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2006 SYMPOSIUM ABSTRACTS

Edited by Ramón Espinasa-Pereña and John Pint

México Session

Inaugural Address

Importance of Lava-Tube Flow Emplacement in the Sierra Chichinautzin Volcanic Field, Mexico

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The Sierra Chichinautzin Volcanic Field (SCVF), located in the central portion of the Transmexican Volcanic Belt, is a volcanic highland elongated in an E-W direction, extending from the flanks of Popocatépetl stratovolcano (presently active) to the east to the flanks of Xinantécatl (Nevado Toluca) stratovolcano to the west. It is made up by over 220 scoria cones and associated block, A'a or pahoehoe lava flows (Martin del Pozzo, 1982). This volcanic field is on the continental drainage divide that separates the closed basin of México, which artificially drains to the north, from the valleys of Cuernavaca and Cuautla, which drain south and the Lerma river basin which flows west. Large cities, including Cuernavaca, Toluca and especially México City, together with several other populated locations, are located nearby, so renewed activity might represent a serious risk for them.

Lava flows in the SCVF vary considerably in their morphology. Some are compound andesite or basaltic andesite A'a flows, some of the thicker blocky lava flows are dacitic and others are basaltic tube-fed pahoehoe flows. Lavas belong to the calc-alkaline suit, and are genetically linked to the subduction of the Cocos plate (Martin del Pozzo, 1982). The tephra cones, lava shields, associated lava flows, tephra sequences and intercalated alluvial sediments that make up the Sierra Chichinautzin cover an area of approximately 2,500 km^2. Paleomagnetic measurements indicate that most exposed rocks were produced during the normal Brunhes Chron and are therefore younger than 0.73-0.79 Ma (Urrutia and Martin del Pozzo, 1993), which is not surprising in view of the very young morphological features of most tephra cones and lava flows.

Recent studies by Siebe (2000) and Siebe *et al*. (2004, 2005) have published dates for 10 of the youngest volcanoes in the SCVF, several of which were emplaced by lava tubes. These and other previously published dates imply a recurrence interval during the Holocene for monogenetic eruptions in the SCVF of <1,250 years (Siebe et al., 2005). Siebe et al. (2004) conclude erroneously that very long lava flows must have necessarily been emplaced by high-effusion rate eruptions, and do not consider that tube-fed pahoehoe flows can reach very far in low to moderate-effusion rates (Peterson *et al*., 1994).

In this paper an attempt is made to quantify the importance of lava tube flow emplacement in the SCVF. All known locations of lava tubes have been plotted on the topographic maps and their source volcano identified. Maps of distribution of tube-emplaced lava flows have shown that almost a third of the surface area of the SCVF is covered by these kind of lava flows, including all those over 10 kilometers in length. The four youngest eruptions known in the area were emplaced through lava tubes. We conclude that lava-tube flow emplacement is very common in the SCVF, a fact that should be taken into account when performing risk assesments.

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Oral Presentation

Lava Tubes of the Suchiooc Volcano, Sierra Chichinautzin, México

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Suchiooc volcano is the youngest of a cluster of tephra cones collectively known as Los Otates, roughly aligned in

a WNW-ESE direction, and located at the crest of the Sierra Chichinautzin. The tephra cone is 200 m high and culminates at 3,100 m.a.s.l. Its tube-fed pahoehoe lavas (SiO_2<52%, Figure 4) flowed south along very steep slopes (up to 12°) until reaching the Sierra de Tepoztlán, a range of mountains made of Miocene vulcanosedimentary deposits which have been heavily eroded, creating large pinnacles with very steep to vertical sides, often separated by very narrow, vertical-sided ravines and gorges. This Tepoztlán Formation consists of alternating layers of lahars, tuffs, fluvial sediments and volcanic breccias, in layers that have a variable dip of 0° to 6° to the north. Numerous E-W and N-S fractures and small faults cut these rocks. They are considered the erosional remnant of the middle portion of a volcaniclastic fan, possibly originating from the Zempoala volcanic center to the northwest.

The Suchiooc lava flow separated into several branches among the Tepoztlán pinnacles, before continuing south towards the Oaxtepec plains, where it stopped at 1,280 m.a.s.l., having covered over 1,800 m in height at an average slope of 5.7°. With over 18 km in length, it is one of the longest lava flows recognized in the Sierra Chichinautzin. Considering an average thickness of 20 m and an area of 25 km^2 covered by the flow, a volume of 0.5 km^3 for the lava flow, plus 0.076 km^3 for the tephra cone was calculated, giving a total of almost 0.6 km^3 for the entire Suchiooc products.

Although the existence of large caves in the lava flows surrounding Tepoztlán was known for many years, no systematic surveys had been done until the SMES started the survey of Cueva del Ferrocarril in 1990. Since then, nearly 30 kilometres of lava tubes have been surveyed in detail in the lava flows of Suchiooc volcano, including the two longest lava-tube caves in continental America, Cuevas de la Iglesia-Mina Superior and Ferrocarril-Mina Inferior, 5 and 6 kilometers in surveyed length respectively, separated only by a small collapse, and also the deepest lava tube in the same continent, Sistema Chimalacatepec, with 201 meters of vertical extent.

Lava tubes have been found in the vent or proximal area, and also in the middle and distal portions of the lava flow, and in widely variable slope conditions. Morphology of the lava tubes is correspondingly very variable and include very complex anastomosing tubes, simple and unbranched unitary tubes, and also large multilevel master tubes, reflecting the variable conditions, history of lava flow emplacement, and evolution of the lava tube during activity.

Thanks to the detailed survey and the study of the numerous primary and secondary features present inside these caves, a model was developed for the evolution of lava tubes through time, and the downslope growth of feeder conduits (master tubes) through coalescence and thermal erosion of the original simple or anastomosing tubes.

Poster Presentation

Sistema Tlacotenco, Sierra Chichinautzin, México: Maps and Profiles

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The Suchiooc lava flow separated into several branches among the Tepoztlán pinnacles, before continuing south towards the Oaxtepec plains, where it stopped at 1,280 m.a.s.l., having covered over 1,800 m in height at an average slope of 5.7°. With over 18 km in length, it is one of the longest lava flows recognized in the Sierra Chichinautzin.

To date over 25 kilometers of lava tubes have been surveyed in the Suchiooc flow. Of these, the most striking are the caves that together form Sistema Tlacotenco, a group of 14 anastomosing caves with a total surveyed length of 16 kilometers along a 301 meter diference in height, developed under the town of San Juan Tlacotenco.

These caves include Cueva del Ferrocarril-Mina Inferior, which at 6,538 m is the longest surveyed lava tube in continental America, and which is only separated from Cueva de la Iglesia-Mina Superior, 5,278 m long, by a collapsed trench less than 20 meters in length. Other important caves in the group include Cueva de Marcelo, 1,268 meters long; Cueva del Capulín, 820 meters long and separated from Ferrocarril by the artificial trench cut during construction of the México-Cuernavaca railroad; Cueva de Tepetomatitla, 554 meters; recently discovered Cueva del Castillo, 455 meters, and Cueva de la Tubería, 428 meters long but 116 meters in vertical extent.

The complex relations among these caves, and their control by the underlying topography is presented through a series of maps in plan, profile and three-dimensional views, which help dilucidate the evolution of this complex lava-tube system, and is also illustrated with several photographs that exemplify the different types of primary and secondary structures and features that decorate these amazing caves.

Aditionally, evidence was found which allowed the development of a model for the evolution of lava tubes through time, and the downslope growth of feeder conduits (master

tubes) through coalescence and thermal erosion of the original anastomosing tubes.

Poster Presentation

Palaeoenvironmental Reconstruction of the Miocene Tepoztlán Formation Using Palynology

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To date, palaeobotany in volcanic settings has dealt with intercalated sediments namely paleosols, fluvial volcaniclastic sandstones, peat or lignites. Even when authors worked on tuffaceous material, they focussed on either the macroflora or charcoals. Publications on palynology in pyroclastic rocks and their reworked deposits (lahars) are rare.

In this study we investigated a volcaniclastic section of the Mid-Miocene Tepoztlán Formation with respect to palaeoenvironment using palynology. The Tepoztlán Formation crops out in the States of Morelos and Estado de Mexico and consists of pyroclastic flows, volcanic debris-flows (lahars), dacitic lava flows, and intercalated fluvial or lacustrine sediments, attaining a total thickness of several hundred meters. K/Ar geochronology on some lava flows has revealed an age of about Early to Mid-Miocene.

For palynological analyses we investigated the fine-grained matrix of lahars, ash-flow deposits, and clayey layers on top of those deposits. The samples reveal a diverse pollen and spore assemblage, enabling a first palaeoenvironmental interpretation of the Tepoztlán Formation. Pollen assemblages dominated by Caryophyllaceae, Chenopodiaceae, Asteraceae and Cupressaceae indicate dry conditions, whereas spore dominated associations accompanied by Cyperaceae pollen types indicate wet to aquatic conditions. Characteristic stratigraphical vegetation patterns are interpreted in terms of short-term destruction-recolonization cycles which are controlled by volcanic eruptions and intermittent quiescence.

Present day vegetation of Central Europe is very similar to that recorded in the Tepoztlán section. Thus, a rather temperate climate is appropriate for the depositional environment of the Tepoztlán Formation.

Poster Presentation

Comparison between the Texcal Lava Flow and the Chichinautzin Volcano Lava Flows, Sierra Chichinautzin, México

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The Texcal lava flow is located to the south of the Sierra Chichinautzin Volcanic Field near the city of Cuernavaca. With 24 kilometers in length, it is the longest lava flow known in the area. Recent work by Siebe *et al*.(2004) dated this volcano at between 2,835±75 and 4,690±90 years before present (ybP), and made morphological comparisons between it and the nearby Chichinautzin volcano, dated at 1,835±55 ybP. They also conclude that the Texcal lava flow must have been emplaced at a very high effusion rate to have reached such a tremendous length with a relatively low total volume, while they consider that Chichinautzin volcano was of low effusion rate, created lava tubes, and therefore had a much shorter lava flow despite a similar volume.

The Chichinautzin flows are compound A'a and toothpaste lavas. Flow channels limited by prominent levees are easily identified both in the field and in aerial photos. Although many inflation structures are noticeable on the Chichinautzin flows, no evidence has been found of emplacement through lava tubes. Meanwhile, the whole Texcal lava flow is made up of pahoehoe, as can be seen on most surface outcrops which show the typical ropy texture. Five large lava tubes have been recently surveyed in the Texcal lava flow, all of them representing a huge master tube, in places over 10 meters wide and 20 meters high, and with evidence of continuous and sustained activity which caused thermal erosion of the underlying lithology. In the downflow direction they are Cueva Grande, Cueva Pelona, Cueva Redonda, Cueva de la Herradura and Cueva del Naranjo Rojo, for a total of nearly 4 kilometers of tubes mapped in this flow.

We therefore conclude that Chichinautzin volcano lavas were emplaced at a high effusion rate, which prevented the formation of large lava tubes and caused the A'a or toothpaste morphology, while the Texcal lava flow was emplaced at low to moderate effusion rates, which favored the formation of lava tubes.

As has been well documented previously, lava tubes isolate the lava from the air and prevent cooling of the flow, favoring the development of extensive and very long lava flows. This was the case of the Texcal lava flow. Risk assessment for the cities of Cuernavaca and México, which could easily be affected in case of renewed activity at the Sierra Chichinautzin, should take this into account, since lava tube emplacement has not been considered by any of the authors who have studied this volcanic field before.

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Siebe, C., Rodríguez-Lara, V., Schaaf, P., and Abrams, M., 2004, Radiocarbon ages of Holocene Pelado, Guespalapa, and Chichinautzin scoria cones, south of Mexico-City: implications for archaeology and future hazards; Bull. Volcanol. 66, pags. 203-225.

Oral Presentation

Surveyed Lava Tubes of Jalisco, Mexico

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La Cueva Cuata, also known as La Cueva de Tequilizinta, was the first lava tube surveyed in the Mexican state of Jalisco. The cave is situated 52 kms northwest of Guadalajara in a canyon wall overlooking the Santiago River and appears to be in the Rio Santiago alkali basalts, which are from 1.3 to 0.4 million years old. The cave is 280.79 m long with passages varying in height from 1.9 m to .25 m and ranging in width from 15 m to 1 m. Dry, powdery sediment covers the floor of the entrance room while the rest of the cave contains a thick layer of mud or clay. The cave has lava stalactites less than 4 cm long and a pool of water measuring 15 x 20 m and less than 60 cm deep, contaminated by the droppings of vampire bats which roost above it. Two other species of bats have been observed in the cave. Cuata Cave was surveyed by Grupo Espeleológico Zotz in 1990.

In 2006, La Madriguera de los Lobos, a cave located directly beneath La Cueva Cuata, was also surveyed by Zotz. The passages in this cave total approximately 100 m in length, ranging in width from 25 m to 1 m. The average passage height is 1 m. The floor of the cave is covered with powdery sediment, bat guano and, in places, what appears to be the dry scat of wolves. Calcite stalactites less than 10 cm long were observed on the ceiling. Bats were found in several parts of the cave and an air current was noted among breakdown at the back of the cave.

Oral Presentation

Cueva Chinacamoztoc, Puebla

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The Los Humeros Caldera was formed by the collapse of a pre-existing stratovolcano due to the eruption of very large pyroclastic flows, which formed the Xaltipan Ignimbrite 0.56±0.21 Ma (Ferriz and Mahood, 1984), distributed mostly to the north of the Caldera. Much later activity generated extensive basaltic lava flows emitted through the rim fractures on the southern side of the Caldera. These lava flows are known from east to west as the El Limón, Tepeyahualco and Tenextepec lava flows. One of them at least, the Tenextepec flow, was emplaced through lava tubes. It is possible that the other lava flows extruded from the caldera rim fractures were also emplaced through lava tubes, explaining their lengths of up to 16 kilometers.

Chinacamoztoc means Cave of the Bats. It was first mentioned in the scientific literature by Virlet d'Aoust (1865). Later, in a study specifically dedicated to the cave, Haarmann (1910) calculated its length at about 500 meters. Finding stream deposits in the cave floor, he proposed that the cave had formed when the lava flow covered a flowing stream, which evaporated and the gas pressure pushed the lava flow upwards leaving a void underneath. The portion of the cave visited by Haarmann is no longer accessible. Wittich (1921) in a study of the geology of the entire area, describes the cave as being almost two kilometers long, and suggests that the stream deposits seen by Haarmann entered the cave after it solidified. He concludes that the cave formed by the solidification of the flow crust, but with liquid lava remaining inside. After the lava broke the crusted front, it flowed onwards, leaving a void behind.

No other references have been found about this cave. In may 2006, members of Sociedad Mexicana de Exploraciones Subterráneas (SMES) and Veracruz section of the Club Exploraciones de México A.C. (CEMAC), visited and surveyed the lava tube. Chinacamoztoc cave is a large master tube 10 to 30 meters wide and >10 meters high in most places. The original entrance, as described by Haarmann, is now completely filled by stream deposits originated on the fields which partially cover the upper end of the lava flow. Haarmann describes the passage, now inaccessible, as being of similar dimensions. He also mentions that the upper portion of the cave ends at an artificial wall built to prevent soil loss. The lower side of the wall was accessible through a lower entrance. Sometime in the last ten years, somebody dug a hole through the artificial wall, probably believing it hid a treasure, and the completely sediment-filled passage beyond is accessible through the dug tunnel for about 15 meters.

A total of eight skylights break up the lava tube, of which three actually segment the 1,577 meters long tube into 4 caves 413, 248, 597 and 164 meters long (in a downflow direction). The skylight areas are used by large white owls as nesting sites, so please try to avoid disturbing them. On some of the skylights, the entrances to small anastomosing tubelets are visible high up the wall, near the ceiling level, and probably represent the original braided tubes from which the master tube evolved through thermal erosion.

Separation of the canyon passage into superposed levels is only visible in two sections close to skylights that might have been open during activity, but other skylights are probably post-activity collapses. The ceiling and walls of one of the lower levels is decorated with many small tubular stalactites. The segregates were extruded straight from the wall, which does not show lining breaks. In two other places, evidence of thermal erosion is seen where collapse of a lava lining exposes tephras and the Xaltipan ignimbrite. This is on a ledge still >10 meters above the lowermost cave floor.

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Poster Presentation

Lava Tubes of the Naolinco Lava Flow, El Volcancillo, Veracruz, México

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Antecedents: The Speleology Commission of the Club de Exploraciones de México Sección Veracruz, A.C., has been prospecting and exploring caves since 2005 on the Río Naolinco lava flow, originating from El Volcancillo around 800 years ago. When we noticed the vulcanospeleological potential we decided to create this project with the aim of locating caves of volcanic origin. To date we have explored the following caves in the Municipio of Jilotepec, although we believe many more caves are to be found.

Cueva de la Virgen N 19°38′1.77″ W 96°56′26.752″ 1388 m.a.s.l.
Cueva de los Cochinos N 19°38′1.77″ W 96°56′26.752″ 1388 m.a.s.l.
Cueva de la Envidia N 19°38′1.77″ W 96°56′34.987″ 1379 m.a.s.l.
Sistema del Falso N19°38′13.099″ W96°56′10.890″ 1358 m.a.s.l.
Cueva del Tirantes N 19°38′17″, W 96°56′31″ 1384 m.a.s.l.
Hoyo del Becerro N 19°36′13″, W 96° 58′22″ 1667 m.a.s.l.

Purpose: To develop a vulcanospeleological investigation in order to obtain specific data on the subterranean systems of the Municipio of Jilotepec, originated on the Río Naolinco lava flow.

Specific Projects: Obtain a photographical and topographical documentation of the caves and pits already found. Analyze the microbiological characteristics of the water found in the caves. Give alternatives to diminish the contamination of the caves due to bad management of residual waters in the towns of La Virgen and Piedra de Agua, Mpio. De Jilotepec. Generate a data base for future geomorphology and biospeleology studies.

Aims: Involve the competent institutions and local authorities in the research. Edit and publish a report with all the results.

Conclusions: Making local inhabitants aware of the underground richness and importance of their area is vital if we want to preserve the caves as geological vestiges of other times.

Oral Presentation

The Lithic Tuff Hosted Cueva Chapuzon, Jalico, México

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Chapuzon Cave is hosted in a rhyolite lithic tuff about 25km west of Guadalajara, Jalisco, Mexico. The host formation appears to be part of the Acatlan pyroclastic flow which was produced by a caldera eruption of about 400 cubic km in size about 1 million years ago. The cave is hosted in a section with about 50% heterolithic lithic fragments varying in size from 1 to 15cm and located about 30km from the likely source caldera. The cave was mapped by Grupo Zotz in 1988 to 623m in length with a vertical range of about 30m.The cave development appears to be typical dissolution of more soluble material originally taking advantage of a clay filled bedding plane. Initial development from the controlling bedding plane was phreatic in the upper part of the cave eroding both above and below the bedding plane, while in the lower part of the cave, there appears more vadose development with deep incised trenches below the same bedding plane. The cave still has an active stream for 6 months of the year which helped maintain a short swim in the lower entrance until it was mainly filled with sand a couple of years ago. The cave is also a significant bat hibernacula with a population estimated roughly of at least 10,000 individuals from at least 7 different species. This cave was featured in a television movie produced for National Geographic about bat phobias that has yet to be aired.

Poster Presentation

Cueva Tecolotlán, Morelos, México: An Unusual Erosional Cave in Volcanic Aglomerates

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Tecolotlán cave, located near the town of Cuentepec, Morelos, with a suveyed length of 870 meters and a vertical extent of 105 meters, is one of the longest erosional caves known in non-calacareous conglomerates. It is contained in volcaniclastic deposits, mainly lahars and fluvial conglomerates and a few intercalated ash layers belonging to the Cuernavaca formation, which constitute the Buenavista volcaniclastic fan, which has its apex at the Sierra Zempoala volcanic complex and extends south to the limits with the state of Guerrero.

This volcaniclastic fan has been eroded by numerous streams running almost paralel to the south, which have excavated deep "barrancas" or gullies. In particular the "barranca" of the Río Tembembe is over 100 meters deep near the location of the cave.

The cave captures the drainage of a surface "arroyo", and is developed along a single passage which for almost 600 meters follows a single fracture, oriented almost east-west. This passage is a subterranean canyon, typically vadose in its configuration, with several cascades along its length. These are developed along lithological changes, and deep plunge pools have developed at their bases. The only chamber is located under a collapse which formed a skylight almost 40 meters high, but no collapse debris remain, as they have been flushed out by the torrential floods that sweep the cave during the rainy season.

The final portion of the cave changes completely in morphology when the passage abandons the main fracture to develop along the contact between two different lahar deposits,

marked by a small ash layer. The huge canyon turns into a small round tube, slightly incised in its floor, which mimics a phreatic passage in karstic caves. The cave resurges at the wall of a small tributary of the Río Tembembe canyon, almost 45 meters above the river level.

The lithology in which the cave is developed prevents solution from playing an important role in the generation of the cave, which owes its origin entirely to mechanical erosion, probably aided in the beginning by a process similar to piping in unconsolidated deposits. The morphology of the final portion would seem to indicate that the cave started its development when the Río Tembembe was at its level or just above it.

Oral Presentation

Limestone Dissolution Driven by Volcanic Activitiy, Sistema Zacatón, México

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Volcanically formed caves are typically considered to be those formed in volcanic terrain, such as lava tubes or other voids in basaltic flows. However, extreme dissolution of limestone as a result of volcanic activity is hypothesized to have developed the deepest phreatic sinkhole in the world, El Zacatón. Sistema Zacatón in northeastern Mexican state of Tamaulipas is an isolated karst area juxtaposed to the Pleistocene volcanic field near Villa Aldama, and is characterized by unique hydrothermal cenotes. The volcanic activity in the area is characterized by the presence of effusive products and explosive deposits. Their compositions range from alkali basalts to trachytes, and the structures developed in the area are flows, sheets, scoria cones, tuff rings and phreatic craters. Shallow level syenitic and granitic plutons crop out northwestern of the volcanic field. The volcanism belongs to the younger magmatic activity in the Eastern Mexican Alkaline Province. This igneous activity introduced elevated levels of CO_2 and H_2S to the groundwater within the Upper Cretaceous limestone. Pre-existing fractures focused circulation of this hyper-acidic groundwater in the localized area of Sistema Zacatón, thus radically accelerating dissolution rates of the carbonate rocks. The source of acidity in this model of karst development is originated at depth and has little influence from surface geochemical processes. This pattern of deep phreatic karst development is also observed in Pozzo del Merro, the deepest underwater cave in the world. Pozzo del Merro lies in Mesozoic limestone adjacent to the Pleistocene volcanic region near Rome, Italy.

Poster Presentation

Possible Structural Connection between Chichonal Volcano and the Sulfur-Rich Springs of Villa Luz Cave (a.k.a. Cueva de las Sardinas), Southern México

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Regional strike-slip faults may serve as groundwater flowpaths from the active Chichonal Volcano to the Villa Luz Cave (a.k.a. Cueva de Las Sardinas, CLS). In this cave, located near Tapijulapa, Tabasco, several springs carry hydrogen sulfide. Previous studies have linked the CLS spring sulfur source to basinal water and an alkaline active magma volcano, but the groundwater flow paths still needed to be reviewed. The understanding of the sulfur origin will provide insights into the possible sources, the extreme microbial environment, the sulfuric acid speleogenetic mechanism (i.e. creation of caves by strong acid dissolution), the subsurface water-rock interactions and groundwater flow paths in the area. The Volcano and CLS location in the Chiapas Strike-Slip structural Province, suggests a left-strike slip fault may be serving as a groundwater flow path, allowing deep-source magmatic water to carry the sulfur-rich water that is dissolving the limestone at CLS. Detailed geological mapping of the surface and the caves in between, coupled with chemical analyses of the water may help to prove this connection. Specifically the springs in the area will be sampled as part of the surface expression of groundwater interaction with the subsurface rock.

Rest of the World Session

In Absentia Presentation

Investigation of a Lava-Tube Cave Located under the Hornito of Mihara-Yama in Izu-Oshima Island, Japan

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A lava-tube cave recently found under the hornito of Mihara-yama in Izu-Oshima island, located in the Pacific Ocean at 120 km south of Tokyo, was surveyed and investigated by the Vulcano-Speleological Society. This lava cave was formed inside of the 1951 eruption lava flow deposited at the edge of the inner crater of Mihara-yama. The lava tube cave consists of a flat region and a sloped region whose total length is about 40 m. Inside of the lava-tube cave, general characteristics such as lava stalactites and lava benches can be found. Two important lava characteristics, yield strength and surface tension, were obtained from the observation of this lava tube cave. By using a simple model of steady state flow in a circular pipe for analysis based on Bingham characteristics of lava flow in the tube (T.Honda,2001) and from the height and slope angle of the lava tube on the sloped region, the yield strength of the lava can be obtained as 50000 dyne/cm^2. This value is very near to the value calculated as 43000 dyne/cm^2 by G.Hulme (1974) for the 1951 eruption

lava flow configuration observed by T.Minakami (1951). From the pitch of lava stalactites on the roof surface (3 to 4 cm), the surface tension of lava was determined as 600 to 1000 dyne/cm. This value agrees well with the extrapolated value obtained by I.Yokoyama (1970) in the melting lava surface tension measurement experiments carried out in the laboratory.

Oral Presentation

Jeju Volcanic Island and Lava Tubes: Potential Sites for World Heritage Inscription

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Mt. Halla, Seongsan Ilchulbong Tuff Cone and Geomunorem Lava Tube System were proposed to be included in the World Heritage Sites by the Korean government in February, 2006. Jeju Island contains a variety of volcanic landforms and more than 120 lava tubes of geological and speleological significance. It essentially consists of one major shield volcano, Mt. Halla, with satellite cones around its flanks. Also notable features include the parasitic cone (Seongsan Ilchubong Tuff Cone), which shows a Surtseyan-type underwater volcanic eruption. Most notable is a variety of lava tubes (Bengdwi Cave, Manjang Cave, Gimnyeonsa Cave, Yongcheon Cave and Dangcheomul), which show a complete flow system and display perfectly preserved internal structures despite their old age. Dangcheomul and Yongcheon Caves contain calcareous speleothems of superlative beauty.

Five aspects are identified which demonstrate the congruence of specific features to criteria for World Heritage status. 1) The volcanic exposures of these features provide an accessible sequence of volcanogenic rocks formed by at least three different eruptive stages between one million and a few thousand years BP. The volcanic processes that made Jeju Island were quite different from those for adjacent volcanic terrains, in that Jeju Island was formed by huge plume activity (hot spot) at the edge of the continent. 2) The nominated features include a remarkable range of internationally important volcanic landforms that contain and provide significant information on the history of the Earth. The environmental conditions of the eruptions have created diverse volcanic landforms. 3) Eroded by the sea, Seongsan Ilchulbong Tuff Cone discloses the inner structure of the volcano of the Surtseyan-type eruption, which provides immense scientific value illustrating a large variety of sedimentary and volcanic characteristics of phreatomagmatic eruption, in addition to its magnificent natural beauty. 4) Geomunoreum Lava Tube System contains a parasitic cone and five significant lava tubes with various dimensions, shapes, internal morphology and speleothems. 5) Perhaps the significance lies in the abundant secondary carbonate mineralization to be found in two of the low-elevation lava tubes, Yongcheon and Dangcheomul Lava Tubes, which can be considered to be the most beautiful lava tubes filled with wonderous calcareous speleothems. They are acknowledged to be the best of this type of lava tubes in the world.

Oral Presentation

New Discovery of a Lime-Decorated Lava Tube (Yongcheon Cave) in Jeju Island, Korea: Its Potential for the World Heritage Nomination

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Jeju Island in Korea is essentially made of one shield volcano with more than two hundred parasitic cones around it. Among more than 120 lava tubes can be found a series of lava tubes formed by several lava flows erupted from the Geomun Oreum (parasitic tuff cone), called the Geomun Oreum Lava Tube System. The system includes several lava tubes such as Seonheul Vertical Cave, Bendwi Cave, Bukoreum Cave, Daerim Cave, Manjang Cave, Gimnyeong Cave, Yongcheon Cave and Dangcheomul Cave. All these caves are estimated to be developed between about 300 and 100 ka BP. Two lava tubes (Yongcheon and Dangcheomul Caves) in low elevation areas contain calcareous speleothems.

Yongcheon Cave was recently discovered accidentally in May, 2006, during the installation of a telephone pole. Yongchoen Cave became especially famous for its superlative beauty from magnificent carbonate speleothems together with Dangcheomul Cave, and has become a potential site for the World Heritage Nomination. The cave is about 3 km long, and lies across the gentle northeastern slope of Mt. Halla, where there is a large area of basalt lava plains, largely in alkaline olivine basalt. This lava tube is situated between Gimnyeong and Dangcheomul Lava Tubes. Inside, a majestic arched ceiling is met by vertical walls, mostly creating a dome-shaped cross section. The cave includes a typical lava tube configuration and shows diverse morphology and micro-topography such as lava shelves, lave benches, lava stalactites, lava stalagmites, extensive lava rolls, lava falls and a spring-water lake. In addition, the cave contains a variety of carbonate speleothems such as soda straws, stalactites, stalagmites, columns, cave corals, curtains, flowstone, rimstone, and cave pearls. Windblown sediments, forming carbonate sand dunes, transported from beaches nearby, are present over the tube. Calcium and carbonate ions responsible for the formation of carbonate speleothems are supplied by dissolution of the carbonate sediments by meteoric water and transportation through plant roots and cracks. Animal skeletons, abalone shells, wooden torches and historical earthenware make Yongcheon Cave even more valuable scientifically.

Oral Presentation

Structural Characteristics of Natural Caves and Yongchon Cave on Jeju Island

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Jeju Island is a volcanic island which was formed after having experienced volcanic reactions over five times on a large scale and over a hundred times on a small scale. This island is located at a latitude of 33° 11′ 27″ - 33° 33′ 50″ north and a longitude of 126° 08′ 43″ - 126° 58′ 20″ west. The island covers an area of 1,845.92 km^2. The island runs approximately 73 kilometers from west and east and 31 kilometers from north to south. Volcanic caves and sea caves are distributed widely on this small island. The total number of natural caves which have been discovered and/or confirmed to exist on Jeju Island according to the studies conducted by the author from the year of 1975 through June of the year of 2006 amounts to 172 which include 137 volcanic caves and 35 sea caves. The purpose of this paper is to present the results of the fundamental academic research which was undertaken for the purpose of having volcanic caves such as Manjang Cave, Beungdwi cave, Dangcheomul Cave and Yongchon Cave be recognized as World Natural Heritages. Further, this research centers on examining Yongchon Cave, which was discovered on May 2005, as a Non-Limestone Cave (also known as Lava cave, Pseudo Limestone Cave, Lime-decorating Lava cave).

The summary of this paper is as follows:

1. The total length of the part of the Yongchon cave that is measured to date is 2470.8m +αm. This length will be greater after a survey of the lake and its vicinity is complete.

2. The height of the cave to the ceiling is between 1.5 meters and 20 meters and the width is between 7 and 15 meters. The cave runs mainly west and southward and north and eastward.

3. The cave has her marvelous features, such as a gigantic lava roll which is approximately 140 meters long, a lava terrace, a lava fall, a lava shelf and other formations.

4. Those carbonate sediments that are distributed variously inside the Yongchon Cave include stalactites, soda straws, columns, stalagmites, cave pearls, cave corals, flow stones and rimstones along with other sediments in eccentrical shape. A cave that reminds people of a chandelier is very rare anywhere in the world.

5. Those materials that were considered to have been brought inside the cave include earthenware allegedly from an ancient period, animal bones, burnt wood and metal ware including a poker. The earthenware which has been subject to archeological study has been determined to belong to the period of between eight and nine centuries.

6. The animal bones which are found inside the cave will be employed as important material to study the ecosystem both inside and outside the cave. These types of bones are various and determined to have been brought in by humans and still being under study.

7. The survey and research has been currently on hold on a temporary basis due to safety and hazard concern after a large scale lake had been found. Once further and closer examination is carried out, the determinations regarding Yongchon Cave will become clearer and her significance will be greater.

Oral Presentation

Recent Contributions to Icelandic Cave Exploration by the Shepton Mallet Caving Club (UK)

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The Shepton Mallet Caving Club has a connection with Icelandic cave exploration going back 35 years to 1971. The interest in caving in this country was re-awakened by participation in the Laki Underground Expeditions in 2000 & 2001 (in association with Bournemouth University). Since these visits, members of the club have carried out further work in 2003 and 2005 on the Reykjanes Peninsula and the Ódáðahraun lava fields in the central part of the country.

This work has been a mixture of original exploration and surveying of previously known sites, in conjunction with Hellarannsóknafélgs Íslands. Major sites surveyed on Reykjanes include Flóki, a 1-km-long maze cave, and Búri, just under 1 km of huge trunk passage recently found by locals. In the Ódáðahraun, the first descent was made of a shaft called Hellingur, which revealed over 500 m of large well decorated passage. This is now the longest cave known in this part of the country.

In Absentia Presentation

Basalt Caves in Harrat Ash Shaam, Middle East

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The Harrat Ash Shaam is one of the largest volcanic fields in the Middle East, ranging across the north-western Arabian plateau, from Saudi Arabia through Jordan and Syria to Israel. The present study deals with voids in Pleistocene basalts, mostly of the last 500,000 years. Circular voids, probably associated with large volcanic gas bubbles, commonly appear on the surface as circular depressions, with vertical or sloped walls.

Lava tubes and pressure ridge caves are common around Jebel Druze plateau. The pressure ridge caves are commonly some tens m long, located very close to the surface, within the last local lava flows. The longest lava tube was found within a porphyritic and vesicular olivine basalt flow. The cave is entered through central skylights, has one level with tributary

and distributary systems. Several stages of internal lava flow are distinguished, with a final aa basalt filling the lower reaches of the tube, covering a former pahoehoe surface.

Oral Presentation

Prospects for Lava-Cave Studies in Harrat Khaybar, Saudi Arabia

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To date one lava tube, Dahl Rumahah, 208 m long, has been surveyed in Harrat Khaybar, a lava field of approximately 12,000 square km, located north of Medina in western Saudi Arabia. However, lava-cave entrances have been observed and/or photographed in the northern, central and southern parts of the same lava field, suggesting that many other caves may be found in this area. Strings of collapses up to 25 km long, observed by helicopter, indicate the possibility that some of these caves may prove to be of significant length.

The lava caves of Harrat Khaybar may have been frequented and used by ancient peoples, but no archeological study has ever been conducted in Saudi lava tubes, whose floors are typically covered by a meter or more of sediment. One of the routes used by the first human beings to leave Africa 50,000 to 70,000 years would have brought early Man close to the edge of Harrat Khaybar. Lava caves in this area would have provided much needed water and shelter to these people. In later years, these caves lay within reach of the Nabatean spice trail between Yemen and Petra. In addition, one of the richest sites of petroglyphs in Saudi Arabia is situated at the edge of Harrat Khaybar.

This paper suggests that Harrat Khaybar is an ideal place to search for unexplored lava tubes in Saudi Arabia and recommends the undertaking of a vulcanospeleological survey of this lava field. In addition, it urges the commencement of an archeological study of lava tubes in Harrat Khaybar.

Oral Presentation

Al-Fahde Cave, Jordan, the Longest Lava Cave Yet Reported from the Arabian Peninsula

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The northeastern region of Jordan is volcanic terrain, part of a vast intercontinental lava plateau, called the Harrat Al Shaam. The centre is formed by young alkali olivine basaltic lava flows, the Harrat Al-Jabban volcanics or the Jordanian Harrat (Al-Malabeh, 2005). The top most and therefore youngest flows are ca. 400 000 years old (Tarawneh et al., 2000). There we explored, surveyed and studied a total of twelve lava caves since September2003, among them six lava tunnels (one has two caves) and five pressure ridges caves. This includes the 923.5 m long Al-Fahda Cave (Lioness Cave), which was surveyed September 16th and 19th 2005 by the authors. It is currently the longest reported from the Arabian Peninsular (J. Pint, pers. comm.).

Two entrances exist. The main entrance is a roof collapse at the apex of a 15 m wide hall, dating much later than the activity of the cave. This entrance gives access to the cave stretching for almost 490 m downslope and almost 190 m upslope. The tunnel is on the one hand amazingly wide (average > 7m!) but also very low (average 1.2 m). The slope measured apparently is less than one degree (8.6 m altitude change on 755 m). This is very low, even compared to the lower levels of Hawaiian lava tunnels and an important observation since it shows why the Harrat lavas could spread so far: They were tube-fed pahoehoe lavas.

Oral Presentation

State of Lava Cave Research in Jordan

Stephan Kempe[1], Ahmad Al-Malabeh[2], Mahmoud Fryhad[3], and Horst-Volker Henschel[4]
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The northeastern region of Jordan is volcanic terrain, part of a vast intercontinental lava plateau, called the Harrat Al-Shaam. The centre is formed by young alkali olivine basaltic lava flows, the Harrat Al-Jabban volcanics or Jordanian Harrat (Al-Malabeh, 2005). The top most and therefore youngest flows are ca. 400 000 years old (Tarawneh et al., 2000). In these lavas we explored, surveyed and studied a total of twelve lava caves since September 2003. 2,525 m of passages were surveyed as of September 2005 (Table 1).

The discovery of so many lava tunnels in the Harrat Al-Shaam lava field by Al-Malabeh in the period between 1986 and 2006 came as a surprise, considering the old age of these volcanics. It also is surprising considering the fact that the Harrat is covered by loess that can be easily washed into caves filling them eventually. Al-Fahda Cave, Beer Al-Hamam, Dabie and the two Abu Al-Kursi Caves are all terminated by sediments. Only Al-Howa Cave is terminated on both ends by roof collapse due to the loading of a later a'a lava flow. It is interesting to note also that branching of the caves is noted only at both ends of Al-Fahda Cave, but not in the others. Other features, so typical for Hawaiian lava tunnels,

Table 1 (Kempe et al.). List of currently known and surveyed lava caves in Jordan, arranged by total passage length.

Name of Cave	Latitude	Longitude	Stations	Length m	Stations	Depth m	Direction	Altitude m	Type
Al-Fahda Cave	32°18'	37°07'	Complex*	**923.5**	2 to 54	6.7	SW-NE	832	Lava Tunnel
Beer Al-Hamam	32°07'	36°49'	32 to 23	**445.0**	1 to 23	17.2	NW-SE		Lava Tunnel
Abu Ras Cave			21 to 35	**231.1**	1 to 23	10.0	NW-SE		Lava Tunnel
Al-Ameed Cave			Complex*	**208.0**	2 to 31	4.0	SW-NE		Pressure Ridge
Dabie Cave	32°10'	36°55'	0 to 14	**193.6**	0 1to 13	1.8	NW-SE	893	Lava Tunnel
Abu Al-Cursi Makai	32°15'	36°39'	20 to 34	**153.7**	1 to 34	12.2	W-E		Lava Tunnel
Al-Howa	32°18'	36°37'	Complex*	**97.1**	2 to 6	10.8	SW-NE		Lava Tunnel
Al-Haya Cave	32°17'	36°34'	1 to 11	**81.3**	1to 9	4.2	NW-SE	911	Pressure Ridge
Abu Al-Cursi Mauka	32°15'	36°39'	2 to 18	**77.1**	2 to 18	8.1	N-S		Lava Tunnel
Azzam Cave	32°17'	36°36'	13 to 25	**44.1**	1 to 25	4.2	NNW-SSE		Pressure Ridge
Al-Ra'ee Cave	32°17'	36°34'	1 to 6	**42.0**	1 to 34	3.5	NW-SE	911	Pressure Ridge
Dahdal Cave	32°17'	36°35'	5 to 12	**28.9**	1 to 12	0.0	SW-NE		Pressure Ridge
Total				**2525.4**					

* calculated from station networks.

like lava falls, plunge pools, and secondary ceilings seem to be absent. Shelves are prominent only in Dabie Cave. The presence of the lava tunnels underscores the fact that the Harrat consists of tube-fed pahoehoe.

Oral Presentation

Gruta das Torres—Visitor Center

Manuel P. Costa[1,4,5], Fernando Pereira[2,4,5], João C. Nunes[2,5], João P. Constância[3,5], Paulo Barcelos[4,5], and Paulo A. V. Borges[2,4,5]

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Located in Pico Island, at 285 m altitude, Gruta das Torres is a volcanic cave originated from *pahoehoe*-type lava flows, extruded from Cabeço Bravo. It is the longest lava tube known on the Azorean Islands: it is around 5 150 m in total length and 15 m in maximum height. It is composed of one main, large-sized tunnel and several secondary lateral and upper tunnels. Gruta das Torres, because of its size, beauty, cave fauna and geological formations, was therefore designated a Regional Natural Monument by regional decree nr. 6/2004/A of March, 18th.

In the year 2000, the Azorean Environmental Services initiated the process to transform part of Gruta das Torres into a "show cave" creating a visitors' center, improving accessibilities, and attributing the tourist exploration to the NGO "Os Montanheiros".

The visits will take place in small groups of 15 visitors, for a 45 minutes guided tour, along 450 meters, with individual lightening system which will also work as an emergency device.

After the opening of Gruta das Torres Visitor Center to the public on the 24th of May, 2005, large numbers of tourists have visited this volcanic cave, reaching the number of 3525 visitors in the period of June to December 2005.

Poster Presentation

GESPEA - Field Work (2003–2006)

Manuel P. Costa[1,4,5], Fernando Pereira[2,4,5], João C. Nunes[2,5], João P. Constância[3,5], Paulo Barcelos[4,5], Paulo A. V. Borges[2,4,5], Isabel R. Amorim[6], Filipe Correia[1], Luísa Cosme[3], and Rafaela Anjos[3]

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In 1998, the Regional Government of the Azores established the GESPEA - Working Group on Volcanic Caves of Azores, with the aim of studying the volcanic caves of the archipelago. That decision was taken because of the geological and biological interest and diversity of the volcanic caves, their importance in terms of Natural Heritage, educational purposes and also their uniqueness and importance in terms of tourism.

In the last three years, GESPEA promoted four scientific

expeditions in three different islands: Picospel 2003 (Pico island), Beira 2003 (São Jorge island), Pico 2004 (Pico island) and Graciosa 2005 (Graciosa island).

On those expeditions, 76 caves were visited, 22 new caves were discovered, and geological and biological information were collected to update the Azorean Speleological Inventory and Classifying System (IPEA). Also new topographies, schemes, videos and photos were performed for some of those caves. New records of animals and plants were obtained for many of the caves. A new species of beetle was discovered in a volcanic pit from S. Jorge during the pre-symposium activities of the XI International Symposium on Vulcanospeleology (Pico Island, Azores, 2004).

Poster Presentation

Catalogue of the Azorean Caves (Lava Tubes, Volcanic Pits, and Sea-Erosion Caves)

Fernando Pereira[1,2,3], Paulo A.V. Borges[1,2,3], Manuel P. Costa[2,4], João P. Constância[2,5], João C. Nunes[2,5,6], Paulo Barcelos[1,2], Teófilo Braga[5], Rosalina Gabriel[3], and Eva A. Lima[5,6]

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In this contribution we present the first catalogue of the currently known Azorean caves, namely lava tubes, volcanic pits and sea-erosion caves. This was possible due to: i) the wealth of information compiled by several Azorean environmental associations (e.g. "Os Montanheiros", "Amigos dos Açores" and Speleological group of CAIP – Circulo dos Amigos da ilha do Pico) and ii) to the development of the IPEA Database and classification system by GESPEA Working Group, created by the Regional Government of the Azores in 1998. A total of 250 structures (185 lava tubes, 23 volcanic pits, 8 pit-caves, 18 sea-erosion caves, and 6 other type of structures) are described in the Catalogue, and for each of them is included information about: name, name synonyms, location (island, locality), length/depth, general description, main geological features, biological interest, main references and a map with the location of the cave/pit in the island. When available, a detailed topography or sketch is also provided. The catalogue also includes comprehensive lists of the fauna and flora known for each cave and the main speleological and biospeleological literature from the Azores. Several of these volcanic caves harbour great geological and biological diversity. Together, they provide a diversified geological, biological and aesthetic patrimony that must be protected and promoted according to the specificities of each structure. It is hoped that the present catalogue may help to achieve a better management of the Azorean caves.

Oral Presentation

Thurston Lava Tube, the Most Visited Tube in the World. What Do We Know about It?

Stephan Kempe[1] and Horst-Volker Henschel[2]
Survey by Stephan Kempe, Matthias Oberwinder, Holger Buchas, Klaus Wolniewicz
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Thurston Lava Tube, discovered in 1913, is a celebrated tourist attraction in the Hawaii Volcanoes National Park. It is visited daily by hundreds, if not thousands. Hardly any other lava tube in the world can match its popularity. In spite of its many references in literature, not much is known about its speleogenesis and previously published maps have not been very detailed (Powers, 1920; Wood, 1979; Halliday, 1982). To get a more detailed view we surveyed it on March 9th, 1996 in high precision, using digital compass and level mounted on antimagnetic tripods (Table 1).

Vulcanologically the cave is important since it is situated very near to the original vent of the Ai-la'au Shield at 1195 m a.s.l., the site of the last massive summit eruption of Kilauea (Holcomb, 1987) ending about 350 years ago and producing Kazumura Cave. When inspecting the cave, a series of questions arise. For the casual observer the cave appears strangely dull, without many detailed features. Also the typical smooth, continuous glazing found in lava tubes is missing throughout. And finally the cave ends at a lava sump, which poses quite a puzzle. These questions will be discussed in light of what is currently known about the cave.

Oral Presentatiion

Geology and Genesis of the Kamakalepo Cave System in Mauna Loa Lavas, Na'alehu, Hawaii

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The Kamakalepo Cave system south of Na'alehu, Hawaii, consists of four larger sections of a once much longer tunnel in Mauna Loa lavas. It formed in very olivine phenocryst-rich, picritic lavas of high density and moderate vessicularity. Similar flows, belonging to the same age group crop out further to the west, from which one ^{14}C age is available, dating the flows to 7360±60 a BP.

Table 1 (Kempe, et al. Thurston Lava Tube). Survey data for Thurston Lava Tube.

Length (from the beginning of cave roof - which is 13.5 m mauka of St. 18 above entrance bridge- to lava sump end at St. 0)	inclined	horizontal
total cave (m)	490.84	490.08 (St 0 to St.18= 476.58 m)
wild section (m)	357.43	356.76
tourist section (m)	133.41	133.32
total survey length (m)	531.75	(total of 19 Stations)
as the crow flies (m)	-	432.5
sinuosity (490.076/432.5)	1.133	
vertical extension (m) (St. 0 at lava sump to floor at St. 18 at makai end of bridge)	-20.08	
width (m)	max. 10.5	min. 3.5
height (m)	max. 11.5	min. 1.6
total lava fall height (m)	1.8	8.96% of total vertical
slope (°) (tan^{-1} (20.08/476.576)	2.413	

The system is entered through two pukas (holes): Lua Nunu o Kamakalepo (Pigeon Hole of the Common People) and Waipouli (Dark Waters). Both give accesses to uphill (mauka) and downhill (makai) caves totalling almost 1 km in length (Table 1). In addition Waipouli is filled with an underground brackish tidal lake 200 m. Two further pukas belong to the system, "Pork Pen Puka" (mauka of Lua Nunu) and "Stonehenge Puka" (makai of Waipouli). Pork Pen Puka is a depression set into the roof of Lua Nunu Mauka, the bottom of which is a secondary ceiling to the cave below. Stonehenge Puka is a 60 * 40 m large and up to 20 m deep crater, which not only issued lava as a rootless vent but from which large blocks were swept out, that today mark its rim (giving it a certain resemblance with the real Stonehenge). Using stratigraphic profiles of Lua Nunu and Waipouli and detailed geological maps we discuss the genesis of the system and its fate due to later lava intrusions.

Oral Presentation

Archeology of the Kamakalepo/Waipouli/Stonehenge Area, Underground Fortresses, Living Quarters, and Petrogylph Fields

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South of Na'alehu, Hawaii, near the coast, the Kamakalepo area contains unique archaeological features both above and below ground (Bonk, 1967; Kempe, 1999). A large cave system consisting of four sections of a once much longer tunnel in Mauna Loa lavas was used extensively by the native Hawaiians. The system is entered through two pukas: Lua Nunu o Kamakalepo (Pigeon Hole of the Common People) and Waipouli (Dark Waters). Both of these pukas give accesses to uphill (mauka) and downhill (makai) caves, totalling together 1 km in length.

Table 1 (Kempe et al. Kamakalepo Cave). Length of Kamakalepo Cave System (north to south).

Lua Nunu o Kamakalepo Mauka (of this mauka of crawl)	416.8 m 111.5 m
Lua Nunu Central Cave	26 m
Lua Nunu o Kamakalepo Makai	169.6 m
Waipouli Mauka	125.5 m
Waipouli Makai	260 m
Total	997.9 m

Underground, the caves of the Lua Nunu are the ones used primarily. Retaining walls are found at both entrances providing for dwelling platforms. The main features are two large defence walls across the cave erected by stacking breakdown blocks. The wall in the Makai Cave collapsed mostly, but the one in the Mauka Cave, ca. 60 m into the cave, is well preserved. It has all the characteristics of a medieval defence wall 25 m long and reaching up to 5.5 m above the floor.

Both of the Waipouli Caves show little signs of Hawaiian presence. In the mauka sections just a few places with charcoal are found and a few bits of seafood shells. The makai part is filled with a brackish tidal lake which is caped by freshwater at times of high groundwater flow. We found one large beach stone on the steep entrance slope and a whale vertebra in the water (^{14}C dating in progress).

Above ground the area shows many signs of usage: beach-

stone covered paths, platforms (heiaus), lava dug up for agricultural purposes, animal pens, and areas with petroglyphs, some of them post-contact.

In Absentia Presentation

Cave Detection on Mars

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Exploration of the Martian subterranean environment offers a unique avenue for: (1) investigating promising localities to search for extinct and/ or extant life; (2) identifying areas likely to contain subterranean water ice; (3) evaluating the suitability of caves for the establishment of human habitation areas; and, (4) investigating subsurface geological materials. Use of remote sensing offers efficient means of cave detection. Due to the long and widespread volcanic history of Mars, the low gravity, possible low seismicity, and low rates of processes that could collapse or fill in caves, lava tubes are expected to be common and widespread. Detection of these features on Mars involves: (a) development and interpretation of thermal dynamic models of caves to identify the thermal sensor requirements for detection; (b) evaluation of available imagery of both Earth and Mars for their utility in cave detection; and, (c) collection, analysis and interpretation of ground-based measurements of thermal dynamics of terrestrial caves (and then relating these data to detection of Martian caves).

Our models suggest detectability will be influenced by both time of day and geological substrate. We have also determined that certain bands in THEMIS IR are best for cave detection and have examined cave size in relation to thermal detectability. Thermal data from terrestrial caves supports model results indicating imagery capture at the appropriate time of day is critical to detection. These data also reveal numerous interesting thermal characteristics of caves, which will improve our understanding of thermal properties of caves on both Earth and Mars.

Biospeleology Session

Oral Presentation

A Comparison of Microbial Mats in Pahoehoe and Four Windows Caves, El Malpais National Monument, NM, USA

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Colorful microbial mats exist in lava tubes in many areas of the world, yet little is known about the composition of these microbial communities. Earlier studies of white microbial mats in Four Windows Caves revealed the presence of members of the *Actinobacteria*, *Betaproteobacteria*, *Chloroflexi*, and *Verrucomicrobia*. We have expanded our research to determine whether microbial mats of yellow/ gold coloration, and located in another lava tube, Pahoehoe Cave, have different or similar community compositions. We also wished to ascertain whether novel microbial species are present. Scanning electron microscopy of white and yellow/ gold colonies showed the presence of a variety of cellular morphologies including filaments (textured and smooth), planctomycete-like shapes, and rods. To avoid the pitfalls of culture-based studies, we extracted DNA from colonies adhered to rock samples collected aseptically. The DNA was cleaned, amplified with polymerase chain reactions, cloned, and sequenced. We compared the resultant 16S rDNA sequences against the BLAST and RDPII databases to determine closest relatives, which we aligned and used to generate a phylogenetic tree of evolutionary relationships. This analysis revealed that (1) the only overlap between the two caves occurred in the *Actinobacteria*, but even here the sequences were not closely related; (2) samples from the white colonies in Pahoehoe Cave were most closely related to *Enterobacteriaceae*, such as *E. coli* and *Shigella* spp., possibly originating from surface contamination; (3) additional groups found in Pahoehoe Cave included *Alphaproteobacteria* and other *Gammaproteobacteria*; (4) several novel species were identified based on genetic sequences.

Oral Presentation

Use of ATLANTIS Tierra 2.0 in Mapping the Biodiversity (Invertebrates and Bryophytes) of Caves in the Azorean Archipelago

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In this contribution the software ATLANTIS Tierra 2.0 is described as a promising tool to be used in the conservation management of the animal and plant biodiversity of caves in Macaronesia. In the Azores, the importance of cave entrances to bryophytes is twofold: i) since these are particularly humid, sheltered habitats, they support a diverse assemblage of bryophyte species and circa 25% of the Azorean brioflora is referred to this habitat and ii) species, either endemic or referred in the European red list due to their vulnerability (19 species) or rarity (13) find refuge there. Cave adapted arthropods are also diverse in the Azores and 21 endemic obligate cave species were recorded. Generally these species have restricted distributions and some are known from only one cave. ATLANTIS Tierra 2.0 allows the mapping of the distribution of all species in a 500 x 500 m grid in a GIS interface. This allows an easy detection of species rich caves (hotspots) and facilitates the interpretation of spatial patterns of species distribution. For instance, predictive models of species distribution could be constructed using the distribution of lava flows or other environmental variables. Using this new tool we will be better equipped to answer the following questions: a) Where are the current "hotspot caves" of biodiversity in the Azores? b) How many new caves need to be selected as specially protected areas in order to conserve the rarest endemic taxa? c) Is there congruence between the patterns of richness and distribution of invertebrates and bryophytes? d) Are environmental variables good surrogates of species distributions?

Poster Presentation

Bryophytes of Lava Tubes and Volcanic Pits from Graciosa Island (Azores, Portugal)

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Mainly due to historical reasons, Graciosa Island is the poorest island of the Azores regarding the number of bryophytes (119), especially of rare and endemic species. However, Lava Tubes (Furna da Maria Encantada, Furna do Abel, Galeria Forninho) and Volcanic Pits (Furna do Enxofre) seem to offer refuge to some interesting plants. Previous studies have recorded, among others, the European endemic moss, *Homalia webbiana*, present only in four of the nine Azorean Islands and with less than 10 localities recorded in the archipelago. The main purposes of the fieldwork were: i) to update with field work, the bibliographic records of bryophytes that may be observed in the volcanic formations of Graciosa; ii) to identify in those formations, endemic bryophyte species (from the Azores, Macaronesia and Europe) and species with a conservation risk associated, according to the European Committee for the Conservation of Bryophytes (ECCB). The results show that although no Endemic plants from the Azores were found at this point, six European endemic species and four Macaronesian endemic species were confirmed in the entrances of these volcanic formations, including one Vulnerable species and three rare species, according to ECCB criteria. In conclusion, besides the rich geological interest of the caves in Graciosa, their entrances continue to harbour rare or endemic bryophytes, not commonly found on other parts of the island, possibly due to the greater stability of these habitats. This is an additional reason to preserve the caves and a further possible motive of interest to all that visit them.

Poster Presentation

First Approach to the Comparison of the Bacterial Flora of Two Visited Caves in Terceira Island, Azores, Portugal

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"Algar do Carvão" and "Gruta do Natal" are two interesting volcanic show caves in Terceira Island. The purposes of this work were: i) to characterize the main groups of bacteria observed on their walls and ceiling in four different illumination conditions: darkness, artificial light, half-light and under natural light; ii) to look for *Actinomycetales*, mainly from the family *Streptomyceteae*, due to their ability to produce high-value biochemical products; iii) to investigate if the human activities associated with the economic exploitation of the caves (artificial illumination, visiting activities, cattle raising in their vicinities) had ecological impacts on the composition of the local microbial flora. Although it was not possible to isolate *Actinomycetales* at this point, the preliminary results show that the bacterial flora of both caves was diverse; 52 different isolates were obtained, and these are mostly the result of water infiltration from the overlying fields. In "Algar do Carvão", the half-light area supported the highest diversity of bacterial flora, with 26 isolates, including mostly bacteria associated with the grazing activity that occurs above the Algar. The most interesting species isolated was *Sphingobacterium multivorum*, which has the natural ability to accumulate zeaxanthin, a molecule used as a food pigment and which recently has been considered important in eye-health, reducing

the risk for age-related macular degeneration. The darkness microhabitat of "Gruta do Natal" was the most diverse of the sampled areas of that cave, producing 13 isolates, the majority of which not associated with faecal contaminations. The microbial flora of the two studied formations shows that human activities, mainly cow and goat grazing, are affecting their composition. It is hoped that a management plan could incorporate this information, in order to ensure that only the natural bacterial flora of these caves develop.

Oral Presentation

Cueva del Diablo: A Batcave in Tepoztlan

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In Mexico, almost half of the 138 species of bats use caves as alternative or primary roosts. One volcanic cave that houses important colonies of these animals is Cueva del Diablo in Tepoztlan, Morelos, central Mexico. At least three bat species have been reported in this cave. One of them, the Mexican long-nosed bat (*Leptonycteris nivalis*), is of particular importance in economical and ecological terms. This species migrates from central to northern Mexico and southern United States in mid spring and come back in mid autumn. In Mexico, *L. nivalis* is classified as a threatened species, and in the U.S. as an endangered one.

Owing to the fact that Cueva del Diablo is the only known roost in which this species mates, the cave was proposed by us as a sanctuary to the CONANP (National Commission of Natural Protected Areas) in 2004. In addition to this proposal, the PCMM (Program for Conservation of Mexican Bats) has conducted environmental education efforts in the region as an attempt to modify the negative ideas about bats and to share the information concerning their importance and that of caves for them.

Other PCMM studies conducted in this cave focus on the diet of the species and understanding its mating system, among the first studies on those subjects for this species. This document represents a compilation of those works in Cueva del Diablo with emphasis in their importance for the general conservation of bats and caves.

Oral Presentation

Troglobites from the Lava Tubes in the Sierra de Chichinautzin, México, Challenge the Competitive Exclusion Principle

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In ecology, the Competitive Exclusion Principle establishes that no two species in the same ecosystem can occupy the same niche indefinitely. Two species which make their living in identical ways, eat the same food, and compete for the same limited resources, are unable to coexist in a stable fashion. If two species try to occupy the same niche, one will out-compete and drive to extinction the other.

Multiple lava tubes from the Sierra de Chichinautzin, Mexico, are inhabited by a troglobitic silverfish (*Anelpistina* sp.: Nicoletiidae: Zygentoma: Insecta). At first glance, individuals appear morphologically uniform as expected when they belong to a single species, but when DNA analyses were performed, it was established that despite their morphological similarity, individuals within these caves belonged to at least two distinct species. As individuals of these different species live side by side, most likely occupying the same niche, the Competitive Exclusion Principle is challenged.

The lava tubes inhabited by these troglobites were formed by lava flows emitted by different volcanoes. This implies that Nicoletiid troglobites cannot only cross the boundary between lava tubes, but even between adjacent lava flows. Since some of the lava flows have been dated, one of them even to recent historical time, their efficient dispersal capabilities can be tracked and roughly dated.

Theoretical Session

Oral Presentation

Uranium in Caves

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Uranium is ubiquitous, it is found everywhere, caves and spelean formations and minerals are no exception. However, its presence represents no harm, as it is only present at concentration levels rarely exceeding 10 μg/g. Radioactive decay of U produces minute amounts of several isotopes, radioactive themselves, with half-lives ranging from seconds to several thousand years. This provides the basis for one of the most widely used geo-chronometers which, only until recently, has been applied to the understanding of cave processes and evolution.

The abundance of short- and long-lived U daughter isotopes in different spelean formations and minerals allows us to establish geochronological constrains on their evolution. Furthermore, such information has allowed an increasing

number of scientists to use spelean formations as indicators of past climatic and hydrologic conditions. For example calcite stalactites, stalagmites and flowstones are "routinely" used as archives of climate change as they can be dated relatively easy measuring the relative abundance of ^{238}U-^{234}U-^{230}Th. On the other hand opal and silica varnishes in lava tuffs 500 m below the surface, have been used to track paleohydrological activity during the last 500,000 years.

The basic principles for dating such mineral phases will be presented, along with more detailed information on the above examples and the potential to apply U-dating methods to spelean formations in lava tubes.

Oral Presentation

Development of a Karst Information Portal (KIP) to Advance Research and Education in Global Karst Science

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The University of New Mexico, the National Cave and Karst Research Institute, and the University of South Florida are developing the Karst Information Portal (KIP) to promote open access to karst, cave, and aquifer information and linkages among karst scientists. The resulting connectivity and collaboration will drive innovative solutions to the critical human and environmental challenges of karst. Our purpose is to advance karst knowledge by: (1) facilitating access to and preservation of karst information both published and unpublished, (2) developing linkages and communication amongst the karst community, (3) promoting knowledge-discovery to help develop solutions to problems in karst, (4) developing interactive databases of information of ongoing karst research in different disciplines, (5) enriching fundamental multidisciplinary and interdisciplinary science, and (6) facilitating collection of new data about karst. The KIP project is currently (1) transforming *A Guide to Speleological Literature of the English Language 1794-1996* into the portal's first searchable on-line product and (2) creating an institutional repository of scanning electron micrographs from research in caves that includes social software to promote linkages among karst scientists. In the future, thematic areas, such as cave sediments, conduit flow models, sinkholes, geo-engineering, and speleothem records of climate change, are among the many topics to be included in the portal. A key project focus is the gathering of lesser-known materials, such as masters' theses, technical reports, agency file reports, maps, images, and newsletters. Thus, this project responds to disciplinary needs by integrating individual scientists into a global network through the karst information portal.

Oral Presentation

A Data Base for the Most Outstanding Volcanic Caves of the World: A First Proposal

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During the XI International Symposium on Vulcanospeleology (Pico Island, Azores, 2004), the Commission on Volcanic Caves (CVC) of the UIS recognized the interest of a database for the most important volcanic caves of the world. At that time it was suggested that the Azorean speleological group GESPEA ought to present a proposal to accomplish this task. Following the challenge of the CVC, the GESPEA designed a proposal, as follows:

Aim: Assemble in a database the world most relevant volcanic caves, grouped into 3 major classes, and selected by dimensions, geological exceptionality and biological exclusivity.

Methodology: *Main Tool:* A database (the "WoMOVoC — World Most Outstanding Volcanic Caves" database) will be available in the Internet, having a non complex structure, but comprising a set of fields that enable an accurate characterisation of the volcanic cave, namely: the cave's name, location (e.g. country/region), geographic coordinates, length/depth, main geological features, biological singularity, general description, main references, location map, topography and photos.

New Proposals: Each proposal must be submitted using an electronic form, available in the web site, and comply with the instructions and the criteria for acceptance. To be accepted, the cave must obey the criteria for each main class of relevance:

Class "Relevant Dimensions": caves more than 3 km long and pits more than 100 m depth.

Class "Geological Exceptionality": one or more rare speleothem.

Class "Biological Singularity": one or more troglobian, endemic species.

Selection: The proposal evaluation will be done by a scientific committee, composed by 5 or 7 individuals, assign by the CVC-UIS. The selection of the volcanic caves will be according to the accepting criteria and having in mind other important aspects, as the information accuracy and conservation status. The committee might accept other geological and biological features, if very well documented and if it is a relevant and unambiguous case of uniqueness.

Data Incorporation: After approval by the scientific committee, the new cave will be added to the database by an executive committee, which can be the GESPEA group.

With this paper we fulfil the CVC desideratum, hoping that the proposed methodology might be a first step to gather worldwide information of the most significant volcanic caves,

and, by that, a broader recognition of the value of this geological heritage.

Oral Presentation

Morphogenesis of Lava Tube Caves: A Review

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It is now many years since there was a published scientific review of the formation of lava tube systems and lava tube caves. Possibly the last was this writer's chapter on volcanic caves in the BCRA's 1976 *The Science of Speleology*, although entries in the more recent encyclopedias of caves and karst update some of this information. Yet there have been significant and substantial discoveries in the last 30 years, including exploration of new cave areas (for example, in Iceland, Rwanda, Saudi Arabia, Jordon, Hawaii and Mexico), a more comprehensive appreciation of the extent of the world's vulcanospeleological resource, creation of regional cave databases (eg, Azores, Iceland, Jeju Island), an increasingly higher standard of mapping of cave forms revealing new details of both labyrinthine complexes and long axial systems, acquisition of improved data on the position of caves and cave groups within their parent lava flows or lava flow fields, and better knowledge of associated cavities in lavas.

The contribution made by cavers in cold lava flows has been supplemented by highly revealing observations of active tube-forming processes, principally from the 1969-74 Mauna Ulu and 1983-present Pu'u 'O'o-Kupaianaha flank eruptions of Kilauea volcano, Hawaii, and the recent activity of Mount Etna, Sicily. These observations have contributed substantially to the formulation of new concepts of flow emplacement. The period is also one in which there has been growing realization that the formation of long lava flows, the building of Hawaiian-type shield volcanoes and, possibly, the emplacement of flood basalts, may be products of tube-fed lava flow. Furthermore, there has been increasing evidence of active and ancient lava tube systems on planetary bodies of the solar system, for example, most recently on Jupiter's innermost moon, Io.

Trying to piece this information together to provide one or more coherent theories of cave formation is challenging. For one thing, despite all the observations of active systems, we still do not observe the most important process of all—the method by which principal feeder conduits, or master tubes, grow (extend) downslope. Another shortfall has been analysis of the evidence internal cave forms may provide of fluid activity within an active tube system and subsequent post-activity modifications. This paper reviews the last 30 years of observation of cave data and active tube-fed flow as an attempt to draw together evidence and ideas on the morphogenesis of lava tube caves, in particular to identify areas of uncertainty that would benefit from further investigation.