

Geology and Hydrology of the El Convento Cave-Spring System, Southwestern Puerto Rico*

by

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INTRODUCTION AND PREVIOUS WORK

The El Convento Cave-Spring System is of particular interest because it is the central feature of the only well-developed, large scale karst area formed on the Tertiary belted limestones of the South Coast of Puerto Rico (Moussa, 1969). Whereas the North Coast Tertiary belted limestones are well known for their extensive karst development (Meyerhoff, 1938; Mitchell, 1954; Doerr and Hoy, 1957; Gurnee, 1958, 1966; Monroe, 1960, 1964a, 1964b, 1964c, 1966, 1968; Beinroth, 1969; Miguel-Giron, 1972), karst topography on the South Coast has only been treated in any detail (to the author's knowledge) by Moussa (1969) and Beck (1973a, 1973b).

Moussa (1969) describes the South Coast karst area and offers general comments on the geomorphic history of the Quebrada de Los Cedros (Cedros Gorge) which is the site of the El Convento Cave-Spring System. The cave itself, however, is not described, nor was it entered (Moussa, 1971, pers. com.). The U.S. Geological Survey and the Commonwealth of Puerto Rico have jointly published two Water-Resources Bulletins which deal with this area: *Water Resources of the Guayánilla-Yauco Area, Puerto Rico* (Crooks, Grossman and Bogart, 1968) and *Water Resources of the Tallaboa Valley, Puerto Rico* (Grossman and others, 1972). Although the former includes the Rio Macaná drainage, of which the Quebrada de Los Cedros is a tributary, it mentions the perennial cave-spring system only briefly. The flow from the El Convento Cave-Spring System is mistakenly indicated as being only the resurgence of a sinking stream (Crooks, Grossman and Bogart, 1968, p. 26 and p. 35) when it is also a third magnitude spring which flows from the cave perennially whether the stream above the cave has water or not. Most recently, Miguel-Giron (1972) includes this area on a map of "Principales Nucleos de Cavidades Subterráneas en Puerto Rico" (p. 2) and shows the location of El Convento and nearby Cueva Mapancho on a "Mapa de Cuevas" (p. 39) but the cave and the area are not mentioned in the text. Except for these brief mentions, then, the El Convento Cave-Spring System is essentially unstudied, except for the author's ongoing research.

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PHYSICAL SETTING AND GENERAL GEOLOGY

The El Convento Cave-Spring System is located in the Quebrada de Los Cedros, which is a tributary of the Río Macaná, in southwestern Puerto Rico (see Fig. 1). The surrounding area is marked by other karst features such as Cueva Mapancho and several large sinkholes which are obvious on the topographic map (Fig. 1). The terrain is rugged and the area is essentially unsettled: a few unpaved roads criss-cross the hills and make them accessible by Jeep or on foot. The lower portion of the Quebrada contains a cattle ranch centered around the perennial water flow which emerges from the cave-spring system.

The area surrounding Guayanilla Bay, to the south, is highly industrialized. In the major alluvial valleys of the Río Macaná and the Río Tallaboa agriculture is dominant, most of the land being devoted to sugar cane. The valley between Peñuelas and Santo Domingo, north of the Quebrada, is also extensively devoted to sugar cane growing. The limestone hills are principally unused except for the previously mentioned cattle ranch.

The karst area surrounding the Quebrada de Los Cedros is formed on the Juana Diaz Formation. The Juana Diaz Formation has been divided into three units: a lower, sandy or gravelly, conglomeratic mudstone up to 190 m thick; a middle zone of dense, biomicritic, reef facies limestone 400 m thick; and an upper chalk or chalky limestone up to 150 m thick which is not everywhere present (P.R.W.R.A., 1972). The karst topography is limited to the middle zone (P.R.W.R.A., 1972). The only other significant karst features on the South Coast Tertiary limestones are developed on a series of dense limestone strata exposed along the coast in the area of Guanica. Here the solutional enlargement of several sets of joints into grikes has broken the thin beds (ca. 0.5 m) into a limestone pavement of separate, jagged blocks marked by raindrop pits, solution pans, and runnels (Moussa, 1969; Beck, 1972). At least one significant cave is also developed in this area. The common factor displayed by these two karst areas and limited to them is the dense, impermeable nature of the strata as compared to the chalky or marly character of the surrounding Juana Diaz and Ponce Formation limestones. A dense, impermeable

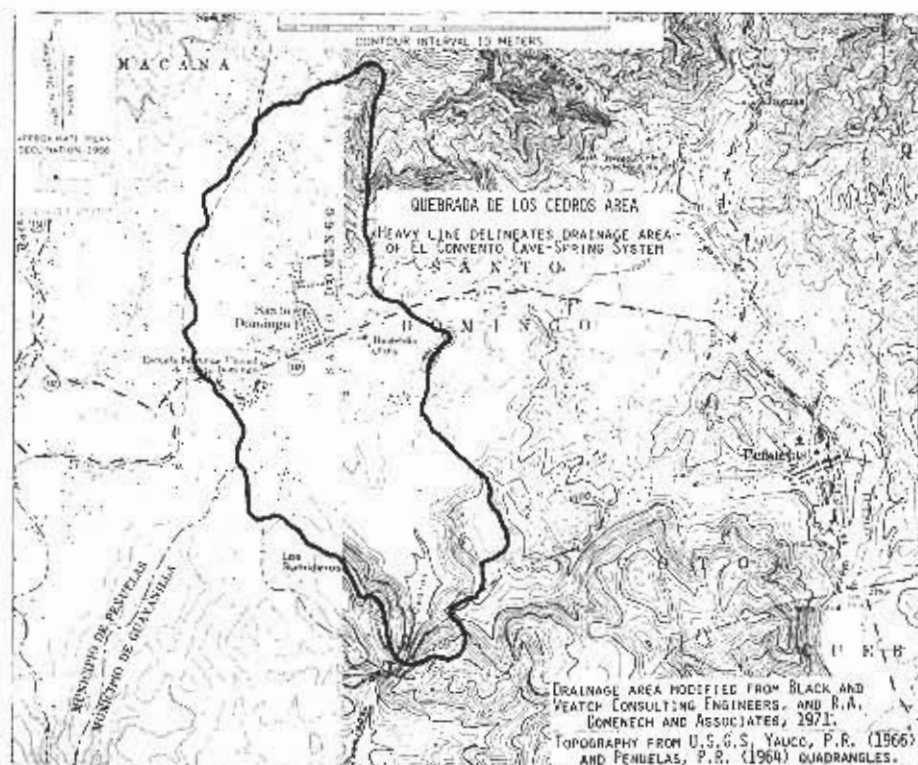


Fig. 1. Drainage Area of the El Convento Cave-Spring System

limestone is sometimes cited as a prerequisite for karst development (Thornbury, 1954) and it appears that it is the localizing factor in this area of Puerto Rico (Moussa, 1969; Beck, 1973a).

CLIMATE AND GENERAL HYDROLOGY

The climate of this portion of Puerto Rico is generally rather dry, but this particular area falls within the subtropical moist forest category using the Holdridge model (Ewel and Whitmore, 1973). Rainfall in this zone ranges from approximately 100 to 200 cm/yr and according to Calvesbert (1972) average annual rainfall in the immediate area of El Convento is approximately 127 cm*.

* Precipitation, evaporation, and temperature data in Calvesbert (1972) and Crooks, Grossman and Bogart (1968) are given in the English system and were converted by the author to metric equivalents using standard conversion factors and rounding off to the nearest unit.

"The distribution of rainfall over the year does not show an absolute wet season-dry season relationship, but only a relatively dry season and a relatively wet season" (ibid., p. 4). Rainfall in the El Convento area is highest in August, September, October, and November (Crooks, Grossman and Bogart, 1968). The majority of Puerto Rico's rainfall is of orographic nature and falls as brief, heavy showers (Calvebert, 1972).

The mean annual temperature is 25°C (Calvesbert, 1972). Data on the range of temperatures is not available for this immediate area but at Santa Isabel, similarly located, the range extends from an average daily minimum of 18°C in February to an average daily maximum of 31°C in August (ibid.). The average annual evaporation at two stations in the South Coast subtropical *dry* forest zone is approximately 205 cm. The subtropical dry forest has a potential evapotranspiration: precipitation ratio of 2.0-1.0 and the subtropical moist forest from 1.0-0.5 (Ewel and Whitmore, 1973). However, the El Convento area is near the drier margin of the moist zone and local conditions in the hills surrounding the Quebrada when visited by the author on numerous occasions throughout 1972 and 1973 indicate that evapotranspiration probably exceeds precipitation here by a noticeable amount.

The Rio Macaná, of which the Quebrada de Los Cedros is a tributary, is perennial as it leaves the Central Mountains, however, it loses its flow to the coastal limestone hills and alluvium (Crooks, Grossman and Bogart, 1968). The Quebrada de Los Cedros occasionally flows to the north of El Convento, but this is generally associated only with periods of heavy rainfall. At such times the flow is completely absorbed by the sinkhole above the El Convento Cave-Spring System. The flow from Clarco Azul (the local name for the pool at the resurgence of the El Convento System), however, is perennial. This feeds a small stream around which the aforementioned cattle ranch is centered and is then absorbed into the alluvium.

DESCRIPTION OF THE EL CONVENTO CAVE-SPRING SYSTEM

The El Convento Cave-Spring System was mapped (see Fig. 3) with a Universal Wilkie*, oil damped, prismatic-sighting compass and a steel tape during 1971 and 1972 by the author and numerous associates (see Acknowledgements). The data were converted to latitude and departure coordinates (Kunath, 1970) on a Wang 500* computer. The total error of closure was approximately twenty-five meters in a one thousand meter loop and this was corrected by distributing the error equally to all stations on the loop. The error is ascribed to the large number of individual mapping expeditions which were compiled to make the map and to the inexact vertical control in the survey of the Quebrada**.

The El Convento Cave-Spring System is composed of several different passage segments separated by the Quebrada (see Figs. 2 and 3). The major passage system

* Registered trademark or copyrighted name.

** The Universal Wilkie compass is highly accurate (in the author's experience) for measuring azimuths, but it is generally inaccurate and imprecise for measuring vertical angles, principally due to a lack of sights for this purpose.

is on the western side of the gorge and connects Charco Azul (the resurgence), El Convento (a high, arched entrance which gives the system its name), Hoyo sin Nombre and La Rendija. The passage is principally tall, canyon type passage (terminology after White, 1967, p. 2-18 and 2-20) with flowing water generally covering the bottom. Rimstone dams frequently span the passage and cause abrupt drops in the water level. The passage parallels the canyon wall from Charco Azul through El Convento to Hoyo sin Nombre and then veers west under the uplands. After several hundred meters it makes almost a 180° turn and returns to the Quebrada at La Rendija, so named because it is a high, narrow canyon passage. The only side passage occurs near the La Rendija end and is a short (ca. 75 m) segment with some water flow emanating from beneath a large flowstone block which marks its terminus. At the La Rendija entrance water seeps from the talus in the Quebrada and flows into the passage system.

The La Rendija entrance is immediately adjacent to a tall cliff (ca. 75 m) which blocks the Quebrada here (see Fig. 2). In the face of the cliff on the west, adjacent to La Rendija, there is a small, unnamed cave with a few chimneys and short crawls leading off from it. The central portion of this room is a large, massive, flowstone mound tapering up and to the near ceiling of the room. From a small crawlway on the east side of this room one can enter another cave, Ojo de Agua, which is a continuation of the El Convento System trending eastward.

Ojo de Agua begins as a tall slot at the eastern corner of the cliff and the

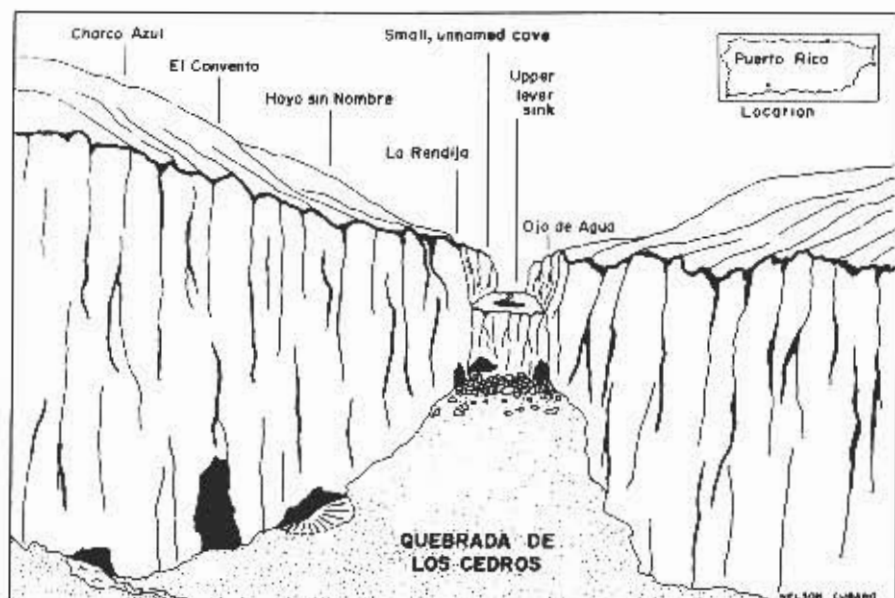


Fig. 2. Artist's sketch of Quebrada de los Cedros looking north with vegetation removed. Cueva Viento, on the east wall, is not shown.

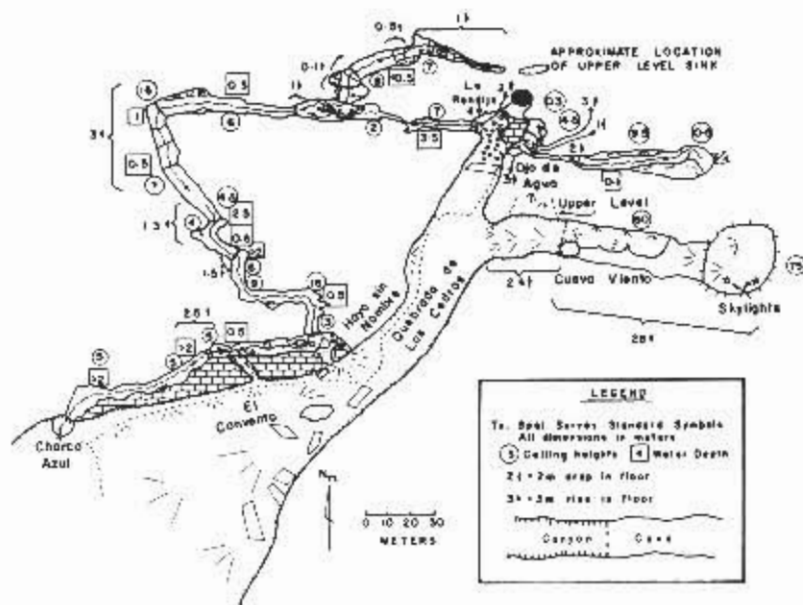


Fig. 3. Map of El Convento Cave-Spring System; compass and steel tape survey by B. F. Beck and others.

Quebrada wall. Inside the entrance on the northwest a clay slope leads upward to the aforementioned crawlway, and to the east the main passage becomes a small (ca. 1 m x 2 m), vertically elongated, elliptical tube. The unnamed cave and this portion of the Ojo de Agua passage are above the level of flowing water. After approximately 20 m, the passage to the east opens into more tall, canyon like passage. At the juncture there is a short drop (ca. 2 m) and the water flowing out of the Ojo de Agua passage sinks into a small hole, from here to pass beneath the previously mentioned dry passage, through the talus at the base of the cliff, and to reappear as the seep at La Rendija. The Ojo de Agua passage continues eastward approximately 50 m and ends in a pool which is clear at low flow but murky in flood. Below the surface of the water in this pool one can see the passage continuing east. Passage heights and water depths for the various areas are shown on Fig. 3.

Indented in the eastern wall of the Quebrada, approximately sixty meters south of the cliff, there is a steep soil and talus slope. This is not shown in Fig. 2 for clarity but is included in the map of Fig. 3. This leads upward to an extremely large, but relatively short, tunnel-like cave, known as Cueva Viento. Although the dimensions are large (20 m wide and 60 m tall) the cross-section is still canyon like. At the rear of Cueva Viento there is a large dome, estimated to be seventy-five meters tall, with two skylights penetrating to the uplands above. Just outside the mouth of Cueva Viento, up a steep limestone face on the north wall, a short,

upper-level cave penetrates totally through the limestone wall and exits back into the Quebrada above the cliff (i.e., on top of the Unnamed Cave and the beginning of the Ojo de Agua passage; see Fig. 3). The lower portions of Cueva Viento are approximately at the same elevation as the floor of the Quebrada above the cliff.

Just above the cliff, the floor of the upper Quebrada slopes downward to the north such that the cliff edge is a high point. At the base of this slope just north of the cliff there is a system of irregular crevices between the rocks which lead downward in a maze of small, intertwining passages which all soon became too small for human entrance. The flood flow from the Central Mountains drains to the base of this slight upward slope and is here totally absorbed into these crevices, later to reappear below in the El Convento Cave-Spring System. The approximate location of this upper sink is shown on Fig. 3 but the details of the upper Quebrada are deleted to avoid overcrowding.

GEOMORPHIC HISTORY

Moussa (1969) discussed the geomorphic history of the Quebrada and El Convento in a general manner. The drainage from the Cordillera Central (the mountains which appear across the northern portion of Fig. 1) at one time apparently flowed to the east and joined the Rio Tallaboa. A sinkhole, which formerly existed approximately in the triangular area north of the Quebrada, pirated a portion of this drainage underground and through various karst conduits to the south. Continuing development and collapse has left the Quebrada as we see it today.

Moussa (1969) believes the gorge is due to the collapse of a former cave system. The large, high, canyon type cave passages which cross the canyon obliquely, however, complicate this theory. On the other hand, the extremely large boulder spanning the Quebrada near the cliff base (see Fig. 3) may well be the remains of a natural bridge, which would tend to substantiate Moussa's (1969) hypothesis. Headward collapse over a receding spring system is most probably an integral part of the development of the Quebrada, but a detailed geomorphic history of the area awaits more extensive study of all the caves and the various karst features in the area.

HYDROLOGY

The details of the hydrology may be followed on Fig. 2 and Fig. 3. Water flowing from the upper drainage area (outlined on Fig. 1) converges and flows into the narrow Quebrada where it then disappears into the sinkhole immediately above the cliff. During the majority of the year this stream is dry, but during the wetter periods it may carry heavy, short duration floods due to thundershowers and a smaller, more persistent flow for several weeks or months.

It is possible to calculate a frequently occurring high flow from the hydrologic parameters. The drainage basin above the Quebrada has an area of approximately 3.4 km² (calculated by the weighed paper technique). A good approximation for the precipitation rate is 2.54 cm/hour for approximately one hour; this is within

the range of, and a good approximate average of, the compiled data associated with a normal convective type thunderstorm rainfall as monitored at Peñuelas (Calvesbert, 1972, pers. com.). The mean annual runoff coefficient may be approximately calculated from the Basin Climatic Index (R.A. Domenech and Associates and Black and Veatch, Consulting Engineers, 1970; figures 2-4 and 2-5) and by this method an approximate value of 22.5% is obtained. However, utilizing very general criteria in Todd (1970, Table 2-26) a value from 55-70% is obtained. Soil maps (U.S. Department of Agriculture, 1969) show most of the drainage as high runoff potential soils. During a high intensity, short duration rainfall, such as we are hypothesizing, the higher values are probably closer to correct, although the lesser value is probably more correct on an annual basis (which it is calculated for). In light of this data 55% will be used as an approximation of the runoff coefficient with an uncertainty of 15%, i.e., $55 \pm 15\%$.

Approximately three to five hours after the thundershower, the flood flow should reach the cave. As an order of magnitude approximation we may calculate the summation of rainfall times the runoff over the area of the drainage basin and assume that all this flow arrives within one hour. This yields a flow of $4.7 \pm 1.3 \times 10^4 \text{ m}^3/\text{hour}$ which is completely swallowed by the system. This is on the order of $10^3 \text{ m}^3/\text{min}$ in flood. Sediment size data indicate a velocity near $300 \text{ m}^3/\text{min}$ which is reasonably close to the lower range of this estimate (Beck, 1973b).

This flow is conducted through a network of openings too small for human passage to at least three different points: the small, unnamed cave where it flows out above the large flowstone mound; the chimney in the connecting passage between this cave and Ojo de Agua; and into the main flow through Ojo de Agua from the pool at the end of the passage. During peak floods all three openings function and water may also enter the system from the rear of the side passage, although this could not be checked. At such times water in Ojo de Agua backs up because of the small exit sump and the upperlevel elliptical tube is totally flooded. Thus, the depth in the main passage must be on the order of 4 m as a minimum. This ponding effect is responsible for the two large sediment banks present here, the bank closer to the source being gravel and that downstream clay and silt, as would be expected when rapidly moving water enters a large volume pool.

As the flow subsides, only Ojo de Agua, and possibly the side passage, continue to carry water from the sinkhole. Dye studies show that the time interval from entering the sinkhole to emerging at the siphon in Ojo de Agua is approximately two hours. Since this path drops approximately 25 m the water might be expected to move more rapidly, but it is probable that there is a large system of passages behind this siphon and that the volume of water contained therein must first be displaced before the dye can emerge.

Even when the stream above is totally dry, as it is for approximately nine months out of the year, Ojo de Agua and the side passage have a flow of water emanating from them. In frequent visits from 1971 through 1973 the author has never seen either passage dry or not flowing. Low flow volumes from these passages were measured using a plywood dam and a Tsurumi-Seiki Kosakusho flowmeter*.

* The T. S. K. flowmeter is designed for measuring flow through a plankton net, but when mounted on a handle it will suffice for the approximate measurement of stream flow.

Table 1. Water flow in the El Convento Cave-Spring System. Measured with a Tsurumi-Seiki Kosakusho flowmeter.

INPUT		OUTFLOW	
LOCATION	FLOW (m^3/MIN)	LOCATION	FLOW (m^3/MIN)
OJO DE AGUA	0.9	CHARCO AZUL	0.4
SIDE PASSAGE	0.1	SPRING (DOWNSTREAM)	0.1
TOTAL	1.0	TOTAL	0.5
LOST TO GROUNDWATER: 0.5 m^3/MIN			

These measurements are tabulated in Table 1. Part of the water which enters the El Convento Cave-Spring System from the siphon in Ojo de Agua passes through the breakdown in the Quebrada below the cliff and emerges in La Rendija (follow on Fig. 2). That portion of the flow passing through La Rendija is then joined downstream by the minor flow from the side passage and the combined volume continues through the cave to Charco Azul. Dye tracing shows that a part of the flow from Ojo de Agua also goes southward, probably through small cave openings, and emerges at a spring which is on the southeast side of the Quebrada approximately 0.3-0.5 km downstream from Charco Azul.

The resurgences for the cave system are Charco Azul and the aforementioned spring. Moussa (1969, p. 717) hypothesizes that "there are probably more springs in the streambed". The author has examined this area firsthand and finds no evidence that any springs other than the obvious one are present. In some places small streamlets branch and rejoin, as in a braided stream, and occasionally these seep through gravel bars; such instances may appear to be springs, but closer examination shows their correct source. The flow from Charco Azul and from the spring is also tabulated in Table 1. During the flow through the cave and associated spring system the flow volume is reduced by approximately half, from 1 m^3/min to 0.5 m^3/min . This loss may occur into deeper passages below water level in the main portion of the El Convento Cave-Spring System*, or it may occur in the unmapped network which goes from Ojo de Agua to the spring, or the loss may well occur in both areas. A higher density of flow measurements throughout the cave-spring system is needed to accurately locate the point of loss.

Dye tests were conducted in the El Convento Cave-Spring System. Flow from the exit of Ojo de Agua, through the breakdown to La Rendija took only forty minutes, implying a relatively open, small volume system. Flow from the siphon in Ojo de Agua to Hoyo sin Nombre took approximately three and one half hours, while flow from Hoyo sin Nombre to Charco Azul took well over four hours (exact

* Directly below one of the rimstone dams just upstream from the Hoyo sin Nombre entrance, a deep hole exists. This is probably simply a plunge pit, but it might be a chimney to lower passages.

time unknown). This longer time interval for a much shorter segment of passage indicates that the latter section from El Convento to Charco Azul is deeper than expected and probably contains a significant volume of water. However, the volume of flow may have been significantly lowered by leakage before reaching this area thus accounting for the longer travel time. The travel time from the siphon in Ojo de Agua to the spring on the southeast side of the Quebrada was more than seven hours and less than twenty-four (exact time not measured).

SOLUTION CHEMISTRY

Water samples were taken at selected sites throughout the cave-spring system and later analyzed in the laboratory. At the time of sampling no water was entering the system from the sink. Two D.O. (dissolved oxygen) bottles were collected at each location; one was fixed for dissolved oxygen measurement by the Winkler method (Strickland and Parsons, 1968) and the other was left untreated. D.O. bottles have a ground glass stopper which is tapered downward to insure that no air bubbles are included with the sample. The bottles were transferred to the laboratory on ice and kept refrigerated until analyzed. The temperature of the water was measured with a standard mercury thermometer at the time of sampling. All samples were clear and the bottles were left immersed and open in the flowing water for more than fifteen minutes to insure equilibration.

pH and alkalinity were measured immediately upon opening the bottle using a Beckman Model G pH meter and titrating with 0.0164 N H_2SO_4 to a pH of 4.50 (Brown et al., 1970). Dissolved CO_2 was calculated from the alkalinity and the initial pH (Brown et al., 1970). Dissolved oxygen was determined by a Winkler titration (Strickland and Parsons, 1968) which is essentially similar to the "Azide Modification of the Iodometric Method" (Am. Pub. Health Association, and others, 1965) or the Alsterburg Azide Method recommended by the U.S.G.S. (Brown et al., 1970). Ca and Mg were measured by atomic absorption spectrometry with a lanthanum chloride additive to reduce interference (Brown et al., 1970). Standards and blanks were also run unknown to the operator. Ca analyses were generally low by 3% or less and Mg was slightly low (1%); accuracy improved with concentration and since the samples were measured at concentrations ten times those of the standards used for comparison the analytical error is probably very small. Total carbonate hardness was calculated using the Ca and Mg values (ASTM, 1965).

The results of the analyses are presented in figures 4 through 6. Fig. 4 shows the dissolved oxygen and carbon dioxide content of the cave waters. Note that the water emanates from both springs within the cave (i.e., in Ojo de Agua and in the side passage) very low in oxygen and high in CO_2 and that it generally loses CO_2 as it passes through the cave system. The dissolved oxygen content rises initially, probably because the water in the Ojo de Agua passage is shallow and fast moving and, at the time of sampling, this passage did not contain a large colony of bats. However, after entering the main passage the dissolved oxygen content decreases again. The water in the main passage system is deep and generally slow moving and

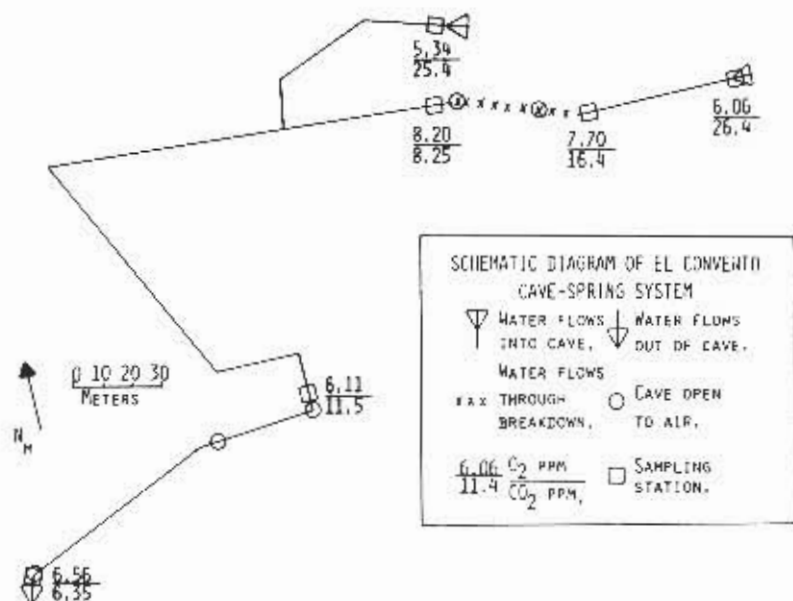


Fig. 4. Dissolved oxygen and carbon dioxide in El Convento Cave-Spring System waters. Oxygen by Winkler titration; Carbon dioxide calculated from pH and alkalinity data.

there are several large bat colonies roosting over it. The water flow over the rim-stone dams is small compared to the overall volume of water and the decaying guano and lack of aeration probably both act to reduce the dissolved oxygen. Similarly, the decaying guano is probably responsible for the small rise in CO₂ content found at the sampling station immediately upstream from Hoyo sin Nombre.

Fig. 5 shows the total hardness as calculated from the calcium and magnesium values. Fig. 6 shows the Ca hardness and pH plotted on the CaCO₃ saturation curve as modified from Picknett's (1972) data. It is recognized that this method of analyzing the saturation is only approximate (Jacobson and Langmuir, 1972), but sufficient data were not obtained to utilize a more sophisticated approach. The presentation of the data on the modified Picknet curve should be satisfactory for observing relative changes inasmuch as errors due to the presence of other pairs should remain relatively constant. An earlier presentation (Beck, 1973a) was slightly in error due to the author's misinterpretation of Picknet's (1972) data; however, the conclusions presented therein were still valid. The samples are numbered sequentially on the graph, 1 and 1' being the sources of water (Ojo de Agua and the side passage) and 5 being the resurgence.

The groundwater as it emerges into the cave passages, both at the siphon in Ojo de Agua and at the terminus of the side passage, is approximately saturated with respect to calcite. As the water flows through the Ojo de Agua passage and through

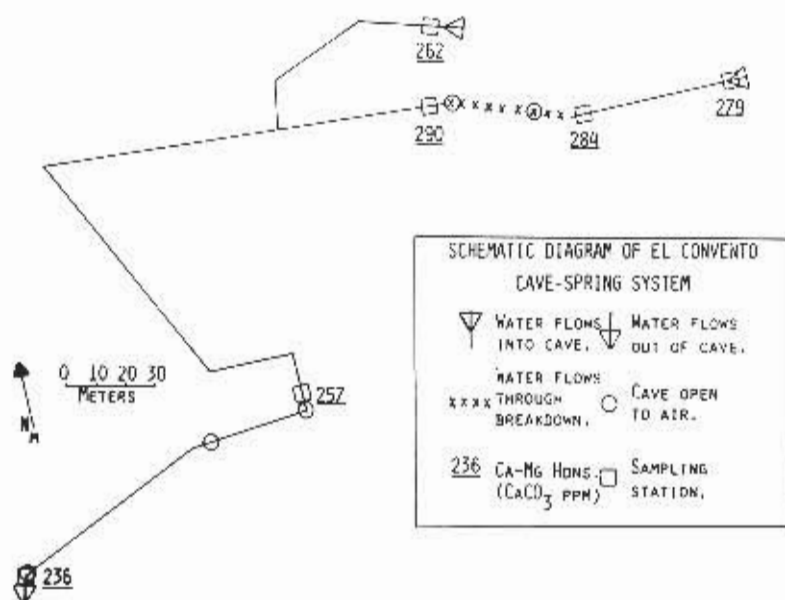


Fig. 5. Total carbonate hardness as CaCO_3 for El Convento Cave-Spring System waters. Hardness calculated from Ca and Mg analyses by atomic absorption.

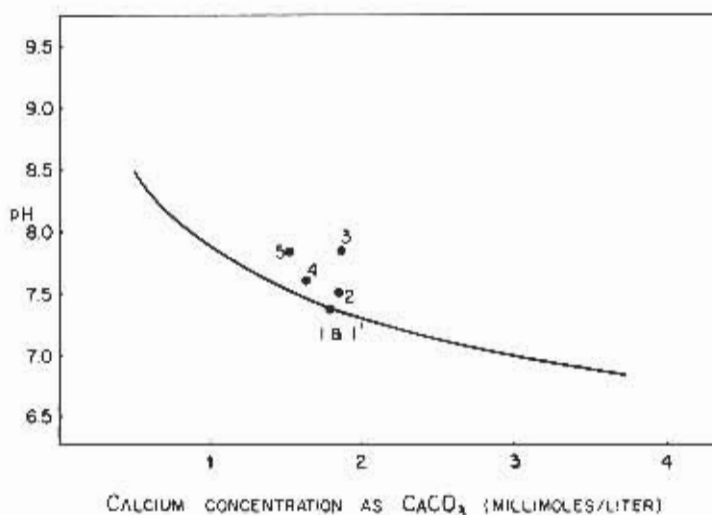


Fig. 6. Hardness for El Convento Cave-Spring System waters plotted on approximate saturation curve for calcite solutions at 25°C with $\text{Ca:Mg} = 3:1$. Modified from Picknett (1972). #1 is the spring in Ojo de Agua; #1 is the spring in the side passage. #2 is in Ojo de Agua where water leaves the passage. #3 is near the entrance to La Rendija. #4 is just upstream from Hoyo sin Nombre. #5 is in Charco Azul.

the breakdown below the cliff, it rapidly loses CO_2 and becomes supersaturated. Once the flow enters the larger main passage, however, the CO_2 content remains relatively constant and the equilibrium trends back toward saturation, probably due to precipitation of CaCO_3 on the numerous rimstone dams. The enrichment with respect to CO_2 at site 4 is probably due to the particularly large amount of bat guano present in the water in that area and the large population of bats living over the water, as mentioned previously.

ABSTRACT*

Whereas the North Coast Tertiary Limestones of Puerto Rico are classic karst locales, their southern counterparts are almost devoid of karst development. The El Convento Cave-Spring System is the most prominent feature of the only large scale karst area developed on the South Coast Tertiary limestones. The karst topography is localized on the middle Juana Diaz Formation, which is a reef facies limestone, apparently because of the high density and low permeability of this zone as compared to the surrounding chalks and marls. In the El Convento System a sinking ephemeral stream combines with the flow from two perennial springs inside the cave. The surface drainage has been pirated from the Rio Tallaboa to the east into El Convento's subterranean course.

The climate is generally semi-arid with 125-150 cm of rain falling principally as short, intense showers during Sept., Oct., and Nov. Sinking flood waters are absorbed by a small sinkhole and appear two to three hours later in the cave. In the dry season this input is absent. The two springs within the cave have a combined inflow to the system of $1.0 \text{ m}^3/\text{min}$ at low flow but half of this leaks back to the groundwater before it reaches the resurgence. The spring waters are saturated with CaCO_3 and high in CO_2 (26.4 ppm). As the water flows through the open cave it first becomes supersaturated by losing CO_2 and then trends back toward saturation by precipitating CaCO_3 .

RESUMEN

Mientras las calizas terciarias de la costa norte de Puerto Rico son localidades cársticas clásicas, sus contrapartes en el suroeste de Puerto Rico están casi totalmente exentas de desarrollo cárstico. El sistema cueva-manantial El Convento es la facción más sobresaliente del único área cárstica de gran escala, desarrollado en las calizas terciarias de la costa sur. La topografía cárstica está localizada sobre la formación Juana Díaz mediana, la cual es una caliza de facie arrecifal, debido aparentemente a la alta densidad y baja permeabilidad de esta zona en comparación a las cretas y margas adyacentes. En el sistema El Convento un arroyuelo intermitente se combina con el flujo de dos manantiales perennes dentro de la cueva. El drenaje,

* Abstract to be published in the National Speleological Society Bulletin.

superficial ha sido pirateado del Río Tallaboa al este, hacia el cauce subterráneo de El Convento.

El clima es generalmente semi-árido con 125-150 cm de precipitación, principalmente en forma de intensas lluvias cortas durante septiembre, octubre y noviembre. Aguas filtrantes procedentes de inundaciones son absorbidas por un pequeño sumidero y reaparecen dos o tres horas más tarde dentro de la cueva. Durante las sequías este flujo no existe. Los dos manantiales dentro de la cueva tienen un flujo combinado para el sistema $1\text{ mts}^3/\text{min}$ durante flujo bajo, pero la mitad de este vuelve a infiltrarse al agua subterránea antes de que llegue a su resurgencia. Las aguas de manantial están saturadas con carbonato de calcio y alto en dióxido de carbón (26.4 ppm). Mientras fluye el agua por la cueva abierta, primeramente es super-saturada cuando pierde el dióxido de carbón y entonces regresa a ser saturado por la precipitación de carbonato de calcio.

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