctor Limestone is composed of several different facies that interfinger in a complex relationship. Near reef cores the bedding is commonly indistinct, while the thin-bedded zones generally represent inter-reef areas. Because the reefs themselves are only a few hundred meters in length and a few tens of meters thick, the type of limestone and the bedding can vary greatly over a short distance. As yet it is not known if solution favors one facies or type of limestone, but it appears that in the Golondrinas area, fracturing plays a more important role in cavern development than variations in the primary porosity.

<u>Agua Nueva Formation.</u> Overlying the El Doctor in the western part of the Golondrinas area is the Agua Nueva Formation. In this area the contact is gradational, with the thin-bedded upper El Doctor grading upward through a zone of about 10 meters into a flaggy, more argillaceous limestone with shale and siltstone interbeds that forms the lower Agua Nueva Formation. Approximately 300 meters of the Agua Nueva are exposed in the vicinity of Tamapatz. Near Tamapatz the thin-bedded flaggy gray limestones and interbedded marls of the basal Agua Nueva grade upward into a more terrigenous unit about 200 meters thick. This is overlain by about 50 meters of light gray medium-bedded limestone with numerous thin nodules of black chert. The Agua Nueva is exposed in a belt extending from 3 km south of Tamapatz to north beyond Tansosob and out of the area investigated. This narrow belt averages about 800 meters in width and is over 10 km long. The upper Agua Nueva, if present, is covered by an overthrust block of El Doctor Limestone.

The Agua Nueva Formation has had an important effect on the settlement of the Golondrinas area, since it is an aquifer from which numerous springs rise. These springs provide permanent water for a line of settlements along the outcrop from Tamapatz to Tansosob. In addition the concentrated runoff from the Agua Nueva has also formed several large caves where it reaches the soluble El Doctor Limestone.

<u>San Felipe Formation.</u> The San Felipe Formation is exposed in a narrow band along the eastern slope of the Sierra de Aquismón. In the vicinity of Aquismón the formation is overturned and the lower part covered by an overthrust block of El Doctor Limestone. The upper San

Felipe in the Aquismón area is a thin-bedded, yellow-brown argillaceous limestone with generally thinner interbeds of yellow shales. The boundary between the San Felipe and the overlying Méndez Formation is drawn where the flaggy limestones replace the obscurely bedded marly shales of the Méndez Formation. The contact is gradational through a zone of about 15 meters. According to Heim (1940) this formation overlies the El Doctor in the Aquismón area, the Agua Nueva being absent (fig. 1).

Méndez Formation. Stratigraphically above the San Felipe is the Méndez Formation. In the Aquismón area it is generally a greenish, shaley marl with indistinct bedding. Only a small part of the thick Méndez Formation is exposed in the Golondrinas area, where this relatively soft formation forms the lowlands east of Aquismón along the Inter-American Highway.

STRUCTURE

Regional Structure

The structure of the Golondrinas area is dominated by three major elements: the overthrust and associated overturned anticline forming the Sierra de Aquismón along the east edge of the area; the complex anticline that forms the Sierra de Linja; and the overthrust forming the Sierra de Unión just west of Sótano de las Golondrinas (fig. 3). All of these structures are roughly parallel. They trend to the north in the southern part of the area and then curve to the northwest in a broad arc. These structures end just to the south of the area mapped, in the east-west Tampaxal Valley that is probably formed along a major strike-slip (tear) fault dividing the structures of the Golondrinas area from those of the Xilitla area to the south. Evidence for the fault is indirect: the anticlines and thrust sheets south of the valley do not match those to the north, and the southern end of the structures to the north of the valley are curved to the west, probably by drag. The geologic map of Heim (1940) shows four closely spaced thrust faults in the valley near Tampaxal, indicating that this area is structurally complex.

North of the Golondrinas area are two sets of anticlines, the main set following the primary north-south alignment of the Sierra Madre, and the other forming a secondary set of northwest-trending ranges. These two sets of structures intersect in the Golondrinas area. The tectonic stress introduced by the Laramide Orogeny at the close of the Cretaceous, combined with the plastic nature of the Méndez Formation, resulted in the overturned folds and thrust sheets present in the Golondrinas area.

Sierra de Aquismón

In the vicinity of Aquismón the crest of this range is formed by an overthrust block of El Doctor Limestone. The east edge of the limestone forms a prominent cliff standing above the relatively soft limestones and marls of the San Felipe Formation. The San Felipe is overturned and dips 20 to 40 degrees to the west under the El Doctor. The rocks exposed along the eastern slope of the Sierra de Aquismón are the east limb of an anticline overturned to the east. To the south the overthrusting and folding diminish, and in the southern part of the area the Sierra de Aquismón is an anticline with a steepened east face, the El Doctor dipping steeply to the east under the San Felipe. North of Aquismón the range continues as an overthrust beyond the mapped area.

Sierra de Linja

This range is a complex asymmetric anticline that roughly parallels the Sierra de Aquismón to the west. Like many other anticlines of the southern Sierra Madre, it has a steep east face and a gentler west slope. The range is composed of several distinct smaller anticlines that plunge sharply to form narrow passes in the range. In the pass traversed by the Aquismón-Tamapatz trail the axis of the anticline to the south plunges north at 30 degrees and the anticline to the north plunges to the south at 70 degrees. The sharp break where these structures meet forms a narrow east-west valley. A sequence of similar steeply plunging local anticlines continues to where the range dies out just north of the mapped area. To the south the range merges with the Sierra de Aquismón to form a broad anticline.

Sierra de Unión

The Sierra de Unión is the most prominent range in the area and extends as an unbroken cliff from Tamapatz north to San Rafael. This cliff is the east edge of an overthrust block of limestone and stands over a narrow, frequently talus-covered outcrop of the west-dipping Agua Nueva Formation. The overthrust continues north of Tansosob but has little topographic expression. From just north of Tamapatz and continuing south for about 2 km is a valley developed along the strike of the Agua Nueva. This valley drains to the west into caves and sinkholes in the El Doctor (fig. 4). One of the larger of these caves, Cueva de Oxtalja, just west of Tamapatz, has developed along the plane of the overthrust. This large cave has a ceiling of massive El Doctor Limestone and the floor and walls are in most places developed on the crumpled and contorted thin-bedded Agua Nueva beneath the

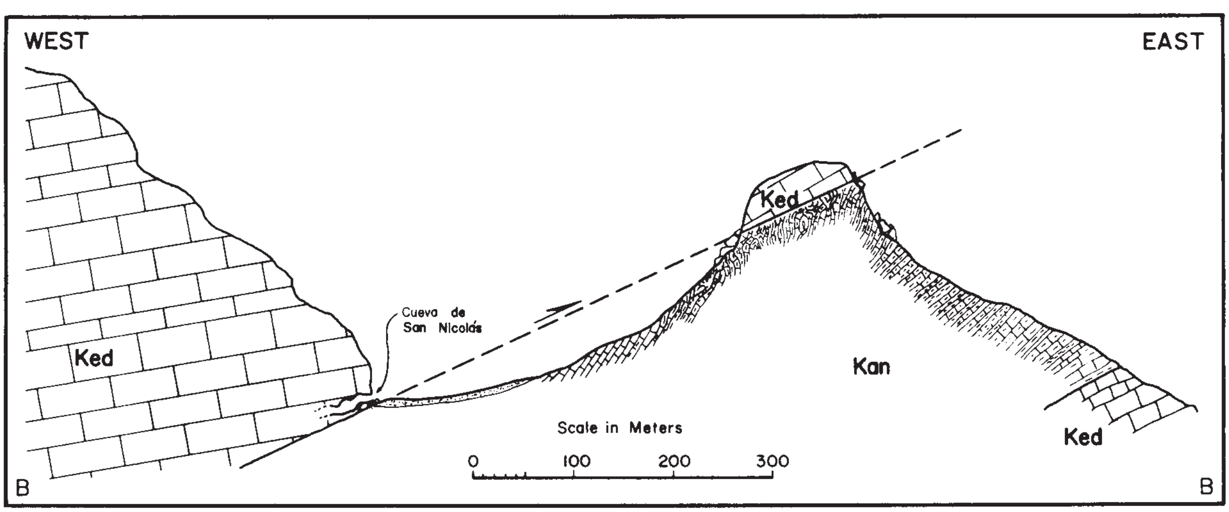


Figure 4. Section B-B' through valley north of Tamapatz.

thrust sheet. The cave follows the plane of the overthrust for about one kilometer to the west; thus, the El Doctor in this area must have been thrust at least this far to the east. The dip of the plane of overthrust was measured in several places. In the cave, Cueva de Oxtalja, the dip averaged 23 degrees to the west, and one-half kilometer north of Tamapatz the dip was about 25 degrees. In an excellent exposure in the valley just to the west of Tansosob the dip was measured to be 22 degrees. In both the Sierra de Aquismón and the Sierra de Unión the beds in the El Doctor dip steeply to the west near the east edge of the overthrusts, but within a few hundred meters dip only gently to the west. West of the Sierra de Unión are several north-south structural trends that may represent additional thrust faults, but as only the massive El Doctor Limestone is involved, the exact relations are difficult to determine.

Minor Structures

Associated with these larger structures are numerous small folds. Several very tight folds are exposed northwest of Aquismón, where beds of the San Felipe are bent back upon themselves in less than a foot. Crumpling and chevron folding are also present in the thin-bedded upper unit of the El Doctor south of Tamapatz. The thin-bedded Agua Nueva is complexly folded and crumpled beneath the overthrust El Doctor. This drag folding is exposed in Cueva de Oxtalja as well as in the hills capped by El Doctor just north of Tamapatz (fig. 4).

GEOMORPHOLOGY

Corrasional Landforms

Although most of the Golondrinas area is underlain by fractured limestone, and solution is the dominant process in shaping the landscape, there are a few areas where solution is not important. East of Aquismón in the wide valley followed by the Inter-American Highway, the soft Méndez marl has been reduced to a mature topography with only a few rounded hills breaking the gentle slopes. The steep outcrop of the San Felipe along the east face of the Sierra de Aquismón is deeply gullied by erosion that is undermining the cliff of El Doctor that stands above the outcrop. The band of Agua Nueva along the east side of the Sierra de Unión is similar, though less gullied. The closed valley along the strike of the Agua Nueva west of Tamapatz was produced by corrasion; the erosion by mechanical means of the soft Agua Nueva is apparently more rapid than the solution of the surrounding El Doctor.

Karst

Solution of the El Doctor Limestone in the Golondrinas area has produced a wide variety of landforms. The effect of solution is controlled by local conditions, primarily the nature of the limestone, rainfall, and local relief, all of which vary widely across the area. In the valley to the west of the Sierra de Aquismón there is little effective local relief. Here the sinkholes are shallow and poorly drained. After eight days of rain during September of 1967 sinkholes in this area were filled with water to depths of over 10 meters. Water completely blocked the main trail to Tamapatz and required several days to infiltrate into the limestone. This entire valley is apparently being lowered by solution. Solutional residue collects in the lower depressions and the local relief is not enough to maintain open drainage channels. The valley to the west of the Sierra de Linja is similar, though sinkholes are somewhat better developed and there is more local relief. However, the area is still comparatively flat, with the sinkholes covering only a small portion of the surface.

In the higher areas west of the Sierra de Unión and south and west of Tamapatz, a much more spectacular type of karst has developed. Here there is much greater local relief, and large elliptical sinkholes frequently over half a kilometer long and one to two hundred meters deep cover the entire surface. These sinkholes are separated by sharp narrow divides and there is little level land. Karren is common and haystack hills have developed in the more fractured areas. Further to the west the sinkholes tend to become larger and more elongate, with flat floors thinly covered with red clay. The largest of these is the La Parada valley, just to the west of the Golondrinas area. This flat-floored solution valley is 10 km long, 1 km wide, and up to 300 meters deep.

Caves and Pits

Considering the amount of rainfall and limestone in the Golondrinas area, caves and pits are not numerous. Apparently in much of the area, solution has been so general and channels for the descending water so plentiful that the entire surface has been reduced by solution. It appears that some mechanism is needed to concentrate the water to have rapid development of large caves. No caves are known in the poorly drained lowlands immediately to the west of the Sierra de Aquismón. In the wide valley to the west of the Sierra de Linja two caves are known. Sótano de las Quilas is a circular pit about 100 meters deep and 80 meters in diameter. Cueva del Camino, 5 meters off the La Laja-Tamapatz trail, is a large passage about 100 meters long with attractive formations.

Several large caves exist along the margin of the Agua Nueva outcrop. To the south is Sótano de Muhaut, a cave about 100 meters long, and Cueva de Muhaut, which has been explored for about 300 meters and continues. Near Tamapatz is the large Cueva de Oxtalja that receives the drainage from an extensive area. This cave is about 1 km long and 200 meters deep, though only two drops, one of 25 meters and the other of 6 meters, require rope. North of this cave is Cueva de San Nicolás, explored for one-half kilometer to a 30 meter drop. North of San Rafael an unexplored cave receives the runoff from a long arroyo.

The most promising area for caves appears to be in the well-developed karst southwest of Tamapatz. Several promising caves have been entered in this area, but none of these have been explored for more than a few meters.

HYDROLOGY

It is not known where the large

amount of water that falls on the Golondrinas area reappears. The Golondrinas area is about equidistant between the series of large springs that forms the Río Huichihuayán and the Nacimiento del Río Coy. The headwaters of the Río Huichihuayán are located about 15 km to the south of the area, and the Nacimiento del Río Coy is about 15 km to the northeast. The Río Coy rises from a large spring (nacimiento) at the end of an isolated limestone hill about 2 km long. Most of this water must flow under the intervening basin from the mountains to the west. The most likely groundwater divide is the Tampaxal valley, just to the south of the Golondrinas area. If this is the divide then the Golondrinas area rainfall reappears at the Nacimiento del Río Coy, 15 km away, at an elevation of about 50 meters.

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HISTORY

For at least 3000 years the Huastecans, the original settlers of the region, had known of the pit. They called it Xol Oclif. To these Indians the large entrance and the immediate surrounding area was of no practical use. It provided no place to cultivate a field and furthermore constituted a hazard, something to be avoided. Thus, little importance was given to this pit or the many others located in the area.

When the Spanish first viewed it, they too attached little importance to this natural feature. To them it was known as Sótano de las Golondrinas. The only interest either group showed was for the swallows that inhabited the pit, and from which the name was derived. They found great sport in attempting to spear or shoot the birds.

Knowledge of Sótano de las Golondrinas by organized exploration groups has not come about until recently. The people of Tamapatz report that a group of six French and Mexican mountain climbers went to the entrance but did not descend. This was in 1957.

Then, during December of 1966, T.R. Evans, Charles Borland, and Ranald Stearns, members of the AMCS and FTA (Fredrick Troglophyllic Association), were guided to Golondrinas. Lacking the proper caving equipment, they were unable to descend and had to satisfy their curiosity by timing the fall of rocks and estimating the depth. At first glance the drop appeared to be between 300 and 400 feet deep. By measuring the time that elapsed between the dropping of a rock and the sound of it hitting the bottom, they obtained a figure of 10 1/2 to 11 seconds. From this they calculated a depth of at least 800 feet.

Only three months passed before T.R. had organized a group to return during the first week of April 1967. Accompanying him were Jon Morse, Sid West, and Bob Hugill from Ft. Detrick, Maryland; Bill Cuddington, John and Sandy Cole, and Dan Hale from Huntsville, Alabama; and Squire Lewis, Nancy Walters, and Bill Deane from Austin, Texas. This time, possessing sufficient equipment, they succeeded in descending and exploring Sótano de las Golondrinas. Initially a single rope was rigged and T.R. commenced what was to be a 30 minute rappel. Later, three shorter ropes were joined to provide a line for prusiking. Using these two routes, eight members of the expedition descended and returned to the surface during the two days the group was at the sótano. Three of them spent the intervening night on the bottom. Most of the prusiking was done the second day, the average time on the rope being 2 to 2 1/2 hours. The length of a nylon rope hanging from the rigging point to the floor was noted and calculations were made to allow for the amount of stretch. The resulting depth of the drop (at the rigging point) was 1070 feet. Consequently, Golondrinas became the deepest known free-fall pit in the world by a substantial margin.

The depth measurements obtained from the April expedition were admittedly not extremely accurate due to several variables. But two months later, during June, John Fish, Ed Alexander, Jonathan Davis, Dick Mitchell, and Ted Peters returned with the purpose of completing an accurate survey of the entire cave. To accomplish this they used a plane table and telescopic alidade to survey the area surrounding the entrance and the floor of the pit, while the actual drop was measured with a steel wire of little and known stretch. The surface survey, the rigging of the drop, and the measurement with the wire required one day to complete, while another day was spent on the bottom finishing the second phase of the survey. The new figures obtained were somewhat higher than those of earlier date. The longest free-fall drop is 1235 feet, the shortest is 1091 feet, and a drop of 1094 feet was measured at the rigging point. The total depth of the cave is 1306 feet. Now, certainly, the authenticity of the new world's record could not be questioned.

Since these early explorations, a large number and variety of groups have visited this awesome sótano. The mass pilgrimage has so aroused the interest and suspicion of the local residents that some believe the strangers come in search of gold, oil, or other valuable objects. Fortunately, the situation has eased and as responsible cavers continue to visit the area, public relations will be established on a really first class level.

EQUIPMENT and TECHNIQUES

As is to be expected, caving equipment and techniques vary from one individual to another. Virtually all methods for ascending and descending a drop have been tried and tested during the past six years of Mexican caving. Through an evolutionary process, the more undesirable means have been abandoned, until now one system predominates ...rappel and prusik.

Of primary importance to the successful negotiation of a sótano is the climbing rope. It is of nylon, varying in diameter from 3/8 inch to 1/2 inch. Either 7/16 inch or 1/2 inch have been most widely used because of the distasteful amount of stretch and general weakness of 3/8 inch rope. These ropes are either laid or braided. In the case of Golondrinas, braided rope was once thought superior due to the absence of spin while climbing. This was disproven when Goldline laid rope was used and only negligible spin noted. No matter what brand of rope is used, great care should be taken to protect it against damage from sharp rocks.

The amount of equipment necessary for the rappel is not great. A seat sling with a locking carabiner is used in conjunction with either a set of two oval carabiners and break bars, or a rappel rack as described in the NSS NEWS, v. 24, n. 6, June 1964. Both methods work well, the advantage of the rappel rack being that less feeding is necessary at the beginning of the rappel. If the rate of rappel is too rapid, the heat that is generated will severely damage the rope. Care should be taken not to exceed a rate of 40 feet per minute or stop at any one point along the rope. A rappel of this magnitude not only affects the equipment but also the explorer. Having a second person pull up the climbing rope a few feet to produce enough slack to allow the rappel device to be attached is very helpful. Once on the rope, it is advisable to move the legs as much as possible because during the 30 minute rappel the seat sling restricts blood circulation.

In addition to a seat sling, the prusik method requires only a set of two or three loops, depending on whether one or two feet are used. If Jumar Ascenders are used, the seat sling loop is attached to one Jumar and either one or two foot loops are attached to the other Jumar. The length of the drop to be ascended does not affect the prusiking equipment, as it does the gear used in rappelling. The only limitation to the distance that it is possible to prusik is the human energy factor. In Golondrinas the average time required to prusik out is 2 to 2 1/2 hours. On the other hand, the distance that it is possible to rappel is limited to the ability of the rappel device to deal with the weight of the climbing rope. As it appears now, some new innovation or improvement of the existing equipment will be needed when it becomes necessary to descend a drop of more than 2000 feet.

PHOTOGRAPHIC DESCRIPTIONS

Figure 1. Aerial view of Aquismón, S. L. P. and surrounding mountains. This photograph was taken looking south down the valley followed by the Inter-American Highway. The right side of the photo shows the eastern edge of the Golondrinas area, which is separated by the Tampaxal Valley from the higher mountains (peaks over 2900 meters) in the background. The trail to Tamapatz begins its ascent at the north edge of Aquismón and crosses the first range in a pass just out of the lower right corner of the photo. The geologic formations are: valley floor - Mendez Formation; slope above Aquismón - San Felipe Formation; and scarps and ridges to the west - El Doctor Limestone.

Figure 2. Westward aerial view of Sótano de las Golondrinas. The entrance is located near the base of the Sierra de Unión and is quite prominent from the air. The main trail crossing the center of the photo connects Tamapatz and Tansosob. The 4 km hike from Tamapatz to the pit requires about 1 1/2 hours. The trail leading out of the lower left corner returns to La Laja and Aquismón. Just to the lower right of center three trails meet at Pozo de Guadalupe, the water supply of the local area. The geologic formations are: Pozo de Guadalupe and below - El Doctor Limestone; center cultivated slope - Agua Nueva Formation; and upper cliffs - El Doctor thrust front.

Figure 3. The entrance of Sótano de las Golondrinas. This wide angle photograph shows the complete entrance with dense tropical vegetation surrounding it on three sides. The surveyed high point of the entrance is in the upper center above the cliff face, while the usual rigging point is in the middle of the group of people. When preparing the equipment prior to descent, the rope must be unbraided on the rough karren in upper foreground.

Figure 4. First exploration group. During April of 1967 the pit was first en-entered. Using 1/2 inch Samson 2 in 1 nylon rope (well padded), an explorer begins the 30 minute, 1094 foot free rappel to the bottom. The man with the white hard hat, closest to the rappeller, uses a walkie-talkie to communicate with an explorer already on the bottom. Extreme caution must be taken when approaching the entrance due to the uneven, deeply fissured karren.

Figure 5. Descending into the pit. Although only about one-sixth of the way to the bottom, the explorer is already approximately 150 to 200 feet below the camera and the lip of the pit.

Figure 6. The entrance shaft. A small waterfall near the entrance shines white in the sunlight while the climbing rope (center) appears dark. The beam of light warms the moist walls and floor, produc-

ing a cloud which oscillates up and down in the pit. The broken appearence of the wall rock and absence of solutional features indicate that Sótano de las Golondrinas was formed by stoping of ceiling and wall rock into a large solutional chamber.

Figure 7. Lengthwise view of bottom. The floor of Golondrinas is composed of medium to small weathered breakdown, deep guano, and some silt. It measures 440 feet by 1000 feet and has an area of about 6 acres. In this eastward view a person is standing in the center of the photo for scale. Halfway between him and the left edge the climbing rope is barely visible. The 40 foot long log in left center is in the middle of the projected entrance area (see cave map). This area is lighter in color due to broken rock pieces. The trough in Figure 8 is down and to the right of this photo.

Figure 8. The trough. The lowest point in Golondrinas (1306 feet below the entrance) is located in the trough, seen here in this photo. It is in the shallow arroyo slightly back and to the left of the person standing in lower center. The left wall of the trough is formed by the pit wall, which is sheer for 500 feet. Steep slopes and a 60 foot high cliff of breakdown with silt and guano matrix form the right wall. The cave at lower left extends only 15 feet and ends. In the upper right corner is a somewhat larger alcove (see cave map).

Sótano de las Golondrinas

Color Photographs

Figures 1 through 8

PHOTOGRAPHY BY

TERRY W. RAINES and BILL DEANE

Figure 1

Figure 2

Figure 3

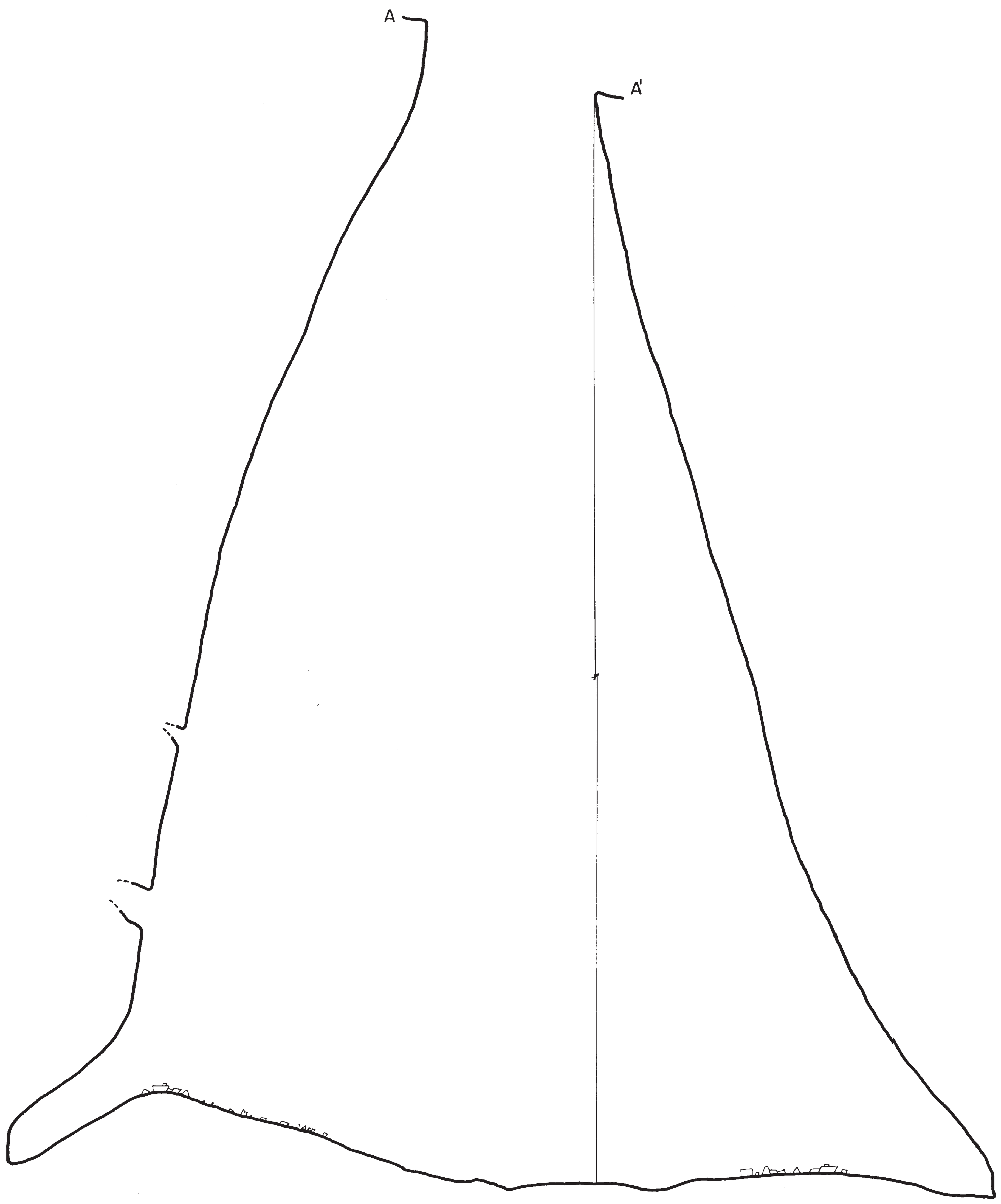
Figure 4

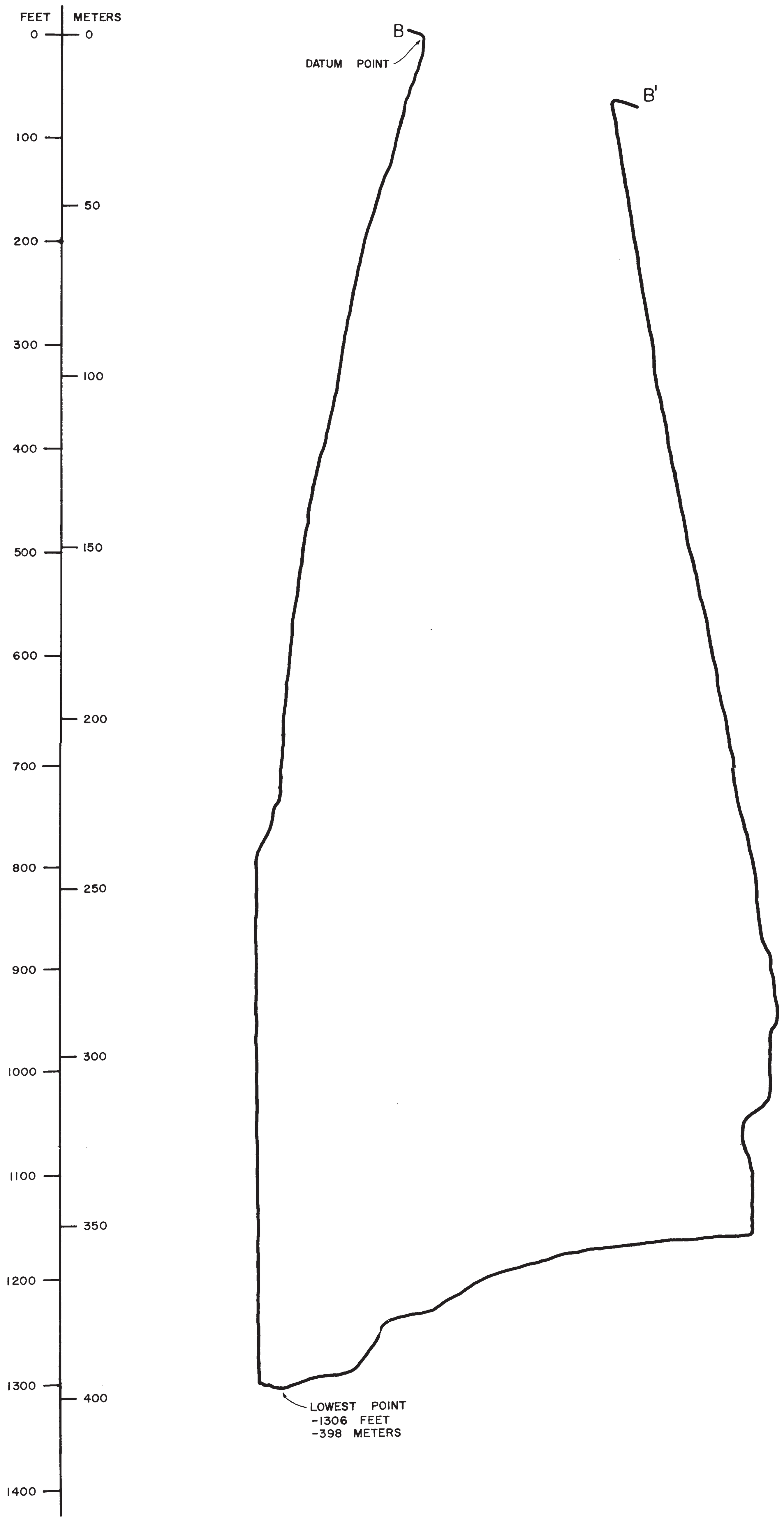
Figure 5

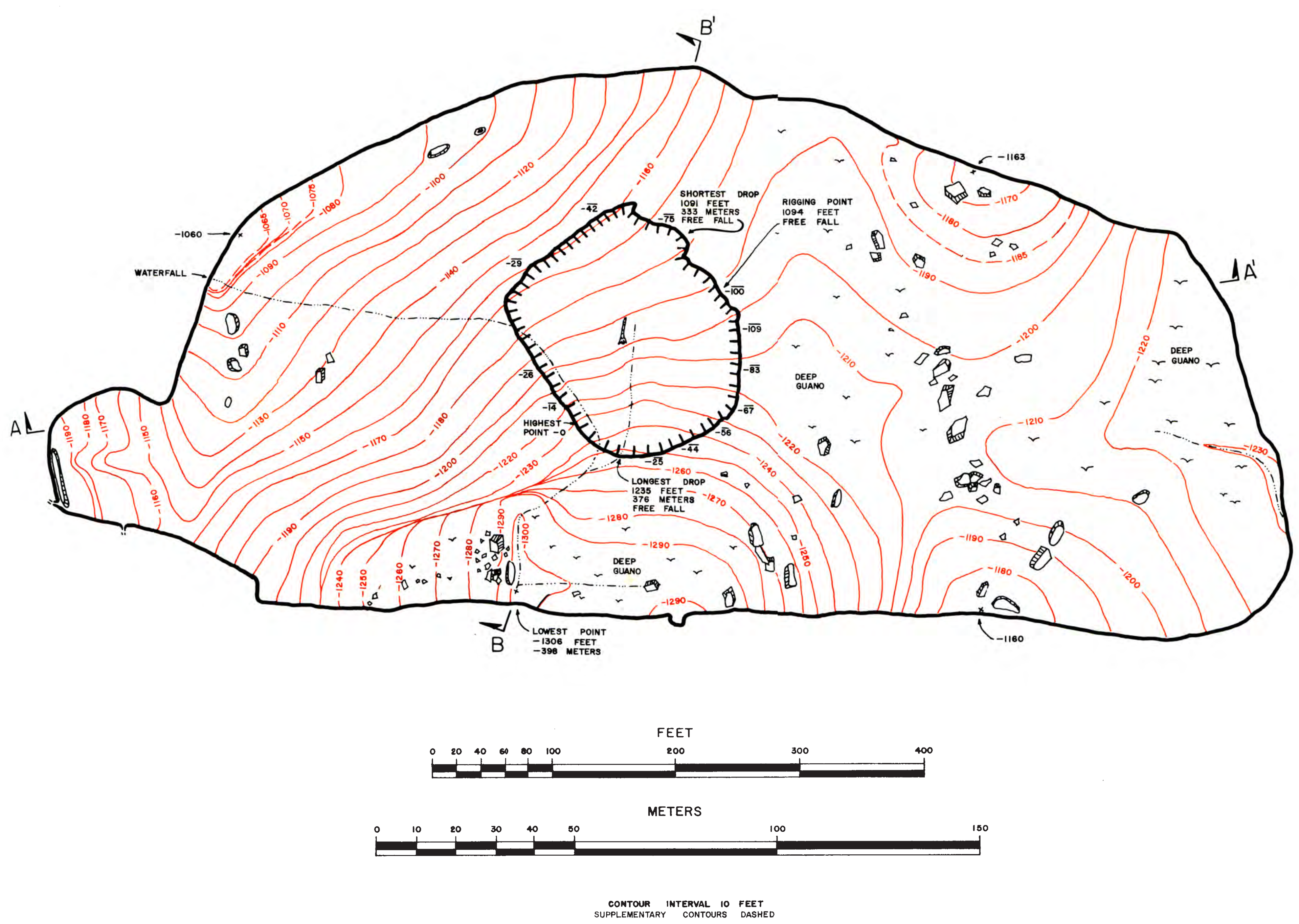
Figure 6

Figure 7

Figure 8







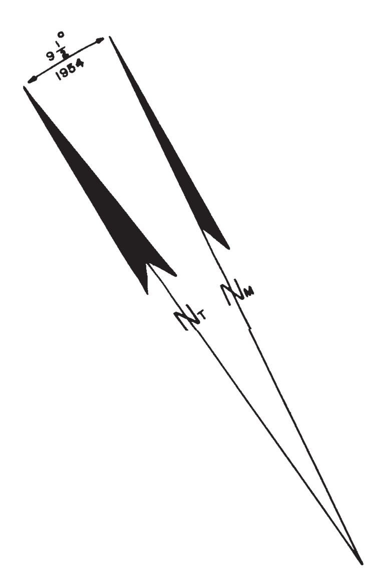
Sótano de las Golondrinas

Municipio de Aquismón, S.L.P., México

Plane Table and Telescopic Alidade Survey, June 1967,

by Ed Alexander, Jonathan Davis, John Fish, Dick Mitchell, Ted Peters

Drafted by John Fish, Carl Kunath



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